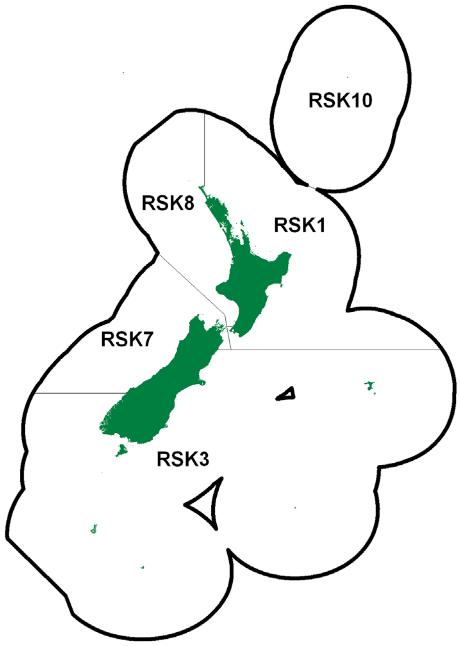
# ROUGH SKATE (RSK)

(*Zearaja nasuta*)
Waewae




## 1. FISHERY SUMMARY

### 1.1 Commercial fisheries

Rough skate (*Zearaja nasuta*, RSK) are fished commercially in New Zealand in close association to smooth skates, which are also known as barndoor skates. Although rough skates grow considerably smaller than smooth skates, RSK is still landed and processed. Two other species of deepwater skate (*Bathyraja shuntovi* and *Raja hyperborea*) are large enough to be of commercial interest but are relatively uncommon and probably comprise a negligible proportion of the landings.

Skate flesh ammoniates rapidly after death, so the wings are removed at sea, and chilled or frozen. On arrival at the shore factories, the wings are machine-skinned, graded and packed for sale. Most of the product is exported to Europe, especially France and Italy. Skates of all sizes are processed, though some factories impose a minimum weight limit of about 1 kg (200 g per wing), and occasionally wings from very large smooth skates are difficult to market.

Rough skates occur throughout New Zealand, but are most abundant around the South Island in depths down to 500 m. Most of the catch is taken as bycatch by bottom trawlers, but skates are also taken by longliners. Significant longline bycatch has been reported from the Bounty Plateau in QMA 6. There is no clear separation of the depth ranges inhabited by rough and smooth skates; however, smooth skate tend to occur slightly deeper than rough skate (Beentjes & Stevenson 2000, 2001, Stevenson & Hanchet 2000).

Many fishers and processors do not distinguish rough and smooth skates in their landing returns, and code them instead as “skates” (SKA). Because it is impossible to determine the species composition of the catch from landings data prior to introduction of these species into the QMS, all pre-QMS data reported here consist of the sum of the three species codes RSK, SSK and SKA. Landings have been converted from processed weight to whole weight by application of conversion factors.

There have been historical changes to the conversion factors applied to skates by MAF Fisheries and Ministry of Fisheries. No record seems to have been kept of the conversion factors in use before 1987, so it is not possible to reconstruct the time series of landings data using the currently accepted factors. Consistent and appropriate conversion factors have been applied to skate landings since the end of the 1986-87 fishing year. Before that, it appears that a lower conversion factor was applied, resulting in an underestimation of landed weight by about 20%. No correction has been made for that in this report.

New Zealand annual skate landings, estimated from a variety of sources, are shown in Table 1. No FSU deepwater data were available before 1983, and it is not known whether deepwater catches, including those of foreign fishing vessels, were significant during that period. CELR and CLR data are provided by inshore and deepwater trawlers respectively. "CELR estimated" landings were always less than "CELR landed" landings, because the former include only the top five fish species (by weight) caught by trawlers, whereas the latter include all species landed. As a relatively minor bycatch, skates frequently do not fall into the top five species. The sum of the "CELR landed" and CLR data provides an estimate of the total skate landings. This estimate usually agreed well with LFRR data supplied by fish processors, especially in 1993-94 and 1994-95, but in 1992-93 the difference was 467 t. The "best estimate" of the annual historical landings comes from FSU data up to 1985-86, and LFRR data thereafter.

**Table 1: New Zealand skate landings for calendar years 1974-1983, and fishing years (1 October - 30 September) 1983-84-1995-96. Values in parentheses are based on part of the fishing year only. Landings do not include foreign catch before 1983, or unreported discards. FSU = Fisheries Statistics Unit; CELR = Catch, Effort and Landing Return; CLR = Catch Landing Return; LFRR = Licensed Fish Receivers Return; Best Estim. = best available estimate of the annual skate catch; - = no data.**

| Year | FSU Inshore | FSU Deepwater | FSU Total | CELR Estim | CELR Landed | CLR | CELR Landed +CLR | LFRR | Best Estimate |
|---|---|---|---|---|---|---|---|---|---|
| 1974 | 23 | - | - | - | - | - | - | - | 23 |
| 1975 | 30 | - | - | - | - | - | - | - | 30 |
| 1976 | 28 | - | - | - | - | - | - | - | 28 |
| 1977 | 27 | - | - | - | - | - | - | - | 27 |
| 1978 | 36 | - | - | - | - | - | - | - | 36 |
| 1979 | 165 | - | - | - | - | - | - | - | 165 |
| 1980 | 441 | - | - | - | - | - | - | - | 441 |
| 1981 | 426 | - | - | - | - | - | - | - | 426 |
| 1982 | 648 | - | - | - | - | - | - | - | 648 |
| 1983 | 634 | 178 | 812 | - | - | - | - | - | 812 |
| 1983-84 | 686 | 298 | 983 | - | - | - | - | - | 983 |
| 1984-85 | 636 | 250 | 886 | - | - | - | - | - | 886 |
| 1985-86 | 613 | 331 | 944 | - | - | - | - | - | 944 |
| 1986-87 | 723 | 285 | 1 007 | - | - | - | - | 1 019 | 1 019 |
| 1987-88 | 1 005 | 421 | 1 426 | - | - | - | - | 1 725 | 1 725 |
| 1988-89 | (530) | (136) | (665) | (252) | (265) | (28) | (293) | 1 513 | 1 513 |
| 1989-90 | - | - | - | 780 | 1 171 | 410 | 1 581 | 1 769 | 1 769 |
| 1990-91 | - | - | - | 796 | 1 334 | 359 | 1 693 | 1 820 | 1 820 |
| 1991-92 | - | - | - | 1 112 | 1 994 | 703 | 2 698 | 2 620 | 2 620 |
| 1992-93 | - | - | - | 1 175 | 2 595 | 824 | 3 418 | 2 951 | 2 951 |
| 1993-94 | - | - | - | 1 247 | 2 236 | 788 | 3 024 | 2 997 | 2 997 |
| 1994-95 | - | - | - | 956 | 1 973 | 829 | 2 803 | 2 789 | 2 789 |
| 1995-96 | - | - | - | - | - | - | - | 2 789 | 2 789 |

Total skate landings (based on the "best estimate" in Table 1) were negligible up to 1978, presumably because of a lack of suitable markets and the availability of other more abundant and desirable species. Landings then increased linearly to reach nearly 3000 t in 1992-93 and 1993-94, and have remained between 2600 and 3100 t ever since (Table 2).

Rough skates (RSK) were introduced into the QMS as separate species from 1 October 2003 with allowances, TACCs and TACs as follow in Table 2. Figures 1 shows the historical landings and TACC values for the main RSK stocks. Owing to problems associated with identification of rough and smooth skates, reported catches of each species are probably not accurate. Initiatives to improve identification of these species begun in 2003 may have resulted in more accurate data.

**Table 2: Reported landings (t) of SKA and RSK by QMA and fishing year, 1996-97 to 2010-11.**

| QMA | 1 | 3 | 7 | 8 | 10 | Total |
|---|---|---|---|---|---|---|
| FMA | 1-2 | 3-6 | 7 | 8-9 | 10 | All |
| Skate (SKA)* | | | | | | |
| 1996-97 | 43 | 894 | 380 | 30 | 0 | 1 347 |
| 1997-98 | 44 | 855 | 156 | 31 | 0 | 1 086 |
| 1998-99 | 48 | 766 | 228 | 12 | 0 | 1 054 |
| 1999-00 | 75 | 775 | 253 | 25 | 0 | 1 128 |
| 2000-01 | 88 | 933 | 285 | 28 | 0 | 1 334 |
| 2001-02 | 132 | 770 | 311 | 35 | 0 | 1 248 |
| 2002-03 | 121 | 857 | 293 | 32 | 0 | 1 303 |
| 2003-04 | < 1 | < 1 | < 1 | < 1 | 0 | 1 |
| Rough skate (RSK) | | | | | | |
| 1996-97 | 15 | 265 | 69 | 3 | 0 | 352 |
| 1997-98 | 32 | 493 | 44 | 5 | 0 | 574 |
| 1998-99 | 22 | 607 | 33 | 4 | 0 | 666 |
| 1999-00 | 20 | 720 | 37 | 2 | 0 | 779 |
| 2000-01 | 27 | 569 | 42 | 4 | 0 | 642 |
| 2001-02 | 24 | 607 | 25 | 3 | 0 | 659 |
| 2002-03 | 18 | 1 060 | 27 | 11 | 0 | 1 118 |
| 2003-04 | 48 | 1 568 | 191 | 33 | 0 | 1 840 |
| 2004-05 | 72 | 1 815 | 173 | 55 | 0 | 2 115 |
| 2005-06 | 72 | 1 446 | 153 | 28 | 0 | 1 699 |
| 2006-07 | 68 | 1 475 | 197 | 35 | 0 | 1 768 |
| 2007-08 | 80 | 1 239 | 206 | 46 | 0 | 1 573 |
| 2008-09 | 79 | 1 591 | 226 | 46 | 0 | 1 942 |
| 2009-10 | 87 | 1 546 | 225 | 46 | 0 | 1 905 |
| 2010-11 | 91 | 1 547 | 199 | 45 | 0 | 1 882 |

*Use of the code SKA ceased once skates were introduced into the QMS in October 2003 and rough skates and smooth skates were recognised as a separate species. From this time all landings of skates have been reported against either the RSK or SSK code.

**Table 3: Recreational, customary, and other mortality allowances (t), Total Allowable Commercial Catches (TACC, t) and Total Allowable Catches (TAC, t) declared for RSK on introduction into the QMS in October 2003.**

| Fishstock | Recreational Allowance | Customary non-commercial Allowance | Other Mortality | TACC | TAC |
|---|---|---|---|---|---|
| RSK 1 (FMAs 1-2) | 1 | 1 | 1 | 111 | 114 |
| RSK 3 (FMAs 3-6) | 1 | 1 | 17 | 1 653 | 1 672 |
| RSK 7 | 1 | 1 | 2 | 201 | 205 |
| RSK 8 (FMAs 8-9) | 1 | 1 | 1 | 21 | 24 |
| RSK 10 | 0 | 0 | 0 | 0 | 0 |

## 1.2 Recreational fisheries

Recreational fishing surveys indicate that rough skates are very rarely caught by recreational fishers.

## 1.3 Customary non-commercial fisheries

Quantitative information on the level of customary non-commercial take is not available.

## 1.4 Illegal catch

Quantitative information on the level of illegal catch is not available.

## 1.5 Other sources of mortality

Because skates are taken mainly as bycatch of bottom trawl fisheries, historical catches have probably been proportional to the amount of effort in the target trawl fisheries. Past catches were probably higher than historical landings data suggest, because of unrecorded discards and unrecorded foreign catch before 1983.

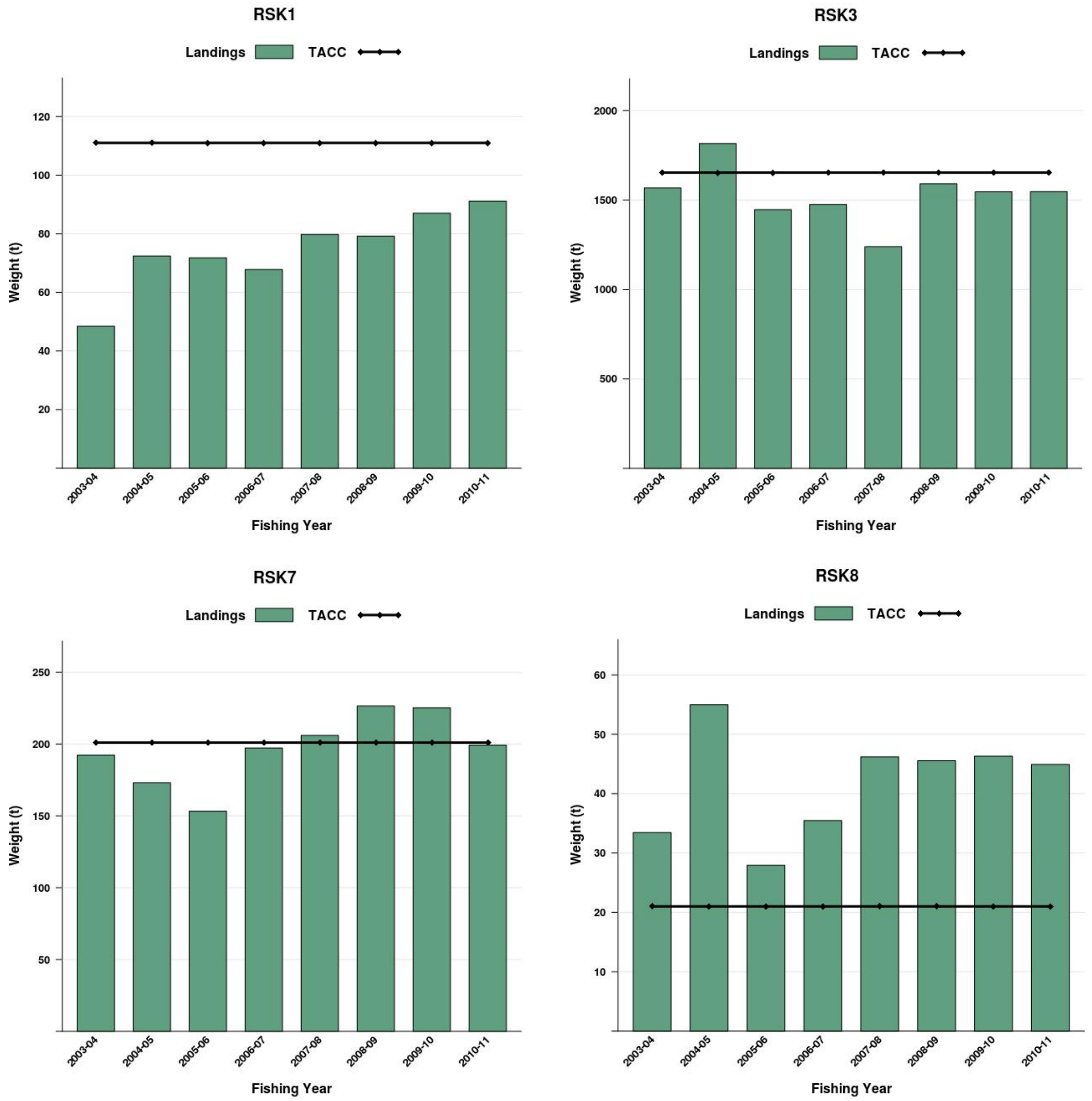



**Figure 1: Historical landings and TACC for the four main RSK stocks. From top left to bottom right: RSK1 (Auckland East), RSK3 (South East Coast, South East Chatham Rise, Sub Antarctic, Southland), RSK7 (Challenger), and RSK8 (Central Egmont, Auckland West). Note that these figures do not show data prior to entry into the QMS.**

## 2. BIOLOGY

Little is known about the reproductive biology of rough skates. Rough skates reproduce by laying yolky eggs, enclosed in leathery cases, on the seabed. Rough skates lay their eggs in spring-summer (Francis 1997). Two eggs are laid at a time, but the number of eggs laid annually by a female is unknown. A single embryo develops inside each egg case and the young hatch at about 10-15 cm pelvic length (body length excluding the tail) (Francis 1997).

Rough skates grow to at least 79 cm pelvic length, and females grow larger than males. The greatest reported age is 9 years for a 70 cm pelvic length female, and females may live longer than males (Francis *et al.* 2001a, b). There are no apparent differences in growth rate between the sexes. Males reach 50% maturity at about 52 cm and 4 years, and females at 59 cm and 6 years. The most plausible estimate of $M$ is 0.25-0.35. Biological parameters relevant to stock assessment are shown in Table 4.

**Table 4: Estimates of biological parameters for Rough skates (RSK).**

| Fishstock | | | Estimate | Source |
|---|---|---|---|---|
| 1. Natural mortality (M) | | | | |
| RSK 3 | | | 0.25-0.35 | Francis *et al*. (2001b) |
| 2. Weight = a (length) $^{b}$ (weight in g, length in cm pelvic length) | | | | |
| | | a | b | |
| RSK males | | 0.0393 | 2.838 | Francis (1997) |
| RSK females | | 0.0218 | 3.001 | Francis (1997) |
| 3. von Bertalanffy growth parameters | | | | |
| | $K$ | $t_0$ | $L_\infty$ | |
| RSK 3 (both sexes) | 0.16 | -1.2 | 91.3 | Francis *et al*. (2001b) |
| RSK 3 (both sexes) | 0.096 | -0.78 | 151.8 | Francis *et al*. (2004) |

## 3. STOCKS AND AREAS

Nothing is known about stock structure or movement patterns in skates. Rough skates are distributed throughout most of New Zealand, from the Three Kings Islands to Campbell Island and the Chatham Islands, including the Challenger Plateau, Chatham Rise and Bounty Plateau. Rough skates have not been recorded from QMA 10.

In this report, rough skate landings have been presented by QMA. QMAs would form appropriate management units in the absence of any information on biological stocks.

## 4. STOCK ASSESSMENT

This is the first stock assessment for skates. No yield estimates have been made for skates.

### 4.1 Estimates of fishery parameters and abundance

Relative biomass estimates are available for rough skates from a number of trawl survey series (Table 5). Biomass estimates are not provided for surveys of: (a) west coast North Island because of major changes in survey areas and strata during the series; or (b) east Northland, Hauraki Gulf and Bay of Plenty because of the low relative biomass of rough skates present (usually less than 100 t). In the first survey of each of two series -east coast South Island and Chatham Rise- the two skate species were not (fully) distinguished. Furthermore, there are doubts about the accuracy of species identification in some other earlier surveys (prior to 1996). Consequently, trends in biomass of individual species must be interpreted cautiously. To enable comparison among all surveys within each series, total skate biomass is also reported.

As the catch from the South Island trawl surveys changes without wide inter-annual fluctuations and the CVs are relatively low it appears that they are able to track rough skate biomass in FMA 3, 7, and on the Stewart Snares. West Coast South Island surveys show that the relative biomass of rough skate in FMA 7 declined in the early 2000s but has since increased marginally.

### 4.2 Biomass estimates

There are no absolute biomass estimates for rough skates.

### 4.3 Estimation of Maximum Constant Yield (*MCY*)

*MCY* cannot be estimated.

The *MCY* estimator, that has the lowest data requirements ($MCY = cY_{AV}$; Method 4), relies on selecting a time period during which there were “no systematic changes in fishing mortality (or fishing effort, if this can be assumed to be proportional to fishing mortality)”. This method was not applied because no information is currently available on skate fishing mortality, or on trawl fishing effort in the main skate fishing areas.

**Table 5: Doorspread biomass estimates (t) and coefficients of variation (CV %) of rough skates and total skates (both rough and smooth).**

| | | Rough skate | | Total | |
|---|---|---|---|---|---|
| Year | Trip Code | Biomass | CV | Biomass | CV |
| East coast North Island | | | | | |
| 1993 | KAH9304 | 76 | 28 | 99 | - |
| 1994 | KAH9402 | 189 | 12 | 333 | - |
| 1995 | KAH9502 | 52 | 20 | 72 | - |
| 1996 | KAH9602 | 309 | 24 | 394 | - |
| South Island west coast and Tasman/Golden Bays (FMA 7) | | | | | |
| 1992 | KAH9204 | 173 | 27 | 512 | - |
| 1994 | KAH9404 | 196 | 23 | 537 | - |
| 1995 | KAH9504 | 251 | 22 | 566 | - |
| 1997 | KAH9701 | 185 | 30 | 487 | - |
| 2000 | KAH0004 | 186 | 23 | 326 | - |
| 2003 | KAH0304 | 43 | 34 | 134 | - |
| 2005 | KAH0503 | 58 | 30 | 138 | - |
| 2007 | KAH0704 | 256 | 23 | 300 | - |
| 2009 | KAH0904 | 114 | 21 | 181 | - |
| 2011 | KAH1104 | 347 | 23 | 532 | - |
| East coast South Island (FMA 3) Winter | | | | | |
| 1991 | KAH9105 | - | - | 1928 | 25 |
| 1992 | KAH9205 | 224 | 24 | 829 | 16 |
| 1993 | KAH9306 | 335 | 21 | 993 | 21 |
| 1994 | KAH9406 | 517 | 20 | 823 | 15 |
| 1996 | KAH9606 | 177 | 19 | 562 | 18 |
| 2007 | KAH0705 | 878 | 22 | 1 580 | - |
| 2008 | KAH0806 | 858 | 19 | 1 412 | - |
| 2009 | KAH0905 | 1 029 | 30 | 1 765 | - |
| East coast South Island (FMA 3) Summer | | | | | |
| 1996-97 | KAH9618 | 1 336 | 15 | 2 057 | - |
| 1997-98 | KAH9704 | 1 082 | 13 | 1 567 | - |
| 1998-99 | KAH9809 | 1 175 | 10 | 1 625 | - |
| 1999-00 | KAH9917 | 329 | 23 | 698 | - |
| 2000-01 | KAH0014 | 222 | 34 | 470 | - |
| Chatham Rise | | | | | |
| 1991-2 | TAN9106 | - | - | 2 129 | - |
| 1992-3 | TAN9212 | 55 | 83 | 1 126 | - |
| 1994 | TAN9401 | 220 | 44 | 1 178 | - |
| 1995 | TAN9501 | 76 | 43 | 845 | - |
| 1996 | TAN9601 | 11 | 100 | 1 522 | - |
| 1997 | TAN9701 | 12 | 58 | 1 944 | - |
| 1998 | TAN9801 | 10 | 100 | 1 935 | - |
| 1999 | TAN9901 | 34 | 60 | 1 772 | - |
| 2000 | TAN0001 | 0 | - | 1 369 | - |
| 2001 | TAN0101 | 72 | 59 | 2 393 | - |
| 2002 | TAN0201 | 37 | 65 | 2 148 | - |
| 2003 | TAN0301 | 32 | 64 | 1 387 | - |
| 2004 | TAN0401 | 22 | 60 | 2 066 | - |
| 2005 | TAN0501 | 89 | 45 | 1 869 | - |
| 2006 | TAN0601 | 56 | 45 | 1 577 | - |
| 2007 | TAN0701 | 29 | 56 | 1 951 | - |
| 2008 | TAN0801 | 0 | - | 1 376 | - |
| 2009 | TAN0901 | 23 | 67 | 1 185 | - |
| 2010 | TAN1001 | - | - | 1 576 | - |
| 2011 | TAN1101 | - | - | 1 009 | - |
| 2012 | TAN1201 | - | - | 813 | - |
| Stewart-Snares Shelf | | | | | |
| 1993 | TAN9301 | 592 | 20 | 1 120 | - |
| 1994 | TAN9402 | 1 064 | 15 | 1 406 | - |
| 1995 | TAN9502 | 801 | 7 | 1 136 | - |
| 1996 | TAN9604 | 1 055 | 11 | 1 559 | - |
| Survey discontinued | | | | | |
| Stewart-Snares Shelf and Sub-Antarctic (Summer)* | | | | | |
| 1991 | TAN9105 | 37 | 72 | 419 | - |
| 1992 | TAN9211 | 52 | 69 | 165 | - |
| 1993 | TAN9310 | 132 | 57 | 249 | - |
| 2000 | TAN0012 | 201 | 56 | 267 | - |
| Stewart-Snares Shelf and Sub-Antarctic (Autumn)* | | | | | |
| 1992 | TAN9204 | 48 | 100 | 141 | - |
| 1993 | TAN9304 | 251 | 57 | 428 | - |
| 1996 | TAN9605 | 22 | 71 | 857 | - |
| 1998 | TAN9805 | 71 | 77 | 607 | - |

*Biomass estimates are for core 300-800 m strata only

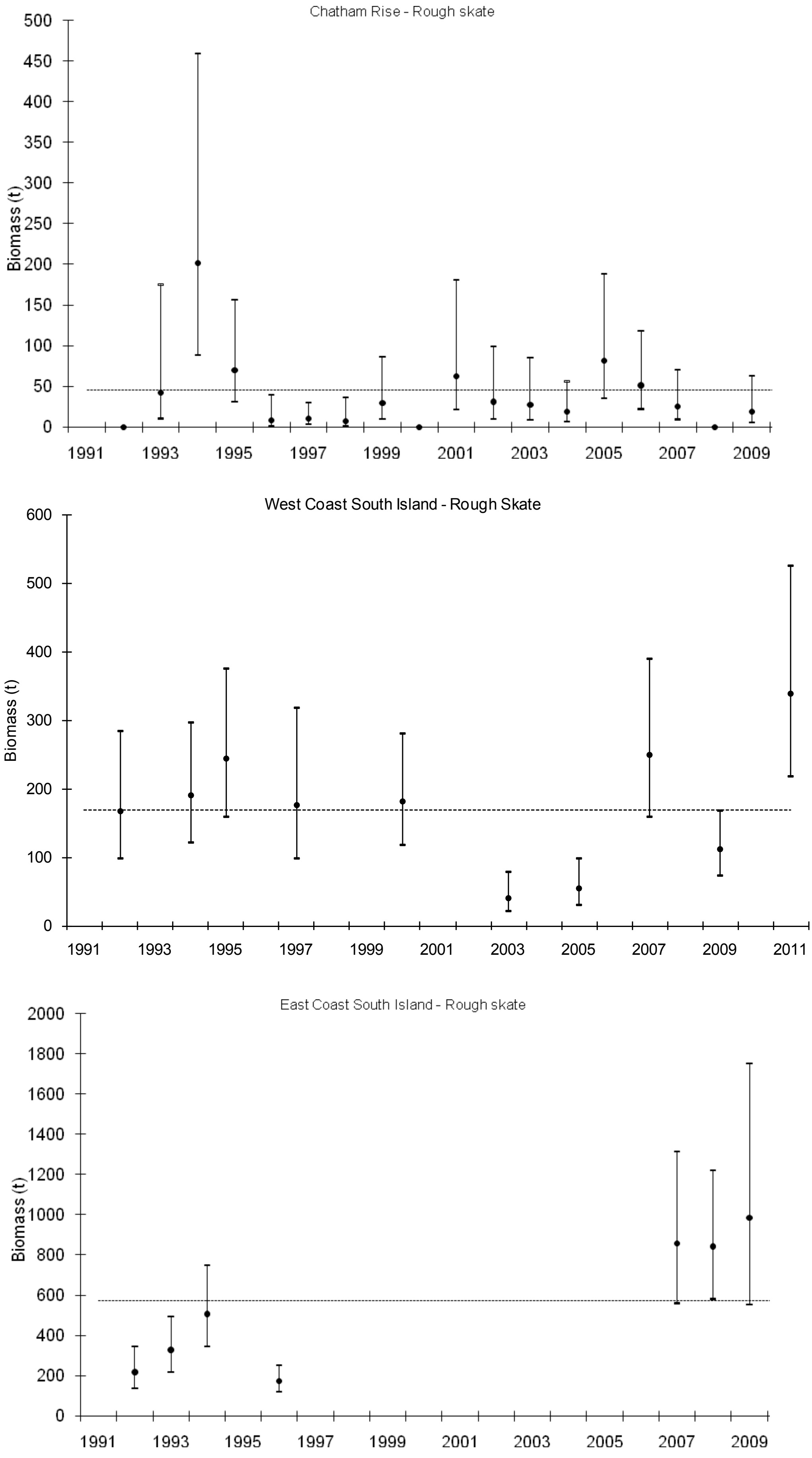



**Figure 3: Rough skate biomass ±95% CI (estimated from survey CVs assuming a lognormal distribution) and the time series mean (dotted line) estimated from the Chatham Rise (Top), West (Middle) and East (bottom) Coast South Island trawl survey.**

### 4.4 Estimation of Current Annual Yield (*CAY*)

*CAY* cannot be estimated.

### 4.5 Other yield estimates and stock assessment results

No other yield estimates are available.

### 4.6 Other factors

Species that constitute a minor bycatch of trawl fisheries are often difficult to manage using TACCs and ITQs. Skates are widely and thinly distributed, and would be difficult for trawlers to avoid after the quota had been caught. A certain level of incidental bycatch is therefore inevitable. However, skates are relatively hardy, and frequently survive being caught in trawls (though mortality would depend on the length of the tow and the weight of fish in the cod end). Skates returned to the sea alive probably have a greater chance of survival than most other fishes.

## 5. STATUS OF THE STOCKS

No estimates of current and reference biomass are available.

For rough skate it is Unknown if recent catch levels or the TACC will cause their populations to decline. Reported landings and TACCs for the 2010-11 fishing year are summarised in Tables 6.

**Table 6: Summary of TACCs (t), and reported landings (t) for rough skates for the most recent fishing year.**

| Fishstock | | QMA | 2010-11 Actual TACC | 2010-11 Reported landings |
|---|---|---|---|---|
| RSK 1 (FMAs 1-2) | Auckland (East) Central (East) | 1 & 2 | 111 | 91 |
| RSK 3 (FMAs 3-6) | South-east (Coast) (Chatham), Southland, and Sub-Antarctic | 3, 4, 5 & 6 | 1 653 | 1 547 |
| RSK 7 | Challenger | 7 | 201 | 199 |
| RSK 8 (FMAs 8-9) | Central (West), Auckland (West) | 8 & 9 | 21 | 45 |
| RSK 10 | Kermadec | 10 | 0 | 0 |
| Total | | | 1 986 | 1 882 |

## 6. FOR FURTHER INFORMATION


Beentjes M.P., Stevenson M.L. 2000. Review of the east coast South Island winter trawl survey time series, 1991-96. NIWA Technical Report 86. 64 p.

Beentjes M.P., Stevenson M.L. 2001. Review of the east coast South Island summer trawl survey time series, 1996-97 to 1999-2000. NIWA Technical Report 108. 92 p.

Francis M.P. 1997. A summary of biology and commercial landings, and a stock assessment of rough and smooth skates (*Raja nasuta* and *R. innominata*). New Zealand Fisheries Assessment Research document 1997/5 27p.

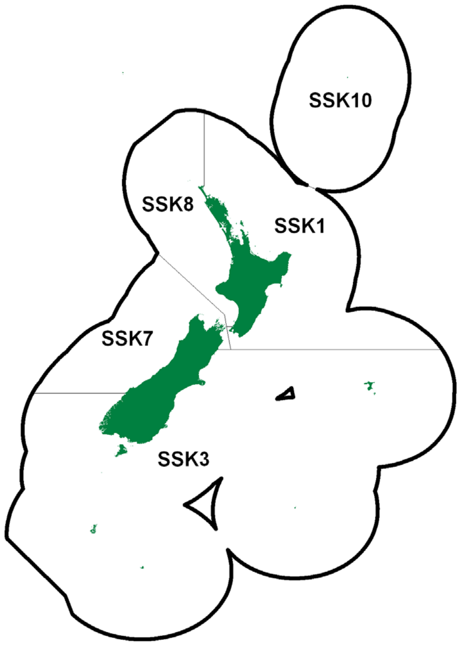
Francis M.P., Ó Maolagáin C., Stevens D. 2001a. Age, growth, and sexual maturity of two New Zealand endemic skates, *Dipturus nasutus* and *D. innominatus*. New Zealand Journal of Marine and Freshwater Research 35: 831-842.

Francis M.P., Ó Maolagáin C., Stevens D. 2001b. Age, growth, maturity, and mortality of rough and smooth skates (*Dipturus nasutus* and *D. innominatus*). New Zealand Fisheries Assessment Report 2001/17. 21 p.

Francis M.P., Ó Maolagáin C., Stevens D. 2004. Revised growth, longevity and natural mortality of smooth skate (*Dipturus innominatus*). Final Research Report for Ministry of Fisheries Project MOF2003/01H (Dated June 2004).

Stevenson M.L., Hanchet S. 2000. Review of the inshore trawl *survey* series of the west coast South Island and Tasman and Golden Bays, 1992-97. NIWA Technical Report 82. 79 p.

# SMOOTH SKATE (SSK)
(*Dipturus innominata*)
Uku




## 1. FISHERY SUMMARY

### 1.1 Commercial fisheries

Smooth skate (*Dipturus innominata*, SSK), which are also known as barndoor skates, are fished commercially in close association with rough skates (RSK) in New Zealand. Smooth skates grow considerably larger than rough skates, but both species are landed and processed. Two other species of deepwater skate (*Bathyraja shuntovi* and *Raja hyperborea*) are large enough to be of commercial interest but are relatively uncommon and probably comprise a negligible proportion of the landings.

Skate flesh ammoniates rapidly after death, so the wings are removed at sea, and chilled or frozen. On arrival at the shore factories, the wings are machine-skinned, graded and packed for sale. Most of the product is exported to Europe, especially France and Italy. Skates of all sizes are processed, though some factories impose a minimum weight limit of about 1 kg (200 g per wing), and occasionally wings from very large smooth skates are difficult to market.

Smooth skates occur throughout New Zealand, but are most abundant around the South Island in depths down to 500 m. Most of the catch is taken as bycatch by bottom trawlers, but skates are also taken by longliners. Significant longline bycatch has been reported from the Bounty Plateau in QMA 6. While there is no clear separation of the depth ranges inhabited by rough and smooth skates, smooth skates tend to occur slightly deeper than rough skate (Beentjes & Stevenson 2000, 2001, Stevenson & Hanchet 2000).

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| Year | FSU Inshore | FSU Deepwater | FSU Total | CELR Estim | CELR Landed | CLR | CELR Landed +CLR | LFRR | Best Estimate |
|---|---|---|---|---|---|---|---|---|---|
| 1974 | 23 | - | - | - | - | - | - | - | 23 |
| 1975 | 30 | - | - | - | - | - | - | - | 30 |
| 1976 | 28 | - | - | - | - | - | - | - | 28 |
| 1977 | 27 | - | - | - | - | - | - | - | 27 |
| 1978 | 36 | - | - | - | - | - | - | - | 36 |
| 1979 | 165 | - | - | - | - | - | - | - | 165 |
| 1980 | 441 | - | - | - | - | - | - | - | 441 |
| 1981 | 426 | - | - | - | - | - | - | - | 426 |
| 1982 | 648 | - | - | - | - | - | - | - | 648 |
| 1983 | 634 | 178 | 812 | - | - | - | - | - | 812 |
| 1983-84 | 686 | 298 | 983 | - | - | - | - | - | 983 |
| 1984-85 | 636 | 250 | 886 | - | - | - | - | - | 886 |
| 1985-86 | 613 | 331 | 944 | - | - | - | - | - | 944 |
| 1986-87 | 723 | 285 | 1 007 | - | - | - | - | 1 019 | 1 019 |
| 1987-88 | 1 005 | 421 | 1 426 | - | - | - | - | 1 725 | 1 725 |
| 1988-89 | (530) | (136) | (665) | (252) | (265) | (28) | (293) | 1 513 | 1 513 |
| 1989-90 | - | - | - | 780 | 1 171 | 410 | 1 581 | 1 769 | 1 769 |
| 1990-91 | - | - | - | 796 | 1 334 | 359 | 1 693 | 1 820 | 1 820 |
| 1991-92 | - | - | - | 1 112 | 1 994 | 703 | 2 698 | 2 620 | 2 620 |
| 1992-93 | - | - | - | 1 175 | 2 595 | 824 | 3 418 | 2 951 | 2 951 |
| 1993-94 | - | - | - | 1 247 | 2 236 | 788 | 3 024 | 2 997 | 2 997 |
| 1994-95 | - | - | - | 956 | 1 973 | 829 | 2 803 | 2 789 | 2 789 |
| 1995-96 | - | - | - | - | - | - | - | 2 789 | 2 789 |

Total skate landings (based on the "best estimate" in Table 1) were negligible up to 1978, presumably because of a lack of suitable markets and the availability of other more abundant and desirable species. Landings then increased linearly to reach nearly 3000 t in 1992-93 and 1993-94, and have remained between 2600 and 3100 t ever since (Table 2).

Smooth (SSK) skates were introduced into the QMS as a separate species from 1 October 2003 with allowances, TACCs and TACs as follow in Table 3. Figures 1 shows the historical landings and TACC values for the main SSK stocks. Owing to problems associated with identification of rough and smooth skates, reported catches of each species are probably not accurate. Initiatives to improve identification of these species begun in 2003 may have resulted in more accurate data.

**Table 2: Reported landings (t) of SKA and SSK by QMA and fishing year, 1996-97 to 2010-11.**

| QMA | 1 | 3 | 7 | 8 | 10 | Total |
|---|---|---|---|---|---|---|
| FMA | 1-2 | 3-6 | 7 | 8-9 | 10 | All |
| Skate (SKA)* | | | | | | |
| 1996-97 | 43 | 894 | 380 | 30 | 0 | 1 347 |
| 1997-98 | 44 | 855 | 156 | 31 | 0 | 1 086 |
| 1998-99 | 48 | 766 | 228 | 12 | 0 | 1 054 |
| 1999-00 | 75 | 775 | 253 | 25 | 0 | 1 128 |
| 2000-01 | 88 | 933 | 285 | 28 | 0 | 1 334 |
| 2001-02 | 132 | 770 | 311 | 35 | 0 | 1 248 |
| 2002-03 | 121 | 857 | 293 | 32 | 0 | 1 303 |
| 2003-04 | < 1 | < 1 | < 1 | < 1 | 0 | 1 |
| Smooth skate (SSK) | | | | | | |
| 1996-97 | 10 | 782 | 102 | 5 | 0 | 899 |
| 1997-98 | 5 | 901 | 121 | 4 | 0 | 1 031 |
| 1998-99 | 5 | 1 011 | 100 | 15 | 0 | 1 131 |
| 1999-00 | 5 | 877 | 73 | 16 | 0 | 971 |
| 2000-01 | 9 | 859 | 104 | 7 | 0 | 979 |
| 2001-02 | 17 | 794 | 89 | 7 | 0 | 907 |
| 2002-03 | 19 | 704 | 167 | 3 | 0 | 893 |
| 2003-04 | 79 | 431 | 146 | 15 | 0 | 671 |
| 2005-06 | 72 | 468 | 163 | 12 | 0 | 715 |
| 2006-07 | 58 | 473 | 155 | 6 | 0 | 693 |
| 2007-08 | 47 | 422 | 171 | 21 | 0 | 661 |
| 2008-09 | 38 | 332 | 168 | 22 | 0 | 560 |
| 2009-10 | 36 | 290 | 194 | 26 | 0 | 546 |
| 2010-11 | 27 | 307 | 243 | 32 | 0 | 609 |

*Use of the code SKA ceased once skates were introduced into the QMS in October 2003 and rough skates and smooth skates were recognised as a separate species. From this time all landings of skates have been reported against either the RSK or SSK code.

**Table 3: Recreational and customary non-commercial allowances (t), Total Allowable Commercial Catches (TACC, t) and Total Allowable Catch (TAC, t) declared for SSK on introduction into the QMS in October 2003.**

| Fishstock | Recreational Allowance | Customary non-commercial Allowance | Other Mortality | TACC | TAC |
|---|---|---|---|---|---|
| SSK 1 (FMAs 1-2) | 1 | 1 | 1 | 37 | 40 |
| SSK 3 (FMAs 3-6) | 1 | 1 | 6 | 579 | 587 |
| SSK 7 | 1 | 1 | 2 | 213 | 217 |
| SSK 8 (FMAs 8-9) | 1 | 1 | 1 | 20 | 23 |
| SSK 10 | 0 | 0 | 0 | 0 | 0 |

## 1.2 Recreational fisheries

Recreational fishing surveys indicate that skates are very rarely caught by recreational fishers.

## 1.3 Customary non-commercial fisheries

Quantitative information on the level of customary non-commercial take is not available.

## 1.4 Illegal catch

Quantitative information on the level of illegal catch is not available.

## 1.5 Other sources of mortality

Because skates are taken mainly as bycatch of bottom trawl fisheries, historical catches have probably been proportional to the amount of effort in the target trawl fisheries. Past catches were probably higher than historical landings data suggest because of unrecorded discards and unrecorded foreign catch before 1983.

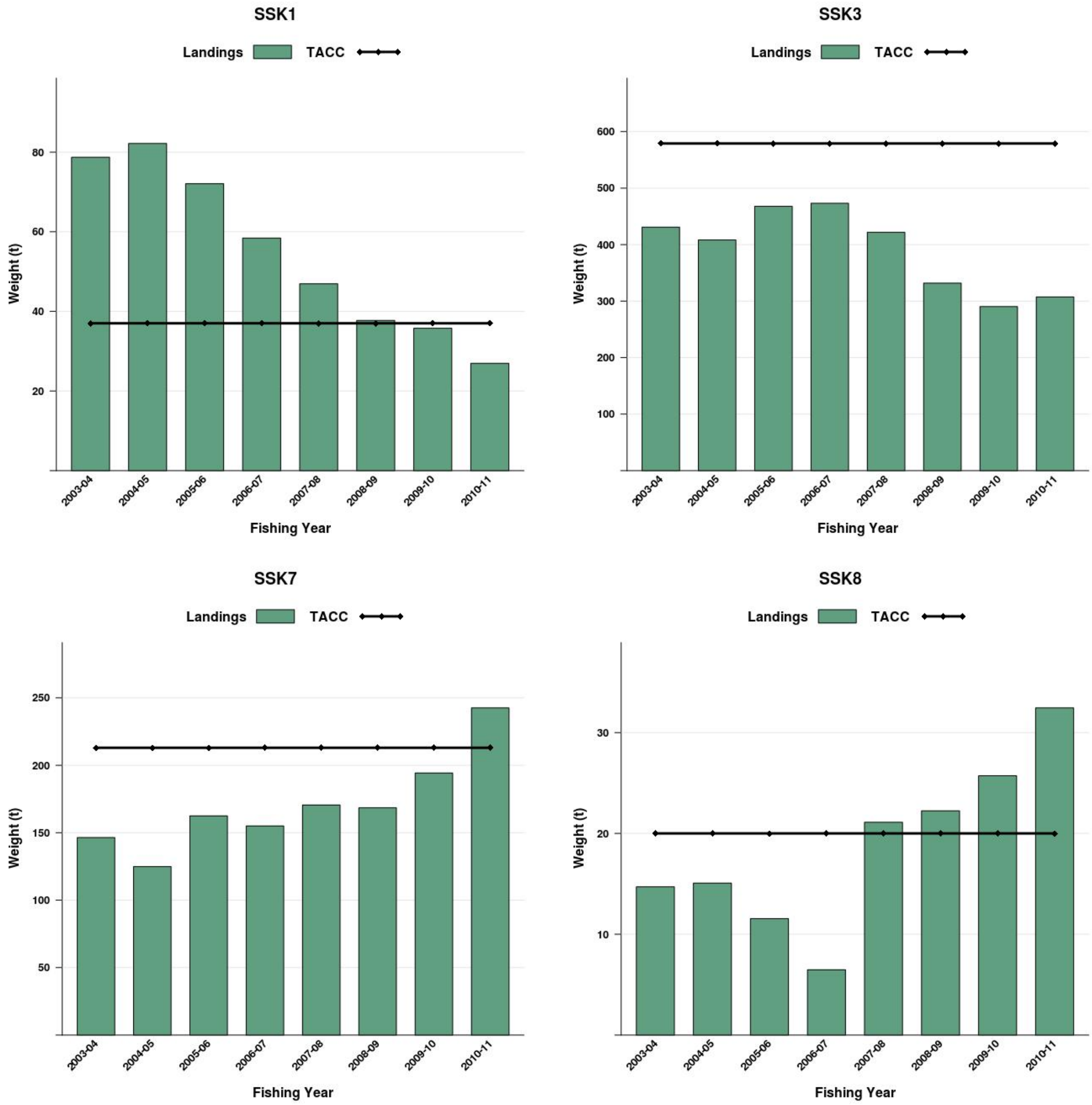



**Figure 1: Historical landings and TACC for the four main SSK stocks. From top left to bottom right: SSK1 (Auckland East), SSK3 (South East Coast, South East Chatham Rise, Sub Antarctic, Southland), SSK7 (Challenger), and SSK8 (Central Egmont, Auckland West). Note that these figures do not show data prior to entry into the QMS.**

## 2. BIOLOGY

Little is known about the reproductive biology of smooth skates. Smooth skates reproduce by laying yolky eggs, enclosed in leathery cases, on the seabed. Two eggs are laid at a time, but the number of eggs laid annually by a female is unknown. A single embryo develops inside each egg case and the young hatch at about 10-15 cm pelvic length (body length excluding the tail) (Francis 1997).

The greatest reported age for smooth skate is 28 years for a 155 cm pelvic length female (Francis *et al.* 2004). Females grow larger than males, and also appear to live longer than them. There are no apparent differences in growth rate between the sexes. Males reach 50% maturity at about 93 cm and 8 years, and females at 112 cm and 13 years. However, the small sample size of mature animals, particularly females, means that the maturity ogives are poorly defined. The most plausible estimate of *M* is 0.10-0.20. Biological parameters relevant to stock assessment are shown in Table 4.

**Table 4: Estimates of biological parameters for skates.**

| Fishstock | | | Estimate | Source |
|---|---|---|---|---|
| 1. Natural mortality ($M$) | | | | |
| SSK 3 | | | 0.12-0.15 | Francis *et al*. (2004) |
| 2. Weight = a (length) $^{b}$ (weight in g, length in cm pelvic length) | | | | |
| | | a | b | |
| SSK both sexes | | 0.0268 | 2.933 | Francis (1997) |
| 3. von Bertalanffy growth parameters* | | | | |
| | $K$ | $t_0$ | $L_\infty$ | |
| SSK 3 (both sexes) | 0.095 | -1.06 | 150.5 | Francis *et al*. (2001b) |
| SSK 3 (Males) | 0.117 | -1.28 | 133.6 | Francis *et al*. (2004) |

## 3. STOCKS AND AREAS

Nothing is known about stock structure or movement patterns of smooth skates. Smooth skates are distributed throughout most of New Zealand, from the Three Kings Islands to Campbell Island and the Chatham Islands, including the Challenger Plateau, Chatham Rise and Bounty Plateau. Smooth skates have not been recorded from QMA 10.

In this report, smooth skate landings have been presented by QMA. QMAs would form appropriate management units in the absence of any information on biological stocks.

## 4. STOCK ASSESSMENT

This is the first stock assessment for skates. No yield estimates have been made for skates.

### 4.1 Estimates of fishery parameters and abundance

Relative biomass estimates are available for smooth skates from a number of trawl survey series (Table 5). Biomass estimates are not provided for surveys of: (a) west coast North Island because of major changes in survey areas and strata during the series; or (b) east Northland, Hauraki Gulf and Bay of Plenty because of the low relative biomass of smooth skates present (usually less than 100 t). In the first survey of each of two series -east coast South Island and Chatham Rise- the two skate species were not (fully) distinguished. Furthermore, there are doubts about the accuracy of species identification in some other earlier surveys (prior to 1996). Consequently, trends in biomass of individual species must be interpreted cautiously. To enable comparison among all surveys within each series, total skate biomass is also reported.

As the catch from the South Island trawl surveys changes without wide inter-annual fluctuations and the CVs are relatively low it appears that they are able to track smooth skate biomass in FMA 3, 7, and on the Chatham Rise. West Coast South Island surveys show that the relative biomass of smooth skate in FMA 7 has declined substantially since 1997. Smooth skate relative biomass on the on the Chatham Rise was fairly stable between 1997 and 2010, fluctuating between 1300 and 2300 t, with no overall trend.

### 4.2 Biomass estimates

There are no absolute biomass estimates for smooth skates.

### 4.3 Estimation of Maximum Constant Yield (*MCY*)

*MCY* cannot be estimated.

The *MCY* estimator, that has the lowest data requirements ($MCY = cY_{AV}$; Method 4), relies on selecting a time period during which there were “no systematic changes in fishing mortality (or fishing effort, if this can be assumed to be proportional to fishing mortality)”. This method was not applied because no information is currently available on skate fishing mortality, or on trawl fishing effort in the main skate fishing areas.

**Table 5: Doorspread biomass estimates (t) and coefficients of variation (CV %) of smooth skates and total skates (smooth and rough).**

| | | Smooth skate | | Total | |
|---|---|---|---|---|---|
| Year | Trip Code | Biomass | CV | Biomass | CV |
| East coast North Island | | | | | |
| 1993 | KAH9304 | 23 | 52 | 99 | - |
| 1994 | KAH9402 | 144 | 38 | 333 | - |
| 1995 | KAH9502 | 20 | 59 | 72 | - |
| 1996 | KAH9602 | 85 | 36 | 394 | - |
| South Island west coast and Tasman/Golden Bays (FMA 7) | | | | | |
| 1992 | KAH9204 | 339 | 19 | 512 | - |
| 1994 | KAH9404 | 341 | 18 | 537 | - |
| 1995 | KAH9504 | 315 | 20 | 566 | - |
| 1997 | KAH9701 | 302 | 26 | 487 | - |
| 2000 | KAH0004 | 140 | 29 | 326 | - |
| 2003 | KAH0304 | 91 | 79 | 134 | - |
| 2005 | KAH0503 | 80 | 30 | 138 | - |
| 2007 | KAH0704 | 55 | 44 | 300 | - |
| 2009 | KAH0904 | 67 | 61 | 181 | - |
| 2010 | KAH1004 | 185 | 33 | 532 | - |
| East coast South Island (FMA 3) Winter | | | | | |
| 1991 | KAH9105 | - | - | 1928 | 25 |
| 1992 | KAH9205 | 605 | 18 | 829 | 16 |
| 1993 | KAH9306 | 658 | 25 | 993 | 21 |
| 1994 | KAH9406 | 306 | 25 | 823 | 15 |
| 1996 | KAH9606 | 385 | 24 | 562 | 18 |
| 2007 | KAH0705 | 705 | 20 | 1 580 | - |
| 2008 | KAH0806 | 554 | 18 | 1 412 | - |
| 2009 | KAH0905 | 736 | 23 | 1 765 | - |
| East coast South Island (FMA 3) Summer | | | | | |
| 1996-97 | KAH9618 | 721 | 32 | 2 057 | - |
| 1997-98 | KAH9704 | 485 | 21 | 1 567 | - |
| 1998-99 | KAH9809 | 450 | 26 | 1 625 | - |
| 1999-00 | KAH9917 | 369 | 30 | 698 | - |
| 2000-01 | KAH0014 | 248 | 33 | 470 | - |
| Chatham Rise | | | | | |
| 1991-2 | TAN9106 | - | - | 2 129 | - |
| 1992-3 | TAN9212 | 1 071 | 18 | 1 126 | - |
| 1994 | TAN9401 | 958 | 23 | 1 178 | - |
| 1995 | TAN9501 | 769 | 31 | 845 | - |
| 1996 | TAN9601 | 1 511 | 30 | 1 522 | - |
| 1997 | TAN9701 | 1 932 | 22 | 1 944 | - |
| 1998 | TAN9801 | 1 425 | 26 | 1 935 | - |
| 1999 | TAN9901 | 1 738 | 20 | 1 772 | - |
| 2000 | TAN0001 | 1 369 | 23 | 1 369 | - |
| 2001 | TAN0101 | 2 321 | 19 | 2 393 | - |
| 2002 | TAN0201 | 2 111 | 17 | 2 148 | - |
| 2003 | TAN0301 | 1 355 | 21 | 1 387 | - |
| 2004 | TAN0401 | 2 006 | 21 | 2 066 | - |
| 2005 | TAN0501 | 1 780 | 24 | 1 869 | - |
| 2006 | TAN0601 | 1 521 | 29 | 1 577 | - |
| 2007 | TAN0701 | 1 922 | 17 | 1 951 | - |
| 2008 | TAN0801 | 1 376 | 26 | 1 376 | - |
| 2009 | TAN0901 | 1 162 | 18 | 1 185 | - |
| 2010 | TAN1001 | 1 576 | 21 | 1 576 | - |
| 2011 | TAN1101 | 1 009 | 32 | 1 009 | - |
| 2012 | TAN1201 | 813 | 22 | 813 | - |
| Stewart-Snares Shelf | | | | | |
| 1993 | TAN9301 | 528 | 20 | 1 120 | - |
| 1994 | TAN9402 | 342 | 21 | 1 406 | - |
| 1995 | TAN9502 | 335 | 19 | 1 136 | - |
| 1996 | TAN9604 | 504 | 29 | 1 559 | - |
| Survey discontinued | | | | | |
| Stewart-Snares Shelf and Sub-Antarctic (Summer)* | | | | | |
| 1991 | TAN9105 | 382 | 23 | 419 | - |
| 1992 | TAN9211 | 113 | 47 | 165 | - |
| 1993 | TAN9310 | 117 | 43 | 249 | - |
| 2000 | TAN0012 | 434 | 66 | 267 | - |
| Stewart-Snares Shelf and Sub-Antarctic (Autumn)* | | | | | |
| 1992 | TAN9204 | 93 | 61 | 141 | - |
| 1993 | TAN9304 | 177 | 33 | 428 | - |
| 1996 | TAN9605 | 835 | 39 | 857 | - |
| 1998 | TAN9805 | 536 | 62 | 607 | - |

*Biomass estimates are for core 300-800 m strata only

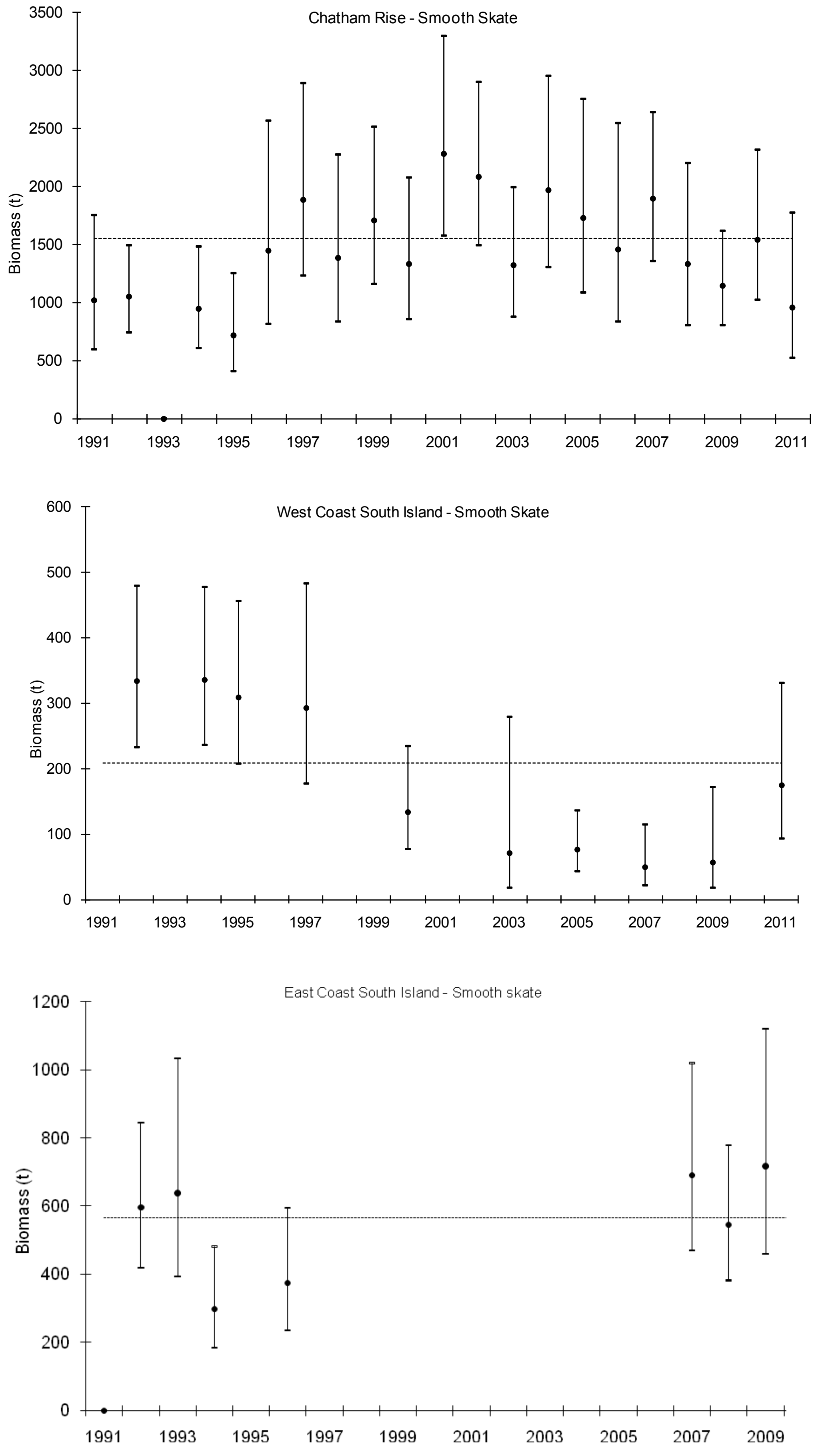



**Figure 2: Smooth skate biomass ±95% CI (estimated from survey CVs assuming a lognormal distribution) estimated from the Chatham Rise (Top), West (Middle) and East (bottom) Coast South Island trawl survey.**

### 4.4 Estimation of Current Annual Yield (*CAY*)

*CAY* cannot be estimated.

### 4.5 Other yield estimates and stock assessment results

No other yield estimates are available.

### 4.6 Other factors

Species that constitute a minor bycatch of trawl fisheries are often difficult to manage using TACCs and ITQs. Skates are widely and thinly distributed, and would be difficult for trawlers to avoid after the quota had been caught. A certain level of incidental bycatch is therefore inevitable. However, skates are relatively hardy, and frequently survive being caught in trawls (though mortality would depend on the length of the tow and the weight of fish in the cod end). Skates returned to the sea alive probably have a greater chance of survival than most other fishes.

## 5. STATUS OF THE STOCKS

No estimates of current and reference biomass are available.

SSK 7 relative biomass estimates from West Coast South Island trawl surveys revealed a strong decline. Although this decline is cause for concern, the reason for the decline is uncertain and requires further investigation.

For all other skate QMAs it is Unknown if recent catch levels or the TACC will cause skate populations to decline. Reported landings and TACCs for the 2010-11 fishing year are summarised in Tables 6.

**Table 6: Summary of TACCs (t), and reported landings (t) for smooth skates for the most recent fishing year.**

| Fishstock | | QMA | 2010-11 Actual TACC | 2010-11 Reported landings |
|---|---|---|---|---|
| SSK 1 (FMAs 1-2) | Auckland (East) Central (East) | 1 & 2 | 37 | 27 |
| SSK 3 (FMAs 3-6) | South-east (Coast) (Chatham), Southland, and Sub-Antarctic | 3, 4, 5 & 6 | 579 | 307 |
| SSK 7 | Challenger | 7 | 213 | 243 |
| SSK 8 (FMAs 8-9) | Central (West), Auckland (West) | 8 & 9 | 20 | 32 |
| SSK 10 | Kermadec | 10 | 0 | 0 |
| Total | | | 849 | 609 |

## 6. FOR FURTHER INFORMATION

Beentjes M.P., Stevenson M.L. 2000. Review of the east coast South Island winter trawl survey time series, 1991-96. NIWA Technical Report 86. 64 p.

Beentjes M.P., Stevenson M.L. 2001. Review of the east coast South Island summer trawl survey time series, 1996-97 to 1999-2000. NIWA Technical Report 108. 92 p.

Francis M.P. 1997. A summary of biology and commercial landings, and a stock assessment of rough and smooth skates (*Raja nasuta* and *R. innominata*). New Zealand Fisheries Assessment Research document 1997/5 27p.

Francis M.P., Ó Maolagáin C., Stevens D. 2001a. Age, growth, and sexual maturity of two New Zealand endemic skates, *Dipturus nasutus* and *D. innominatus*. New Zealand Journal of Marine and Freshwater Research 35: 831-842.

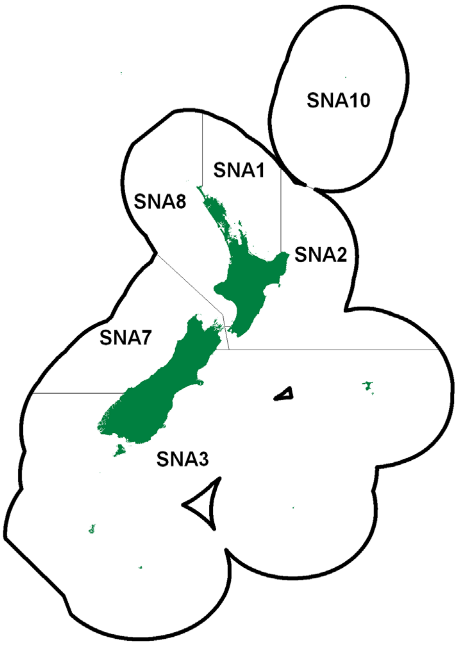
Francis M.P., Ó Maolagáin C., Stevens D. 2001b. Age, growth, maturity, and mortality of rough and smooth skates (*Dipturus nasutus* and *D. innominatus*). New Zealand Fisheries Assessment Report 2001/17. 21 p.

Francis M.P., Ó Maolagáin C., Stevens D. 2004. Revised growth, longevity and natural mortality of smooth skate (*Dipturus innominatus*). Final Research Report for Ministry of Fisheries Project MOF2003/01H (Dated June 2004).

Stevenson M.L., Hanchet S. 2000. Review of the inshore trawl *survey* series of the west coast South Island and Tasman and Golden Bays, 1992-97. NIWA Technical Report 82. 79 p.

# SNAPPER (SNA)

(*Pagrus auratus*)
Tamure, Kouarea




## 1. FISHERY SUMMARY

### 1.1 Commercial fisheries

The snapper fishery is one of the largest and most valuable coastal fisheries in New Zealand. The commercial fishery, which developed last century, expanded in the 1970s with increased catches by trawl and Danish seine. Following the introduction of pair trawling in most areas, landings peaked in 1978 at 18 000 t (Table 1). Pair trawling was the dominant method accounting for on average 75% of the annual SNA 8 catch from 1976 to 1989. In the 1980s an increasing proportion of the SNA 1 catch was taken by longlining as the Japanese "iki jime" market was developed. By the mid 1980s catches had declined to 8500-9000 t, and some stocks showed signs of overfishing. The fisheries had become more dependent on the recruiting year classes as stock size decreased. With the introduction of the QMS in 1986, TACCs in all Fishstocks were set at levels intended to allow for some stock rebuilding. Decisions by the Quota Appeal Authority saw TACCs increase, in the case of SNA 1 to over 6000 t, and for SNA 8 from 1330 t to 1594 t (Table 2).

In 1986-87, landings from the two largest Fishstocks (i.e., SNA 1 and SNA 8) were less than their respective TACCs (Table 2), but catches subsequently increased in 1987-88 to the level of the TACCs (Figure 1). Landings from SNA 7 remained below the TACC after introduction to the QMS, and in 1989-90 the TACC was reduced to 160 t. Changes to TACCs that took effect from 1 October 1992 resulted in a reduction for SNA 1 from 6010 t to 4904 t, an increase for SNA 2 from 157 t to 252 t, and a reduction for SNA 8 from 1594 t to 1500 t. The TACC for SNA 1 was exceeded in the 1992-93 fishing year by over 500 t. Some of this resulted from carrying forward of up to 10% under-runs from previous years by individual quota holders, but most of this over-catch was not landed against quota holdings (deemed penalties were incurred for about 400 t).

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

| Year | SNA 1 | SNA 2 | SNA 7 | SNA 8 | Year | SNA 1 | SNA 2 | SNA 7 | SNA 8 |
|---|---|---|---|---|---|---|---|---|---|
| 1931 | 3 465 | 0 | 69 | 140 | 1961 | 5 318 | 589 | 583 | 1 178 |
| 1932 | 3 567 | 0 | 36 | 159 | 1962 | 5 582 | 604 | 582 | 1 352 |
| 1933 | 4 061 | 21 | 65 | 213 | 1963 | 5 702 | 636 | 569 | 1 456 |
| 1934 | 4 484 | 168 | 7 | 190 | 1964 | 5 643 | 667 | 574 | 1 276 |
| 1935 | 5 604 | 149 | 10 | 108 | 1965 | 6 039 | 605 | 780 | 1 182 |
| 1936 | 6 597 | 78 | 194 | 103 | 1966 | 6 429 | 744 | 1 356 | 1 831 |
| 1937 | 5 918 | 114 | 188 | 85 | 1967 | 6 557 | 856 | 1 613 | 1 477 |
| 1938 | 6 414 | 122 | 149 | 89 | 1968 | 7 333 | 765 | 1 037 | 1 491 |
| 1939 | 6 168 | 100 | 158 | 71 | 1969 | 8 674 | 837 | 549 | 1 344 |
| 1940 | 5 325 | 103 | 174 | 76 | 1970 | 9 792 | 804 | 626 | 1 588 |
| 1941 | 5 003 | 148 | 128 | 62 | 1971 | 10 737 | 861 | 640 | 1 852 |
| 1942 | 4 279 | 74 | 65 | 57 | 1972 | 9 574 | 878 | 767 | 1 961 |
| 1943 | 4 643 | 60 | 29 | 75 | 1973 | 9 036 | 798 | 1 258 | 3 038 |
| 1944 | 5 045 | 49 | 96 | 69 | 1974 | 7 635 | 716 | 1 026 | 4 340 |
| 1945 | 4 940 | 59 | 118 | 124 | 1975 | 5 894 | 732 | 789 | 4 217 |
| 1946 | 5 382 | 77 | 232 | 244 | 1976 | 7 220 | 732 | 1 040 | 5 326 |
| 1947 | 5 815 | 36 | 475 | 251 | 1977 | 7 514 | 374 | 714 | 3 941 |
| 1948 | 6 745 | 53 | 544 | 215 | 1978 | 10 128 | 454 | 2 720 | 4 340 |
| 1949 | 5 866 | 215 | 477 | 277 | 1979 | 10 460 | 662 | 1 776 | 3 464 |
| 1950 | 5 107 | 285 | 514 | 318 | 1980 | 7 370 | 636 | 732 | 3 309 |
| 1951 | 4 301 | 265 | 574 | 364 | 1981 | 7 872 | 283 | 592 | 3 153 |
| 1952 | 3 795 | 220 | 563 | 361 | 1982 | 7 242 | 160 | 591 | 2 636 |
| 1953 | 3 703 | 247 | 474 | 1 124 | 1983 | 6 256 | 160 | 544 | 1 814 |
| 1954 | 4 316 | 293 | 391 | 1 093 | 1984 | 7 141 | 227 | 340 | 1 536 |
| 1955 | 4 442 | 309 | 504 | 1 202 | 1985 | 6 774 | 208 | 270 | 1 866 |
| 1956 | 4 742 | 365 | 822 | 1 163 | 1986 | 5 969 | 255 | 253 | 959 |
| 1957 | 5 285 | 452 | 1 055 | 1 472 | 1987 | 4 532 | 122 | 210 | 1 072 |
| 1958 | 5 154 | 483 | 721 | 1 128 | 1988 | 5 082 | 165 | 193 | 1 565 |
| 1959 | 5 778 | 372 | 650 | 1 114 | 1989 | 5 816 | 227 | 292 | 1 571 |
| 1960 | 5 697 | 487 | 573 | 1 202 | 1990 | 5 757 | 429 | 200 | 1 551 |

Notes:

1. The 1931-1943 years are April-March but from 1944 onwards are calendar years.
2. The "QMA totals" are approximations derived from port landing subtotals, as follows: SNA 1, Mangonui to Whakatane; SNA 2 Gisborne to Wellington/Makara; SNA 7, Marlborough Sounds ports to Greymouth; SNA 8 Paraparaumu to Hokianga.
3. Before 1946 the "QMA" subtotals sum to less than the New Zealand total because data from the complete set of ports are not available. Subsequent minor differences result from small landings in SNA 3, not listed here.
4. Data up to 1985 are from fishing returns: Data from 1986 to 1990 are from Quota Management Reports.

**Table 2: Reported landings (t) of snapper by Fishstock from 1983-84 to 2010-11 and gazetted and actual TACCs (t) for 1986-87 to 2010-11. QMS data from 1986-present.**

| Fishstock | | SNA 1 | | SNA 2 | | SNA 3 | | SNA 7 | | SNA 8 |
|---|---|---|---|---|---|---|---|---|---|---|
| QMAs | | 1 | | 2 | | 3,4,5,6 | | 7 | | 8,9 |
| | Landings | TACC | Landings | TACC | Landings | TACC | Landings | TACC | Landings | TACC |
| 1983-84† | 6 539 | - | 145 | - | 2 | - | 375 | - | 1 725 | - |
| 1984-85† | 6 898 | - | 163 | - | 2 | - | 255 | - | 1 546 | - |
| 1985-86† | 5 876 | - | 177 | - | 0 | - | 188 | - | 1 828 | - |
| 1986-87 | 4 016 | 4 710 | 130 | 130 | 0 | 30 | 257 | 330 | 893 | 1 330 |
| 1987-88 | 5 061 | 5 098 | 152 | 137 | 1 | 30 | 256 | 363 | 1 401 | 1 383 |
| 1988-89 | 5 793 | 5 614 | 210 | 157 | 1 | 30 | 176 | 372 | 1 526 | 1 508 |
| 1989-90 | 5 826 | 5 981 | 364 | 157 | < 1 | 30 | 294 | 160 | 1 550 | 1 594 |
| 1990-91 | 5 315 | 6 002 | 427 | 157 | < 1 | 31 | 160 | 160 | 1 658 | 1 594 |
| 1991-92 | 6 191 | 6 010 | 373 | 157 | < 1 | 31 | 148 | 160 | 1 464 | 1 594 |
| 1992-93 | 5 423 | 4 904 | 316 | 252 | 2 | 32 | 165 | 160 | 1 543 | 1 500 |
| 1993-94 | 4 846 | 4 928 | 307 | 252 | < 1 | 32 | 147 | 160 | 1 542 | 1 500 |
| 1994-95 | 4 831 | 4 938 | 307 | 252 | < 1 | 32 | 150 | 160 | 1 434 | 1 500 |
| 1995-96 | 4 941 | 4 938 | 279 | 252 | < 1 | 32 | 146 | 160 | 1 558 | 1 500 |
| 1996-97 | 5 049 | 4 938 | 352 | 252 | < 1 | 32 | 162 | 160 | 1 613 | 1 500 |
| 1997-98 | 4 524 | 4 500 | 286 | 252 | < 1 | 32 | 182 | 200 | 1 589 | 1 500 |
| 1998-99 | 4 411 | 4 500 | 283 | 252 | 3 | 32 | 142 | 200 | 1 636 | 1 500 |
| 1999-00 | 4 500 | 4 500 | 391 | 252 | < 1 | 32 | 174 | 200 | 1 604 | 1 500 |
| 2000-01 | 4 347 | 4 500 | 360 | 252 | < 1 | 32 | 156 | 200 | 1 630 | 1 500 |
| 2001-02 | 4 372 | 4 500 | 252 | 252 | 1 | 32 | 141 | 200 | 1 577 | 1 500 |
| 2002-03 | 4 484 | 4 500 | 334 | 315 | < 1 | 32 | 187 | 200 | 1 558 | 1 500 |
| 2003-04 | 4 466 | 4 500 | 339 | 315 | < 1 | 32 | 215 | 200 | 1 667 | 1 500 |
| 2004-05 | 4 641 | 4 500 | 399 | 315 | < 1 | 32 | 178 | 200 | 1 663 | 1 500 |
| 2005-06 | 4 539 | 4 500 | 389 | 315 | < 1 | 32 | 166 | 200 | 1 434 | 1 300 |
| 2006-07 | 4 429 | 4 500 | 329 | 315 | < 1 | 32 | 248 | 200 | 1 327 | 1 300 |
| 2007-08 | 4 548 | 4 500 | 328 | 315 | < 1 | 32 | 187 | 200 | 1 304 | 1 300 |
| 2008-09 | 4 543 | 4 500 | 307 | 315 | < 1 | 32 | 205 | 200 | 1 344 | 1 300 |
| 2009-10 | 4 465 | 4 500 | 296 | 345 | < 1 | 32 | 188 | 200 | 1 280 | 1 300 |
| 2010-11 | 4 516 | 4 500 | 320 | 345 | < 1 | 32 | 206 | 200 | 1 312 | 1 300 |

**Table 2 Continued**:

| Fishstock | SNA 10 | | | |
|---|---|---|---|---|
| QMAs | 10 | | Total | |
| | Landings | TACC | Landings§ | TACC |
| 1983-84† | 0 | - | 9 153 | - |
| 1984-85† | 0 | - | 9 228 | - |
| 1985-86† | 0 | - | 8 653 | - |
| 1986-87 | 0 | 10 | 5 314 | 6 540 |
| 1987-88 | 0 | 10 | 6 900 | 7 021 |
| 1988-89 | 0 | 10 | 7 706 | 7 691 |
| 1989-90 | 0 | 10 | 8 034 | 7 932 |
| 1990-91 | 0 | 10 | 7 570 | 7 944 |
| 1991-92 | 0 | 10 | 8 176 | 7 962 |
| 1992-93 | 0 | 10 | 7 448 | 6 858 |
| 1993-94 | 0 | 10 | 6 842 | 6 883 |
| 1994-95 | 0 | 10 | 6 723 | 6 893 |
| 1995-96 | 0 | 10 | 6 924 | 6 893 |
| 1996-97 | 0 | 10 | 7 176 | 6 893 |
| 1997-98 | 0 | 10 | 6 583 | 6 494 |
| 1998-99 | 0 | 10 | 6 475 | 6 494 |
| 1999-00 | 0 | 10 | 6 669 | 6 494 |
| 2000-01 | 0 | 10 | 6 496 | 6 494 |
| 2001-02 | 0 | 10 | 6 342 | 6 494 |
| 2002-03 | 0 | 10 | 6 563 | 6 557 |
| 2003-04 | 0 | 10 | 6 686 | 6 557 |
| 2004-05 | 0 | 10 | 6 881 | 6 557 |
| 2005-06 | 0 | 10 | 6 527 | 6 357 |
| 2006-07 | 0 | 10 | 6 328 | 6 357 |
| 2007-08 | 0 | 10 | 6 367 | 6 357 |
| 2008-09 | 0 | 10 | 6 399 | 6 357 |
| 2009-10 | 0 | 10 | 6 230 | 6 357 |
| 2010-11 | 0 | 10 | 6 355 | 6 357 |

† FSU data. SNA 1 = stat areas 1-10; SNA 2 = stat areas 11-16; SNA 3 = stat areas 18-32; SNA 7 = stat areas 17, 33-36, 38; SNA 8 = stat areas 37, 39-48. § Includes landings from unknown areas before 1986-87.

**Table 3: TACs, TACCs and allowances (t) for snapper by Fishstock from 1 October 2005.**

| Fishstock | TAC | TACC | Customary allowance | Recreational allowance | Other mortality |
|---|---|---|---|---|---|
| SNA 1 | 7 550 | 4 500 | | 2 600* | 450 |
| SNA 2 | 450 | 315 | 14 | 90 | 31 |
| SNA 3 | | 32.3 | | | - |
| SNA 7 | 306 | 200 | 16 | 90 | - |
| SNA 8 | 1 785 | 1 300 | 43 | 312 | 130 |
| SNA 10 | | 10 | | | |

* SNA 1 has a combined non-commercial allowance of 2 600 t.

From 1 October 1997 the TACC for SNA 1 was reduced to 4500 t, within an overall TAC of 7550 t, while the TACC for SNA 7 was increased to 200 t within an overall TAC of 306 t. In SNA 2, the bycatch of snapper in the tarakihi, gurnard and other fisheries has resulted in overruns of the snapper TACC in all years from 1987-88 up to 2000-01. From 1 October 2002, the TACC for SNA 2 was increased from 252 to 315 t, within a total TAC of 450 t. Although the 315 t TACC was substantially over-caught from 2002-03 to 2006-07, catches have since been closer to the TACC. From 1 October 2005 the TACC for SNA 8 was reduced to 1300 t within a TAC of 1785 t to ensure a faster rebuild of the stock. Table 3 shows the TACs, TACCs and allowances for each Fishstock from 1 October 2004. All commercial fisheries have a minimum legal size (MLS) for snapper of 25 cm.

## Foreign fishing

Japanese catch records and observations made by New Zealand naval vessels indicate significant quantities of snapper were taken from New Zealand waters from the late 1950s until 1977. There are insufficient data to quantify historical Japanese catch tonnages for the respective snapper stocks. However, trawl catches have been reported by area from 1967 to 1977, and longline catches from 1975 to 1977 (Table 4). These data were supplied to the Fisheries Research Division of MAF in the late 1970s, however, the data series is incomplete, particularly for longline catches.

**Table 4: Reported landings (t) of snapper from 1967 to 1977 by Japanese trawl and longline fisheries.**

| Year | (a) Trawl | Trawl catch (all species) | Total snapper trawl catch | SNA 1 | SNA 7 | SNA 8 |
|---|---|---|---|---|---|---|
| 1967 | | 3092 | 30 | NA | NA | NA |
| 1968 | | 19 721 | 562 | 1 | 17 | 309 |
| 1969 | | 25 997 | 1 289 | - | 251 | 929 |
| 1970 | | 31 789 | 676 | 2 | 131 | 543 |
| 1971 | | 42 212 | 522 | 5 | 115 | 403 |
| 1972 | | 49 133 | 1 444 | 1 | 225 | 1 217 |
| 1973 | | 45 601 | 616 | - | 117 | 466 |
| 1974 | | 52 275 | 472 | - | 98 | 363 |
| 1975 | | 55 288 | 922 | 26 | 85 | 735 |
| 1976 | | 133 400 | 970 | NA | NA | 676 |
| 1977 | | 214 900 | 856 | NA | NA | 708 |

| Year | (b) Longline | Total Snapper | SNA 1 | SNA 7 | SNA 8 |
|---|---|---|---|---|---|
| 1975 | | 1 510 | 761 | - | 749 |
| 1976 | | 2 057 | 930 | - | 1 127 |
| 1977 | | 2 208 | 1 104 | - | 1 104 |

In 1997 the sensitivity of the SNA 1 and SNA 8 assessments (Davies 1999) to the assumed level of Japanese catch was investigated. Higher assumed levels of catch generally resulted in higher estimates of virgin biomass and mean recruitment.

Japanese catch was assumed to have occurred between 1960 and 1977, with cumulative total removals over the period at 30 000 t. The pattern of annual catches was assumed to increase linearly to a peak in 1968 (reaching 2202 t) then decline linearly to 1978 (zero). The catch was split evenly between East Northland and the Hauraki Gulf/Bay of Plenty.

For SNA 8, Japanese longline catch was assumed to be at a constant annual removal each year for 1965-74. An annual catch level of 2000 t was assumed. Trawl catches for 1967-77 and longline catch for 1975-77 were assumed to be at the reported levels.

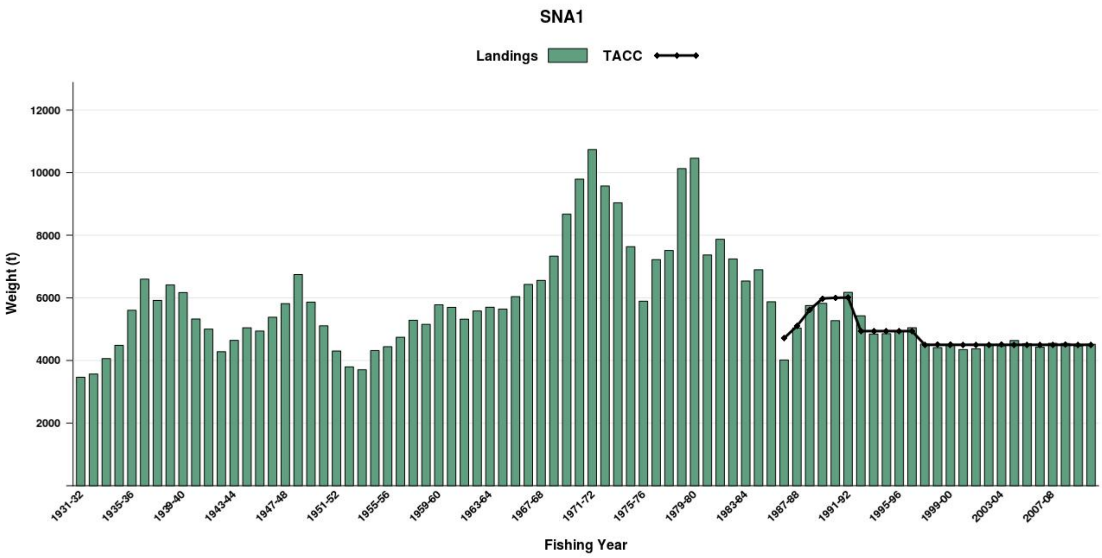
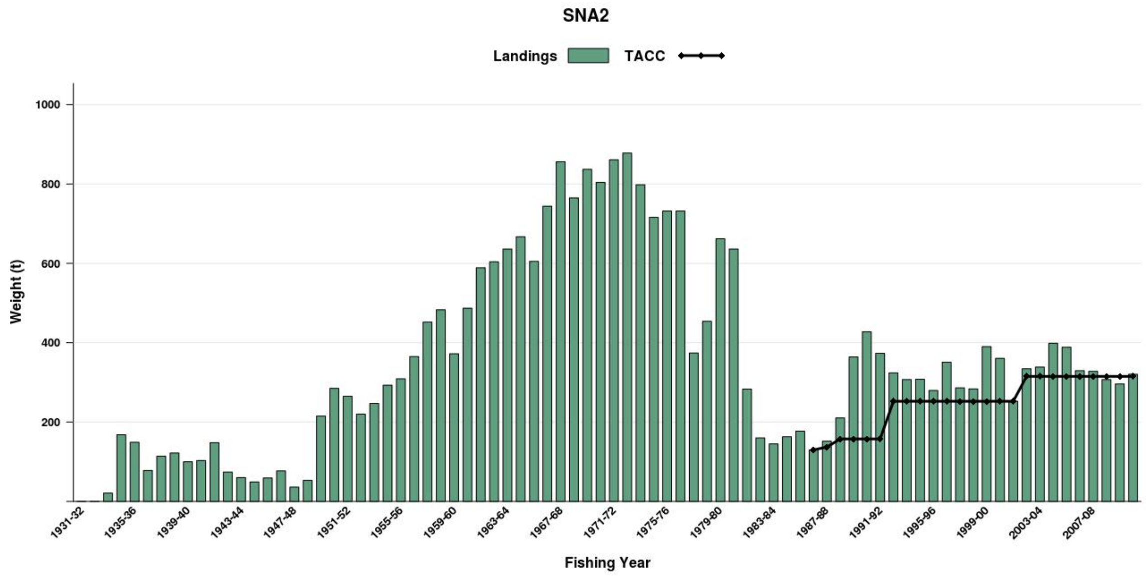
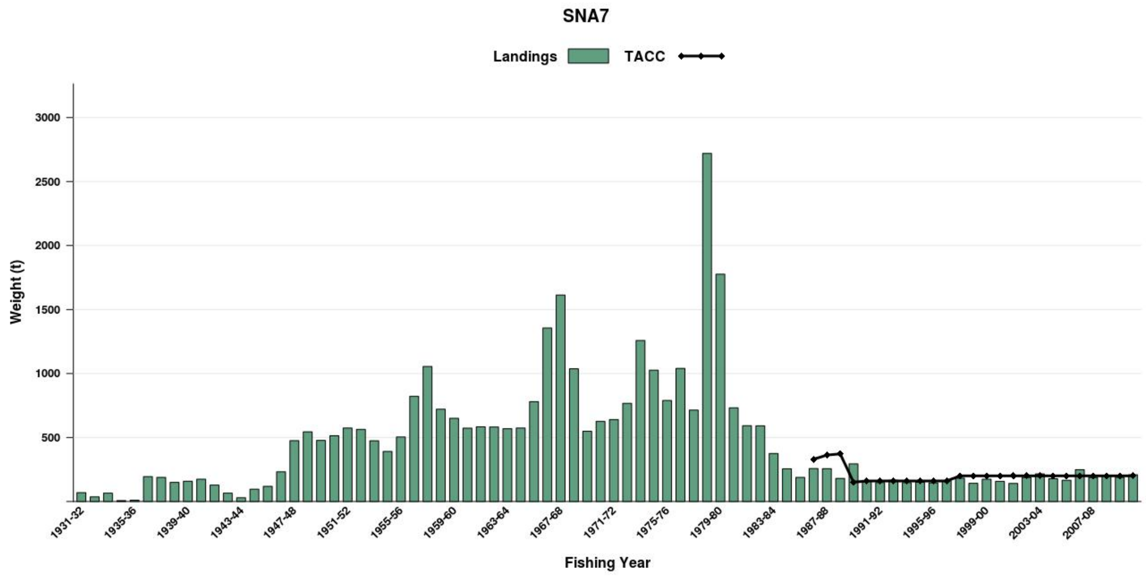



**Figure 1: Historical landings and TACC for the four main SNA stocks. SNA1 (Auckland East). [Continued on next page].**



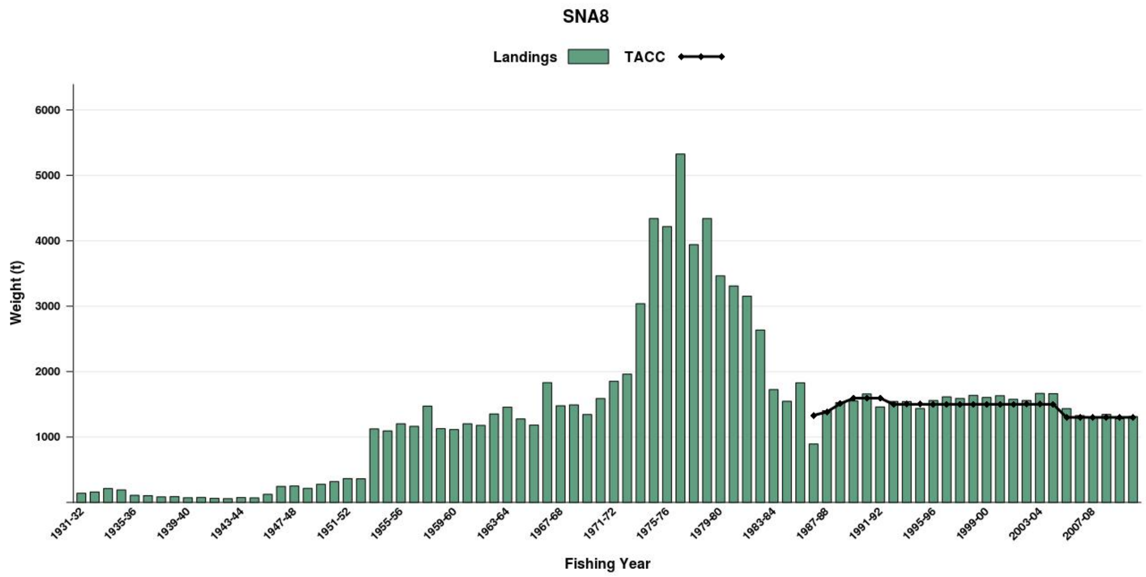




**Figure 1 [Continued]: Historical landings and TACC for the four main SNA stocks. From top to bottom: SNA2 (Central East), SNA7 (Challenger) and SNA8 (Central Egmont).**

## 1.2 Recreational fisheries

The snapper fishery is the largest recreational fishery in New Zealand. It is the major target species on both coasts of the North Island. The allowances within the TAC for each Fishstock are shown in Table 3.

Nationally the snapper bag limit for amateur fishers was set at 30 per person and minimum legal size (MLS) at 25 cm in January 1985. This bag limit was retained until 30 September 1993 when a new limit of 20 per person was applied in FMA 1 and 9. Following further consideration on snapper bag limits in northern New Zealand, against the backdrop of sustainability measures required for the overall fishery in SNA 1 and SNA 8, differential bag limits were introduced for SNA 1 and SNA 8 stocks on 30 October 1995. In FMA 9 (the northern part of SNA 8) between Tirua Point and North Cape, the bag limit was set at 15, whereas the limit in SNA 1 was set at 9 and the size limit in both FMA 1 and 9 was raised to 27 cm for amateur fishers only. The amateur daily bag limit for FMA 9 was reduced to 10 in 2005. In FMA 8 (the southern part of SNA 8) and in SNA 2 the bag limit is 10 per person per day with a MLS of 27 cm. Around the South Island (most of SNA 3 and SNA 7) the snapper bag limit is 10 per person per day and the MLS is 25 cm.

The tag ratio method gave the first estimates of recreational catch (Table 5). A tonnes per tag ratio was obtained from commercial tag returns and this was applied to the recreational returns to estimate catch. Regional telephone and diary surveys gave later estimates: MAF Fisheries South (1991-92), Central (1992-93) and North (1993-94) regions (Teirney *et al*. 1997). 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 2002) and a rolling replacement of diarists in 2001 (Boyd & Reilly in press) allowed estimates for a further year (population scaling ratios and mean weights were not re-estimated). The diary method used mean weights of snapper obtained from fish measured at boat ramps.

**Table 5: Recreational catch estimates for snapper stocks. Totals for a stock are given in bold. The telephone/diary surveys ran from December to November but are denoted by the January calendar year. Mean fish weights were obtained from boat ramp surveys. Numbers and mean weights are not calculated in the tag ratio method.**

| Stock | Year | Method | Number of fish (thousands) | Mean weight (g) | Total weight (t) |
|---|---|---|---|---|---|
| SNA 1 | | | | | |
| East Northland | 1985 | Tag ratio | - | - | 370 |
| Hauraki Gulf | 1985 | Tag ratio | - | - | 830 |
| Bay of Plenty | 1984 | Tag ratio | - | - | 400 |
| Total | 1985[1] | Tag ratio | - | - | **1 600** |
| Total | 1994 | Telephone/diary | 3 804 | 871 | **2 857** |
| East Northland | 1996 | Telephone/diary | 684 | 1 039 | 711 |
| Hauraki Gulf/Bay of Plenty | 1996 | Telephone/diary | 1 852 | 870 | 1 611 |
| Total | 1996 | Telephone/diary | 2 540 | 915 | **2 324** |
| East Northland | 2000 | Telephone/diary | 1 457 | 1 154 | 1 681 |
| Hauraki Gulf | 2000 | Telephone/diary | 3 173 | 830 | 2 632 |
| Bay of Plenty | 2000 | Telephone/diary | 2 274 | 872 | 1 984 |
| Total | 2000 | Telephone/diary | 6 904 | 904 | **6 242** |
| East Northland | 2001 | Telephone/diary | 1 446 | -[5] | 1 669 |
| Hauraki Gulf | 2001 | Telephone/diary | 4 225 | -[5] | 3 507 |
| Bay of Plenty | 2001 | Telephone/diary | 1 791 | -[5] | 1 562 |
| Total | 2001 | Telephone/diary | 7 462 | -[5] | **6 738** |
| Hauraki Gulf | 2004 | Aerial overflight | - | - | 1 334 |
| East Northland | 2005 | Aerial overflight | - | - | 557 |
| Hauraki Gulf | 2005 | Aerial overflight | - | - | 1 354 |
| Bay of Plenty | 2005 | Aerial overflight | - | - | 516 |
| Total | 2005 | Aerial overflight | - | - | **2 419** |

**Table 5 [Continued].**

| Stock | Year | Method | Number of fish (thousands) | Mean weight (g) | **Total weight (t)** |
|---|---|---|---|---|---|
| SNA 2 | 1993 | Telephone/diary | 28 | 1 282 | **36** |
| | 1996 | Telephone/diary | 31 | 1 282[2] | **40** |
| | 2000 | Telephone/diary | 268 | 1 2004 | **322** |
| | 2001 | Telephone/diary | 144 | -[5] | **173** |
| SNA 7 | | | | | |
| Tasman/Golden Bays | 1987 | Tag ratio | - | - | **15** |
| Total | 1993 | Telephone/diary | 77 | 2 3983 | **184** |
| Total | 1996 | Telephone/diary | 74 | 2 398 | **177** |
| Total | 2000 | Telephone/diary | 63 | 2 148 | **134** |
| Total | 2001 | Telephone/diary | 58 | -[5] | **125** |
| Total | 2005/06 | Aerial overflight | - | - | **42.6** |
| SNA 8 | | | | | |
| Total | 1991 | Tag ratio | - | - | **250** |
| Total | 1994 | Telephone/diary | 361 | 658 | **238** |
| Total | 1996 | Telephone/diary | 271 | 871 | **236** |
| Total | 2000 | Telephone/diary | 648 | 1 020 | **661** |
| Total | 2001 | Telephone/diary | 1 111 | - | **1 133** |
| Total | 2007 | Aerial overflight | - | - | **260** |

[1] The Bay of Plenty programme was carried out in 1984 but is included in the 1985 total estimate
[2] Mean weight obtained from 1992-93 boat ramp sampling
[3] Mean weight obtained from 1995-96 boat ramp sampling
[4] Mean weight obtained from 1999-2000 commercial landed catch sampling
[5] The 2000 mean weights were used in the 2001 estimates

Several potential causes of bias have been identified for the recreational catch estimates. The three most serious are described:

- The tag ratio method requires that all tagged fish caught by recreational fishers are recorded, or at least that the under-reporting rate of recreational fishers is the same as that of commercial fishers. This was assumed, although no data were available to test the assumption. If the recreational under-reporting rate was greater than that of the commercial fishers a negative bias would result. In SNA 8 there was evidence that many tags recovered by commercial fishing were reported as recreational catch, which would give a positive bias to estimates.
- In the telephone/diary method fishers are 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 is thereby under-estimated. The 2000 telephone/diary survey (pilot studies) demonstrated that this effect occurred when recreational fishing was established as the subject of the interview at the outset. It established that soft refusals were highly likely to have biased all the previous telephone/diary surveys. A correction would be required to overcome this bias in the pre-2000 estimates.
- Another equally serious cause of bias in telephone/diary surveys was identified. This was the potential for diarists who did not immediately record their day’s catch after a trip to overstate their catch or even to overstate the number of trips they had made. There is some indirect evidence that this may have occurred in all the telephone/diary surveys (Wright *et al*. 2004).

The Recreational Technical Working Group concluded that the harvest estimates from the diary surveys should be used only with the following qualifications: a) they may be very inaccurate; b) the 1996 and earlier surveys contain a methodological error; and, c) the 2000 and 2001 estimates are implausibly high for many important fisheries.

Owing to the limitations of diary surveys a combined aerial overflight / boat ramp survey was developed for SNA 1. It was tested in the Hauraki Gulf in 2004 and then applied to the entire SNA 1

QMA in 2005. Based on the success of this approach it was later applied to SNA 7 (2005-06 fishing year) and SNA 8 (2006-07). The Recreational and Snapper Working Groups both concluded that the boat ramp/ aerial overflight approach provides the most reliable estimates of recreational harvest for these Fishstocks. The methodology is described in Hartill *et al*. (2007).

In 2005, the Snapper Working Group and Plenary considered recreational catches from SNA 8. Two alternative levels were assumed for the recreational catch from 1990 to 2004, either 300 t or 600 t. The Plenary considered these values were likely to bracket the true average level of catch in this period. The estimate from the 2006-07 aerial overflight survey of the SNA 8 fishery (260 t) suggests that the assumed value of 300 t may have been the more plausible. There are potential sources of bias associated with the overflight estimate, both negative (a potential underestimation of the shore based harvest, especially to the south) and positive (over reporting of harvests by charter boat operators in a log book survey).

### 1.3 Customary non-commercial fisheries

Snapper form important fisheries for customary non-commercial, but the annual catch is not known.

### 1.4 Illegal catch

No new information is available to estimate illegal catch. For modelling SNA 1 and SNA 8 an assumption was made that non-reporting of catch was 20% of reported domestic commercial catch prior to 1986 and 10% of reported domestic commercial catch since the QMS was introduced. This was to account for all forms of under-reporting. These proportions were based on the black market trade in snapper and higher levels of under-reporting (to avoid tax) that existed prior to the introduction of the QMS. The 10% under-reporting post-QMS accounts for the practice of "weighing light" and the discarding of legal sized snapper.

### 1.5 Other sources of mortality

No estimates are available regarding the quantum of other sources of mortality on snapper stocks; although high-grading of longline fish and discarding of under-sized fish by all methods occurs.
An at-sea study of the SNA 1 commercial longline fishery in 1997 (McKenzie 2000) found 6-10% of snapper caught by number were under 25 cm (MLS). Results from a holding net study indicate mortality levels amongst lip-hooked snapper caught shallower than 35 m were low.

Estimates for incidental mortality were based on other catch-at-sea data using an age-length structure model for longline, trawl, seine and recreational fisheries. In SNA1, estimates of incidental mortality for the year 2000 from longline were less than 3% and for trawl, seine and recreational fisheries between 7% and 11% (Millar *et al*. 2001). In SNA8, estimates of trawl and recreational incidental mortality were lower, mainly because of low numbers of 2 and 3 year old fish estimated in 2000.

In SNA 1, recreational fishers release a high proportion of their snapper catch, most of which is less than 27 cm (recreational MLS). An at sea study in 2006–07 recorded snapper release rates of 54.2% of the catch by trailer boat fishers and 60.1% of the catch on charter boats (Holdsworth & Boyd 2008). Incidental mortality estimated from condition at release was 2.7% to 8.2% of total catch by weight depending on assumptions used.

## 2. BIOLOGY

Snapper are demersal fish found down to depths of about 200 m, but are most abundant in 15-60 m. They are the dominant fish in northern inshore communities and occupy a wide range of habitats, including rocky reefs and areas of sand and mud bottom. They are widely distributed in the warmer waters of New Zealand, being most abundant in the Hauraki Gulf.

Snapper are serial spawners, releasing many batches of eggs over an extended season during spring and summer. The larvae have a relatively short planktonic phase which results in the spawning grounds corresponding fairly closely with the nursery grounds of young snapper. Young fish school in shallow water and sheltered areas and move out to deeper water in winter. The fish disperse more widely as they grow older. They first reach maturity from 20 to 28 cm fork length at 3-4 years of age. Large schools of snapper congregate before spawning and move on to the spawning grounds, usually in November-December. The spawning season may extend to January-March in some areas and years before the fish disperse, often inshore to feeding grounds. The winter grounds are thought to be in deeper waters where the fish are more widespread.

Water temperature appears to play an important part in the success of recruitment. Generally strong year classes in the population correspond to warm years, weak year classes correspond to cold years. (Francis 1993)

Growth rate varies geographically and from year to year. Snapper from Tasman Bay/Golden Bay and the west coast of the North Island grow faster and reach a larger average size than elsewhere. Snapper have a strong seasonal growth pattern, with rapid growth from November to May, and then a slowing down or cessation of growth from June to September. They may live up to 60 years or more and have very low rates of natural mortality. An estimate of M = 0.06 $yr^{-1}$ was made from catch curves of commercial catches from the west coast North Island pair trawl fishery in the mid-1970s. These data were re-analysed in 1997 and the resulting estimate of 0.075 $yr^{-1}$ has been used in the base case assessments for SNA 1, 2, and 7 (and SNA 8 up to 2004). In the 2005 assessment for SNA 8, natural mortality was estimated within the model.

Estimates of biological parameters relevant to stock assessment are shown in Table 6.

**Table 6: Estimates of biological parameters.**

| Fishstock | Estimate | | | Source |
|---|---|---|---|---|
| 1. Instantaneous rate of natural mortality (*M*) | | | | |
| SNA 1, 2 & 7 | 0.075 | | | Hilborn & Starr (unpub. analysis) |
| SNA 8 | 0.051 or 0.054 | | | estimated within model |
| 2. Weight = *a*(length)*b* (Weight in g, length in cm fork length) | | | | |
| All | *a* = 0.04467 | *b* = 2.793 | | Paul (1976) |
| 3. von Bertalanffy growth parameters | | | | |
| | Both sexes combined | | | |
| | *K* | $t_0$ | $L_\infty$ | |
| SNA 1 | 0.102 | -1.11 | 58.8 | Gilbert & Sullivan (1994) |
| SNA 2 | 0.061 | -5.42 | 68.9 | NIWA (unpub. analysis) |
| SNA 7 | 0.122 | -0.71 | 69.6 | MAF (unpub. data) |
| SNA 8 | 0.16 | -0.11 | 66.7 | Gilbert & Sullivan (1994) |
| 4. Age at recruitment (years) | | | | |
| SNA 1* | 4 (39%) 5 (100%) | | | Gilbert *et al*. (2000) |
| SNA 7 | 3 | | | MAF (unpub. data) |
| SNA 8 | 3 | | | Gilbert & Sullivan (1994) |

* For years when not estimated

## 3. STOCKS AND AREAS

There are no new data that would alter the stock boundaries given in previous assessment documents (Gilbert *et al.* 2000).

New Zealand snapper are thought to comprise either seven or eight biological stocks based on: the location of spawning and nursery grounds; differences in growth rates, age structure and recruitment strength; and the results of tagging studies. These stocks comprise three in SNA 1 (East Northland, Hauraki Gulf and BoP), two in SNA 2 (one of which may be associated with the BoP stock), two in SNA 7 (Marlborough Sounds and Tasman/Golden Bay) and one in SNA 8. Tagging studies reveal that limited mixing occurs between the three SNA 1 biological stocks, with greatest exchange between BoP and Hauraki Gulf.

## 4. ENVIRONMENTAL & ECOSYSTEM CONSIDERATIONS

This section was updated with new tables for the May 2012 Fishery Assessment Plenary based on reviews of similar chapters by the Aquatic Environment Working Group. This summary is from the perspective of the snapper fisheries; a more detailed summary from an issue-by issue perspective is, or will shortly be, available in the Aquatic Environment & Biodiversity Annual Review (http://fs.fish.govt.nz/Page.aspx?pk=113&dk=22982).

### 4.1 Role in the ecosystem

Not yet considered

### 4.2 Incidental catch (fish and invertebrates)

Not yet considered

### 4.3 Incidental Catch (seabirds, mammals, and protected fish)

For protected species, capture estimates presented here include all animals recovered to the deck (alive, injured or dead) of fishing vessels but do not include any cryptic mortality (e.g., seabirds struck by a warp or caught on a hook but not brought onboard the vessel, Middleton & Abraham 2007, Brothers *et al.* 2010).

#### 4.3.1 Marine mammal interactions

There were no observed captures of marine mammals in trawls targeting snapper between 2002-03 and 2009-10 but low observer coverage of inshore trawlers (average 0.85% in FMAs 1 and 9 over these years, Thompson & Abraham 2012) means that the frequency of interactions is highly uncertain. In these same years, there were no observed marine mammal captures in snapper longline fisheries where coverage has averaged 1.6% of hooks set (3.0 and 4.3% in the two most recent years).

#### 4.3.2 Seabird interactions

There were only two observed captures of seabirds (one flesh-footed shearwater and one unidentified small bird) in trawls targeting snapper between 2002-03 and 2009-10 but low observer coverage of inshore trawlers (average 0.85% in FMAs 1 and 9 over these years, Thompson and Abraham 2012) means that the frequency of interactions is highly uncertain. The estimated number of seabird captures in the snapper bottom longline fishery declined from 3 436 in 2000-01 to 247–644 in 2003-04 (depending on the model used, Table 7, estimates from McKenzie & Fletcher 2006, Baird & Smith 2007, 2008, Abraham & Thompson 2010). The estimated number of captures between 2003-04 and 2006-07 appears to have been relatively stable at about 400–600 birds each year.

**Table 7: Model based estimates of seabird captures in the SNA 1 bottom longline fishery from 1998-99 to 2006-07 (from McKenzie & Fletcher 2006 (for vessels under 28 m), Baird & Smith 2007, 2008, Abraham & Thompson 2010). Numbers in parentheses are 95% confidence limits or estimated cvs.**

| | Model based estimates of captures | | | | | |
|---|---|---|---|---|---|---|
| Fishing year | MacKenzie & Fletcher | | Baird & Smith | | Abraham & Thompson | |
| 1998-99 | 1 464 | (271 – 9 392) | – | – | – | – |
| 1999-00 | 2 578 | (513 – 13 549) | – | – | – | – |
| 2000-01 | 3 436 | (697 – 17 907) | – | – | – | – |
| 2001-02 | 1 856 | (353 – 11 260) | – | – | – | – |
| 2002-03 | 1 583 | (299 – 9 980) | – | – | 739 | (332 – 1 997) |
| 2003-04 | 247 | (51 – 1 685) | 546 | (c.v. = 34%) | 644 | (301 – 1 585) |
| 2004-05 | – | – | 587 | (c.v. = 42%) | 501 | (245 – 1 233) |
| 2005-06 | – | – | – | – | 469 | (222 – 1 234) |
| 2006-07 | – | – | – | – | 457 | (195 – 1 257) |

Between 2002–03 and 2009–10, there were 83 observed captures of birds in snapper longline fisheries (Table 8) but no estimates of total captures for the later years are yet available. The rate of capture varied between 0 and 0.1 birds per 1000 hooks observed, fluctuating without obvious trend. Seabirds observed captured in snapper longline fisheries were mostly flesh-footed shearwater (43%), black (Parkinson's) petrel (34%) or fluttering shearwater (14%) and all were taken in the Northland-Hauraki area (Table 9). These numbers should be regarded as only a general guide on the composition of captures because the observer coverage is low, is not uniform across the area, and may not be representative.

**Table 8: Number of tows by fishing year and observed seabird captures in the snapper bottom longline fishery, 2002–03 to 2009–10. No. obs, number of observed hooks; % obs, percentage of hooks observed; Rate, number of captures per 1000 observed hooks. Data from Thompson & Abraham (2012), retrieved from http://bycatch.dragonfly.co.nz/v20120315/**

| | All hooks | No. obs | % obs | Captures | Rate |
|---|---|---|---|---|---|
| 2002–03 | 13 730 262 | 0 | 0.0 | 0 | - |
| 2003–04 | 12 276 448 | 193 893 | 1.6 | 10 | 0.052 |
| 2004–05 | 11 548 941 | 250 985 | 2.2 | 13 | 0.052 |
| 2005–06 | 11 696 613 | 116 290 | 1. 0 | 12 | 0.103 |
| 2006–07 | 10 351 591 | 62 360 | 0.6 | 0 | 0 |
| 2007–08 | 9 052 322 | 0 | 0.0 | 0 | - |
| 2008–09 | 8 970 134 | 268 746 | 3.0 | 21 | 0.078 |
| 2009–10 | 11 032 105 | 479 078 | 4.3 | 27 | 0.056 |

**Table 9: Number of observed seabird captures in the snapper longline fishery, 2002–03 to 2009–10, by species or species group. The risk ratio is an estimate of aggregate potential fatalities across trawl and longline fisheries relative to the Potential Biological Removals, PBR (from Richard *et al.* 2011 where full details of the risk assessment approach can be found). It is not an estimate of the risk posed by fishing for snapper. Other data from Thompson & Abraham (2012), retrieved from http://bycatch.dragonfly.co.nz/v20120315/**

| Species | Risk ratio | Captures |
|---|---|---|
| Flesh footed shearwater | 2.51 | 36 |
| Black petrel | 11.15 | 28 |
| Fluttering shearwater | – | 12 |
| Gannets | 0.10 | 2 |
| Pied shag | – | 2 |
| Black backed gull | 0.00 | 1 |
| Petrels, prions, and shearwaters | – | 1 |
| Red billed gull | – | 1 |
| **Total other birds** | | **83** |

## 4.4 Benthic interactions

Snapper are sometimes taken using bottom trawls and Danish seines, both of which have direct contact with the seabed. Snapper tows accounted for about 6% of all tows reported on TCEPR forms to have been fished on close to the bottom between 1989–90 and 2004–05 (Baird *et al.* 2011), but 54% of snapper trawls and all Danish seine sets during those years were reported on CELR forms. The TCEPR trawl tows were located in Benthic Optimised Marine Environment Classification (BOMEC, Leathwick *et al* 2009) classes A, C (northern shelf) and H (upper slope) (Baird & Wood 2012), and 90% were shallower than 100 m (Baird *et al.* 2011).

Trawling and Danish seining for snapper, like trawling for other species, is likely to have effects on benthic community structure and function (e.g., Rice 2006) and there may be consequences for benthic productivity (e.g., Jennings 2001, Hermsen *et al.* 2003, Hiddink *et al.* 2006, Reiss *et al.*2009). These consequences are not considered in detail here but are discussed in the Aquatic Environment and Biodiversity Annual Review (2012).

### 4.5 Other considerations
None

## 5. STOCK ASSESSMENT

The stock assessments for SNA 2, SNA 7 and SNA 8 were done in 2009, 2002 and 2005 respectively. A partial new assessment of SNA 1 was conducted in 2012, the previous assessment was undertaken in 2000.

### 5.1 SNA 1 (Auckland East)

#### 5.1.1 Model structure

The model used for the 2012 assessment is an age structured population model, built using NIWA's CASAL (C++ Algorithmic Stock Assessment Laboratory) stock modelling software (Bull *et al.* 2012). The model contains significant improvements to the stock structure and movement assumptions on the 2000 assessment.

The 2012 assessment model for SNA 1 assesses three stocks (east Northland; Hauraki Gulf; BoP). In the 2000 assessment, only two stocks were assessed: East Northland and a combined Hauraki Gulf and BoP stock (these stock areas had to be combined due to data and modelling limitations).

The 2012 model has 20 age partitions: 19 age classes (1- 19) plus a 20+ amalgamated age class. Recruitment is defined as the number of fish entering the population at age 1.

As with the 2000 assessment, the 2012 model commences in 1970 at an estimated exploited state. One reason for commencing the model in 1970 was to reduce the importance of assumptions concerning Japanese, recreational and other historical catch uncertainties. To initialise the starting stock populations, a starting equilibrium age structure is derived by estimating recruitment in 1970 for each stock as a proportion ($R_{init}$) of mean recruitment in an unfished state ($R_0$). This is a simplification from the initialisation procedure used in the previous assessment, which estimated the exploited age structure in 1970 using two estimates of $Z$ for each stock.

The model spanned the years 1970 to 2011; 2011 being the 2010-11 fishing year and 1970 being the 1969-70 "start" fishing year. The model had two time steps within each year (Table 10). The model was a single sex model with the proportion mature for the purposes of spawning stock biomass (SSB) calculation assumed to be 0% at age 3, 50% at age 4, and 100% at age 5 onwards.

**Table 10: Annual model time steps and the processes and observations used in each time step Note that the home area for a fish is where it spawns (and was recruited). Each year some fish migrate away from their home ground (in step 2) and then return home in step 1 of the following year.**

| Time step | Model processes (in temporal order) | Observations[2,3] |
|---|---|---|
| 1 | age incrementation, migration to home area, recruitment, spawning, tag release | |
| 2 | migration from home area, natural and fishing mortality[1] | biomass, length and age compositions, tag recapture |

[1]Fishing mortality was applied after half the natural mortality
[2]The tagging biomass estimate was assumed to occur immediately before the mortality; all other observations occurred half-way through the mortality
[3]See Table x for more details of all observations

Year class strengths (YCS) were estimated as free parameters but only for years where there was at least one observation of catch-at-age. The YCS estimation period in the model was also the period over which the R0 parameter was also estimated. YCS estimation conformed to the Haist parameterisation in which the mean of the YCSs is constrained to 1 (Bull *et al.* 2012). For years where YCS could not be estimated as free parameters YCS was set to 1.

For the purposes of converting numbers at-age to length for each stock, the model is provided with three mean length-at-age tables. These tables were derived using a combination of longline catch-at-age observations (ages 6 and above) and trawl survey observations (ages 5 and below). The reason for using a growth table as opposed to a simple growth function (as was done on the 2000 assessment) was to incorporate temporal changes in snapper growth rates into the assessment. Global length-at-age averages were used for years where no independent data existed. As with the 2000 assessment a constant natural mortality of 0.075 was used..

A Beverton and Holt (BH) stock recruit relationship was incorporated into the 2012 assessment model with an assumed steepness of 0.85. This is a significant difference to the 2000 assessment model where no stock recruitment relationship was used (i.e. equivalent to assuming a steepness of 1.0 in the BH model).

Selectivity functions for all gear methods represented in the model were 3-parameter double-normal functions (Bull *et al.* 2012).

A major change in the 2012 assessment was that the tagging data (with the exception of 1983 Bay of Plenty tagging data which were not available) were analysed inside the model while the 2000 assessment these data were analysed separately from the model to produce estimates of biomass that were included in the model (Table 11).

**Table 11: Details of observations used in the stock assessment model**

| Type | Likelihood | Area[1] | Source | Range of years | No. of years |
|---|---|---|---|---|---|
| Absolute biomass | Lognormal | BOP | 1983 tagging | 1983 | 1 |
| Relative biomass (CPUE or survey) | Lognormal | BOP | longline | 1990-2011 | 22 |
| | | ENLD | longline | 1990-2011 | 22 |
| | | HAGU | longline | 1990-2011 | 22 |
| | | BOP | single trawl | 1996-2011 | 16 |
| | | HAGU | research survey | 1983-2001 | 13 |
| Age composition | Multinomial | HAGU | longline | 1985-2010 | 22 |
| | | BOP | longline | 1990-2010 | 19 |
| | | ENLD | longline | 1985-2010 | 18 |
| | | HAGU | Danish seine | 1970-1996 | 11 |
| | | HAGU | research survey | 1985-2001 | 10 |
| | | HAGU | single trawl | 1975-1994 | 6 |
| | | BOP | single trawl | 1990-1995 | 4 |
| | | BOP | research survey | 1990-1996 | 3 |
| | | ENLD | research survey | 1990 | 1 |
| | | BOP | Danish seine | 1995 | 1 |
| Length composition | | BOP | recreational fishing | 1991-2011[2] | 13 |
| | | ENLD | recreational fishing | 1991-2011[2] | 13 |
| | | HAGU | recreational fishing | 1991-2011[2] | 13 |
| | | **Area tagged[1]** | **Year tagged** | **Areas recaptured[1]** | **Years recaptured** |
| Tag recapture | Binomials | ENLD | 1983 | ENLD, HAGU | 1984, 1985 |
| | | HAGU | 1983 | ENLD, HAGU | 1984, 1985 |
| | | ENLD | 1993 | ENLD, HAGU, BOP | 1994, 1995 |
| | | HAGU | 1993 | ENLD, HAGU, BOP | 1994, 1995 |
| | | BOP | 1993 | ENLD, HAGU, BOP | 1994, 1995 |

[1]Areas are East Northland (ENLD), Hauraki Gulf (HAGU), and Bay of Plenty (BOP)

[2]All length composition data sets were split into pre-1995 (2 years) and post-1995 (11 years) because recreational selectivity was assumed to change in 1995

The 2012 assessment explicitly modelled the movement of fish between areas, whereas the 2000 assessments ignored movement. Two alternative movement models were considered: Markovian and home-fidelity (HF) and the HF model was selected. Under the HF movement assumption, fish spawn in their home area and some move to other areas at other times of the year where they are subject to fishing. Model yield calculations (SSBs, *MSY*, BMYS, $B_0$, etc) under a HF movement dynamic pertain to the unit "home" stock, not to an area. The yield from a specific area is derived as an area integration of "home" stock yields as determined by the movement dynamics.

### 5.1.2 Catch History

**Recreational catch**

Annual recreational harvest estimates used in the model were based on the commercial longline CPUE index by stock (1990 to 2011) scaled to the 2004-05 harvest estimates from the aerial over-flight survey by stock (Table 8) (Hartill *et al*. 2007). Estimates between 1989-90 and 1994-95 were scaled up by 10% to compensate for the lower MLS (25 cm), more hooks allowed per longline (50) and higher bag limit (15 per person) that was in place at that time. Harvest by recreational fishers in 1970 was assumed to be 70% of the 1989-90 estimate with a linear increase in annual catch across the intervening years. The customary harvest is not known and is assumed to be included in the recreational catch.

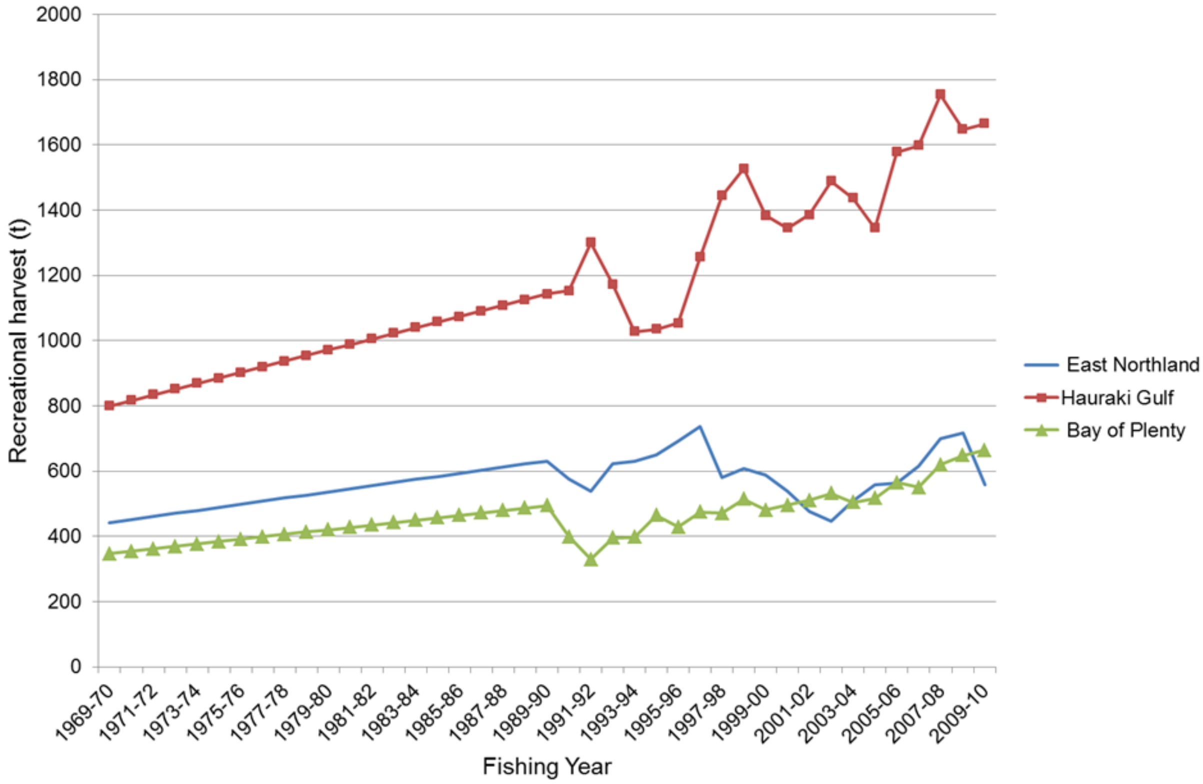



**Figure 2: Recreational catch history used in the 2012 SNA 1 assessment model**

**Commercial catch**

The SNA 1 commercial catch histories for the various method area fisheries after 1989-90 were derived from the Ministry of Fisheries catch effort reporting database (*warehou*). Historical catches for method and area, over the preceding two decades, were constructed on the basis of data contained in the fishery characterisation reports of King (1985; 1986; 1987) and Paul & Sullivan (1988). Area-method catches were prorated to the SNA 1 annual catch totals given in Table 1 & 2. Commercial catch was divided into four method fisheries: longline; single bottom trawl; pair bottom trawl; Danish seine; “other” commercial methods (predominately setnet) (Figure3 & 4) As was done for the 2000 assessment; commercial catch totals prior to the 1986 QMS year were adjusted upwards to account for an assumed 20% level of under-reporting. Catch totals post QMS were likewise scaled assuming 10% under-reporting.

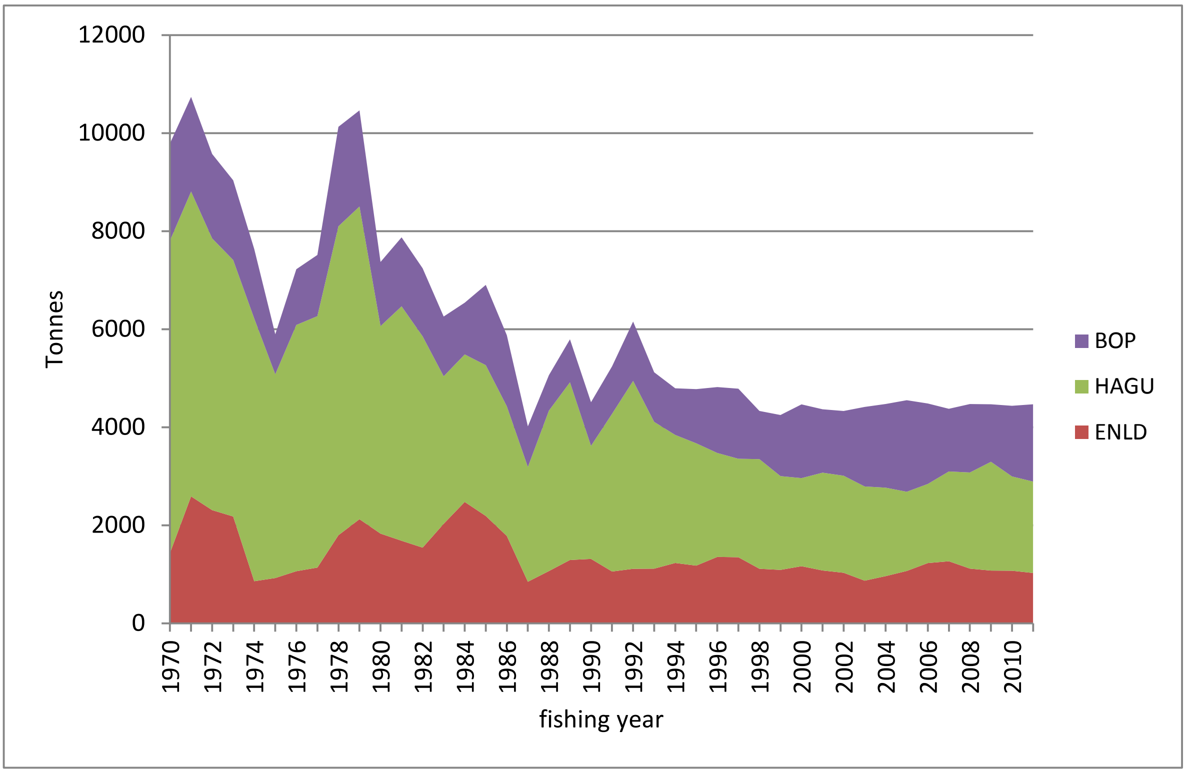



**Figure 3: Area commercial catch histories (not adjusted for under reporting) used in the 2012 SNA 1 assessment model.**

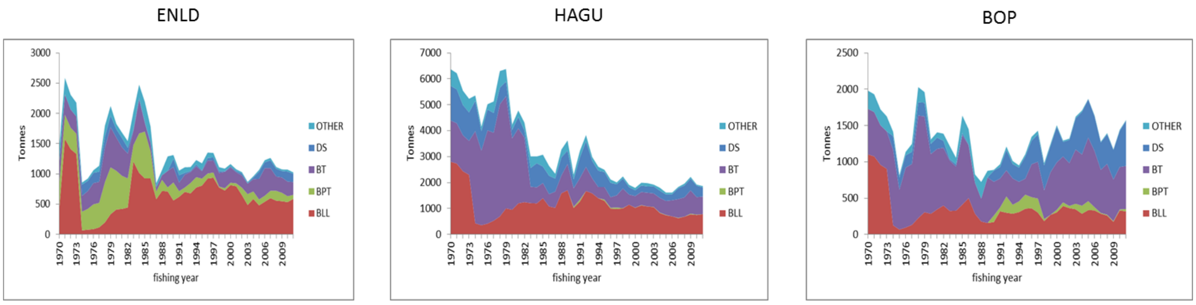



**Figure 4: Method-area commercial catch histories (not adjusted for under reporting) used in the 2012 SNA 1 assessment model.**

### 5.1.3 Abundance indices

**Trawl surveys**

Trawl surveys were carried out in all three areas between the mid-1980s to 2000. Unfortunately, the only area for which a viable series of abundance estimates exists is the Hauraki Gulf. An index of relative numbers of fish surveyed from the Hauraki Gulf trawl survey series was fitted in the model and was assigned an overall cv of 0.15. (Table 9).

**Longline CPUE**

The area specific longline CPUE indices were fitted by the 2012 model, with each series assigned overall cv of 0.15 (section below; Table 9).

**Bay of Plenty single trawl CPUE**

The single trawl Bay of Plenty CPUE was fitted with assigned overall cv of 0.15 (section below; Table 9).

### 5.1.4 Catch at age and length observations

**Commercial data**
Catch-at-age observations from single trawl, Danish Seine and longline are available from the Bay of Plenty and Hauraki Gulf stocks; longline only for east Northland (Table 11).

**Recreational data**

Observations of recreational catch at length are available from 1990, spanning the 1994 change in minimum legal size (Table 11).

**Research Trawl data**

Catch-at-age observations from research trawl surveys are available for most surveys and fitted in the model for all areas (Table 11).

### 5.1.5 Snapper 1983, 1985 and 1994 tagging programmes

Analysis of past snapper tagging programmes revealed a number of sources of bias that need to be accounted for if these data are to be used for assessment purposes. Data from the 1985 and 1994 tagging programmes were corrected for bias and input directly into the assessment model. Data from the 1983 Bay of Plenty tagging programme was unavailable. The published biomass estimate (6000 t Sullivan 1987) was fitted in the model as a point estimate but given a high cv (0.4) in recognition the likely inherent but unaccountable biases in the data.

**Initial mortality**

The release data were adjusted for initial mortality outside the model using methods given in Gilbert & McKenzie (1999).

**Tag-loss**

The effect of tag-loss was only an issue for the 1983 and 1985 tagging programmes where external tags were used. A revised estimate of tag loss was derived from a double-tagging experiment in 1985.

**Trap avoidance**

Trap avoidance was found to occur for both trawl and longline tagged fish (Gilbert and McKenzie 1999), the result of this was that released fish were less likely to be recaptured using the same method.

Trawl and longline methods were used to tag fish in both the 1985 and 1994 tagging programmes. The CASAL models used the scaling factors derived by Gilbert and McKenzie (1999) to adjust the tagging data for trap-avoidance.

**Detection of recaptured tags**

Because a fishery independent tag recovery process was used in the 1994 programme, a reliable estimate of tag under-detection was obtained. The model was provided this estimate to adjust the 1994 tag recovery data.

The recovery of tags in 1983 and 1984 programmes relied on fishers to voluntarily return tags. Estimates of under-reporting from these programmes are less precisely known but were assumed to be 15% (1988 Snapper Plenary Report).

### Differential growth of tagged fish

There is evidence that tagged fish may stop growing for 6 months after tagging (Davies *et al.* 2006).The growth differential between tagged and untagged fish may bias results as the model will expect these fish to be larger than they are. As it was not possible to incorporate this source of bias in the model, it was assumed that, given the majority of tags recovered in both programmes came from the first year after release, growth bias would be minimal.

### 5.1.7 Selectivity

The selectivity parameterisation in the model was the same for all three stocks. The composition data allowed selectivity to be estimated for all methods, with the exception of pair trawl, and the lumped commercial method "other" category (Figure 4).

The selectivity curves used by the model for pair trawl and method "other", were based on selectivity curves used in previous SNA 1 & 8 assessments (Gilbert *et al.* 2000, Davies *et al.* 2006, Bian *et al.* 2009).

### 5.1.6 Model Parameters and likelihood weighting

### Model parameters

The fixed and estimated parameters used in the 2012 assessment model are given in Tables 12 and 13.

**Table 12: Details of parameters estimated in the stock assessment model**

| Type | Description | No. of parameters | Prior |
|---|---|---|---|
| $R_0$ | Mean unfished recruitment for each stock | 3 | uniform-log |
| $R_{init}$ | Pre-1970 recruitment (as proportion of $R_0$) | 3 | uniform |
| YCS | Year class strengths by year and stock | 115[1] | lognormal[3] |
| Migration | Proportions migrating from home grounds | 6 | uniform |
| Selectivity | Proportion selected by age by a survey or fishing method | 18[2] | uniform[4] |
| *q* | Catchability (for relative biomass observations) | 5 | uniform-log |

[1]YCSs were estimated for years 1969-2007 (for East Northland and Hauraki Gulf) and 1971-2001 (Bay of Plenty)
[2]Selectivities (assumed to be double normal and independent of area) were estimated for research surveys, and the following fishing methods: longline, single trawl, Danish seine, and pre-1995 recreational, and post-1995 recreational
[3]With mean 1 and coefficient of variation (0.6)
[4]Except for the recreational selectivities, where normal priors were assumed for each parameter with means 4.55, 0.50, 10.24 (pre-1995) and 5.30, 0.50, 10.40 (post-1995) and coefficients of variation 0.20, 0.05, and 0.05 (both pre- and post-1995)

**Table 13: Details of parameters that were fixed in the stock assessment model**

| | |
|---|---|
| Natural mortality | 0.075 $y^{-1}$ |
| Stock-recruit steepness | 0.085 |
| Tag shedding (instantaneous rate, 1985 tagging) | 0.486 $y^{-1}$ |
| Tag detection (1985 and 1994 tagging) | 0.85 |
| Proportion mature | 0 for ages 1-3, 0.5 for age 4, 1 for ages > 4 |
| Length-weight [mean weight (kg) = $a$ (length (cm))$^b$] | $a = 4.467 \times 10^{-5}$, $b = 2.793$ |
| Mean lengths at age | provided for years 1989-2011 |
| Coefficients of variation for length at age | 0.10 at age 1, 0.20 at age 20 |

### Model likelihoods and data weighting

The tagging data were fitted in the model using binomial likelihoods representing the probability of tags being present or absent in scanned/examined catches. It was not feasible to adjust the relative weighting of these data in the model. The CV's on the various abundance data sets were defined *a priori* to be consistent with the most "plausible" fit the model was expected to achieve to the data (as agreed by the working group). Reweighting of the compositional data fits in the model used method TA1.8 of Francis (2011).

### 5.1.7 Base model and model sensitivity parameterisation

Input values for the base and sensitivity model runs, as agreed by the working group, are given in Table 14.

**Table 14: Base model fixed model and sensitivity model input values**

| Element | Base model | Sensitivities | 2000 SNA 1 assessment (base) |
|---|---|---|---|
| Natural mortality | 0.075 | 0.065(mLw) 0.085(mHi) | 0.075 |
| BH steepness | 0.8 | 0.85(hLw) 0.9(hHi) | 1 (no stock recruit) |
| trap avoidance | 0.65 | - | 1.0 (no trap) |
| recreational catch | relative abundance fixed at 2005 aerial survey estimate | scale up 2005 survey estimate by 25% (rec25%) | history of the same order |

### 5.1.8 Model projections

Five year stock projections were undertaken using the base model under the following assumptions:
- Commercial and recreational harvest at the level of the TACC with gear and area catches being proportionally the same as the final model year (2011)
- Recreational catch in each area being the average of the last three years
- Recruitment is to be based on strengths of year classes entering the fishery from 1995 to 2004 for which at least three observations were available.

The deterministic $B_{MSY}$ was estimated using the approach developed for hoki by Francis (see Hoki 2011 WG Report).

### 5.1.9 Results

**Base model**

The base model MPD achieved good fits to the abundance data and reasonably good fits to the composition data. The model fitted the majority of tag movement data cells within the confidence bounds of most of the observations. The expected number of Hauraki Gulf/Hauraki Gulf and East Northland/East Northland recoveries in 1995 were not well fitted, although these represent 2 out of 26 possible recovery cells, these cells had some of highest numbers of tag observations.

The likelihood profiles on the $R_{init}$ parameter for the Hauraki Gulf stock show the initial starting status of the stock in 1970 was well determined by the early Danish seine age composition data. $R_{init}$ for the Bay of Plenty and east Northland stocks was poorly determined in each stock. Stock status ($B_{2011}/B_0$) was not sensitive to $R_{init}$ over the 95% confidence range of this parameter for the three stocks. This implies that poor determination of $R_{init}$ had little influence on the stock status conclusions from the model, i.e. $B_0$, recent SSBs and projections.

Patterns observed in MCMC traces for $B_0$ and the ratio of $B_{2011}/B_0$ suggest the model MCMCs are inadequate for estimating probabilities and other derived parameters required for management. Consequently all results shown below for this model are MPD results.

The model stock movement estimates (Table 15) suggest that most fish stay in their home area, the exception being the Bay of Plenty where 27% move to the Hauraki Gulf.

**Table 15: Model stock movement estimates from and to east Northland (ENLD), Hauraki Gulf (HAGU) and the Bay of Plenty (BOP)] The table describes the movement away from the home area.**

| | to | | |
|---|---|---|---|
| from | ENLD | HAGU | BOP |
| ENLD | 0.94 | 0.04 | 0.02 |
| HAGU | 0.07 | 0.89 | 0.04 |
| BOP | 0.03 | 0.27 | 0.70 |

Model biomass and stock status trajectories (Figure 4) for stocks and areas are reasonably similar for East Northland and Hauraki Gulf, less so for the Bay of Plenty due to the higher level of interchange. In the context of this model, management advice can be given in two ways: 1) by stock (where the fish spawn); 2) by area (where the fish are caught and observed) (Table 16).

**Table 16: MPD $B_0$ (000t) estimates by stock and area**

| | ENLD | HAGU | BOP |
|---|---|---|---|
| stock | 69 | 255 | 145 |
| area | 85 | 270 | 114 |

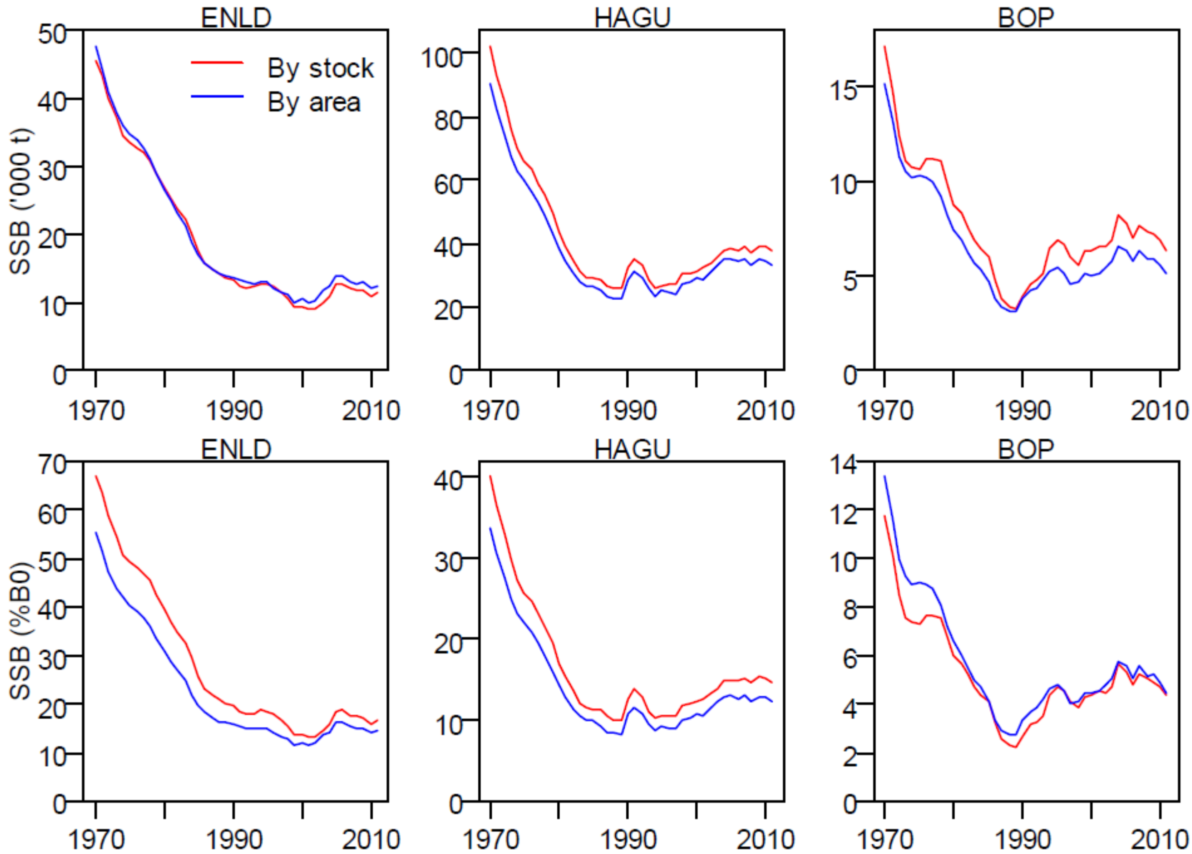



**Figure 5: MPD base model SSB and status trajectories by stock and area.**

Figure 5 shows the east Northland, Hauraki Gulf, and Bay of Plenty 2011 SSBs are all below 20% $B_0$. In the Bay of Plenty, 2011 SSB was estimated to be below 10% $B_0$. The reason for the model's poor prognosis for the Bay of Plenty stock is that the area has been subjected to high fishing pressure

(Figure 5). However, stock status is influenced by the rate of exchange between the BoP and HG. There is uncertainty in this estimate because there are only 45 tag recoveries available.

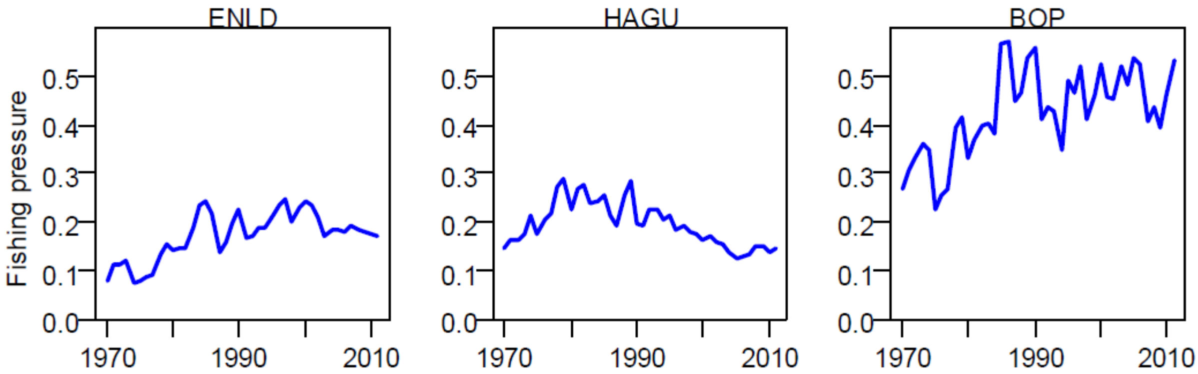



**Figure 6: Estimated MPD exploitation rates (aggregated across all fishing methods) by year and area.**

The model SSB trajectories for all three stocks after 2007 are either decreasing or flat (Figure 5). Model five year projections from the MPD predict decreasing SSBs in all three stocks (Figure 7). The 5-year projections suggest that current catches will not rebuild populations in EN and HG, and are likely to reduce abundance in the BoP. This result is consistent with trends in standardised CPUE, which although increasing in EN and HG had flattened off in recent years.

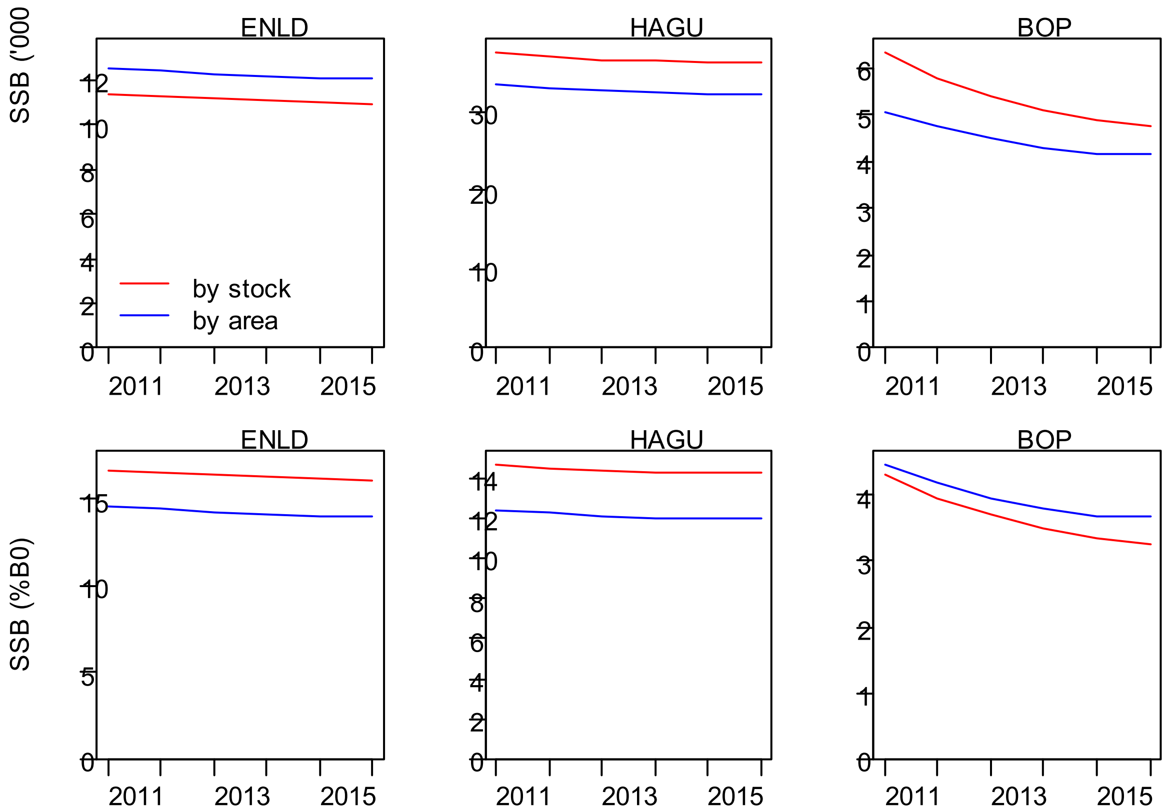



**Figure 7: Projected spawning-stock biomass (SSB) from MPD projections**

## Deterministic $B_{MSY}$

Deterministic $B_{MSY}$ was 26-27% $B_0$ for all stocks and areas. There are several reasons why $B_{MSY}$, as calculated in this way, is not a suitable target for management of the SNA 1 fishery. First, it assumes a harvest strategy that is unrealistic in that it involves perfect knowledge including perfect catch and biological information and perfect stock assessments (because current biomass must be known exactly in order to calculate the Stock $B_{MSY}$s corresponding with exploitation rates that achieve maximum yield from the fishery are shown target catch), a constant-exploitation management strategy with annual changes in TACC (which are unlikely to happen in New Zealand and not desirable for most stakeholders), and perfect management implementation of the TACC and catch splits with no under- or overruns. Second, it assumes perfect knowledge of the stock-recruit relationship, which is actually very poorly known (Francis 2009). Fourth, it would be very difficult with such a low biomass target to avoid the biomass occasionally falling below 20% $B_0$, the default soft limit according to the Harvest Strategy Standard. Thus, the actual target probably needs to be considerably above this theoretical optimum; but the extent to which it needs to be above has not been determined.

## Model sensitivity runs

The higher recreational catch sensitivity produced implausible fits to the observed data. Increased recreational catch also resulted in a lower biomass in HG, and prevented the model from fitting the observed 1983 biomass estimate in the BoP. The increased recreational catch sensitivity run was therefore inconsistent with observations and rejected by the Working Group.

Stock area SSB trajectories from all model sensitivity runs show very little difference in predicted biomass over the recent model history (mid-1980s to 2011) (Figure 8). This result implies the recent (mid-1980s to 2011) area biomass estimates are reasonably well determined by the model. Changing natural mortality and steepness had most effect on the area $B_0$ estimates (Table 17; Figure 8). Higher m and h values lowered $B_0$ lower m and h values raised $B_0$. The range in m and h explored had similar magnitude effects on $B_0$ (Table 17; Figure 8).

**Table 17: Area and (stock) base and sensitivity model $B_0$ and 2011 stock status estimates**

| | East Northland | | Hauraki Gulf | | Bay of Plenty | |
|---|---|---|---|---|---|---|
| **Model name** | $B_0$ | $B_{2011}/B_0$ | $B_0$ | $B_{2011}/B_0$ | $B_0$ | $B_{2011}/B_0$ |
| Base | 85 (68) | 0.15 (0.17) | 270 (256) | 0.12 (0.14) | 114 (146) | 0.04 (0.05) |
| M low [0.065] | 103 (80) | 0.12 (0.15) | 334 (307) | 0.1 (0.11) | 162 (213) | 0.03 (0.03) |
| M Hi [0.085] | 74 (59) | 0.17 (0.2) | 226 (218) | 0.15 (0.16) | 82 (103) | 0.06 (0.07) |
| h Low [0.80] | 97 (73) | 0.13 (0.16) | 331 (287) | 0.1 (0.12) | 206 (274) | 0.03 (0.03) |
| H Hi [0.90] | 79 (63) | 0.16 (0.18) | 235 (232) | 0.14 (0.15) | 81 (100) | 0.06 (0.07) |

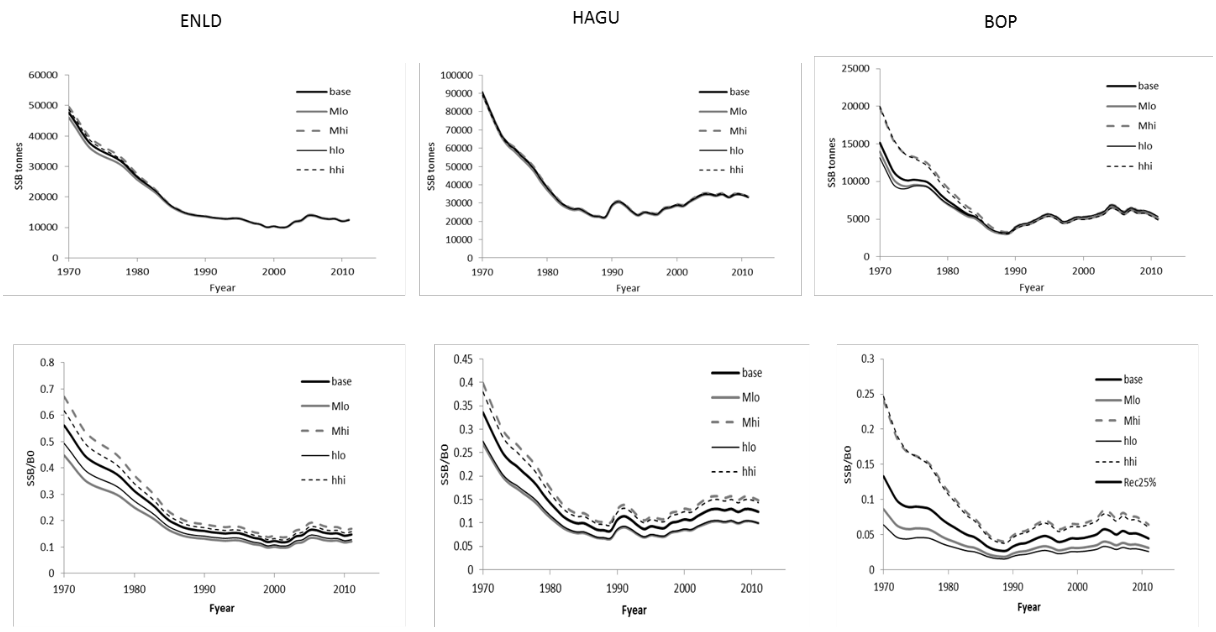



**Figure 8: Area MPD SSBs and SSB/$B_0$ ratios for base and sensitivity model runs.**

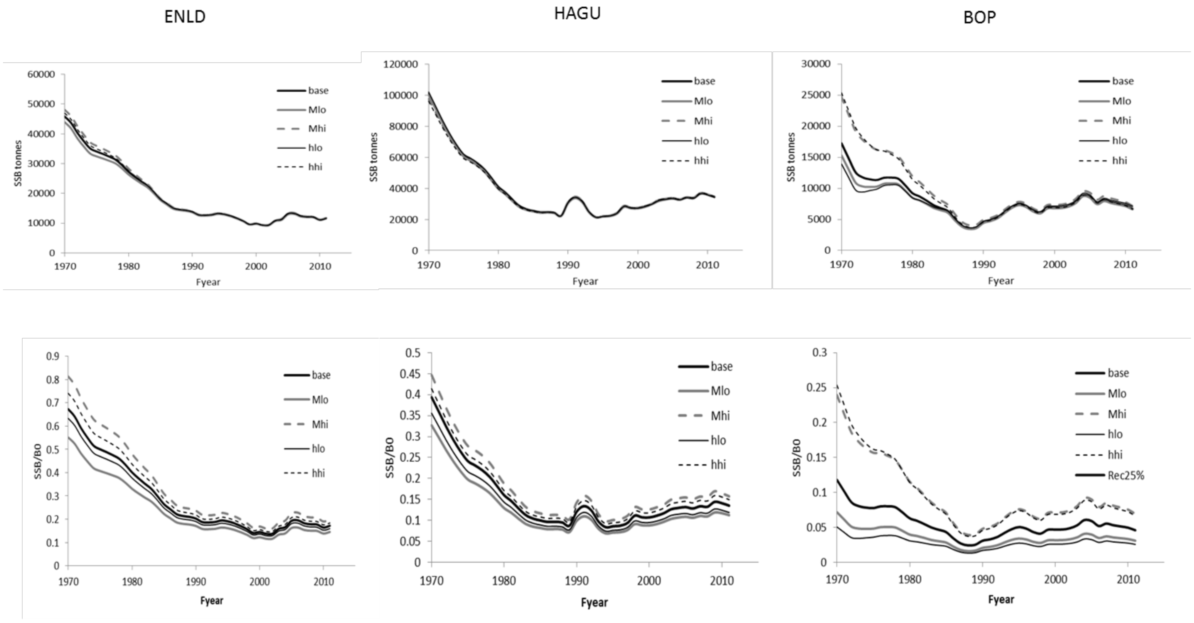



**Figure 9: Stock MPD SSBs and SSB/$B_0$ ratios for base and sensitivity model runs.**

### 5.1.5 Updated CPUE indices 1989-90 - 2010-11

A CPUE index was developed based on data from bottom longline fisheries operating in the East Northland, Hauraki Gulf and Bay of Plenty sub-stocks within SNA1. While this analysis used methods similar to the CPUE analysis described above, with each data series covering the 1989-90 to the 2010-11 fishing years, it differed in several aspects:

a) the analysis was based on prorating the landings for each trip back to the estimated catches recorded in each effort record;

b) the analysis used log(catch) from each effort record as the dependent variable rather than the log(catch/hook) as in the previous analysis. Number hooks and number sets were offered to the model as explanatory variables approximated by a third-order polynomial, thus allowing for a non-linear relationship between catch and the effort variables;

c) there was a change in the way data were reported commencing 1 October 2007. Previously, effort data were reported on an effective daily basis while the new forms reported effort on an "event" basis. The analysis therefore required combining daily catch information from the earlier daily CELR data series with event based information from the LTCER form series after 2006-07 fishing year. Combining the data required aggregating the more detailed LTCER data at the daily catch level. The validity of doing this was explored by looking for discontinuities in the annual median number of hooks reported by the core vessels over the form change interval. It was concluded combining the two data series in a single analysis was appropriate.

The NINSWG accepted these indices as indices of abundance.

Since 1989 the East Northland index has fluctuated without trend, with no overall change (Figure 10a). The Hauraki Gulf and Bay of Plenty indices have shown a steady increase since 1989, with > 50% improvement since 1989 (Figure 10 b & c).

### 5.1.6 Longline catch-at-age 1984-85 - 2009-10

Catch-at-age sampling since 1985 in East Northland shows a greater accumulation of fish older than 20 years than observed in the Hauraki Gulf or Bay of Plenty sub-stocks (Figures 5-7). There is some evidence that there has been an increase in the relative proportion of the 20+ age class in all three sub-stocks since the mid-2000s (Figure 11).

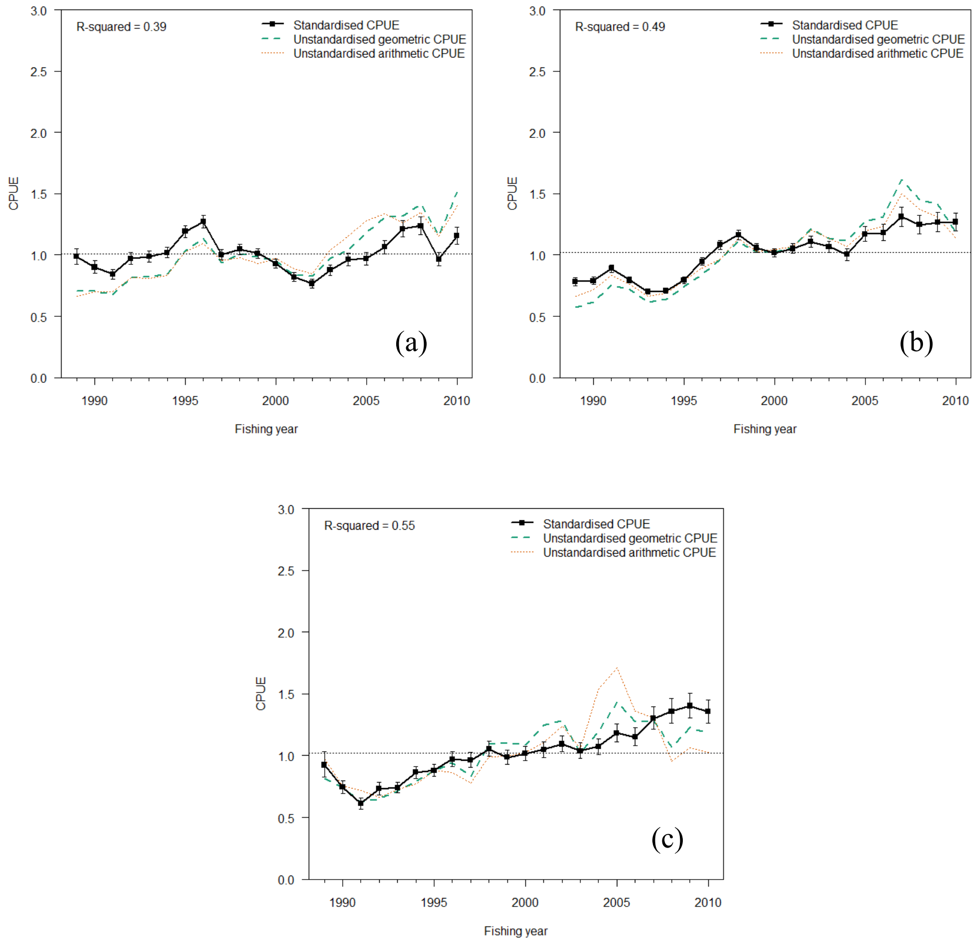



**Figure 10: Longline CPUE indices of abundance from 1989-2011 for the three component stocks of SNA 1: (a) East-Northland, (b) Hauraki Gulf, (c) Bay of Plenty.**

Despite having proportionally fewer fish older than 20 years than east Northland, the age composition of the Hauraki Gulf longline fishery has fluctuated since 1995-96 with little discernable trend up 2007-08, after which there is some evidence that the Hauraki Gulf age composition has broadened (Figure 12).

The Bay of Plenty long line age composition is similar to SNA 8, with the fishery largely comprised of only 4-6 dominant age classes with few fish older than 20 years present in the catch samples. Like the Hauraki Gulf, there is some evidence that Bay of Plenty age structure may have broadened over the last three years to 2009-10 (Figure 13).

### 5.2 SNA 2

Previous assessments of SNA 2 were done by Harley & Gilbert (2000) and Gilbert & Phillips (2003). A stock assessment for SNA 2 was done in 2009 (Langley 2010). The model incorporates seven years of catch at age data sampled from the commercial fishery between 1991-92 and 2007-08 and a standardised CPUE index for the bottom trawl fishery for the recent period of the fishery (1989-90 to 2008-09).

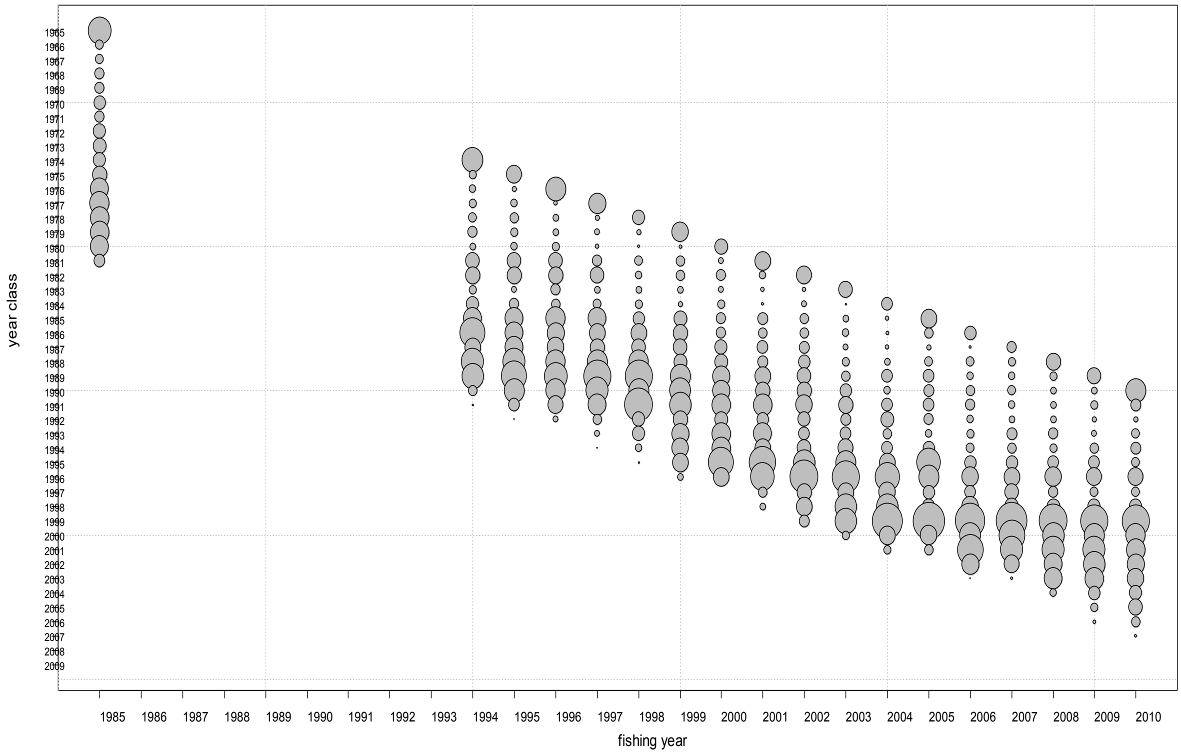



**Figure 11: Relative year-class strength observed in the east Northland longline fishery 1984-85 - 2009-10. Year on the X-axis refers to the second part of the fishing year. The oldest year class is a 20+ group.**

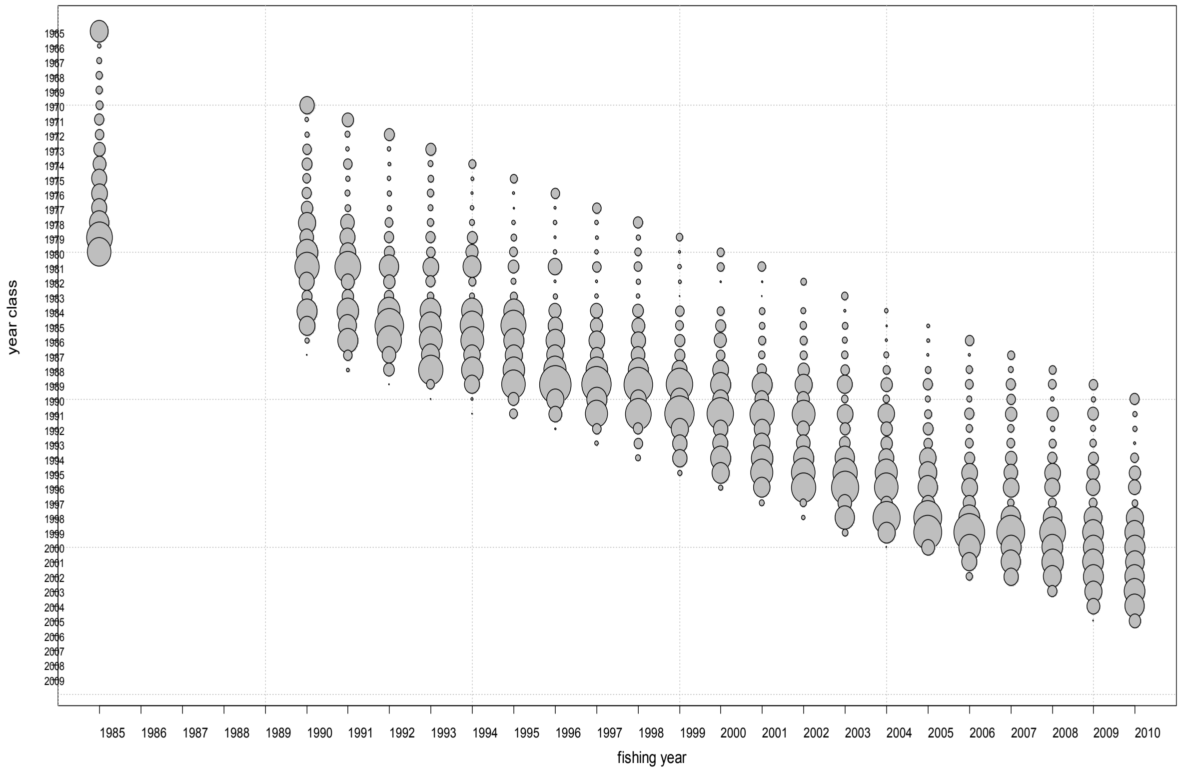



**Figure 12: Relative year-class strength observed in the Hauraki Gulf longline fishery 1984-85 - 2009-10. Year on the X-axis refers to the second part of the fishing yearThe oldest year class is a 20+ group**

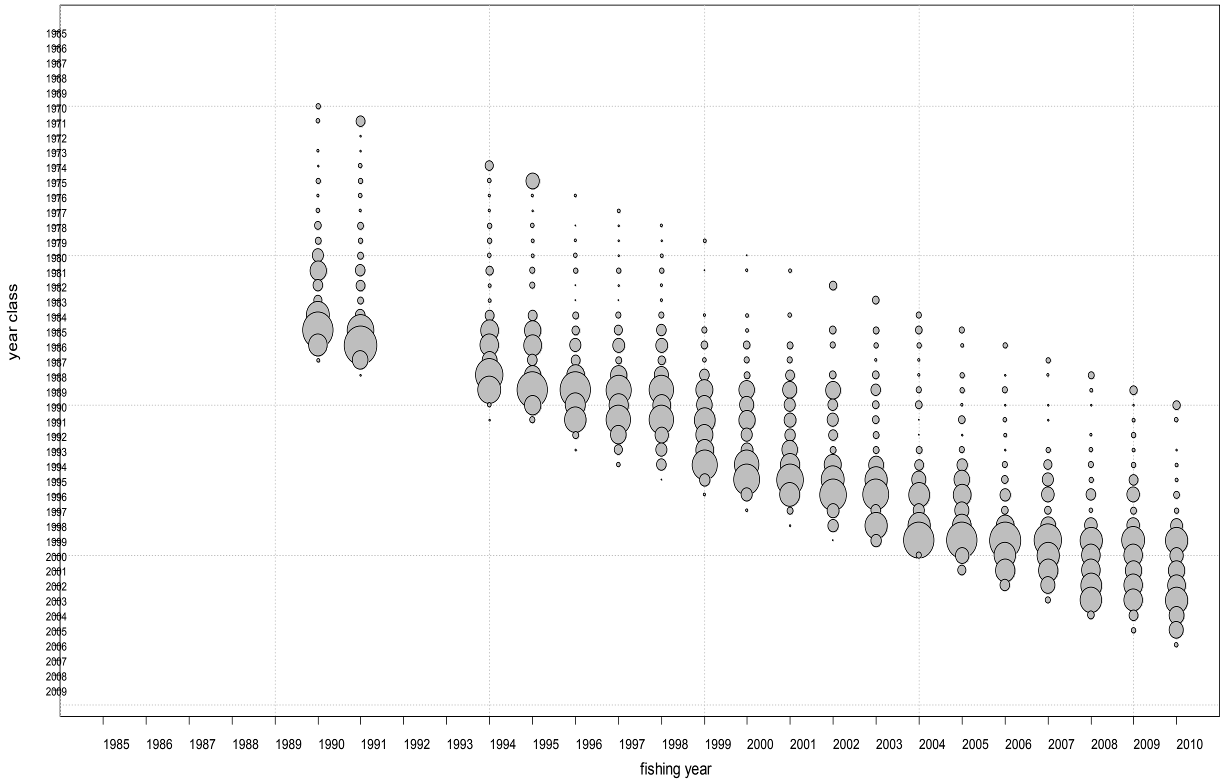



**Figure 13: Relative year-class strength observed in the Bay of Plenty longline fishery 1990-91 - 2009-10. Year on the X-axis refers to the second part of the fishing year. The oldest year class is a 20+ group.**

### 5.2.1 Model data sets

**CPUE indices**

A series of standardised indices were derived from the inshore trawl fishery for 1989-90 to 2008-09 (Kendrick & Bentley In press). These indices were accepted by the NINS WG; however, given that the indices are principally derived from a bycatch fishery, there are concerns that the indices are likely to be influenced by changes in regulations affecting the fishery. For example, the decline in the CPUE indices in the two most recent years may be attributable to changes in targeting behaviour caused by a considerable increase in the deemed value for SNA 2. Therefore, the resulting CPUE indices are unlikely to be a reliable index of abundance. In addition, the CPUE indices reveal a very large decline in the early years of the time series. These observations are inconsistent with the observed age frequency data from the fishery and the underlying population dynamic of the species.

**Catch at age data**

Seven years of age frequency data are available from the commercial fishery. There is considerable variability in the age compositions among years which is likely to be due, in part, to the sampling of the snapper bycatch from a number of different target fisheries. The age compositions are principally comprised of younger age classes and few old fish are sampled from the catch. Consequently, the age frequency distributions are likely to be uninformative regarding the cumulative impact of fishing mortality on the underlying population age structure. There are also concerns regarding the representative nature of the sampling and comparability of the ageing in earlier years.

**Commercial catch**

The pre-QMS catches are assumed to include a level of unreported catch (equivalent to 20%) of the reported catch. Following the introduction of the QMS, the unreported catch was assumed to be 10% of the reported catch in 1986 and then decline by 1% annually to 1996 and maintained at that level for the remainder of the model period.

**Recreational catch**
Four estimates of recreational catch are available for the SNA 2 fishery. Estimates were obtained by way of a diary survey in 1992–93 and 1996, and cover the whole of the SNA 2 fishery (Bradford 1998, Teirney *et al*. 1997). The more recent recreational catch estimates (for 2000 and 2001) were substantially higher and were considered to be less reliable and consequently were not used.

Recreational catches from 1933-2008 were assumed using a step function that increased catches from 0 in 1933 by 5 t every 10 years with an annual catch of 45 t in the last decade. The assumed catch history was consistent with the lower estimates of recreational catch obtained in the 1990s.

**Customary non-commercial catch**
No estimates are available on the levels of customary non-commercial catch. It has been assumed that the recreational catch estimates include a portion of the catch representing the customary take.

### 5.2.2 Model structure
A statistical, age-structured population model was implemented using the Stock Synthesis (Methot 2009). The model encompasses the 1933-2009 period. The model structure includes two sexes, 1-19 year age classes, and an accumulating age class for older fish (20+ years). The age structure of the population at the start of the model is assumed to be in an unexploited, equilibrium state.

The total annual catch is attributed to a single fishery and the CPUE indices represent an index of the vulnerable component of the population. There is considerable variability in the age frequency data among years and, consequently, these data were assigned a relatively low weight in the total objective function (sample size of 50).

Preliminary model runs revealed that the model was highly sensitive to the assumptions regarding fishery selectivity. Two initial scenarios were considered: full selectivity of the older age classes (logistic selectivity) or estimation of the age selectivity of the older age classes (double normal). The double normal selectivity resulted in a very low selectivity for the older age classes and a very optimistic current stock status, although this was largely attributable to the model estimating a large, cryptic component of the population.

It was considered that there was insufficient information content in the age frequency data to estimate the selectivity of the older age classes due to confounding with fishing mortality. On that basis, it was decided to adopt an externally derived selectivity function. The selectivity of the Bay of Plenty SNA 1 single bottom trawl fishery (Gilbert *et al.* 2000), modified to account for the more rapid growth of younger snapper in SNA 2, was applied to define the selectivity of the older age classes. The selectivity of the younger (1-5 year) age classes was based on the age-specific estimates of selectivity obtained from the double normal selectivity model.

It is important to note that the model results, particularly current stock status, are highly dependent on the selectivity function applied and, consequently, should be considered very uncertain. The model results were also highly sensitive to the relative weighting assigned the CPUE indices and the age frequency data. For this reason, the estimates of current stock status from the model are not reported. Nonetheless, other model stock indicators (particularly estimates of *MSY*) were less sensitive to the selectivity assumption and the model is likely to be more informative regarding estimates of yield.

Model assumptions:
- Natural mortality $M = 0.075\ y^{-1}$ or $0.06\ y^{-1}$,
- Deterministic recruitment for 1933-1984 and 2003-09 assuming no stock recruitment relationship. Recruitment deviates estimated for 1985-2002 assuming a standard deviation of the natural logarithm of recruitment ($\sigma_R$) equal 0.6,
- Fishery selectivity was temporally invariant and fixed based on an externally derived selectivity function.
- SNA 2 specific growth parameters (Table 18).

Two model runs are presented based on the alternative values assumed for natural mortality.

Model uncertainty was estimated using a Markov chain Monte Carlo (MCMC) approach. However, the model is highly constrained by the assumptions that the key parameters (selectivity, M, and growth) are known without error and, therefore, the level of uncertainty is greatly under-estimated. The resulting estimate of virgin, equilibrium recruitment ($R_0$) is largely dependent on the historical catch history.

Current stock status is unknown and therefore stock projections are not considered informative.

### 5.2.3 Results

The model fit to both the age composition data and the CPUE indices is poor. There is a clear conflict between the two data sources as evidenced by the fit to the most recent years' data; the model fits the recent decline in the CPUE indices only by estimating lower year class strengths than evident in the commercial age frequency observations. Conversely, the model is unable to fit to the strong decline in the CPUE indices in the early 1990s given the observed age compositions.

The biomass trajectory derived from the model displays a strong decline in biomass during the 1960s and 1970s concomitant with the higher levels of catch during the period (Figure 14). The estimated biomass trajectory is highly constrained throughout this period and during the preceding years due to structural assumptions of the model, principally the fixed selectivity, deterministic recruitment and fixed biological parameters. The model is essentially estimating a $R_0$ that is consistent with these assumptions and thereby yields a minimum level of virgin biomass necessary to support the historical catches under the assumptions of deterministic recruitment.

**Table 18: The median and 5 and 95 percentiles of the marginal posterior distributions for SNA 2 model runs assuming different values for natural mortality (Steepness = 1). $B_0$ is the virgin biomass (mature female); $B_{MSY}$ is biomass at *MSY*; *MSY* is maximum sustainable yield and includes under-reporting and non-commercial catch. The current stock status is very uncertain and, consequently, not reported (see text for details).**

| Run | $B_0$ | $B_{MSY}$ | *MSY* | $B_{MSY}/B_0$ |
|---|---|---|---|---|
| *M* 0.075 | 8,669<br>(8,583-8,816) | 1,650<br>(1,634-1,678) | 496<br>(491-505) | 0.190<br>(0.190-0.190) |
| *M* 0.06 | 9,228<br>(9,166-9,314) | 1,798<br>(1,786-1,815) | 443<br>(440-447) | 0.195<br>(0.195-0.195) |

The fishing mortality rates derived from the model in the more recent period are determined, in part, by the observed age composition and the assumed selectivity function. Consequently, the assumed selectivity function has considerable influence on the estimates of current stock status. Further, given the conflict between the data sources, the relative weighting of the CPUE and age frequency data is also highly influential. On that basis, estimates of current stock status are not considered reliable and it is not possible to make conclusions regarding current stock status from the assessment models.
Nonetheless, for the range of model options investigated, the estimates of *MSY* are comparable. This is attributable to the similar estimates of $R_0$ (and therefore $B_0$) among the various model options. Again, the estimates of virgin biomass are consistent with the minimum biomass levels necessary to support the catch history during the period prior to the mid 1980s.

### 5.2.4 Yield Estimates

**Maximum Sustainable Yield (*MSY*)**

The two models yielded median values of *MSY* of 496 t and 443 t for the higher (*M* = 0.075) and lower (*M* = 0.06) natural mortality scenarios, respectively. The *MSY* estimates are highly constrained due to the structural assumptions of the model and the confidence intervals do not represent the high uncertainty associated with the yield estimates. These yield estimates are likely to be conservative as they are based on estimates of $R_0$ that approach the minimum level of (deterministic) recruitment necessary to support the historical catches from the stock. Conversely, the models will over-estimate yields to the extent that the historical catches have been over-estimated i.e. the allowance for 20% over-catch of the reported catch.

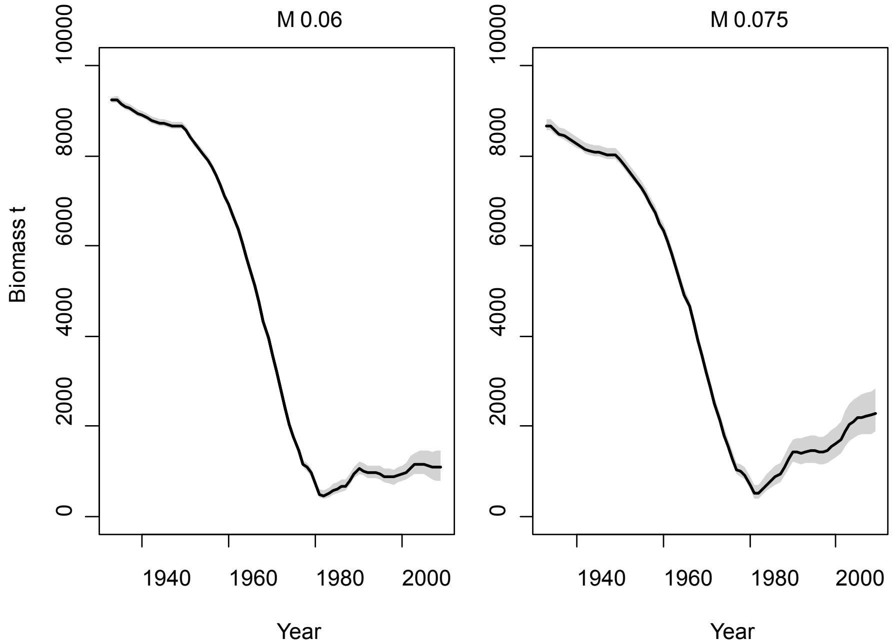



**Figure 14: Biomass (median and 90 percentiles of the posterior distribution) for SNA 2 with the alternative assumptions of lower (0.06) and higher (0.075) natural mortality. Biomass is defined as mature, female biomass.**

## 5.3 SNA 7 (Challenger)

### 5.3.1 Stock Assessment

A stock assessment of SNA 7 was undertaken in 2002 (Gilbert & Phillips 2002) (see 2008 Plenary for details). This assessment was externally reviewed in 2006. Based on that review, the Snapper Working Group concluded (25 September 2006) that the model was depicting the 2001 SNA 7 biomass at an unrealistically high level (100-200% $B_{MSY}$) and rejected the results of the assessment. This was largely a result of the model using long-term historical catch (since 1930s) to estimate initial biomass. The historical catch data indicated that the initial biomass was large and that the associated productivity would be expected to be high under average recruitment. Based on the 1986-88 tag estimate of absolute biomass and low catches, the stock was assumed to have collapsed, and the TACC was reduced. Current catch levels are below the expected level of productivity predicted by the model, which suggests that the stock should be rebuilding. This prediction has not been corroborated by catches or other information external to the model.

The Working Group concluded that an assessment should not be repeated for SNA 7 until a reliable index of abundance is available.

### 5.3.2 Index of Abundance

A characterisation of the SNA 7 fishery identified three fisheries operating in Tasman Bay/Golden Bay that could potentially provide indices of abundance (Hartill & Sutton 2011). These were the trawl fisheries targeting SNA, FLA, and BAR. Although standardised indices derived from all three fisheries showed a high degree of interannual variability, the general long-term trend was broadly the same,. The characterisation suggested that all three fisheries could potentially interact with different components of the wider stock, both spatially and temporally. The Southern Inshore Working Group suggested that catch data from all three fisheries should be combined into a single model that explicitly considered the manner in which these fisheries might interact with the components of the Tasman Bay/Golden Bay snapper stock. The resulting combined fishery CPUE index was considered to be the most plausible index of abundance available for SNA 7 (Figure 15). The level of inter-annual variability seen in this combined fishery index, while lower than in the three individual fishery indices, remained large, with between year swings that are larger than would be expected from abundance changes in such a long-lived species. CPUE generally declined to 2001, after which it has fluctuated without trend.

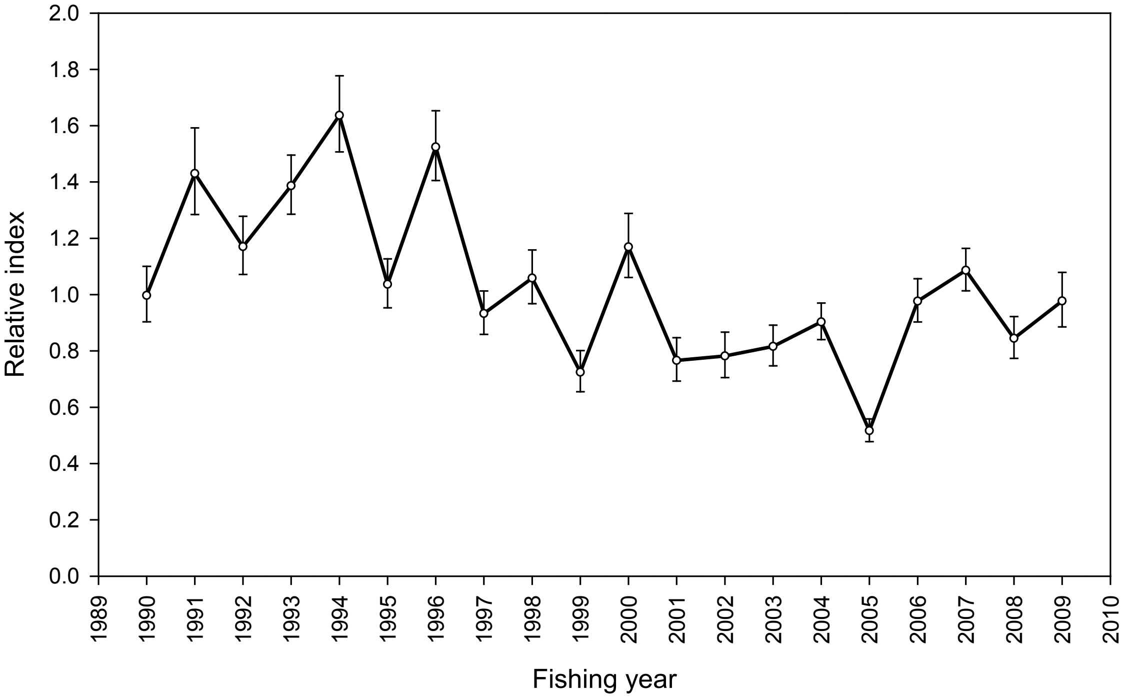



**Figure 15: A Standardised snapper CPUE index derived from catch effort data provided by trawlers operating in Tasman Bay/Golden Bay (Statistical Reporting Areas 037 & 038). This index was based on data provided by a core set of trawlers for days where either SNA, FLA, and/or BAR were targeted (Hartill & Sutton 2011).**

## 5.4 SNA 8 (Auckland West/Central West)

A revised assessment of SNA 8 was completed in 2005 including updated observations on:

- method-specific catch weights to 2003-04;
- catch-at-age for commercial pair and single trawl in 2003-04; and,
- single trawl CPUE time series from 1996-2004 incorporating tow duration as the unit of effort from core vessels in the fleet.

New information added to the 2005 assessment included:

- single trawl catch-at-age 1974 to 1976;
- pair trawl catch-at-age with recalculated observations for 1974 to 1976; 1978 to 1980;
- mean size-at-age 1975, 1976 and 1979;
- pair trawl catch-at-sea length frequency in 1986; and,
- boat ramp samples of recreational length frequency in 1991, 1994, 1996 and 2000.

Using this new information assisted the estimation of selectivities-at-length for the single trawl, pair trawl and recreational fishing methods, and natural mortality. A revised time series of observed and assumed mean size-at-age was input to the model for the period 1931-04.

**Estimates of fishery parameters and abundance**

The assessment model was written using CASAL (Bull *et al*. 2004). It was age-based but included approximations for length-based selectivities. It models the SNA 8 exploitation history by maximising the likelihood fit to a time series of observations. Bayesian estimates for the fitted parameters were the means of the estimated marginal posterior distributions; priors were specified for key model parameters such as $R_0$ (mean recruitment), $q$ (catchability coefficient), selectivity at length, natural mortality and year class strengths. For particular types of observations the model incorporates process error as defined by Bull *et al*. (2004). Stochastic projections of the model to 2025 were undertaken to assess the probability of population increase and the decline in annual harvest proportions under alternative future catch levels.

Model assumptions:

- an equilibrium unexploited population in 1931, calculated using constant annual recruitment, was assumed to represent virgin stock biomass,
- the level of under-reporting for domestic commercial catch was 20% before 1987 and 10% after 1987,
- Japanese longline catch in the period 1965-74 was assumed to be 2000 t per year,
- YCS was estimated for the 1971-00 year classes (30 parameters),
- 1971-2000 represented mean recruitment, i.e., average year class strength (YCS) = 1.0,
- the catch at age fit assumed a multinomial distribution,
- CPUE, trawl survey YCS indices, and tag-recapture biomass and population proportions at length were fitted assuming log-normal distributions,
- 1990 and 2002 tag-recapture estimates were fitted as absolute biomass and proportions-at-length assuming log-normal distributions,
- the CVs assumed for the 1990 and 2002 absolute biomass estimates were 0.3 and 0.2 respectively,
- selectivity-at-length was estimated for the single trawl, pair trawl and recreational methods as independent parameters; time-variant recreational selectivities were specified to take account of changed minimum legal size (MLS) from 25 cm to 27 cm in October 1994;
- selectivity-at-length for the longline method was assumed to be constant at a value of 1.0.

## Catch at age

Catch at age information from the Ministry of Fisheries stock monitoring programme was available for the following methods and years:

- pair trawl 1974-76, 1978-80, 1986-87, 1989-90, 2000-04,
- single trawl 1974-76, 1991-04.

For the period 1974 to 1980, estimates were calculated as the mean catch-at-age weighted by the catches taken in each season sampled in that year.

## Year class strength (YCS)

The age structured model was constructed to estimate constant annual recruitment (number of 1-year-old fish entering the stock) from 1928 to 1970. Year class strength information came from catch at age data and trawl survey indices (Table 19). Separate catchability coefficients were estimated for the 2+ and 3+ indices to account for differences in vulnerability. The annual YCS's were estimated as indices relative to the average recruitment for 1971-2000.

**Table 19: SNA 8 trawl survey indices of relative year class strength with the ages at which individual year classes were sampled.**

| Survey year | Year class | Index | CV | Age surveyed |
|---|---|---|---|---|
| 1987 | 1984 | 0.82 | 0.27 | 3+ |
| | 1985 | 2.73 | 0.28 | 2+ |
| 1989 | 1986 | 0.78 | 0.10 | 3+ |
| | 1987 | 0.67 | 0.20 | 2+ |
| 1991 | 1988 | 0.18 | 0.37 | 3+ |
| | 1989 | 0.96 | 0.32 | 2+ |
| 1994 | 1991 | 1.27 | 0.15 | 3+ |
| | 1992 | 0.79 | 0.26 | 2+ |
| 1996 | 1993 | 0.93 | 0.31 | 3+ |
| | 1994 | 0.89 | 0.20 | 2+ |
| 1999 | 1996 | 1.90 | 0.13 | 3+ |
| | 1997 | 0.29 | 0.19 | 2+ |

**Recreational catch**

Recreational catch estimates range between 236 and 1133 t (Table 5). The uncertainty in these estimates discussed above, means that their utility is mainly limited to identifying a plausible range. The Working Group agreed to use two alternative recreational catch scenarios that were deemed to represent the upper and lower bounds of average recreational catch. For the lower catch scenario an annual recreational catch of 300 t was assumed between 1990 and 2004. For the higher catch scenario the 1990 to 2004 value was 600 t. For both scenarios the 1931 catch was assumed to be 20% of the 1990 catch and the intermediate year catches were determined by linear interpolation. These two recreational catch scenarios were used in the alternative stock assessments presented below. No additional catch is assumed for customary catch above either recreational level.

**CPUE analyses**

A time series of annual pair trawl CPUE indices (catch per day) for 1974-91 for SNA 8 was derived by Vignaux (1993). The recent time series of single and pair trawl catch and effort data cover the period 1989-90 through 2003-04. There was a shift to more detailed reporting forms in 1994-95. To use the data prior to this year, a coarser unit of effort must be defined over the whole time series that limits the resolution of a descriptive effort variable. In past analyses the unit used was catch per tow (Davies *et al*. 1999). Davies *et al*. found that there were significant differences between pair and single trawl CPUE after 1989-90. The Snapper Working Group rejected the pair trawl index after 1990-91 on the grounds that it possibly contained duplicated effort data.

For the 2004 assessment a time series of single trawl CPUE indices was calculated using the recent detailed catch-effort data reported since 1994-95. The effort term was catch per nautical mile derived from “tow speed” and “tow duration”. Covariates in the general linear model included: a length/breadth/depth (LBD) parameter representing vessel-power; month; stat-area; and target. Zero catches were included in the GLM by the addition of 1 kg to all recorded catch estimates. The index derived from the GLM fit is given in Figure 5.

This series was updated to 2003-04 for the 2005 assessment and a GLM standardisation was undertaken using the same parameters as in 2004. The data showed a decreasing trend in the proportion of zero catches which the WG felt was important to include in the standardised model. Various methods were attempted to include this information, such as adding a constant to the zero catches or using a combined model where the zero catches were modelled separately based on a binomial distribution and then combining the binomial model with the lognormal model (positive catch data) using a delta method. The former approach resulted in unacceptable model diagnostics and the delta method showed that the effect of adding the trend in proportion zero catch was relatively minor compared to the trend obtained from the positive catch data. Consequently the WG recommended not including the zero catch data in the GLM fits but that this issue could be explored more fully in future assessments.

The WG also requested that the LBD parameter previously used to describe vessel fishing power be replaced by an individual categorical “vessel” variable and that the analysis be restricted to vessels which had been active in the fishery for at least three years. This data selection resulted in the construction of two datasets describing the catch and effort data for the top 20 and the top 12 catching vessels.

The updated single trawl GLM index showed a shallow decreasing trend from 1995-96 to 2000-01 followed by a general increase to 2003-04 (Figure 16). The Working group considered these indices were more appropriate than the analysis used to generate the 2004 series, given that the 2005 analysis was based on data from core vessels only and that the model diagnostics were acceptable. There was virtually no difference between the year indices based on the data from the top 20 or the top 12 vessels and the WG adopted the series based on the top 12 vessels to include in the SNA 8 assessment model.

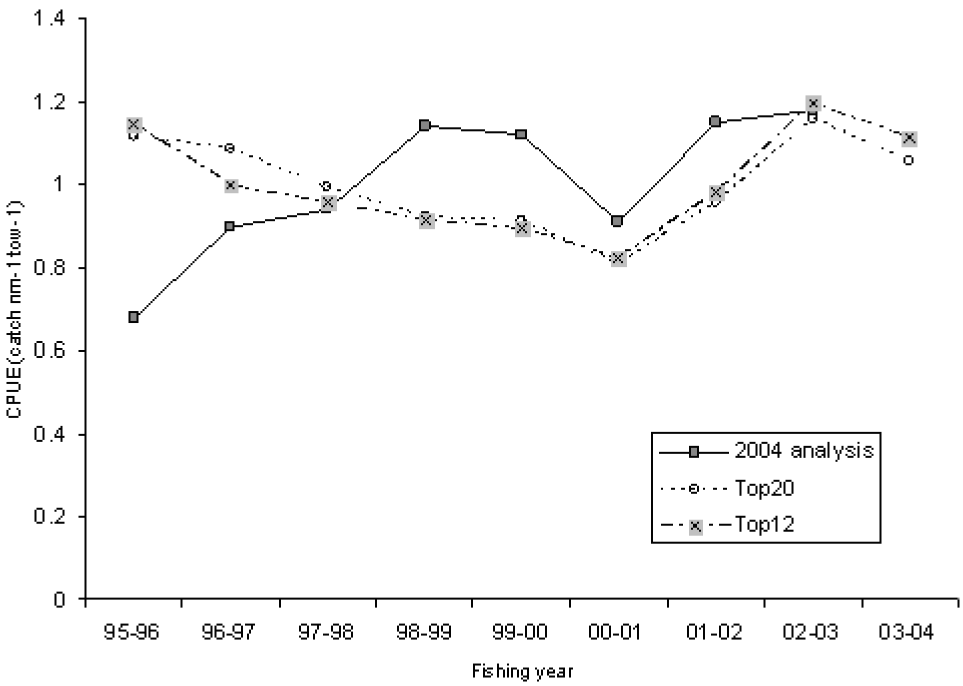



**Figure 16: Single trawl CPUE indices of catch per n. mile used in the 2004 and 2005 assessments.**

## 2002 Tagging program biomass

A tag-recapture programme was carried out in 2002 and 2003 to estimate recruited population size in SNA 8. In February 2002, 22854 fish were tagged with internal passive integrated transponder tags. Fish 20 cm and larger were tagged from 335 trawl tows distributed from Ninety Mile Beach to South Taranaki, out to a depth of 75 m. SNA 8 was divided into five inshore strata (less than 75 m) and five adjacent offshore strata. Fish were not tagged from the offshore strata because of the likely high mortality rate of snapper that are caught in deeper water. It was assumed that fish would mix between inshore and offshore strata. Some fish under 25 cm were tagged to allow the estimation of the growth rate of recruiting fish. Commercial landings were scanned for tags between October 2002 and July 2003. The fishing location of each landing or part-landing was recorded. The primary data were therefore the release location and size of each fish tagged; the location, date, weight and a length frequency sample of each part-landing that was scanned; and a unique identifier (tag number) and length for each recaptured fish.

Ancillary data were required to allow the estimation of initial (immediate post-tagging) mortality, scanner failure rates and the difference between the growth rates of tagged and untagged fish. Length frequency samples taken during the release phase were also used to improve the precision of the estimates of numbers at length. Evidence obtained from double-tagged fish showed that tag deterioration and tag loss did not occur over the duration of the experiment.

## Estimation

Maximum likelihood was used to estimate the recruited population size as a vector of numbers at length in each of the ten strata in February 2002. A model was developed to calculate the binomial likelihood of a tagged fish being either recaptured or not recaptured in each scanned landing. Likelihoods for initial survival, movement, growth of fish and scanner failure were included. Binomial likelihoods were also calculated for the numbers of survivals from three initial mortality experiments (in 1992, 1994 and 2002) where tagged fish were retained in a holding net for two weeks. The probability of a tagged fish being detected by each scanner was calculated from a series of tag seeding trials. A normal likelihood involving the growth of untagged fish was calculated from sample proportions by age and length from commercial landings and research trawl survey samples. Multinomial likelihoods were also obtained for length frequency samples taken during the release and the recapture phases.

A total of 103 parameters were estimated. These were: 16 numbers at length parameters for each inshore/offshore pair of strata; a North/South movement parameter; two growth parameters for tagged fish and two for untagged fish; a phase parameter for growth seasonality; a parameter for growth variability; five scanner success rate parameters; three initial survival rate parameters; four release phase selectivity parameters and four recapture phase (commercial fishery) selectivity parameters.

The population in each stratum between 15 and 80 cm was obtained by interpolating between adjacent pairs of the 16 numbers at length parameters. The numbers of fish between 15 and 24 cm was estimated to account for the recruitment of fish below 25 cm into the population in the period from February 2002 (tag release) to October 2002 to July 2003 (recapture period).

Because fish were not tagged from the offshore strata there was a confounding of inshore/offshore movement and the offshore population size. The populations in the offshore strata were therefore assumed to have the same proportions at length as the adjacent inshore strata and two non-estimated parameters were also required: inshore/offshore movement and the proportion of fish whose home stratum was offshore.

Each fish had a hypothetical home stratum. The probability that a fish would, at any time, be in another stratum was a constant function of how far that stratum was from the home stratum, dependent on the two movement parameters. Thus the model did not allow net movement over time. Inshore and offshore movement was equally likely and northerly and southerly movement was equally likely. The probability of movement more than one stratum north or south declined as a power function of the movement parameter. Impermeable boundaries were assumed at the north of the Ninety Mile Beach stratum and at the south of South Taranaki.

### Results

The estimated biomass in each stratum is given in Table 20. A substantial fraction of the total biomass (37%) comes from fish above 55 cm in length. The CV of the recruited population biomass estimate was 0.12. The estimated numbers per centimetre length class have CVs that fall from 0.24 at 25 cm to a minimum of 0.06 in the mid-30’s and then rise to exceed 0.30 at 66 cm, based on the estimated Hessian matrix. Estimates in adjacent length classes are highly correlated with correlation coefficients exceeding 0.85 above 31 cm. CASAL does not at present contain any multivariate likelihood function with covariances. To simply ignore these high correlations would give these data excessive weighting.

**Table 20: Estimated population biomass.**

| Stratum name | | Biomass (t) |
|---|---|---|
| | < 75 m | ≥ 75 m |
| Ninety Mile Beach | 685 | 104 |
| Kaipara | 887 | 135 |
| Manukau | 3 465 | 526 |
| North Taranaki | 2 131 | 324 |
| South Taranaki | 1 897 | 288 |
| Total | | 10 442 |
| CV of total | | 0.12 |

The estimate of biomass from the 1990 tagging programme in SNA 8 was recalculated. After correcting for sources of bias, the revised estimate was 9505 t; a CV of 0.18 was assumed. The programme also provided estimates of the recruited population length composition. The CVs assumed for these (0.11 to 0.48) were double those derived from the 2002 programme.

After consideration of the low CVs estimated from the 2 tagging programmes the WG agreed to fit the absolute biomass estimates and proportions at length for the 1990 and 2002 tagging data in both alternative runs, but to increase the CVs of the absolute biomass estimate to 0.3 for the 1990 programme and to 0.2 for the 2002 value.

### Mean weight-at-age estimates

Comparison of mean weight at age data from the age samples over time indicated that, on average, fish at the same age were heavier in the 1990s than in the 1970s. It is not known what has caused this change in mean weight-at-age, but it is possible that it results from density-dependence or from changes in the mean temperature. This shift in mean weight at age has important implications for the calculation of the $B_0$ and $B_{MSY}$ reference points because they will differ, depending on which set of mean weight at age are used.

The WG agreed to calculate all biomass levels prior to 1980 using the mean weight at age derived from the 1975-79 catch-at-age samples. Biomass levels after 1989 used the post-1989 mean weight-at-age estimates. Biomass levels in the period from 1980 to 1988 used a mean weight at age values calculated from the mean of the two sets of available estimates. This means in the model that $B_0$, based on the 1931 initial equilibrium biomass, has been calculated using the mean weight-at-age levels appropriate to the 1970s.

**Revised selectivity estimates from tagging**

Length-based selectivity curves for single and pair trawl were obtained from the tagging estimator model, primarily from the recapture phase length frequencies. Both had steeply declining right hand limbs with 50% selectivity at 49.2 and 54.1 cm respectively. Although these estimates were consistent with the lower recapture rates of larger fish, previous estimates and other data in the population model suggested shallower declines, especially for pair trawl. In the population model runs single and pair trawl length-based selectivities were estimated as independent parameters, with the tagging selectivity estimates defining the means of informed priors. Alternative recreational length-based selectivities before and after 1994 were estimated to take account of the effect of a change in the minimum legal size (MLS) from 25 cm to 27 cm in October 1994. Knife-edge left hand limbs and the join parameters corresponding to the MLS values were assumed, with the right hand limbs of the selectivity functions being estimated.

**Assumed error and priors**

The level of observational and process error (*see* Bull *et al*. 2004) assumed for fitting to the observational data is given in Table 22. Process error was added to CPUE, trawl survey recruitment indices (TSI), and boat ramp length frequency data. The level of process error for CPUE was set such that the total CV was approximately 0.2 to 0.3. Process error for TSI and boat ramp length frequency data was added to reduce the relative weight of these observations in the overall model fit (Table 21). The list of priors assumed for model parameters is given in Table 20. The uniform prior for YCS was deliberately chosen to overcome a problem with the YCS parameterisation for calculating Bayesian estimates using the MCMC algorithm; the impact of this on the assessment has not been determined.

The natural weighting for the observations fitted in the model is that which produces a standard deviation for the standardised residuals that is close to 1.0. This was not the weighting used in the SNA 8 model. A lower weighting was assigned to the catch-at-age data and pair trawl length frequency data (low effective sample sizes) to maintain the relative weight of the tagging programme estimates in the overall model fit.

**Table 21: Observation error assumed for data input to the SNA 8 model (effective sample size = N, coefficient of variation =CV), and process error assumed.**

| Observation type | Observation error | Process error | Error type |
|---|---|---|---|
| Catch at age pair trawl post-1986 | N = 13 to 63 | 0 | Multinomial |
| Catch at age single trawl post-1991 | N = 13 to 72 | 0 | Multinomial |
| Catch at age pair trawl 1974-80 | N = 8 to 86 | 0 | Multinomial |
| Catch at age single trawl 1974-76 | N = 7 to 35 | 0 | Multinomial |
| CPUE pair trawl 1974-1991 | CV range = 0.07 - 0.67 | 0.2 | Log-normal |
| CPUE single trawl 1996-2004 | CV range = 0.023 - 0.047 | 0.2 | Log-normal |
| Tag biomass 1990 | CV = 0.3 | 0 | Log-normal |
| Observation type | Observation error | Process error | Error type |
| Tag biomass 2002 | CV = 0.2 | 0 | Log-normal |
| Tag population proportions at length 1990 | CV range = 0.11 - 1.28 | 0 | Log-normal |
| Tag population proportions at length 2002 | CV range = 0.06 - 0.76 | 0 | Log-normal |
| Trawl survey 2+ year class strength index | CV range = 0.19 - 0.32 | 0.2 | Log-normal |
| Trawl survey 3+ year class strength index | CV range = 0.10 - 0.37 | 0.4 | Log-normal |
| Boat ramp recreational catch length frequency | *N* = 100 | N = 60 | Multinomial |
| Pair trawl catch-at-sea length frequency 1986 | *N* = 10 | 0 | Multinomial |

**Table 22: Assumed model priors.**

| Parameter | Prior | Specification |
|---|---|---|
| Mean recruitment, $R_0$ | Uniform-log | Range = ($10^4$, $10^8$) |
| Year class strengths (1971-00) | Uniform | Range = (0.01, 20.0) |
| Catchability coefficients (CPUE and trawl survey indices), $q_1$, $q_2$, $q_3$, $q_4$ | Uniform-log | Range = ($10^{-9}$, 3.0) |
| Selectivity (all double-normal) - single and pair trawl | Normal | Means = tag 2002 estimates (6 parameters)<br>CVs range = 0.11 - 0.63 |
| Selectivity (all double-normal) - recreational | Normal | Means = 12 cm above Ljoin (2 parameters)<br>CV = 0.5 |
| Natural mortality, $M$* | Log-normal | Mean = 0.075, CV = 0.5 |

* $M$ was fixed in the MCMC for both runs at the value estimated in the MPD

## Alternative model runs

A range of alternative models were explored to test the sensitivity of the model to alternative assumptions concerning the value of natural mortality, assumed catch history and the information obtained from the tagging programmes. The WG finally agreed on two runs that differed only in the level of recreational catch assumed (either 300 t or 600 t from 1990 to 2004). Both runs fit the tag-recapture data from 1990 and 2002 as absolute biomass estimates plus proportions at length.

## Results

As the weights at age vary over the time period of the model it is necessary to determine what population parameters should be used in defining the virgin biomass. The 1989-04 length-at-age data give greater weights-at-age than the 1975-79 data. It was inferred that these increased growth rates were a result of density dependence rather than of a positive relationship with mean water temperature. The WG agreed that virgin stock biomass ($B_0$) should therefore be defined as that resulting from mean recruitment and the 1975-79 mean weights-at-age and is equal to the modelled 1931 biomass.

The model estimates of natural mortality were 0.051 and 0.054, depending on which level of recreational catch was assumed. These estimates are lower than the value (0.075) assumed in previous SNA 8 assessments, based on the catch-at-age data collected in the 1970's, but analysed independent of the assessment model. The model fit to the observations was significantly improved when estimating natural mortality compared to a model fit when assuming a fixed value of 0.075. The effect of lower estimates of natural mortality is to reduce the estimates of mean recruitment and the stock productivity.

The mean of the posterior distributions and 90% credible intervals for $B_0$ and $B_{04}$ are shown in Table 23 for the alternative runs. A higher $B_0$ estimate was obtained for the run that assumed higher recreational catch (R600), but stock status was similar. This range for $B_0$ is not considered to adequately describe the full uncertainty in $B_0$ for a number of reasons:

- the model may be described as a "total catch history model", so the time series of historical catches strongly determines the estimate of $B_0$. The alternative recreational catch history resulted in a higher estimate of $B_0$ but with similar levels of uncertainty. There is further substantial uncertainty in the assumed catch history for Japanese longline catch, commercial catch overruns and the pattern of recreational catches.
- There are a large number of observations to which the model was fitted over the period 1974 to 2004. Amongst these the catch-at-age data in the 1970's has moderate leverage on the estimates of $R_0$ and $M$. An evident constraint on the model biomass is that it remains above zero in the mid-1980s while at the same time fits the absolute abundance estimates from the later tagging programmes. Throughout this period, 1986 to 1990, there was strong agreement in the model fit to six of the data types. The model fits to these data serves to constrain the estimates of $R_0$ and $M$, and, hence, $B_0$.
- The model trajectory differed somewhat from the recent CPUE index. However the observed indices were within a narrow range (0.9 to 1.2) and the fit was consistent with the CV's.

**Table 23: Mean of posterior distributions of biomass for the SNA 8 model using recreational catch levels of 300 t (R300) and 600 t (R600). $B_0$ is virgin stock biomass. $B_{04}$ is the start of year biomass for 2003-04, and $B_{04}/B_0$ is the ratio of 2003-04 biomass to $B_0$. The 90% credible intervals were derived from the marginal posterior distributions for the Base case. The biomass units are 1000 t.**

| Model run | $B_0$ | 5% | 95% | $B_{04}$ | 5% | 95% | $B_{04}/B_0$ | 5% | 95% |
|---|---|---|---|---|---|---|---|---|---|
| R300 | 110 | 108 | 112 | 10.8 | 8.5 | 13.4 | 9.8% | 7.8% | 12.1% |
| R600 | 117 | 114 | 119 | 11.7 | 9.2 | 14.6 | 10.0% | 8.0% | 12.5% |

The Working Group discussed the use of appropriate reference points for reporting the stock status of SNA8. Because the model uses variable growth curves through the calculation period, $B_{MSY}$ will vary depending on the assumed growth rate and how growth might vary with stock size. For instance, if a constant mean size-at-age equal to that for 1931-2004 was used, $B_{MSY}$ = 18.3% $B_0$. Alternatively, if the 1989-2004 mean size-at-age were used, $B_{MSY}$ = 17.5% $B_0$. Ideally, a functional relationship defining density dependent growth would be used to calculate the SNA 8 $B_{MSY}$ but the functional relationship of size-at-age with density is not defined and was not possible to model in the time available. Based on exploratory modelling of density-dependent growth, the Working Group adopted 20% $B_0$, where $B_0$ is the Base case model estimate of biomass in 1931, as the definition for $B_{MSY}$. Under the mean size-at-age for 1931-2004 the catch to biomass ratio at $B_{MSY}$ was 0.098.

Bayesian posterior estimates for the model parameters were derived from MCMC chains of 3.2 million (R300) and 2.6 million (R600) iterations (Figure 17). It was necessary to hold M constant at the MPD values (0.051 and 0.054) to produce convergence of the MCMC. The MCMC traces for the two main model runs showed no obvious signs of non-convergence.

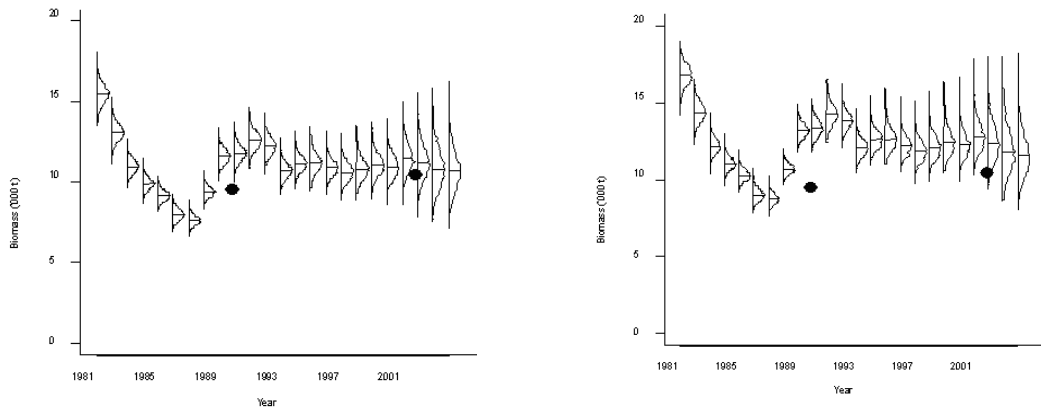



**Figure 17: Posterior distributions of the biomass trajectories for the SNA 8 model estimates assuming historical recreational catch of 300 t (left panel) and 600 t (right panel) with the tagging programme estimates of biomass (solid circles).**

## Projections

Projections of population biomass have been modelled assuming future commercial catch over the range 500 to 1500 t, with a 10% overrun component. Two options were investigated for future recreational catch in projections: firstly, assuming a constant recreational exploitation rate at the level estimated in the model in 2004 ($F_{rec}$); and secondly, assuming a constant catch capped at the level assumed for 1990-2004 ($R_{cap}$). Two alternative levels were assumed for the recreational catch from 1990 to 2004, either 300 t or 600 t. The WG considered these values were likely to bracket the true average level of catch in this period. The impact of the increase in minimum legal size (MLS) in the recreational fishery has been incorporated into the model assumptions. A projection was also investigated that included zero future removals (commercial or non-commercial) from the population in all years. This was to determine the maximum rate of rebuilding possible for the population.

The posteriors of the model parameters were sampled for projections while assuming stochastic recruitments (by randomly resampling with replacement the year class strengths (Figure 18) in each draw), and constant commercial catches. Constant mean size-at-age using the 1989-2004 mean was assumed. At each catch level, simulations were carried out, projecting forward to 2025. For projections assuming future annual recreational exploitation rates are constant ($F_{rec}$) the value was estimated from the model MPD value (i.e. the recreational catch to absolute biomass ratio in 2004).

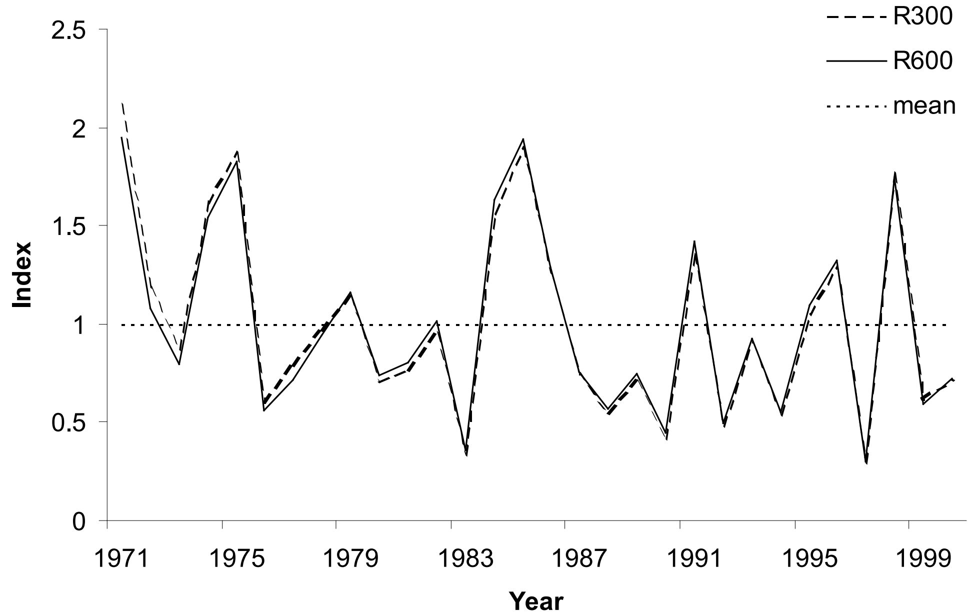



**Figure 18: SNA 8 Base case model MPD estimates of the relative strengths of the 1971 to 2000 year classes.**

In this case the commercial catch was assumed to be constant at the alternative levels, however, the recreational catch varied as stock size and age structure changed. For projections assuming constant future recreational catch ($R_{cap}$) this did not occur.

Under all future recreational catch options and at alternative levels of future TACC the stock is predicted to increase on average (Table 24, and Figure 19). The rate of increase was slightly lower for $F_{rec}$ options (constant recreational exploitation rate, Figure 19a and 19c) compared to the $R_{cap}$ projection options (constant recreational catch, Figure 18b and 18d). The rate of rebuilding varied widely depending upon the assumed future TACC.

Under the $F_{rec}$ projection option, recreational take increases as the stock increases but is mediated by the domed recreational selectivity curve. The high proportion of young fish in the population after a period of rapid rebuild gives recreational fishers higher catches for the same effort. Under the slower rebuild the young fish make up a relatively smaller fraction of the population leading to relatively smaller recreational catch.

In summary the SNA 8 stock is predicted to increase under any future TACC level and alternative recreational catch assumptions. However, with a TACC of 1500 t the rate of rebuild is very slow.

**Estimation of Maximum Constant Yield (*MCY*)**
Estimates of *MCY* were not calculated.

**Estimation of Current Annual Yield (*CAY*)**
Estimates of *CAY* were not calculated.

**Table 24: SNA 8: Projection estimates for the R300 and R600 model runs under two alternative options for recreational catch: a) constant proportional recreational catch (Frec) equivalent to the proportional recreational harvest in 2005; and b) constant annual recreational catch (Rcap). Estimates are shown for a range of future TACCs and for a projection under zero removals, i.e. TACC = 0 t and zero recreational catch. $B_{05}$ and $B_{10}$ are start of year biomasses for 2004-05, and 2009-10, respectively. P($B_{10}$>$B_{05}$) is the probability of $B_{10}$ exceeding $B_{05}$ and *E( )* denotes expected value. The 90% credible interval for $B_{10}$>$B_{05}$ were derived from the marginal posterior distributions. $CR_{2010}$ is recreational catch in 2010. $E(B_y)$ denotes the year $B_{MSY}$ is expected to be reached.**

(a) R300_Rcap

| TACC | $E(B_{05})$ (t) | $E(B_{10})$ (t) | $B_{10}/B_{05}$ Expected | 5% | 95% | $P(B_{10} > B_{05})$ | $E(CR_{2010})$ | Year when $E(By) = B_{MSY}$ |
|---|---|---|---|---|---|---|---|---|
| 500 | 10 891 | 18 538 | 1.7 | 1.29 | 2.13 | 1 | 300 | 2011 |
| 1 000 | 10 882 | 15 266 | 1.39 | 0.99 | 1.81 | 0.94 | 300 | 2014 |
| 1 250 | 10 869 | 13 709 | 1.25 | 0.83 | 1.67 | 0.84 | 299 | 2018 |
| 1 375 | 10 866 | 12 876 | 1.17 | 0.74 | 1.59 | 0.74 | 297 | 2021 |
| 1 500 | 10 904 | 12 206 | 1.1 | 0.71 | 1.51 | 0.64 | 296 | >2025 |

(b) R300_Frec

| TACC | $E(B_{05})$ (t) | $E(B_{10})$ (t) | $B_{10}/B_{05}$ Expected | 5% | 95% | $P(B_{10} > B_{05})$ | $E(CR_{2010})$ | Year when $E(By) = B_{MSY}$ |
|---|---|---|---|---|---|---|---|---|
| 0 | 10 929 | 23 614 | 2.18 | 1.77 | 2.68 | 1 | - | 2010 |
| 500 | 10 929 | 17 747 | 1.63 | 1.3 | 2.01 | 0.96 | 561 | 2012 |
| 1 000 | 10 901 | 14 746 | 1.35 | 1.02 | 1.71 | 0.96 | 472 | 2016 |
| 1 250 | 10 913 | 13 288 | 1.21 | 0.84 | 1.57 | 0.83 | 426 | 2022 |
| 1 375 | 10 929 | 12 556 | 1.14 | 0.79 | 1.48 | 0.75 | 401 | >2025 |

(c) R600_Rcap

| TACC | $E(B_{05})$ (t) | $E(B_{10})$ (t) | $B_{10}/B_{05}$ Expected | 5% | 95% | $P(B_{10} > B_{05})$ | $E(CR_{2010})$ | Year when $E(By) = B_{MSY}$ |
|---|---|---|---|---|---|---|---|---|
| 500 | 11 693 | 18 429 | 1.57 | 1.17 | 2.01 | 0.99 | 600 | 2012 |
| 1 000 | 11 713 | 15 353 | 1.3 | 0.87 | 1.74 | 0.88 | 599 | 2016 |
| 1 250 | 11 683 | 13 781 | 1.17 | 0.76 | 1.58 | 0.73 | 596 | 2020 |
| 1 375 | 11 676 | 13 087 | 1.1 | 0.7 | 1.53 | 0.64 | 591 | >2025 |
| 1 500 | 11 695 | 12 337 | 1.04 | 0.67 | 1.46 | 0.53 | 583 | >2025 |

(d) R600_Frec

| TACC | $E(B_{05})$ (t) | $E(B_{10})$ (t) | $B_{10}/B_{05}$ Expected | 5% | 95% | $P(B_{10} > B_{05})$ | $E(CR_{2010})$ | Year when $E(By) = B_{MSY}$ |
|---|---|---|---|---|---|---|---|---|
| 0 | 11 730 | 25 592 | 2.2 | 1.77 | 2.7 | 1 | - | 2010 |
| 500 | 11 676 | 17 346 | 1.49 | 1.19 | 1.84 | 1 | 1 013 | 2014 |
| 1 000 | 11 729 | 14 596 | 1.24 | 0.93 | 1.57 | 0.9 | 856 | 2021 |
| 1 250 | 11 710 | 13 106 | 1.11 | 0.8 | 1.43 | 0.71 | 767 | >2025 |
| 1 375 | 11 702 | 12 419 | 1.05 | 0.75 | 1.39 | 0.59 | 726 | >2025 |

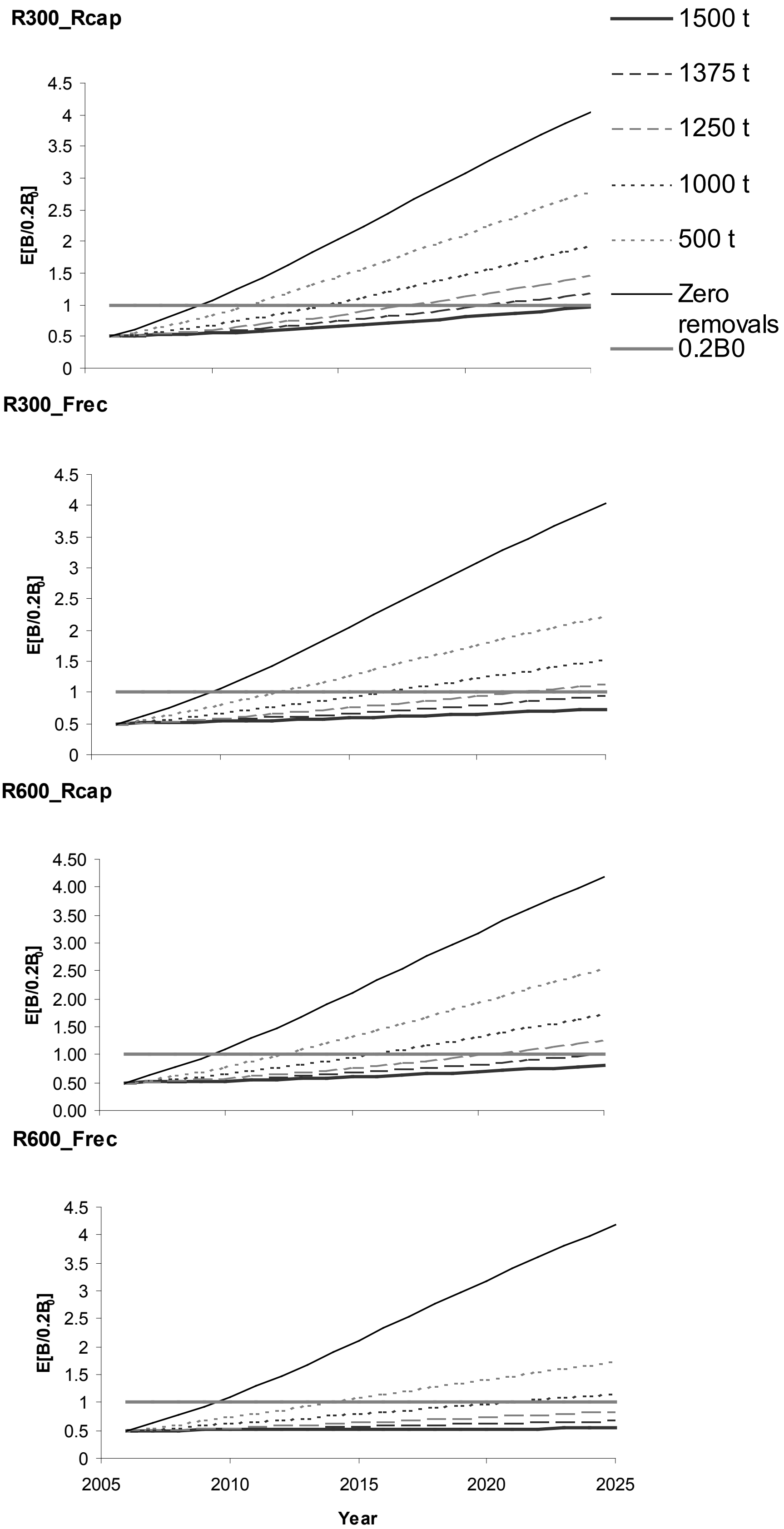



**Figure 19: Mean of expected biomass relative to 20% of virgin biomass ($B_0$) forecast to 2025 for the R300 and R600 models under two alternative options for recreational catch: Frec, constant annual exploitation rate at the MPD level estimated in 2004; and, Rcap, constant annual catch of 300 or 600 t respectively. For each model option a range of future TACC levels were investigated (500 to 1500 t), and compared to an option for zero removals from the population.**

**Other factors that may modify assessment results**
The WG considered that there were a number of other factors that should be considered in relation to the stock assessment results presented here for SNA 8. The current assessment produces very precise results, which are the product of the available data and various model assumptions. However, many of the model assumptions may be violated to some extent. Some of the more important considerations are:

- the tagging estimates may be biased;
- the MPD residuals are not consistent with the statistical assumptions of the model and give extra weight to the tagging estimates;
- natural mortality is not known exactly (as was assumed in the MCMCs);
- the catch history is uncertain with regard to Japanese longline catch and commercial catch overruns in addition to recreational catch.

A full exploration of these factors has not been performed. Additional sensitivity runs taking account of these factors would produce a greater range of uncertainty than is present in the current assessment.

## 6. STATUS OF THE STOCKS

**Stock Structure Assumptions**

New Zealand snapper are thought to comprise either seven or eight biological stocks based on: the location of spawning and nursery grounds; differences in growth rates, age structure and recruitment strength; and the results of tagging studies. These stocks comprise three in SNA 1 (East Northland, Hauraki Gulf and BoP), two in SNA 2 (one of which may be associated with the BoP stock), two in SNA 7 (Marlborough Sounds and Tasman/Golden Bay) and one in SNA 8. Tagging studies reveal that limited mixing occurs between the three SNA 1 biological stocks, with greatest exchange between BoP and Hauraki Gulf.

**SNA 1**

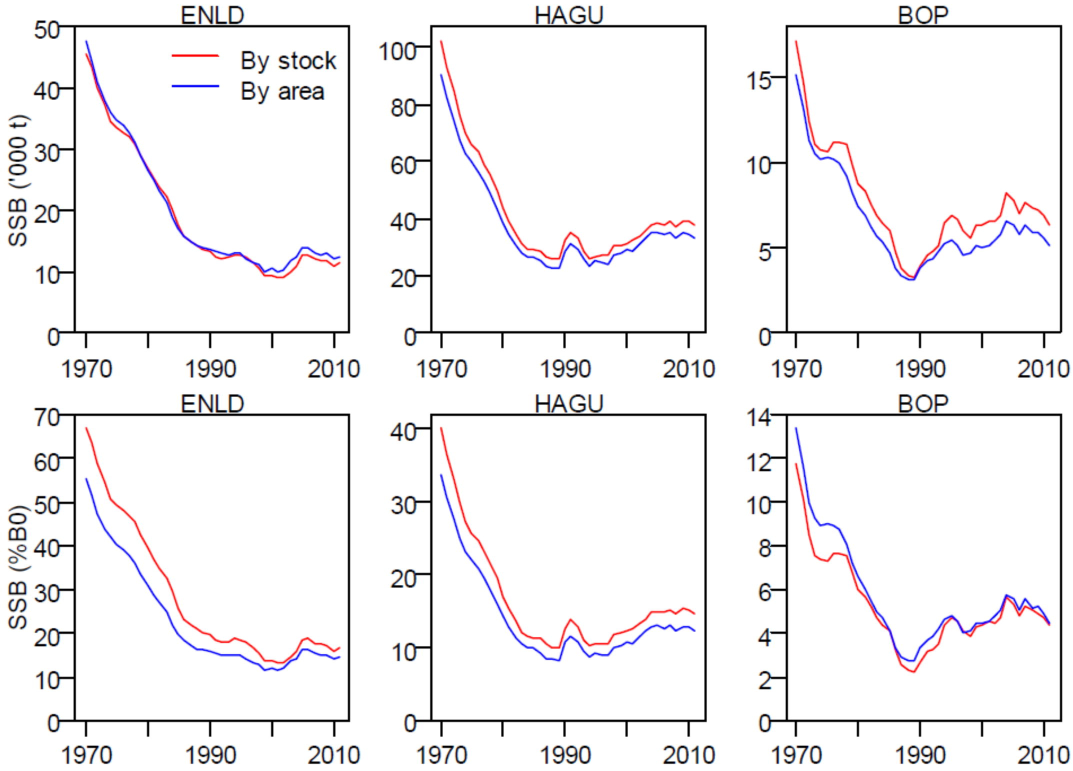
| **Stock Status** | |
|---|---|
| Year of Most Recent Assessment | 2012 |
| Assessment Runs Presented | Base case models ($M$ = 0.075, $h$ = 0.85) for East Northland and the Hauraki Gulf and Bay of Plenty to 2010-11 |
| Reference Points[3] | Interim target: $B_{MSY}$ (40% $B_0$)<br>Deterministic $B_{MSY}$: 26-27% $B_0$<br>Soft Limit: 20% $B_0$ (HSS default)<br>Hard Limit: 10% $B_0$ (HSS default) |
| Status in relation to Target | <u>East Northland</u><br>$B_{2011}$ was Very Unlikely (< 10%) to be at or above 40% $B_0$<br><br><u>Hauraki Gulf</u><br>$B_{2011}$ was Very Unlikely (< 10%) to be at or above 40% $B_0$<br><br><u>Bay of Plenty</u><br>$B_{2011}$ was Very Unlikely (< 10%) to be at or above 40% $B_0$ |
| Status in relation to Limits | <u>East Northland</u><br>$B_{2011}$ was About as Likely as Not (40-60%) to be below 20% $B_0$ (Soft Limit)<br>$B_{2011}$ was Unlikely (< 40%) to be below 10% $B_0$ (Hard Limit)<br><br><u>Hauraki Gulf</u><br>$B_{2011}$ was About as Likely as Not (40-60%) to be below 20% $B_0$ (Soft Limit)<br>$B_{2011}$ was Unlikely (< 40%) to be below 10% $B_0$ (Hard Limit) |

Bay of Plenty

$B_{2011}$ was Likely (> 60%) to be below 20% $B_0$ (Soft Limit)

$B_{2011}$ was About as Likely as Not (40-60%) to be below 10% $B_0$ (Hard Limit)

**Historical Stock Status Trajectory and Current Status**




**MPD base model SSB and status trajectories by stock and area.**

**Fishery and Stock Trends**

Recent Trend in Biomass or Proxy

East Northland

Stock biomass was estimated to have experienced a long steep decline from 1970 to about 2000, after which it increased to 2005 and has then declined slightly.

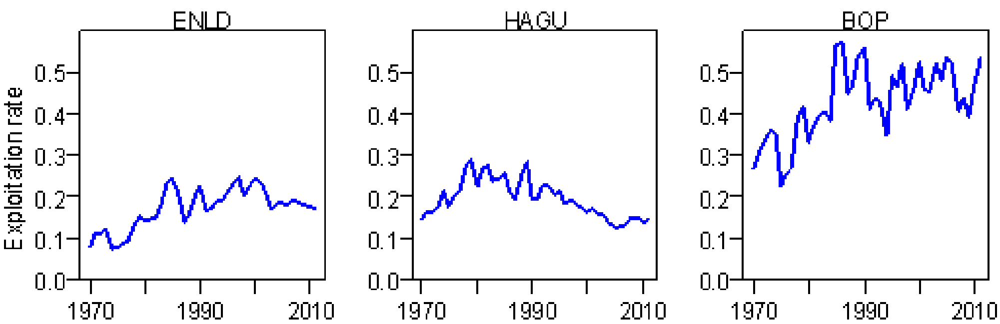
Hauraki Gulf

Stock biomass was estimated to have experienced a long steep decline from 1970 to about 1990, after which it gradually increased to about 2007 and then stabilised.

Bay of Plenty

Stock biomass was estimated to have experienced a long steep decline from 1970 to about 1990, after which it steadily increased to 2005 and has then declined slightly.

Recent Trend in Fishing Mortality or Proxy




East Northland

The exploitation rate in this area increased steadily from 1970 to 2000 and then

| | |
|---|---|
| | decreased marginally and stabilised in the early 2000s.<br><br>Hauraki Gulf<br><br>The exploitation rate in this area increased steadily from 1970 to 1980 and then decreased to about the 1970 level by the mid-2000s and has remained stable since then.<br><br>Bay of Plenty<br><br>The exploitation rate in this area increased sharply from 1970 to the mid-1980s and while it has fluctuated markedly it has remained high. |
| Other Abundance Indices | None |
| Trends in Other Relevant Indicators or Variables | None |

| **Projections and Prognosis** | |
|---|---|
| Stock Projections or Prognosis | Model five year projections from the MPD predict decreasing SSBs in all three stocks. |
| Probability of Current Catch or TACC causing decline below Limits (5 years) | The 5-year projections suggest that current catches will not rebuild populations in EN and HG, and are Likely to reduce abundance in the BoP. |

| **Assessment Methodology and Evaluation** | | |
|---|---|---|
| Assessment Type | Level 1: Quantitative stock assessment. | |
| Assessment Method | Spatially-disaggregated, 3-stock, age-structured, single-sex model undertaken in CASAL | |
| Assessment Dates | Latest assessment: 2012 | Next assessment: 2013 |
| Overall assessment quality rank | 2 - Medium Quality. MCMC did not converge | |
| Main data inputs (rank) | - Proportions-at-age from the commercial fisheries, and historic trawl surveys. | 1 – High Quality |
| | - Proportions-at-length from the recreational fishery | 1 – High Quality |
| | - Estimates of biological parameters (e.g., growth, age-at-maturity and length/weight). | 1 – High Quality |
| | - Standardised longline CPUE indices | 1 – High Quality |
| | - Standardised single trawl for the BoP | 1 – High Quality |
| | - Estimates of recreational Harvest | 1 – High Quality |
| | - Commercial catch | 1 – High Quality |
| | - Tag-based biomass estimates (BoP - 1983) | 2 – Medium or Mixed Quality: data no longer available |
| | - Data from tagging experiments in 1985 (HG, EN) and 1994 (All areas) | 1 – High Quality |
| Data not used (rank) | N/A | |
| Changes to Model Structure and Assumptions | - BoP stock area considered as separate from the Hauraki Gulf<br>- Model accounts for movement between three SNA 1 stock areas: | |

| | |
|---|---|
| | East Northland; Hauraki Gulf; Bay of Plenty<br>- 1985 and 1994 SNA 1 tagging data fitted in the model<br>- Model recruitment at age 1; 20 age classes explicitly modelled<br>- Revised estimates of tag loss for the 1985 programme<br>- Tag observational data adjusted for trap avoidance<br>- Stock recruit relationship explicit in model (Beverton & Holt) with a steepness of 0.85 (base model)<br>- Method for relative weighting of abundance and composition data |
| Major Sources of Uncertainty | Degree of exchange between BoP and HG<br>The stocks size in 1970 relative to $B_0$ is poorly estimated. |

| **Qualifying Comments** |
|---|
| Alternative hypotheses such as stock structure and the full range of parameter estimates have not been fully explored. This is assessment is regarded to be a work in progress and will be improved as the work progresses. A more thoroughly explored assessment is expected in 2013. |

| **Fishery Interactions** |
|---|
| Main QMS bycatch species are trevally, red gurnard, John dory and tarakihi. |

**SNA 2**

| **Stock Status** | |
|---|---|
| Year of Most Recent Assessment | 2010 |
| Assessment Runs Presented | Two model runs, both with a steepness fixed at 1, are reported with alternative values of natural mortality and a fixed fishery selectivity function. |
| Reference Points | Target: Not established but $B_{MSY}$ assumed<br>Soft Limit: 20% $B_0$ (HSS default)<br>Hard Limit: 10% $B_0$ (HSS default) |
| Status in relation to Target | Unknown |
| Status in relation to Limits | Soft: Unlikely (< 40%)<br>Hard: Unlikely (< 40%) |
| Historical Stock Status Trajectory and Current Status<br><br>Due to the unreliability of the assessment no figure is displayed. | |

| **Fishery and Stock Trends** | |
|---|---|
| Recent Trend in Biomass or Proxy | For the range of model runs investigated, estimates of *MSY* (443-496 t) are higher than the recent catch levels (376 t). By inference, the stock biomass would be expected to have increased slowly over the last decade if recruitment has been maintained at or above long-term average levels. |
| Recent Trend in Fishing Mortality or Proxy | Unknown |
| Other Abundance Indices | - |
| Trends in Other Relevant Indicators or Variables | The broad range of ages present in the catch suggests that the stock is unlikely to be at very low levels. |

| **Projections and Prognosis** | |
|---|---|
| Stock Projections or Prognosis | Given that the catch is below the range of *MSY* estimates, it is Likely that biomass would increase at current catch levels provided that recruitment is maintained at or above average levels. |
| Probability of Current Catch or | Soft Limit: Unlikely (< 40%) |

| | |
|---|---|
| TACC causing decline below Limits | Hard Limit: Unlikely (< 40%) |

| Assessment Methodology | | |
|---|---|---|
| Assessment Type | Level 1- Quantitative Stock Assessment. | |
| Assessment Method | Bayesian statistical catch at age model implemented in Stock Synthesis | |
| Main data inputs | - Proportions at age data from the commercial fishery<br>- Estimates of biological parameters (e.g., *M*, growth, age-at-maturity and length/weight)<br>- Commercial catch<br>- Standardised single trawl CPUE index of abundance<br>- Estimates of recreational harvest<br>- Estimates of commercial over catch | |
| Period of Assessment | Latest assessment: 2010 | Next assessment: to be determined |
| Changes to Model Structure and Assumptions | The previous assessment was done in 2002. The 2010 model includes three additional years of catch-at-age data from the commercial fishery and a series of CPUE indices (1989/90-2008/09). The most crucial difference between the two assessments is the assumptions relating to the selectivity of the commercial fishery. The previous assessment assumed logistic selectivity (full selectivity for older age classes) while the current assessment assumed a fixed dome shaped selectivity. | |
| Major Sources of Uncertainty | • There is a high degree of uncertainty regarding the assumed selectivity function for the commercial fishery. Furthermore, selectivity of the commercial fishery is likely to have changed over the history of the fishery.<br>• The CPUE indices are unlikely to represent a reliable index or abundance.<br>• The catch-at-age data do not track year classes well and may not be representative of the catch.<br>• The values of M have been derived from other snapper stock and may not be appropriate for SNA 2.<br>• There is uncertainty regarding the catch history prior to the introduction of the QMS.<br>• There is assumed to be no stock-recruitment relationship. | |

| Qualifying Comments |
|---|
| There is a high level of uncertainty associated with the assessment, with the result that stock status and projections cannot be reliably determined. However, estimates of *MSY* were robust to the range of assumptions investigated but are dependent on the assumptions regarding historical catch. For the range of model scenarios considered, estimates of *MSY* were higher than the recent and current levels of catch.<br>Despite the limitations of the catch-at-age data, the broad range of ages present in the catch suggests that the stock is unlikely to be at very low levels. |

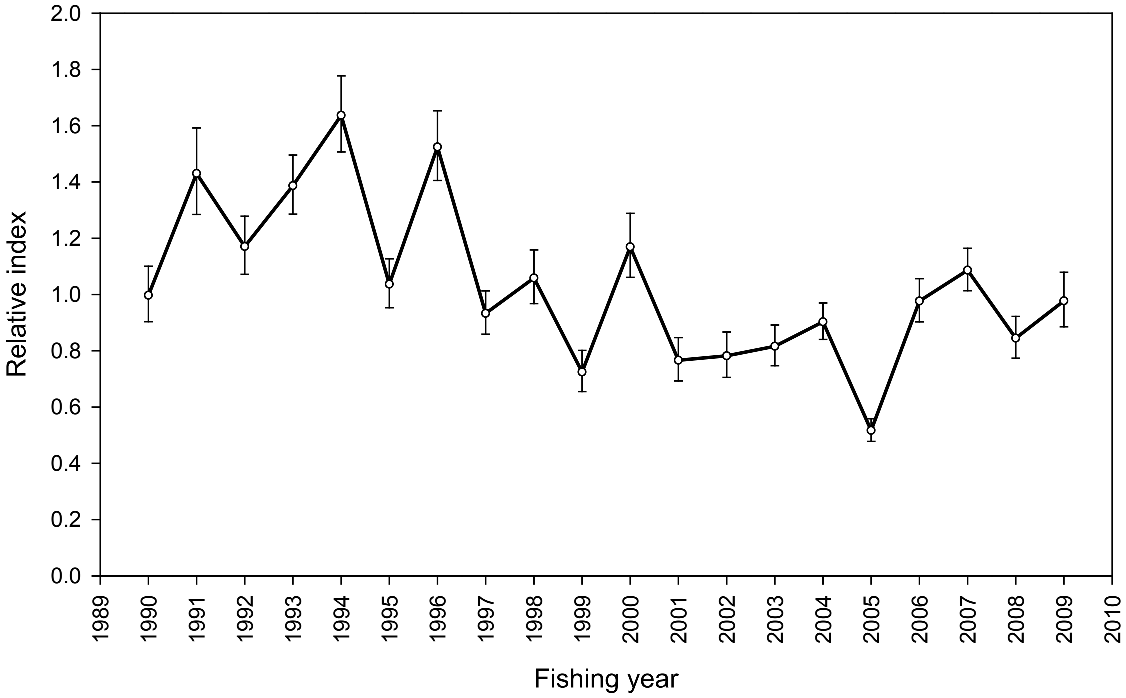
| Fishery Interactions |
|---|
| Snapper is a bycatch of the main inshore fisheries within SNA 2, principally the red gurnard and tarakihi bottom trawl fisheries. The operation of these fisheries is constrained by the SNA 2 TACC. |

**SNA 7**

| Stock Status | |
|---|---|
| Year of Most Recent Assessment | 2011 |

| | |
|---|---|
| Assessment Runs Presented | A CPUE index that combined the snapper catch and effort from trawl fisheries directed at SNA, FLA and BAR in Tasman and Golden Bays |
| Reference Points | Target(s): Not established but $B_{MSY}$ assumed<br>Soft Limit: 20% $B_0$ (HSS default)<br>Hard Limit: 10% $B_0$ (HSS default) |
| Status in relation to Target | Unknown |
| Status in relation to Limits | Soft Limit: Unknown<br>Hard Limit: Unknown |

**Historical Stock Status Trajectory and Current Status**




**A Standardised snapper CPUE index derived from catch effort data provided by trawlers operating in Tasman Bay/Golden Bay (Statistical Reporting Areas 037 & 038). This index was based on data provided by a core set of trawlers for days where either SNA, FLA, and/or BAR were targeted (Hartill & Sutton 2011).**

**Fishery and Stock Trends**

| | |
|---|---|
| Recent Trend in Biomass or Proxy | CPUE generally declined to 2001, after which it has fluctuated without trend |
| Recent Trend in Fishing Mortality or Proxy | Unknown |
| Other Abundance Indices | Unknown |
| Trends in Other Relevant Indicators or Variables | Catch-at-age data collected in 2003-04 and 2006-07 had a lack of fish over 8 years old, which were relatively common in earlier samples collected between 1997 and 2001.<br>The current level of commercial catch is 25% of the average catch from 1945-1980. |

**Projections and Prognosis**

| | |
|---|---|
| Stock Projections or Prognosis | Current catch or TACC is About as Likely as Not (40-60%) to cause the stock to decline |
| Probability of Current Catch or TACC causing decline below Limits | Soft Limit: Unknown<br>Hard Limit: Unknown |

**Assessment Methodology**

| | | |
|---|---|---|
| Assessment Type | Level 2 - Qualitative Evaluation | |
| Assessment Method | Characterisation and CPUE analysis | |
| Main data inputs | Trawl catch and effort from SNA, FLA and BAR target sets. | |
| Period of Assessment | Latest assessment: 2011 | Next assessment:2012 |
| Changes to Model Structure and Assumptions | | |
| Major Sources of Uncertainty | | |

| **Qualifying Comments** |
|---|
| Lack of older age classes implies that the available stock biomass should be strongly affected by recruitment variability.<br>The voluntary closure of shallow regions in TB/GB on 1 October 1994 probably influenced the spatial distribution of fishing effort and potentially, catch rates and any index should probably start from this date.<br>There is no evidence of a rebuild as suggested by the 2000-01 stock assessment. |

| **Fishery Interactions** |
|---|
| The primary species landed in association with snapper in SNA 7 are flatfish, barracouta, gurnard and trevally. There is spatial conflict between commercial and recreational fisheries in Tasman and Golden Bays. There are seasonal area closures for the commercial fishery. |

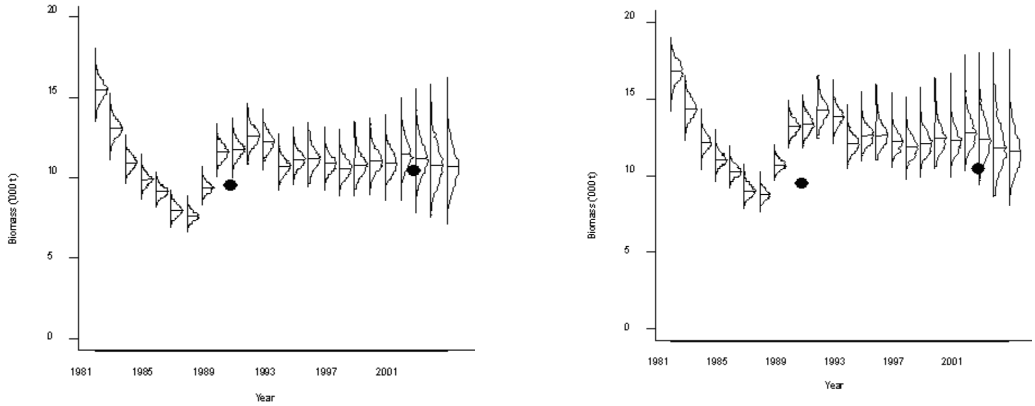
**SNA 8**

**Stock Structure Assumptions**

Tagging, genetic and morphological studies have revealed that snapper off the west coast of the North Island (i.e., SNA 8) comprise a separate biological unit.

| **Stock Status** | |
|---|---|
| Year of Most Recent Assessment | 2005 |
| Assessment Runs Presented | Given the uncertainty in estimates of recreational harvest, two alternate model runs 1) recreational harvest of 300 t and<br>2) recreational harvest of 600 t. |
| Reference Points | Target: Not established but $B_{MSY}$ (20% $B_0$) assumed.<br>Soft Limit: 20% $B_0$ (HSS default)<br>Hard Limit: 10% $B_0$ (HSS default) |
| Status in relation to Target | <u>R300</u><br>$B_{2004}$ estimated to be 9.8% $B_0$, Very Unlikely (< 10%) to be at or above the target.<br><br><u>R600</u><br>$B_{2004}$ estimated to be 10% $B_0$, Very Unlikely (< 10%) to be at or above the target. |
| Status in relation to Limits | Soft Limit: Very Likely (> 90%) to be below (in 2005)<br>Hard Limit: About as Likely as Not (40-60%) |

**Historical Stock Status Trajectory and Current Status**




**Posterior distributions of the biomass trajectories for the SNA 8 model estimates assuming historical recreational catch of 300 t (left panel) and 600 t (right panel) with the tagging programme estimates of biomass (solid circles).**

| **Fishery and Stock Trends** | |
|---|---|
| Recent Trend in Biomass or Proxy | Unknown |
| Recent Trend in Fishing Mortality or Proxy | Unknown |
| Other Abundance Indices | Unknown |
| Trends in Other Relevant Indicators or Variables | Recent catch-at-age sampling shows that the age structure in the fishery has changed little over the last 20 years averaging around 6 years (this is the lowest average of all the snapper stocks). The fishery is held up in most years by only 4-5 dominant age classes with a negligible accumulation of biomass beyond 20 years. Given the current age structure the stock would be very vulnerable to recruitment failure extending more than 2-3 years in duration. |

| **Projections and Prognosis** | |
|---|---|
| Stock Projections or Prognosis | The 2005 stock assessment indicated that current biomass (start of year 2004-05) was between 8% and 12% $B_0$ and the biomass was predicted to slowly increase at the TACC level of 1500 t. However, from 1 October 2005 the TACC was reduced to 1300 t to ensure a faster rebuild of the stock. At this TACC level the predicted rebuild to $B_{MSY}$<br>(20% $B_0$) occurred after 2018 in all cases assuming either constant recreational effort, or capped recreational catch at the alternative levels of 300 t or 600 t per year. Rebuilding tended to be slower for runs that allowed the recreational catch to rise with increasing biomass. |
| Probability of Current Catch or TACC causing decline below Limits | Soft Limit: Unlikely (< 40%)<br>Hard Limit: Unlikely (< 40%) |

| **Assessment Methodology** | |
|---|---|
| Assessment Type | Level 1 - Quantitative Stock Assessment |
| Assessment Method | Age-structured Bayesian stock assessment implemented with CASAL software. |
| Main data inputs | - Proportions at age data from the commercial fisheries, recreational fishery and historic trawl surveys.<br>- Estimates of biological parameters (e.g., growth, age-at-maturity and length/weight).<br>- Standardised single trawl CPUE index of abundance.<br>- Sea Surface temperatures<br>- Estimates of recreational Harvest |

| | | |
|---|---|---|
| | - Commercial catch<br>- Two tag-based biomass estimates. | |
| Period of Assessment | Latest assessment: 2005 | Next assessment: Unknown |
| Changes to Model Structure and Assumptions | A revised assessment of SNA 8 was completed in 2005 including updated observations on:<br>• method-specific catch weights to 2003-04;<br>• catch-at-age for commercial pair and single trawl in 2003-04; and,<br>• single trawl CPUE time series from 1996-2004 incorporating tow duration as the unit of effort from core vessels in the fleet.<br>New information added to the 2005 assessment included:<br>• single trawl catch-at-age 1974 to 1976;<br>• pair trawl catch-at-age with recalculated observations for 1974 to 1976; 1978 to 1980;<br>• mean size-at-age 1975, 1976 and 1979;<br>• pair trawl catch-at-length frequency in 1986; and,<br>• boat ramp samples of recreational length frequency in 1991, 1994, 1996 and 2000.<br>Using this new information assisted the estimation of selectivities-at-length for the single trawl, pair trawl and recreational fishing methods, and natural mortality. A revised time series of observed and assumed mean size-at-age was input to the model for the period 1931-2004. | |
| Major Sources of Uncertainty | The current assessment produces very precise results, which are the product of the available data and various model assumptions. However, many of the model assumptions may be violated to some extent. Some of the more important considerations are:<br>• the tagging estimates may be biased;<br>• the MPD residuals are not consistent with the statistical assumptions of the model because extra weight was given to the tagging estimates;<br>• natural mortality is not known exactly (as was assumed in the MCMCs);<br>• the catch history is uncertain with regard to Japanese longline catch and commercial catch overruns in addition to recreational catch.<br><br>A full exploration of these factors has not been performed. Additional sensitivity runs taking account of these factors would produce a greater range of uncertainty than is present in the current assessment. | |

| **Qualifying Comments** |
|---|
| An aerial overflight survey in 2007 estimated recreational harvest to be 260 t, thereby suggesting the 600 t run was less plausible than the 300 t estimate.<br><br>All SNA 8 stock assessments have assumed steepness is 1.0 (no stock recruitment relationship), which given the stocks low biomass relative to $B_0$ is a questionable assumption. Alternative values of steepness have not been investigated for SNA 8. |

| **Fishery Interactions** |
|---|
| The primary species caught in association with snapper in bottom trawl fisheries are trevally, red gurnard, John dory and tarakihi. |

Yield estimates, TACCs and TACs for the 2010-11 fishing year are summarised in Table 25.

**Table 25: Summary of yield estimates (t), TACCs (t) and reported landings (t) for the most recent fishing year.**

| Fish stock | QMA | *MCY* | $CAY_{99\text{-}00}$ | *MSY* | 2010-11 Actual TACC | 2010-11 Commercial landings |
|---|---|---|---|---|---|---|
| SNA 1 | 1 | 9 911 | 8 712 | 10 050 | 4 500 | 4 516 |
| SNA 2 | 2 | - | - | 440-500 | 315 | 320 |
| SNA 3 | 3, 4, 5 & 6 | - | - | - | 32 | < 1 |
| SNA 7 | 7 | - | - | 850 | 200 | 208 |
| SNA 8 | 8, 9 | - | - | - | 1 300 | 1 313 |
| SNA 10 | 10 | - | - | - | 10 | 0 |
| Total | | | | | 6 357 | 6 358 |

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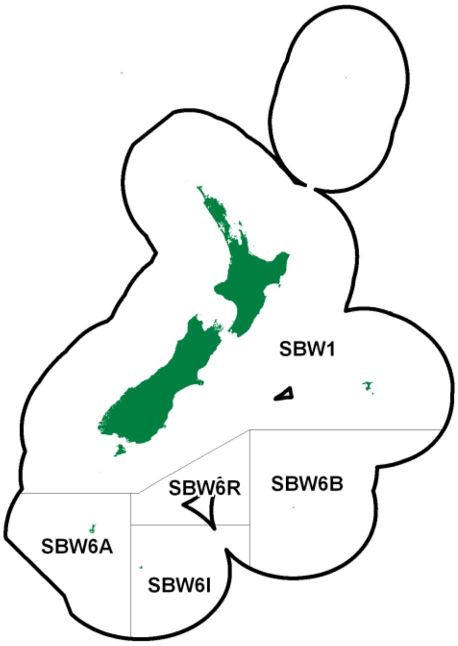
# SOUTHERN BLUE WHITING (SBW)

(*Micromesistius australis*)




## 1. FISHERY SUMMARY

### 1.1 Commercial fisheries

Southern blue whiting are almost entirely restricted in distribution to sub-Antarctic waters. They are dispersed throughout the Campbell Plateau and Bounty Platform for much of the year, but during August and September they aggregate to spawn near the Campbell Islands, on Pukaki Rise, on Bounty Platform, and near Auckland Islands over depths of 250-600 m. During most years, fish in the spawning fishery range between 35-50 cm fork length (FL), although occasionally a smaller size class of males (29-32 cm FL) is also present.

Reported landings for the period 1971 to 1977 are shown in Table 1. Estimated landings by area from the trawl catch and effort logbooks and QMRs are given from 1978 to the present in Table 2, while Figure 1 shows the historical landings and TACC values for the main SBW stocks. Landings were chiefly taken by the Soviet foreign licensed fleet during the 1970s and early 1980s, and the fishery fluctuated considerably peaking at almost 50 000 t in 1973 and again at almost 30 000 t in 1979. The Japanese surimi vessels first entered the fishery in 1986, and catches gradually increased to a peak of 76 000 t in 1991-92. A catch limit of 32 000 t, with area sub-limits, was introduced for the first time in the 1992-93 fishing year (Table 2). The total catch limit increased to 58 000 t in 1996-97 for three years. The southern stocks of southern blue whiting were introduced to the Quota Management System on 1 Nov 1999, with the TACCs given in Table 2. The fishing year was also changed to 1 April to 31 March to reflect the timing of the main fishing season. TACC changes since 2000-01 are shown in Table 2. A nominal TACC of 8 t (SBW 1) was set for the rest of the EEZ, and typically less than 10 t per year has been reported from SBW 1 since 2000-01.

Landings have been between 25 000 t and 40 000 t since 2000, with the majority of the catch currently taken by foreign charter vessels (predominantly Ukrainian) producing headed and gutted or dressed product. On the Campbell Island Rise and the Bounty Platform the TACC has been almost fully caught in each year since 2005-06. However on the other grounds, the catch limits have generally been under-caught in most years since their introduction. This reflects the relatively low economic value of the fish and difficulties in both the timing and locating of aggregations experienced by operators. On the Pukaki Rise and Auckland Islands Shelf, operators have generally found it difficult to justify expending time to locate fishable aggregations, given the small allocation available in these areas, the relatively low value of the product, and the more certain option available to fish southern blue whiting at Campbell Island where aggregations are concurrent.

The TACC for the Bounty Platform stock was increased to 9800 t for the 2008 season and further increased to 14 700 t for the 2009 and 2010 seasons but decreased to 6860 t for the 2011 season. From 1 April 2006, the TACC for the Campbell Island Rise stock was reduced from 25 000 t to 20 000 t, where it remained until 2009. For the 2010 season the catch limit for the Campbell stock was raised to 23 000 t, and in 2011 it was further raised to 29 400 t. Catch limits for Pukaki Rise and Auckland Islands have remained unchanged since 1997.

**Table 1: Reported annual landings (t) of southern blue whiting from 1971 to 1977.**

| Fishing year | Total |
|---|---|
| 1971 | 10 400 |
| 1972 | 25 800 |
| 1973 | 48 500 |
| 1974 | 42 200 |
| 1975 | 2 378 |
| 1976 | 17 089 |
| 1977 | 26 435 |

**Table 2: Estimated catches (t) and actual TACCs of southern blue whiting by area from vessel logbooks and QMRs. - no catch limit in place. *, before 1997-98 there was no separate catch limit for Auckland Is.**

| | Bounty Platform | | Campbell Island Rise | | Pukaki Rise | | Auckland Is. | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| Fishing year | Catch | Limit | Catch | Limit | Catch | Limit | Catch | Limit* | Catch | Limit |
| 1978*ƒ* | 0 | - | 6 403 | - | 79 | - | 15 | - | 6 497 | - |
| 1978-79+ | 1 211 | - | 25 305 | - | 601 | - | 1 019 | - | 28 136 | - |
| 1979-80+ | 16 | - | 12 828 | - | 5 602 | - | 187 | - | 18 633 | - |
| 1980-81+ | 8 | - | 5 989 | - | 2 380 | - | 89 | - | 8 466 | - |
| 1981-82+ | 8 325 | - | 7 915 | - | 1 250 | - | 105 | - | 17 595 | - |
| 1982-83+ | 3 864 | - | 12 803 | - | 7 388 | - | 184 | - | 24 239 | - |
| 1983-84+ | 348 | - | 10 777 | - | 2 150 | - | 99 | - | 13 374 | - |
| 1984-85+ | 0 | - | 7 490 | - | 1 724 | - | 121 | - | 9 335 | - |
| 1985-86+ | 0 | - | 15 252 | - | 552 | - | 15 | - | 15 819 | - |
| 1986-87+ | 0 | - | 12 804 | - | 845 | - | 61 | - | 13 710 | - |
| 1987-88+ | 18 | - | 17 422 | - | 157 | - | 4 | - | 17 601 | - |
| 1988-89+ | 8 | - | 26 611 | - | 1 219 | - | 1 | - | 27 839 | - |
| 1989-90+ | 4 430 | - | 16 542 | - | 1 393 | - | 2 | - | 22 367 | - |
| 1990-91+ | 10 897 | - | 21 314 | - | 4 652 | - | 7 | - | 36 870 | - |
| 1991-92+ | 58 928 | - | 14 208 | - | 3 046 | - | 73 | - | 76 255 | - |
| 1992-93+ | 11 908 | 15 000 | 9 316 | 11 000 | 5 341 | 6 000 | 1 143 | - | 27 708 | 32 000 |
| 1993-94+ | 3 877 | 15 000 | 11 668 | 11 000 | 2 306 | 6 000 | 709 | - | 18 560 | 32 000 |
| 1994-95+ | 6 386 | 15 000 | 9 492 | 11 000 | 1 158 | 6 000 | 441 | - | 17 477 | 32 000 |
| 1995-96+ | 6 508 | 8 000 | 14 959 | 21 000 | 772 | 3 000 | 40 | - | 22 279 | 32 000 |
| 1996-97+ | 1 761 | 20 200 | 15 685 | 30 100 | 1 806 | 7 700 | 895 | - | 20 147 | 58 000 |
| 1997-98+ | 5 647 | 15 400 | 24 273 | 35 460 | 1 245 | 5 500 | 0 | 1 640 | 31 165 | 58 000 |
| 1998-00† | 8 741 | 15 400 | 30 386 | 35 460 | 1 049 | 5 500 | 750 | 1 640 | 40 926 | 58 000 |
| 2000-01# | 3 997 | 8 000 | 18 049 | 20 000 | 2 864 | 5 500 | 19 | 1 640 | 24 804 | ‡35 140 |
| 2001-02# | 2 262 | 8 000 | 29 999 | 30 000 | 230 | 5 500 | 10 | 1 640 | 31 114 | ‡45 140 |
| 2002-03# | 7 564 | 8 000 | 33 445 | 30 000 | 508 | 5 500 | 262 | 1 640 | 41 795 | ‡45 140 |
| 2003-04# | 3 812 | 3 500 | 23 718 | 25 000 | 163 | 5 500 | 116 | 1 640 | 27 812 | ‡35 640 |
| 2004-05# | 1 477 | 3 500 | 19 799 | 25 000 | 240 | 5 500 | 95 | 1 640 | 21 620 | ‡35 640 |
| 2005-06# | 3 962 | 3 500 | 26 190 | 25 000 | 58 | 5 500 | 66 | 1 640 | 30 287 | ‡35 640 |
| 2006-07# | 4 395 | 3 500 | 19 763 | 20 000 | 1 115 | 5 500 | 84 | 1 640 | 25 363 | ‡30 640 |
| 2007-08# | 3 799 | 3 500 | 20 996 | 20 000 | 513 | 5 500 | 278 | 1 640 | 25 587 | ‡30 640 |
| 2008-09# | 9 863 | 9 800 | 20 483 | 20 000 | 1 377 | 5 500 | 143 | 1 640 | 31 867 | ‡36 948 |
| 2009-10# | 15 468* | 14 700 | 19 040 | 20 000 | 4 853 | 5 500 | 174 | 1 640 | 39 540 | ‡42 148 |
| 2010-11# | 13 912 | 14 700 | 20 224 | 23 000 | 4 433 | 5 500 | 131 | 1 640 | 38 708 | ‡44 848 |
| 2011-12# | 6 590 | 6 860 | 30 840 | 29 400 | 677 | 5 500 | 65 | 1 640 | 38 174 | ‡43 400 |

*ƒ* 1 April-30 September + 1 October-30 September
† 1 October 1998-31 March 2000 # 1 April -31 March
‡ SBW 1 (all EEZ areas outside QMA6) had a TACC of 8 t, and reported catches of 9 t in 2000-01, 1 t in 2001-02, 16 t in 2002-03, 3 t in 2003-04, 9 t in 2004-05, 2 t in 2005-06, 7 t in 2006-07, 1 t in 2007-08, 21 t in 2008-09, 5 t in 2009-10, 8 t in 2010-11, and 2 t in 2011-12.
***** Reported catch total for 2009-10 does not include fish lost when *FV Oyang 70* sank on 18 August 2010.

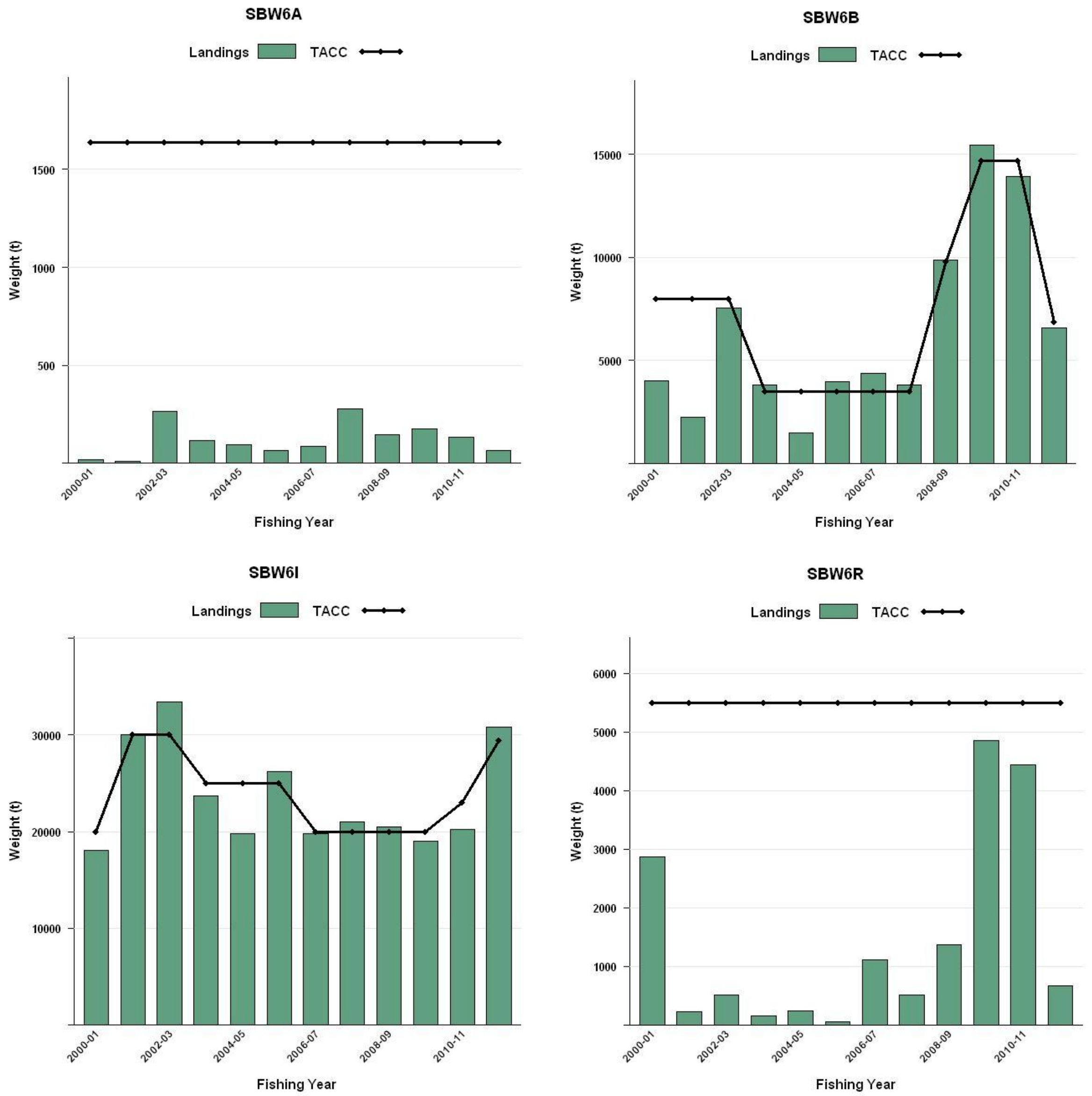



**Figure 1: Historical landings and TACC for the four main SBW stocks. From top left to bottom right: SBW6A (Auckland Islands), SBW6B (Bounty Platform), SBW6I (Campbell Island Rise), and SBW6R (Pukaki Rise). Note that these figures do not show data prior to entry into the QMS.**

### 1.2 Recreational fisheries
There is no recreational fishery for southern blue whiting.

### 1.3 Customary non-commercial fisheries
Customary non-commercial take is not known to occur for southern blue whiting.

### 1.4 Illegal catches
The level of illegal and unreported catch is thought to be low. However, a number of operators have been convicted for area misreporting; where the catch returns have been revised the corrected totals by area are shown in Table 2. In addition, the operators of another vessel were convicted of discarding without reporting fish in 2004: crew members estimated that between 40 and 310 t of SBW were illegally discarded during a two and a half week period fishing on the Campbell Island Rise.

### 1.5 Other sources of mortality
Scientific observers have occasionally reported discards of undersize fish and accidental loss from torn or burst codends. The amount of possible discarding was estimated by Clark *et al.* (2000) and Anderson (2004, 2009). Anderson (2004) quantified total annual discard estimates (including

estimates of fish lost from the net at the surface) as ranging between 0.4% and 2.0% of the estimated SBW catch over all the SBW fisheries. Anderson (2009) reviewed fish and invertebrate bycatch and discards in the SBW fishery based on observer data from 2002 to 2007. He estimated that 0.23% of the catch was discarded from observed vessels. The low levels of discarding occur primarily because most catch came from vessels that targeted spawning aggregations.

In August 2010, the F.V. Oyang 70 sank while fishing for SBW on the Bounty Platform. It was fishing an area between 48°00' S and 48°20' S, and 179°20' E and 180°00' E between 15 and 17 August 2010, before sinking on 18 August 2010. The Ministry of Fisheries estimated that it had taken a catch of between 120 t and 190 t that was lost with the vessel.

## 2. BIOLOGY

Southern blue whiting is a schooling species that is confined to sub-Antarctic waters. Early growth has been well documented with fish reaching a length of about 20 cm FL after one year and 30 cm FL after two years. Growth slows down after five years and virtually ceases after ten years. Ages have been validated up to at least 15 years by following strong year classes, but ring counts from otoliths suggest a maximum age of 25 years.

The age and length of maturity, and recruitment to the fishery, varies between areas and between years. In some years a small proportion of males mature at age 2, but the majority do not mature until age 3 or 4, usually at a length of 33-40 cm FL. The majority of females also mature at age 3 or 4 at a length of 35-42 cm FL. Ageing studies have shown that this species has very high recruitment variability.

Southern blue whiting are highly synchronised batch spawners. Four spawning areas have been identified: on Bounty Platform, Pukaki Rise, Auckland Islands Shelf, and Campbell Island Rise. The Campbell Island Rise has two separate spawning grounds, to the north and south respectively. Fish appear to recruit first to the southern ground but thereafter spawn on the northern ground. Spawning on Bounty Platform begins in mid-August and finishes by mid-September. Spawning begins 3-4 weeks later in the other areas, finishing in late September/early October. Spawning appears to occur at night, in mid-water, over depths of 400-500 m on Campbell Island Rise but shallower elsewhere.

Natural mortality (*M*) was estimated using the equation $\log_e(100)$/maximum age, where maximum age is the age to which 1% of the population survives in an unexploited stock. Using a maximum age of 22 years, M was estimated to equal 0.21. The value of 0.2 is assumed to reflect the imprecision of this value. Recent Campbell Island stock assessments have estimated *M* within the model, using an informed prior with a mean of 0.2 (see Table 3).

**Table 3: Estimates of biological parameters for the Campbell Island Rise southern blue whiting stock.**

| **Fishstock** | | | | **Estimate** | **Source** |
|---|---|---|---|---|---|
| 1. Natural mortality (*M*) | | | | | |
| | | | Males | Females | |
| Campbell Island Rise | | | 0.2 | 0.2 | Hanchet (1992) |
| 2. Weight = a (length)$^b$ (Weight in g, length in cm fork length) | | | | | |
| | | Males | | Female | |
| | a | b | a | b | |
| Campbell Island Rise | 0.00515 | 3.092 | 0.00407 | 3.152 | Hanchet (1991) |

Note: Estimates of natural mortality and the length-weight coefficients are assumed to be the same for the other stocks. Observed length-at-age data are used for all stocks.

## 3. STOCKS AND AREAS

Hanchet (1999) reviewed the stock structure of southern blue whiting. He examined historical data on southern blue whiting distribution and abundance, reproduction, growth, and morphometrics. There appear to be four main spawning grounds of southern blue whiting; on the Bounty Platform, Pukaki

Rise, Auckland Islands Shelf, and Campbell Island Rise. There are also consistent differences in the size and age distributions of fish, in the recruitment strength, and in the timing of spawning between these four areas. Multiple discriminant analysis of data collected in October 1989 and 1990 showed that fish from Bounty Platform, Pukaki Rise and Campbell Island Rise could be distinguished on the basis of their morphometric measurements. The Plenary concluded that this constitutes strong evidence that fish in these areas return to spawn on the grounds to which they first recruit. No genetic studies have been carried out, but given their close proximity, it is unlikely that there would be detectable genetic differences in the fish between these four areas.

For the purposes of stock assessment it is assumed that there are four stocks of southern blue whiting with fidelity within stocks: the Bounty Platform stock, the Pukaki Rise stock, the Auckland Islands stock, and the Campbell Island stock.

## 4. ENVIRONMENTAL & ECOSYSTEM CONSIDERATIONS

This section was updated with new tables for the May 2012 Fishery Assessment Plenary based on reviews of similar chapters by the Aquatic Environment Working Group. This summary is from the perspective of the southern blue whiting fishery; a more detailed summary from an issue-by issue perspective is, or will shortly be, available in the Aquatic Environment & Biodiversity Annual Review (http://fs.fish.govt.nz/Page.aspx?pk=113&dk=22982).

### 4.1 Role in the ecosystem
Not discussed by the AEWG.

### 4.2 Incidental catch (fish and invertebrates)
Not discussed by the AEWG.

### 4.3 Incidental Catch (seabirds, mammals, and protected fish)
For protected species, capture estimates presented here include all animals recovered to the deck (alive, injured or dead) of fishing vessels but do not include any cryptic mortality (e.g., seabirds struck by a warp or caught on a hook but not brought onboard the vessel, Middleton & Abraham 2007, Brothers *et al*. 2010).

#### 4.3.1 Marine mammal interactions
Southern blue whiting trawlers occasionally catch marine mammals, including NZ sea lions and NZ fur seals (which were classified as “Nationally Critical” and “Not Threatened”, respectively, under the NZ Threat Classification System in 2010, Baker *et al*. 2010).

In the 2009-10 fishing year there were 11 observed captures of NZ sea lion in southern blue whiting trawl fisheries (Table 1). There were 25 (95% c.i.: 16 - 38) estimated captures, with the estimates made using a statistical model. The model includes less than 50% of the tows for 2009/10 so the estimate of captures should be treated with caution. Sea lion captures were all close to the Campbell Islands in SBW 6I (Thompson & Abraham 2012) and are almost all males.

In the 2009-10 fishing year there were 16 observed captures of NZ fur seal in southern blue whiting trawl fisheries. There were 106 (95% c.i.: 45 - 223) estimated captures, with the estimates made using a statistical model (Table 2). Since 2002–03, about 8% of the estimated total captures of NZ fur seals in trawl fisheries have been taken in the southern blue whiting fishery; these captures have been throughout the Subantarctic region in SBW 6B, 6I, and 6R. The rate of capture for NZ fur seals species has averaged 8.1 captures per 100 tows and has fluctuated without obvious trend (with a high in 2005-06).

**Table 4: Number of tows by fishing year and observed and model-estimated total NZ sea lion captures in southern blue whiting trawl fisheries, 2002–03 to 2009–10. No. obs, number of observed tows; % obs, percentage of tows observed; Rate, number of captures per 100 observed tows, % inc, percentage of total effort included in the statistical model. Data from Thompson & Abraham (2012), retrieved from http://bycatch.dragonfly.co.nz/v20120315/**

| | | Observed | | | | Estimated | | |
|---|---|---|---|---|---|---|---|---|
| | Tows | No.obs | %obs | Captures | Rate | Captures | 95%c.i. | %inc. |
| 2002–03 | 638 | 275 | 43.1 | 0 | 0.00 | 0 | 0-3 | 95.0 |
| 2003–04 | 740 | 241 | 32.6 | 1 | 0.41 | 3 | 1-9 | 95.4 |
| 2004–05 | 870 | 335 | 38.5 | 2 | 0.60 | 5 | 2-12 | 83.8 |
| 2005–06 | 624 | 217 | 34.8 | 3 | 1.38 | 10 | 3-21 | 81.7 |
| 2006–07 | 630 | 224 | 35.6 | 3 | 1.34 | 15 | 5-29 | 88.7 |
| 2007–08 | 819 | 331 | 40.4 | 5 | 1.51 | 8 | 5-14 | 68.3 |
| 2008–09 | 1187 | 299 | 25.2 | 0 | 0.00 | 1 | 0-6 | 52.1 |
| 2009–10 | 1115 | 397 | 35.6 | 11 | 2.77 | 25 | 16-38 | 48.0 |

**Table 5: Number of tows by fishing year and observed and model-estimated total NZ fur seal captures in southern blue whiting trawl fisheries, 2002–03 to 2009–10. No. obs, number of observed tows; % obs, percentage of tows observed; Rate, number of captures per 100 observed tows, % inc, percentage of total effort included in the statistical model. Data from Thompson & Abraham (2012), retrieved from http://bycatch.dragonfly.co.nz/v20120315/**

| | | Observed | | | | Estimated | | |
|---|---|---|---|---|---|---|---|---|
| | Tows | No.obs | %obs | Captures | Rate | Captures | 95%c.i. | %inc. |
| 2002–03 | 638 | 275 | 43.1 | 8 | 2.91 | 22 | 10-51 | 100.0 |
| 2003–04 | 740 | 241 | 32.6 | 13 | 5.39 | 38 | 18-87 | 100.0 |
| 2004–05 | 870 | 335 | 38.5 | 33 | 9.85 | 76 | 44-152 | 100.0 |
| 2005–06 | 624 | 217 | 34.8 | 52 | 23.96 | 65 | 55-84 | 100.0 |
| 2006–07 | 630 | 224 | 35.6 | 13 | 5.80 | 24 | 15-44 | 100.0 |
| 2007–08 | 819 | 331 | 40.4 | 24 | 7.25 | 80 | 38-173 | 100.0 |
| 2008–09 | 1187 | 299 | 25.2 | 17 | 5.69 | 107 | 49-224 | 100.0 |
| 2009–10 | 1115 | 397 | 35.6 | 16 | 4.03 | 106 | 45-223 | 100.0 |

### 4.3.2 Seabird interactions

Annual observed seabird capture rates ranged from 0.00 to 1.34 per 100 tows in southern blue whiting fisheries between 1998-99 and 2007-08 (Baird 2001, 2004 a,b,c, 2005a, Abraham & Thompson 2009, Abraham *et al*. 2009, Abraham & Thompson 2011) and have fluctuated without obvious trend. In the 2009-2010 fishing year there were 10 observed captures of birds in southern blue whiting trawl fisheries at a rate of 2.52 birds per 100 observed tows (Thompson & Abraham 2012). No estimates of total captures were made. The average capture rate in southern blue whiting trawl fisheries over the last eight years (all areas combined) is only 0.8 birds per 100 tows, a low rate relative to trawl fisheries for squid (13.3 birds per 100 tows), scampi (3.53 birds per 100 tows) and hoki (2.2 birds per 100 tows) over the same years. Observed seabird captures since 2002–03 have been dominated by grey petrels (15 of the 20 observed seabird captures since 2002-03). Grey petrel was estimated to have a relatively low risk ratio (potential captures across all New Zealand trawl and longline fisheries equal to 39% of PBR) by Richard *et al* (2011). Captures in the southern blue whiting fishery have been observed in SBW 6B, 6I, and 6R.

Mitigation methods such as streamer (tori) lines, Brady bird bafflers, warp deflectors, and offal management are used in the southern blue whiting trawl fishery. Warp mitigation was voluntarily introduced from about 2004 and made mandatory in April 2006 (MFish 2006). The 2006 notice mandated that all trawlers >28 m in length use a seabird scaring device while trawling (being "paired streamer lines", "bird baffler" or "warp deflector" as defined in the notice).

## 4.4 Benthic interactions

Southern blue whiting are taken using trawls that are sometimes fished on or near the seabed. Target southern blue whiting tows accounted for only 1% of all tows reported on TCEPR forms to have been fished on close to the bottom between 1989–90 and 2004–05 (Baird *et al*. 2011). These tows were located in Benthic Optimised Marine Environment Classification (BOMEC, Leathwick *et al.* 2009) classes F (upper slope), I, L (mid-slope), and M (mid-deep slope) (Baird & Wood 2012), and 95% were between 300 and 600 m depth (Baird *et al*. 2011).

**Table 6: Number of tows by fishing year and observed seabird captures in southern blue whiting trawl fisheries, 2002–03 to 2009–10. No. obs, number of observed tows; % obs, percentage of tows observed; Rate, number of captures per 100 observed tows. Data from Thompson & Abraham (2012), retrieved from http://bycatch.dragonfly.co.nz/v20120315/**

| | Tows | No. obs | % obs | Captures | Rate |
|---|---|---|---|---|---|
| 2002–03 | 638 | 275 | 43.1 | 0 | 0.00 |
| 2003–04 | 740 | 241 | 32.6 | 0 | 0.00 |
| 2004–05 | 870 | 335 | 38.5 | 2 | 0.60 |
| 2005–06 | 624 | 217 | 34.8 | 2 | 0.92 |
| 2006–07 | 630 | 224 | 35.6 | 3 | 1.34 |
| 2007–08 | 819 | 331 | 40.4 | 3 | 0.91 |
| 2008–09 | 1187 | 299 | 25.2 | 0 | 0.00 |
| 2009–10 | 1115 | 397 | 35.6 | 10 | 2.52 |

Trawling for southern blue whiting with some or all of the gear contacting the bottom, like trawling for other species, is likely to have effects on benthic community structure and function (e.g., Rice 2006) and there may be consequences for benthic productivity (e.g., Jennings 2001, Hermsen *et al*. 2003, Hiddink *et al*. 2006, Reiss *et al*.2009). These consequences are not considered in detail here but are discussed in the Aquatic Environment and Biodiversity Annual Review (2012).

### 4.5 Other considerations

None

## 5. STOCK ASSESSMENT

A new assessment of the Campbell Island Rise stock was completed in 2012 using research time series of abundance indices from wide-area acoustic surveys from 1993 to 2011, and proportion-at-age data from the commercial fishery. New information included a wide area acoustic survey of the Campbell Island Rise carried out in August-September 2011. The general purpose stock assessment program, CASAL (Bull *et al.* 2012) was used and the approach, which used Bayesian estimation, was similar to that in previous assessments (Dunn & Hanchet 2011).

A stock assessment was also completed for the Bounty Platform stock using data up to 2009 from industry acoustic surveys of aggregations. However, more recent data from surveys in 2010 and 2011 led the Working Group to believe this assessment model did not adequately explain the observations. The model-based assessment was therefore not accepted by the Working Group. In 2012, the assessment advice was based on the 2011 acoustic results alone (see section 4.4).

No new assessment is available for the Pukaki Rise stock. No assessment has been made of the Auckland Islands Shelf stock. The years given in the biomass and yield sections of this report refer to the August-September spawning/fishing season.

### 5.1 Estimates of fishery parameters and abundance indices

Between 1993 and 2001, a series of wide area acoustic surveys for southern blue whiting were carried out by the R.V. *Tangaroa* on the Bounty Platform. From 2004 to 2011, a series of local area aggregation surveys has been carried out from industry vessels fishing the Bounty Platform (O'Driscoll 2012). The fishing vessels have opportunistically collected acoustic data from the Bounty Platform fishing grounds using a random survey design over an ad-hoc area that encompassed an aggregation of southern blue whiting (O'Driscoll 2012). The local area aggregation surveys have had mixed levels of success (Table 7). Acoustic data collected in 2005 could not be used because of acoustic interference from the scanning sonar used by the vessel for searching for fish marks and inadequate survey design. There was originally some concern that the surveys in 2006 and 2009 may not have sampled the entire aggregation as fish marks extended beyond the area being surveyed on some transects. However, the surveys in 2010 and 2011 appeared to have sampled the entire aggregation and gave a similar estimate of biomass to that in 2009, suggesting that the 2009 survey was not overly biased.

**Table 7: Estimates of biomass (t) for age 4+ fish from wide area acoustic surveys of the Bounty Platform in 1993-2001 (from Grimes *et al*. 2007), and of spawning stock biomass (SSB) from local aggregation surveys in 2004 to 2011 (O'Driscoll 2012a). Sampling CVs are given in parentheses.**

| | *Wide are surveys* | *Local aggregation surveys* |
|---|---|---|
| **Year** | **Age 4+ fish** | **SSB** |
| 1993 | 47 087 (64%) | - |
| 1994 | 20 844 (25%) | - |
| 1995 | 23 480 (24%) | - |
| 1997 | 31 929 (32%) | - |
| 1999 | 34 194 (73%) | - |
| 2001 | 16 396 (36%) | - |
| 2004 | - | 13 473 (69%) |
| 2005 | - | - |
| 2006 | - | 21 765 (12%) |
| 2007 | - | 159 589 (19%) |
| 2008 | - | 144 187 (34%) |
| 2009 | - | 28 242 (21%) |
| 2010 | - | 27 782 (36%) |
| 2011 | - | 35 597 (28%) |

O'Driscoll (2011) explored various reasons for the much lower observed biomass estimates from the surveys in 2009 and 2010 compared with 2007 and 2008, including changes in survey methodology, equipment (including calibration), and changes in timing and extent of survey coverage. He could find no reason in the survey methodology, equipment, or changes in timing and extent of survey coverage for the observed reduction in these estimates.

A wide area survey of the Campbell Island Rise was carried out in August-September 2011 O'Driscoll *et al*. (2012b). Estimates of 2 year old fish were above average, but estimates of 3 year olds were very low. The adult biomass was high, but not as high as might have been expected based from the estimates of 2 and 3 year old fish in 2009 (Table 8).

Estimates of biomass from acoustic surveys from the Bounty Platform, Pukaki Rise and Campbell Island Rise are shown in Table 8.

A standardised CPUE analysis of the Campbell Island stock was completed up until the 2002 fishing season, and the indices are shown in Table 8. In the past there has been concern that because of the highly aggregated nature of the fishery, and the associated difficulty in finding and maintaining contact with the highly mobile schools in some years, the CPUE series may not be monitoring abundance. The indices have therefore not been used in the stock assessment since 1998. A standardised CPUE analysis was also recently carried out for the Bounty Platform. However, this analysis was based on a much more limited data set, the results were inconsistent with the acoustic survey estimates, and there was strong evidence of targeting. The indices were therefore rejected by the WG as indices of abundance and have not been used in assessments.

**Table 8: Estimates of biomass (000 t) for age 1, 2, 3 and 4+ fish from acoustic surveys of Bounty Platform, Pukaki Rise, and Campbell Island Rise, and CPUE indices for the Campbell Island Rise. - no data. *Estimates include fish from outside the standard survey area.**

| Year | Bounty Platform | | | | Pukaki Rise | | | | Campbell Island Rise | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4+ | 1 | 2 | 3 | 4+ | 1 | 2 | 3 | 4+ | CPUE |
| 1986 | - | - | - | - | - | - | - | - | - | - | - | - | 1.00 |
| 1987 | - | - | - | - | - | - | - | - | - | - | - | - | 0.91 |
| 1988 | - | - | - | - | - | - | - | - | - | - | - | - | 0.88 |
| 1989 | - | - | - | - | - | - | - | - | - | - | - | - | 1.38 |
| 1990 | - | - | - | - | - | - | - | - | - | - | - | - | 1.06 |
| 1991 | - | - | - | - | - | - | - | - | - | - | - | - | 1.30 |
| 1992 | - | - | - | - | - | - | - | - | - | - | - | - | 0.60 |
| 1993 | 29.06 | 11.35 | 0.78 | 47.09 | 1.06 | 41.97 | 9.21 | 18.82 | 0.21 | 107.19 | 13.40 | 16.78 | 1.03 |
| 1994 | 0.30 | 9.08 | 36.44 | 20.84 | 0.02 | 1.98 | 8.91 | 27.12 | 0.70 | 19.63 | 168.01 | 23.21 | 1.19 |
| 1995 | 155.46 | 7.11 | 7.87 | 23.48 | 0.00 | 0.14 | 0.88 | 8.38 | 0.00 | 17.27 | 27.95 | 124.89 | 1.23 |
| 1996 | - | - | - | - | - | - | - | - | - | - | - | - | 2.28 |
| 1997 | 5.05 | 7.28 | 30.67 | 31.93 | 0.04 | 4.44 | 0.89 | 22.70 | - | - | - | - | 2.28 |
| 1998 | - | - | - | - | - | - | - | - | 8.68 | 20.90 | 35.58 | 139.39 | 1.74 |
| 1999 | 0.99 | 1.13 | 5.62 | 34.19 | - | - | - | - | - | - | - | - | 2.55 |
| 2000 | - | - | - | - | 0.10 | 10.18 | 5.58 | 16.28 | 2.44 | 15.61 | 8.79 | 110.93 | 1.85 |
| 2001 | 0.38 | 4.67 | 7.26 | 16.40 | - | - | - | - | - | - | - | - | 1.83 |
| 2002* | - | - | - | - | - | - | - | - | 13.44 | 4.61 | 10.63 | 103.42 | 1.94 |
| 2004* | - | - | - | - | - | - | - | - | 3.14 | 24.38 | 36.68 | 39.01 | - |
| 2006* | - | - | - | - | - | - | - | - | 2.23 | 27.93 | 10.20 | 56.21 | - |
| 2009 | - | - | - | - | - | - | - | - | 0.00 | 110.25 | 115.94 | 92.60 | - |
| 2011 | - | - | - | - | - | - | - | - | 0.00 | 61.51 | 1.67 | 116.40 | - |

## 5.2 Biomass estimates

### (i) Campbell Island stock (2012 stock assessment)

### The stock assessment model

An updated stock assessment for the Campbell Island stock was completed in 2012. The model partitioned the Campbell Island stock into two sexes and age groups 2-11, with a plus group at age 11. There are two time steps in the model (Table 9). In the first time step 90% of natural mortality takes place. In the second time step, fish ages are incremented; the 2-year-olds are recruited to the population, which is then subjected to fishing mortality; and the remaining 10% of natural mortality.

**Table 9: Annual cycle of the stock model, showing the processes taking place at each step, and the available observations. Fishing mortality (F) and natural mortality (*M*) that occur within a time step occur after all other processes. *M*, proportion of *M* occurring in that time step.**

| Period | Process | *M* | Length at age | Observations |
|---|---|---|---|---|
| 1. Nov-Aug | Natural mortality | 0.9 | - | - |
| 2. Sep-Oct | Age, recruitment, F, M | 0.1 | Matrix applies here | Proportion at age, acoustic indices |

The model assumes that a logistic fishing selectivity with full selectivity typically estimated for fish aged 4+. Selectivities were assumed constant over all years in the fishery, and hence there was no allowance for annual changes in selectivity. A Beverton-Holt stock-recruitment relationship was assumed with steepness of $h = 0.9$. The proportion of males at recruitment (age 2) was assumed to be 0.5 of all recruits. We assumed a constant maturity ogive based on estimates derived in previous model with most (95%) fish mature at age 4 and all fish assumed mature at age 5. The maximum exploitation rate ($U_{max}$) was set at a value of 0.7. The choice of the maximum exploitation rate has the effect of determining the minimum possible virgin biomass allowed by the model. Because of the large inter-annual differences in growth, caused by the occurrence of the strong and weak year classes, length-at-age vectors were calculated for each year, and used in the modelling. Lengths-at-age were converted to weights-at-age in the model using the length-weight relationship given in Table 3.

The model was fitted to the two series of acoustic biomass estimates of ages 2, 3, and 4+ fish given in Table 10 and the proportions-at-age data from the commercial fishery. The acoustic survey estimates were used as relative estimates of mid-season biomass (i.e., after half the catch has been removed), with associated CVs estimated from the survey analysis. Catch-at-age observations were available from the commercial fishery for the period 1979 to 2011. Catch-at-age data were fitted to the model as proportions-at-age, where estimates of the proportions-at-age and associated CVs by age were estimated using the NIWA catch-at-age software by bootstrap (Bull & Dunn 2002).

Lognormal likelihoods, with the survey sampling CVs were assumed for the relative biomass (acoustic indices) data. Multinomial likelihoods, with sample sizes derived from the bootstrap estimates of CVs, were used for the proportions-at-age data. The likelihoods errors for these data allowed for sampling error only. However, additional variance assumed to arise from differences between model simplifications and real world variation, was added to the sampling variance. The additional variance, termed process error, was estimated in an initial run of the model using all the available data. Additional process error was iteratively estimated for the proportions-at-age data and was added to each observation for all subsequent model runs. The process error estimated for the relative biomass indices was zero.

**Table 10: Decomposed biomass estimates (t) and CVs by survey and age group used for the Campbell Island Rise stock assessment.**

| Year | Age 2 | | Age 3 | | Age 4+ | |
|---|---|---|---|---|---|---|
| | Biomass | CV | Biomass | CV | Biomass | CV |
| 1993 | 107 192 | 0.28 | 13 396 | 0.23 | 16 784 | 0.25 |
| 1994 | 19 634 | 0.29 | 168 006 | 0.32 | 23 213 | 0.28 |
| 1995 | 17 269 | 0.27 | 27 952 | 0.21 | 124 892 | 0.25 |
| 1998 | 20 895 | 0.15 | 35 579 | 0.12 | 139 388 | 0.18 |
| 2000 | 15 606 | 0.16 | 8 785 | 0.16 | 110 931 | 0.17 |
| 2002 | 4 609 | 0.65 | 10 632 | 0.64 | 103 422 | 0.68 |
| 2004 | 24 380 | 0.15 | 36 683 | 0.30 | 39 007 | 0.39 |
| 2006 | 27 933 | 0.23 | 10 199 | 0.34 | 56 206 | 0.32 |
| 2009 | 110 250 | 0.22 | 115 944 | 0.26 | 92 598 | 0.27 |
| 2011 | 61 512 | 0.17 | 1 668 | 0.22 | 116 396 | 0.22 |

## Estimation

Model parameters were estimated using Bayesian methods implemented using the NIWA stock assessment program CASAL v2.30 (Bull *et al.* 2012). For initial runs only the mode of the joint posterior distribution was sampled. For the final runs presented here, the full posterior distribution was sampled using Markov Chain Monte Carlo (MCMC) methods, based on the Metropolis-Hastings algorithm.

MCMC chains were estimated using a burn-in length of 1 million iterations, with every 10 000$^{th}$ sample taken from the next 10 million iterations (i.e., a final sample of length 1000 was taken from the Bayesian posterior).

Equilibrium “virgin” biomass is equal to the population that there would have been if all the YCS were equal to one and there was no fishing. However, there was a period of unknown (and possibly large) catches from the Campbell Island stock before 1979, and there is high recruitment variability in the stock, so the initial 1979 biomass was allowed to differ from the equilibrium virgin biomass. The initial population in 1979 (ages 3 to 11+) was estimated for each of the ages in the initial population, and assumed to be equal by sex. Year class strengths were estimated for all years from 1977 to 2008, under the assumption that the estimates from the model should average one.

## Prior distributions and penalty functions

The assumed prior distributions used in the assessment are given in Table 11. Most priors were intended to be relatively uninformative, and had wide bounds. However, a log-normal prior was used for natural mortality and for the acoustic survey 4+ *q*.

The prior used for the wide area acoustic survey catchability coefficient for ages 4+ was originally obtained using the approach of Cordue (1996), and was detailed by Hanchet (2002). Uncertainty over various factors, including mean target strength, acoustic system calibration, target identification, shadow or dead zone correction, and areal availability were included within the derivation of the prior. That approach suggested a mean of 1.4 and CV 0.2 with bounds 0.1-2.8. Following the recalibration of the acoustic estimates with revised estimates of the target strength relationship and sound absorption coefficients, the Middle Depths Fisheries Assessment Working Group revised the prior parameters to have mean 1.0 but retained the CV and bounds.

**Table 11: The distributions, priors, and bounds assumed for the various parameters being estimated in the Campbell Island Rise stock assessment. The parameters are mean and CV for lognormal; and mean and s.d. for normal. Process errors were fixed at MPD values when carrying out MCMCs.**

| Parameter | *N* | Distribution | Values | | Bounds | |
|---|---|---|---|---|---|---|
| | | | Mean | CV / s.d. | Lower | Upper |
| $B_0$ | 1 | Uniform-log | - | - | 30 000 | 800 000 |
| Acoustic *q*s age 2, 3 | 2 | Uniform-log | - | - | 0.1 | 2.8 |
| Acoustic age 4+ *q* | 1 | Lognormal | 1.00 | 0.20 | 0.1 | 2.8 |
| YCS | 28 | Lognormal | 1.00 | 1.30 | 0.001 | 100 |
| Initial population | 18 | Uniform-log | - | - | 5e5 | 1e10 |
| Selectivity (by sex) | 3 | Uniform | - | - | 1 | 20 |
| *M* (average) | 1 | Lognormal | 0.20 | 0.20 | 0.075 | 0.325 |
| *M* (difference) | 1 | Normal | 0.00 | 0.05 | -0.05 | 0.05 |
| Lognormal process error | 4 | Uniform-log | | | 0.0001 | 1 |

The prior on natural mortality was determined by assuming that the true value could differ from the current value by about 0.05, and not more than 0.1. Natural mortality was parameterised by the average of male and female, with the difference estimated with an associated normal prior with mean zero and standard deviation 0.05. Penalty functions were used to constrain the model so that any combinations of parameters that did not allow the historical catch to be taken were strongly penalised. A small penalty was applied to encourage the estimates of year class strengths to average to 1.

## Base case

Two main model runs were considered, based on the development of exploratory models. The first assumed a constant age-based selectivity ogive for the fishery, while the second made the same assumptions for the model population structure, but assumed that the fishing selectivities were size-based (Table 12). As the results from the age-based and sized-based models were similar, the Working Group agreed that the age-based model would be reported as the base case.

For each model run, MPD fits were obtained and qualitatively evaluated. MCMC estimates of the median of the posterior and 95% credible intervals are reported for virgin biomass, $B_{2011}$ and $B_{2011}$ (as $\%B_0$).

**Table 12: Model run labels and descriptions for the base case.**

| Model run | Description |
|---|---|
| 1.2 | Age-based fishing selectivity |
| 1.3 | Size-based fishing selectivity |

Recruitment in the Campbell Island Rise stock is characterised by periods of moderate recruitment interspersed by relatively infrequent but extremely strong recruitment events. Given the high variability in recruitment levels and the few strong year classes that have been observed, $B_0$ is probably not well determined. At the time of the last assessment, only one such event (1991 year class) has been observed (although historical data suggests that this may have happened in the past). The catch-at-age data and the acoustic indices available for this assessment suggested that there was at least one more strong year class since 1991, in 2006, 2007, and possibly 2009.

## Results

The estimated MCMC marginal posterior distributions for spawning stock biomass trajectories are shown for the base case (model 1.2) in Figure 2, and the results summarised in Table 13. The run suggests that the stock biomass showed a steady decline from the early 1980s until 1993 followed by a large increase to 1996, and a general decline thereafter. A moderate year class in 2003 and then two strong year classes in 2006 and 2007 have resulted in a relatively stable stock size until 2009, and then increased in 2010 as the 2006 and 2007 year classes recruited to the fishery. Exploitation rates and relative year class strengths are shown in Figure 3. Estimates of the adult acoustic *q* and *M* are given in Table 14.

**Table 13: Bayesian median and 95% credible intervals of equilibrium ($B_0$), initial, and current biomass for the model runs 1.2 (base case) and 1.3 (sensitivity)**

| Model | $B_0$ | $B_{1991}$ (%$B_0$) | $B_{2011}$ | $B_{2011}$ (%$B_0$) |
|---|---|---|---|---|
| 1.2 (Base case) | 396 510 (339 760–476 900) | 10.9 (7.4–17.7) | 199 120 (146 670–278 820) | 50 (35–67) |
| 1.3 | 340 130 (300 730–386 840) | 13.9 (10.1–18.8) | 220 391 (154 050–317 060) | 65 (45–86) |

**Table 14: Bayesian median and 95% credible intervals of the catchability coefficients (q) and natural mortality parameters for the wide area acoustic biomass indices for model runs 1.2 (base case ) and 1.3 (sensitivity)**

| Model | | Catchability | | Natural mortality | |
|---|---|---|---|---|---|
| | Age 2 | Age 3 | Age 4 | Male | Female |
| 1.2 (Base case) | 1.12 (0.79–1.48) | 1.02 (0.73–1.30) | 0.72 (0.56–0.88) | 0.17 (0.12–0.22) | 0.17 (0.13–0.22) |
| 1.3 | 0.92 (0.63–1.28) | 0.86 (0.61–1.19) | 0.73 (0.56–0.92) | 0.22 (0.17–0.28) | 0.23 (0.17–0.28) |

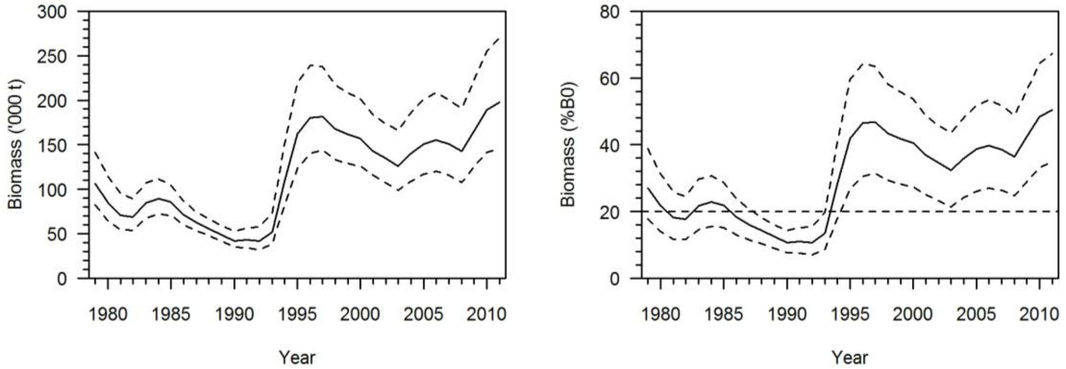



**Figure 2: MCMC posterior plots of the biomass trajectories of (left) $B_0$ and (right) current biomass (%$B_{2011}/B_0$) for the Campbell Island stock for the base case.**

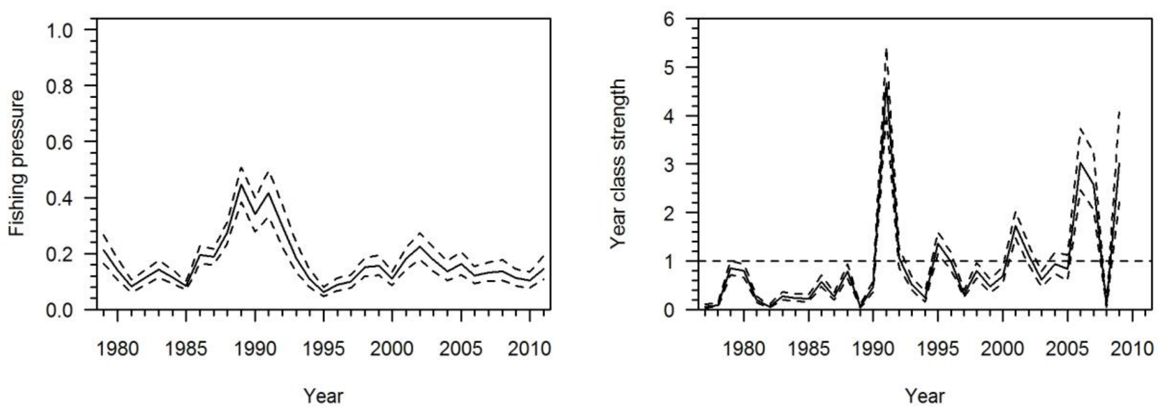



**Figure 3: Estimated posterior distributions of (left) exploitation rates and (right) relative year class strength for the Campbell Island stock for the base case.**

Projections were made assuming fixed catch levels of 30 000 t. Projections were made using the MCMC samples, with recruitments drawn randomly from the distribution of year class strengths for the period 1977–2008 estimated by the model and (i) applied from year 2009 onwards (i.e., ignoring the estimate of a high year class strength for 2009) or (ii) applied from year 2010 onwards. The two scenarios were chosen as the 2011 acoustic survey indicated that the size of the 2009 year class was likely to be large (from age 2 estimates), but this should be considered uncertain as the year class has not yet been observed entering the fishery.

For each scenario, the probability that the mid-season biomass for the specified year will be less than the threshold level (20% $B_0$) is given in Table 15. The probability of dropping below the threshold biomass at catch levels of 30 000 t is less than 10% for all models and all years. Under average recruitment conditions the biomass is expected to increase in the few years immediately after 2011, then begin to decline. The probability that the mid-season biomass for the specified year will be less than the limit reference biomass ($B_{1991}$) is reported in Table 15.

**Table 15: Probability that the projected mid-season vulnerable biomass for 2012-2016 will be less than 20% $B_0$, and the median projected biomass (%$B_0$), at a projected catch of 30 000 t, for the base case model assuming average recruitment over the period 1997—2008 for 2009+ and for 2010+.**

| Catch (t) | Recruitment | Pr (SSB < 0.2$B_0$) | | | | | Median SSB (%$B_0$) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2012 | 2013 | 2014 | 2015 | 2016 | 2012 | 2013 | 2014 | 2015 | 2016 |
| 30 000 | 2009+ | 0.00 | 0.00 | 0.00 | 0.01 | 0.03 | 53.2 | 52.5 | 49.0 | 45.4 | 41.7 |
| | 2010+ | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 64.0 | 72.3 | 69.4 | 59.9 | 54.9 |

### (ii) Bounty Platform stock (2010 assessment)

The assessment documented below was completed in 2010 and included data up to and including the 2009 season. It differs from the previous (2004) assessment primarily in the inclusion of the time series of industry based acoustic aggregation surveys from 2003 to 2009 as well as proportion-at-age data from 1990 to 2009.

Preliminary model runs did not provide a satisfactory fit to either the aggregation acoustic survey estimates or the proportion-at-age data. Hence, the development of the assessment focused on (i) freeing up the aggregation survey catchability between years so that the large variation in biomass estimates between years could be adequately fitted; (ii) constraining the aggregation survey estimates to have a similar *q* to that of the adult (4+) biomass from the wide area surveys; (iii) allowing the fishing selectivity to vary over time to allow for the conflict between the observations from the aggregation survey biomass estimates, and (iv) resolving computational difficulties when considering the 2002 year class estimate in the calculation of virgin biomass. The resulting stock assessments are likely to be highly dependent on these underlying assumptions, possibly over-parameterised, and the uncertainty may not be adequately reflected in the quantitative outputs.

### Population dynamics and model structure

A two-sex, single stock and area Bayesian statistical catch-at-age model for the Bounty Platform southern blue whiting stock was implemented in CASAL (Bull *et al.* 2008). The model partitioned the stock into two sexes with age groups 2-11, with a plus group at age 11, and was run for the years 1979 to 2009. Five year projections were run for the years 2010-2014. The annual cycle was partitioned into two time steps. In the first time step (nominally the non-spawning season), 90% of natural mortality was assumed to have taken place. In the second time step (spawning season), fish ages were incremented; the 2-year-olds were recruited to the population, which were then subjected to fishing mortality and the remaining 10% of natural mortality. A two sex model was used because there are significant differences observed between males and females in both the proportions at age in the commercial catch for fished aged 2-4 (see later) and their mean size at age (Hanchet & Dunn 2010). The stock recruitment relationship was assumed to be Beverton-Holt with a steepness of 0.9, with the proportion of males at recruitment (at age 2) assumed to be 0.5 of all recruits.

Southern blue whiting exhibit large inter-annual differences in growth, presumably caused by local environmental factors but also closely correlated with the occurrence of the strong and weak year classes. Hence, an empirical size-at-age matrix was used which was derived by qualitatively reviewing the empirically estimated mean sizes-at-age from the commercial catch-at-length and -age data (Hanchet & Dunn 2010). Missing estimated mean sizes in the matrix were inferred from the relative size of their cohort and the mean growth of similar ages in other years; and cohorts with unusually small or large increments were similarly adjusted. The mean size-at-ages in the future years were assumed for projections. The mean size in 2010 was calculated by adding the observed mean growth increment from 1990-2009 to each age class in 2009 to determine their expected sizes in 2010, with the mean size of aged 2 fish in 2010 assumed to be equal to the mean of the annual mean sizes of aged 2 fish from 1990-2009. By iteratively applying the above algorithm, the mean sizes for the years 2011-2014 were determined.

In general, southern blue whiting are assumed to be fully or almost fully selected by the fishery at either age four or five and not vulnerable to fishing at age one. It was assumed that fishing selectivities were logistic by sex, and that the maximum exploitation rate (Umax) was 0.8. Further, in order to include potential changes in selectivity either as a function of age or sex, both age-based selectivities with an annual shift parameter and size-based selectivities with an annual shift parameter were investigated. The choice of models with either age- or size-based selectivities are described later.

In previous models of southern blue whiting on the Bounty Platform (e.g., Hanchet & Dunn 2009a) fish available to the fishery were all assumed to be mature and spawning, with all of these fish equally likely to be vulnerable to fishing (i.e., a fishing selectivity was assumed that was equal to one for all mature fish). In the models presented here, the estimates of the maturity ogive were disentangled from the fishing selectivity. Hence, a fixed proportion of fish at age and sex was assumed to be mature, and a logistic shaped fishing selectivity was estimated for males and females respectively.

The model was started in 1990 and the numbers in the population at the start of the model were estimated for each age and sex separately (i.e., described as a Cinitial starting state in Bull *et al*. 2008). Estimates of the initial age structure were constrained so that the number of males within each age class was equal to the number of females within that age class. However, in developing the models for southern blue whiting on the Bounty Platform, it was found that in the exploratory model runs the estimates of the very large year class observed in 2002 were strongly confounded with model estimates of the overall mean recruitment, equilibrium ($B_0$), and initial abundance (Cinitial). To resolve this issue, the mean year class strength constraint was modified to exclude the 2002 year class, i.e., the constraint that the mean of the relative year class strengths for years 1988-2006 equal one was replaced with the constraint that the mean of the relative year class strengths for the years 1988-2001 and 2003-2006 combined equal one. This modification removed most of the confounding between key parameters, and resulted in much more numerically stable models.

Note that in other, similar assessment models, the equilibrium unexploited spawning biomass ($B_0$) is typically defined as being equal to the spawning biomass that there would have been if the mean relative year class strength was equal to one over some defined period and there was no fishing (see Bull *et al*. 2008 for rationale). Here, as we ignore the 2002 year class in the averaging process, we define the equilibrium unexploited spawning biomass as being equal to the spawning biomass that there would have been if the mean relative year class strength was equal to one over the period 1998-2001 and 2003-2006 combined with no fishing.

This modification has a number of consequences. First, projections that assume a mean relative year class strength of one ignore the possibility of a very strong year class like that observed in 2002, and second, biomass reference points will have a lower value than otherwise i.e., 20% $B_0$ will have a lower absolute value with this assumption than it would have if the 2002 year class was included in the calculations.

**Observations**

The model was fitted to two time series of acoustic biomass estimates and the proportion-at-age data from the fishery. One time series of acoustic biomass estimates came from a wide area survey series conducted by the research vessel Tangaroa in the years 1993-1996, 1997, 1999, and 2001 (Hanchet & Dunn 2010). The acoustic survey estimates were used as relative estimates of mid-season biomass (i.e., after half the catch has been removed), with associated CVs estimated from the survey analysis (Table 16).

The second time series of acoustic biomass estimates came from a series of southern blue whiting local area aggregation surveys carried out from industry vessels fishing the Bounty Platform (Table 7). It was assumed that the local area aggregation survey estimates were relative estimates of mid-season spawning stock biomass (i.e., after half the catch has been removed), with a CV equal to the sampling CV estimated from the survey. However, as the coverage was likely to have been different in each year, the series was assumed to be a time series with non-constant catchability, and hence the catchability coefficient (q) for each year was allowed to be an independent parameter in the model. In order to use these survey estimates and allow the biomass estimates to provide some information to the model, it was assumed that the local area aggregation survey catchability coefficients were related to the wide area acoustic survey estimates via a *q* ratio prior (see Section 6.5.7 of Bull *et al.* 2012 for detail). Hence a prior distribution on the ratio of catchabilities for the local area aggregation survey and the wide area surveys were specified, with the ratio prior assumed to be lognormally distributed and parameterised by a mean and CV

Catch-at-age observations by sex were available from the commercial fishery for the period 1990 to 2009. These catch-at-age data were fitted to the model as proportions-at-age, where estimates of the proportions-at-age and associated CVs by age were estimated using the NIWA catch-at-age software by bootstrap (Bull & Dunn 2002).

**Table 16: R.V. *Tangaroa* age 2, 3 and 4+ acoustic biomass estimates for the Bounty Platform using the revised target strength and sound absorption coefficient, 1993-2001 (Grimes *et al.* 2007).**

| Year | Age 2 | | Age 3 | | Age 4+ | |
|---|---|---|---|---|---|---|
| | Biomass | CV | Biomass | CV | Biomass | CV |
| 1993 | 11 347 | 0.25 | 777 | 0.37 | 47 087 | 0.64 |
| 1994 | 9 082 | 0.28 | 36 445 | 0.25 | 20 844 | 0.25 |
| 1995 | 7 108 | 0.32 | 7 874 | 0.34 | 23 480 | 0.24 |
| 1997 | 7 274 | 0.36 | 30 668 | 0.41 | 31 929 | 0.32 |
| 1999 | 1 134 | 0.33 | 5 618 | 0.62 | 34 194 | 0.73 |
| 2001 | 4 669 | 0.23 | 7 261 | 0.19 | 16 396 | 0.36 |

## Estimation

Model parameters were estimated using Bayesian methods implemented using the NIWA stock assessment program CASAL v2.20 (Bull *et al.* 2008). Initial model fits were evaluated at the maximum of the posterior density (MPD) and by investigating model fits and residuals. For the final runs presented here, the full posterior distribution was sampled using Markov Chain Monte Carlo (MCMC) methods, based on the Metropolis-Hastings algorithm. MCMCs were estimated using a burn-in length of 1x106 iterations, with every 10 000th sample taken from the next 1x107 iterations (i.e., a systematic sample of length 1000 was taken from the Bayesian posterior). Chain diagnostic plots, autocorrelation estimates, and single chain convergence tests of Geweke (1992) and Heidelberger & Welch (1983) stationarity and half-width were used to determine evidence of non-convergence. The tests used a significance level of 0.05 and the diagnostics were calculated using the Bayesian Output Analysis software (Smith 2003).

## Prior distributions and penalty functions

In general, the assumed prior distributions used in the assessment were intended to be non-informative with wide bounds (Table 17). The exceptions to this were the priors and penalties on biomass catchability coefficients and on relative year class strengths. The prior assumed for the relative year class strengths was lognormal, with mean 1.0 and CV 1.3, for all year classes except for the 2002 year class. To allow for the possibility that the 2002 year class was much stronger than average, the lognormal prior CV was modified to be less constraining and set to 10.

A log-normal prior was used for the wide area acoustic survey catchability coefficient with mean 1.0 and CV 0.2. The prior used for the wide area acoustic survey catchability coefficient was originally obtained using the approach of Cordue (1996), and was detailed by Hanchet (2002). Uncertainty over various factors, including mean target strength, acoustic system calibration, target identification, shadow or dead zone correction, and areal availability were included within the derivation of the prior. That approach suggested a mean of 1.4 and CV 0.2 with bounds 0.1-2.8. Following the recalibration of the acoustic estimates with revised estimates of the target strength relationship and sound absorption coefficients, the Middle Depths Working Group revised the prior to have mean 1.0 with CV 0.2, and retained the same bounds.

Priors for the local area aggregation surveys were non-informative, but a q ratio prior was added to encourage the estimates to be specific ratios of the wide area acoustic catchability coefficient. The specification of the q ratio priors was based on the assumption that (i) the wide area surveys covered all of the vulnerable population, (ii) the 2004, 2007, and 2008 local area aggregation surveys also covered all of the vulnerable population, and (iii) the 2006 and 2009 surveys missed a large, but unknown, proportion of the vulnerable population.

Two alternative model scenarios were implemented. The first assumed a prior that strongly constrained the catchability coefficients of the 2004, 2007, and 2008 surveys to be very like the catchability coefficient of the wide area surveys (tight prior), and the second where this assumption was relaxed to be less constraining (diffuse prior). The values of the prior assumed for the *q* ratio for each survey and for the two scenarios are given in Table 18.

Lognormal errors, with known CVs, were assumed for the relative biomass and proportions-at-age data. The CVs available for these data allow for sampling error only. However, additional variance, assumed to arise from differences between model simplifications and real world variation, was added to the sampling variance. The additional variance, termed process error, was estimated in each of the initial runs (MPDs) using all the available data. Process errors were estimated separately for the proportion-at-age data, and for the acoustic estimates from the wide area and local area aggregation surveys.

**Table 17: The distributions, priors, and bounds assumed for the various parameters being estimated for the Bounty Platform stock assessment (*q* ratio priors are given in Table 18).**

| Parameter | *N* | Distribution | Values | | Bounds | |
|---|---|---|---|---|---|---|
| | | | Mean | CV | Lower | Upper |
| $B_0$ | 1 | Uniform-log | - | - | 20 000 | 250 000 |
| Initial population (by sex) | 10 | Uniform | - | - | 2e2 | 2e9 |
| Male fishing selectivity | 2 | Uniform | - | - | 1 | 20 |
| Female fishing selectivity | 2 | Uniform | - | - | 0.02 | 20 |
| Selectivity shift parameters | 3 | Uniform | - | - | -20 | 20 |
| Year class strength | 19 | Lognormal | 1.0 | 1.3 [1] | 0.001 | 100 |
| Wide area catchability 4+ *q* | 1 | Lognormal | 1.0 | 0.2 | 0.1 | 2.8 |
| Wide area catchability 3+ *q* | 1 | Uniform | - | - | 0.1 | 2.8 |
| Wide area catchability 2+ *q* | 1 | Uniform | - | - | 0.1 | 2.8 |
| 2004 local area catchability *q* | 1 | Uniform | - | - | 0.1 | 2.8 |
| 2006 local area catchability *q* | 1 | Uniform | - | - | 0.1 | 2.8 |
| 2007 local area catchability *q* | 1 | Uniform | - | - | 0.1 | 2.8 |
| 2008 local area catchability *q* | 1 | Uniform | - | - | 0.1 | 2.8 |
| 2009 local area catchability *q* | 1 | Uniform | - | - | 0.1 | 2.8 |

Note 1: Except for 2002. Here the CV = 10.

**Table 18: Aggregation survey biomass estimates for the Bounty Platform (with the revised target strength and sound absorption coefficient) from O'Driscoll (2011b) and the assumed *q* ratio prior, 2004-2009.**

| Year | Biomass | CV | Reference | *q* ratio prior | | | |
|---|---|---|---|---|---|---|---|
| | | | | Tight prior | | Diffuse prior | |
| | | | | *μ* | CV | *μ* | CV |
| 2004 | 13 473 | 0.69 | (O'Driscoll & Hanchet 2004) | 1.00 | 0.05 | 1.00 | 0.50 |
| 2006 | 21 765 | 0.12 | (O'Driscoll *et al*. 2006) | 0.50 | 0.50 | 0.50 | 0.50 |
| 2007 | 159 589 | 0.19 | (O'Driscoll *et al*. 2007) | 1.00 | 0.05 | 1.00 | 0.50 |
| 2008 | 144 187 | 0.34 | (O'Driscoll & Dunford 2008) | 1.00 | 0.05 | 1.00 | 0.50 |
| 2009 | 28 242 | 0.21 | (O'Driscoll *et al*. 2009) | 0.50 | 0.30 | 0.50 | 0.30 |

**Model runs and sensitivity tests**

As a result of preliminary investigations the WG agreed on two main scenarios for modelling the Bounty Platform stock. The first assumed age-based selectivity ogives for the fishery, but with an annual shift parameter for the years 2005-2007. The second made the same assumptions for the model population structure and selectivity shifts, but assumed that the fishing selectivities were size-based.

Further, in order to investigate the impact of the q ratio prior assumption on the models outputs, we investigated 'tight' and 'diffuse' prior assumptions. The first assumed a prior that strongly constrained the catchability coefficients of the 2004, 2007, and 2008 surveys to be very like the catchability coefficient of the wide area surveys (tight priors, Table 18), and the second where this assumption was relaxed to be less constraining (diffuse priors, Table 18). These four model runs are summarised in Table 19.

**Table 19: Model run labels and descriptions for the model runs.**

| Model type | Label | Description |
|---|---|---|
| Final Models | 3.4 | Age-based fishing selectivity with 'tight' *q* ratio priors (3 fisheries) |
| | 3.6 | Size-based fishing selectivity with 'tight' *q* ratio priors (3 fisheries) |
| | 4.4 | Age-based fishing selectivity with 'diffuse' *q* ratio priors (3 fisheries) |
| | 4.6 | Size-based fishing selectivity with 'diffuse' *q* ratio priors (3 fisheries) |

## Results

MCMC diagnostics showed that the trace plots for the key parameters ($B_0$ and B2009) were not ideal and showed some evidence of large scale correlation between iterations. The lag plots for the tight prior models identified problems with some autocorrelation in parameters for up to 6000-7000 iterations. In contrast, there was little evidence for similar autocorrelations in the diffuse prior models (4.4 and 4.6). Plots of median jump size indicated that the shift parameters for the 2005-2007 selectivity shift for the 2007 year for models 3.4 and 4.4 had poor chain performance. This was also indicated by chain convergence tests of Geweke (1992) and Heidelberger & Welch (1983) stationarity and half-width tests that tended to indicate some evidence for poor convergence of at least one of the shift parameters in all of the models.

The MCMC posterior plots for $B_0$ and current biomass (%B2009/$B_0$) are shown for the four models in Figures 4-7 and the results summarised in Table 20. Median estimates of $B_0$ were similar across models and ranged from 60 000 to 73 000 t. Estimates of $B_0$ from the diffuse prior models (4.4 and 4.6) were slightly higher than the estimates from the tight prior models (3.4 and 3.6). Median estimates of B2009 were much more variable, ranging from 82 000 to 150 000 t. The highest estimates of B2009 came from the tight prior model with the size based fishing selectivity (model 3.6). The other three models were more similar with estimates of B2009 ranging from 82 000 to 105 000 t.

Estimates of the adult (4+) catchability coefficient q for the wide area surveys were reasonably similar for the four models ranging from 0.98-1.23. However, in order to fit the various acoustic local area aggregation surveys the estimates of q from the individual aggregation surveys ranged from 0.33 to 2.05 across the various model runs and surveys fitted. The catchability coefficients need to be interpreted with some caution because they are fitted to the model biomass estimates via the selectivity ogive and the selectivity ogive was right shifted (by about a year) for the two size-base selectivity models 3.6 and 4.6. (This means that the qs for model 3.4 should be best compared with model 4.4 and for model 3.6 should be compared with model 4.6). Notwithstanding this, the estimates of the adult acoustic q for southern blue whiting should be reasonably close to 1, and the median estimates from model runs 3.6, 4.4 and 4.6 for the 2007 and 2008 surveys might be less plausible. The estimates of adult acoustic q for model 3.4 are the most plausible across the entire time series of wide area and aggregation surveys.

After the modelling work was completed, an additional aggregation survey was carried out on the Bounty Platform in August 2010 (see Table 7). Two snapshots were completed during the survey which appeared to fully cover the spawning aggregation. The estimate of adult biomass from the two snapshots was similar to that recorded for 2009. O'Driscoll (2011a) explored various reasons for the much lower observed biomass estimates from the surveys in 2009 and 2010 compared with 2007 and 2008, including changes in survey methodology, equipment (including calibration), and changes in timing and extent of survey coverage, but could find no reason for these low estimates. Given the conclusions of

O'Driscoll (2011a) and the low biomass estimates in 2009 and 2010, the Working Group concluded that the estimates of current biomass calculated from the model were likely to be biased high. It further noted that some of the model assumptions (e.g., the assumption of a constant rate of natural mortality or the priors on the acoustic surveys for 2007-2009) will need to be investigated to resolve the inconsistency.

**Table 20: Bayesian estimates of median and credible intervals of ($B_0$), initial, and current biomass for the model runs.**

| Model | $B_0$ | $B_{2009}$ | $B_{2009}$ (%$B_0$) |
|---|---|---|---|
| Model 3.4 | 60 710 (53 270-72 930) | 105 020 (88 470-125 170) | 173 (143-210) |
| Model 3.6 | 62 100 (55 720-70 550) | 150 420 (132 990-171 920) | 242 (206-283) |
| Model 4.4 | 73 180 (61 030-94 010) | 82 080 (51 190-130 270) | 111 (74-162) |
| Model 4.6 | 69 580 (60 150-82 830) | 92 290 (57 510-138 330) | 132 (88-186) |

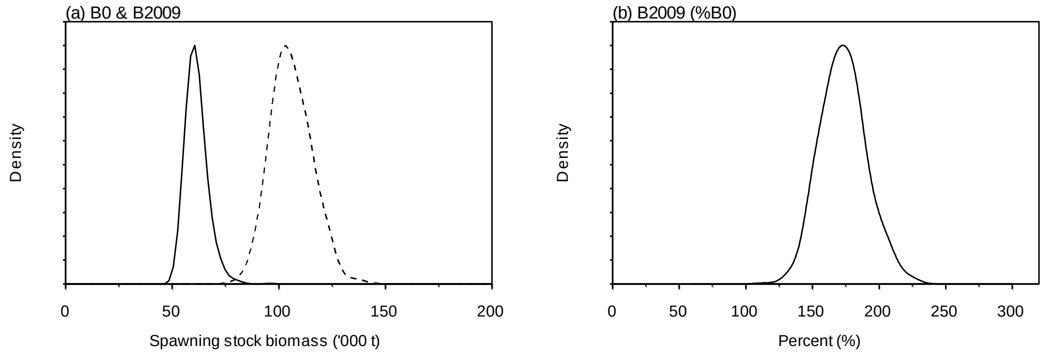



**Figure 4: MCMC posterior plots for (a) $B_0$ and (b) current biomass (%$B_{2009}/B_0$) for model 3.4.**

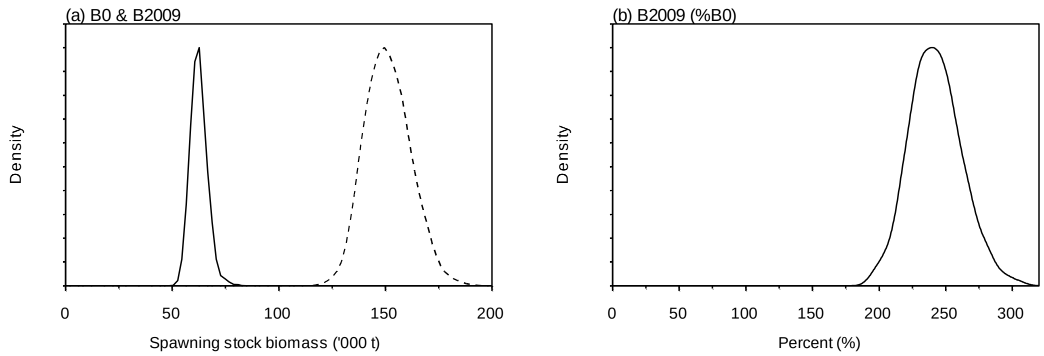



**Figure 5: MCMC posterior plots for (a) $B_0$ and (b) current biomass (%$B_{2009}/B_0$) for model 3.6.**

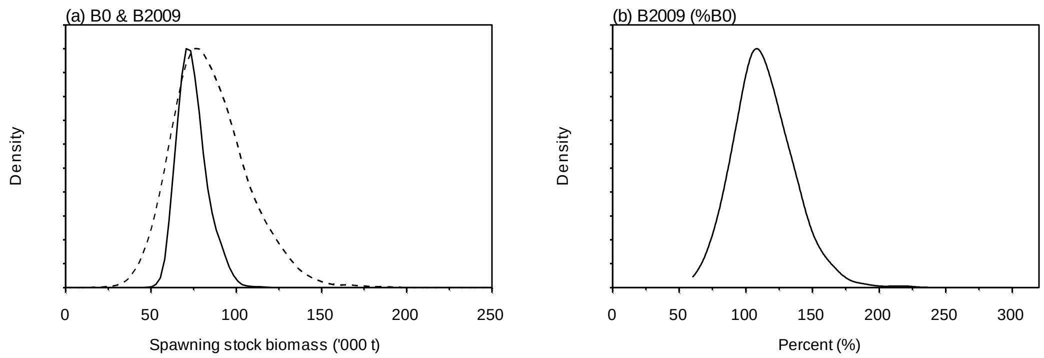



**Figure 6: MCMC posterior plots for (a) $B_0$ and (b) current biomass (%$B_{2009}/B_0$) for model 4.4.**

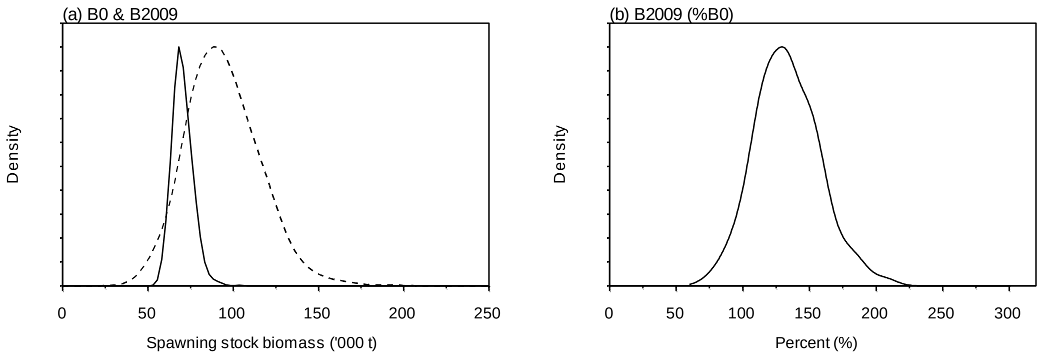



**Figure 7: MCMC posterior plots for (a) $B_0$ and (b) current biomass (%$B_{2009}$/$B_0$) for model 4.6.**

## (iii) Pukaki Rise stock

A new assessment of the Pukaki Rise stock was carried out in 2002. The sSPA model was used to estimate the numbers at age in the initial population in 1989 and subsequent recruitment. The model estimates selectivity for ages 2, 3, and 4 and assumes that the selectivity after age 4 is 1.0. No stock-recruitment relationship is assumed in the sSPA.

Preliminary runs of the model were fitted to proportion-at-age data from 1989 to 2000, and the acoustic indices given in Table 21, which differ from those in Table 8 because they were calculated with an older estimate of target strength and sound absorption. The indices were fitted in the model as relative estimates of mid-season biomass (i.e., after half the catch has been removed), with the CVs as shown in Table 22. The proportion-at-age data are assumed to be multinomially distributed with a median sample size of 50 (equivalent to a CV of about 0.3). Details of the input parameters for the initial and sensitivity runs are given in Table 22.

**Table 21: R.V. *Tangaroa* age 2, 3 and 4+ acoustic biomass estimates (t) for the Pukaki Rise used in the 2002 assessment. Estimates differ from those in Table 8 because they were calculated with old estimates of target strength and sound absorption.**

| Year | Age 1 | Age 2 | Age 3 | Age 4+ |
|---|---|---|---|---|
| 1993 | 578 | 26 848 | 9 315 | 31 152 |
| 1994 | 13 | 1 193 | 6 364 | 35 969 |
| 1995 | 0 | 102 | 775 | 11 743 |
| 1997 | 22 | 2 838 | 864 | 34 086 |
| 2000 | 58 | 7 268 | 5 577 | 24 931 |

**Table 22: Values for the input parameters to the separable Sequential Population Analysis for the initial run and sensitivity runs for the Pukaki Rise stock.**

| Parameter | Initial run | Sensitivity runs |
|---|---|---|
| M | 0.2 | 0.15, 0.25 |
| Acoustic age 3 and 4+ indices *CV* | 0.3 | 0.1, 0.5 |
| Acoustic age 1, 2 indices *CV* | 0.7 | 0.5, 1.0 |
| Weighting on proportion-at-age data | 50 | 5, 100 |
| Years used in analysis | 1989-2000 | 1979-2000 |
| Acoustic *q* | estimated | 0.68, 1.4, 2.8 |

Biomass estimates in the initial run and also in the sensitivity runs all appeared to be over-pessimistic because the adult (4+) acoustic *q* was very high. For example, for the initial run the 4+ acoustic *q* was estimated to be 2.7. The WG did not accept this initial run as a base case assessment, but agreed to present a range of possible biomass estimates. The Plenary also agreed to present a range, based on assumptions concerning the likely range of the value for the acoustic *q*.

Bounds for the adult (4+) acoustic *q* were obtained using the approach of Cordue (1996). Uncertainty over various factors including mean target strength, acoustic system calibration, target identification, shadow or dead zone correction, and areal availability were all taken into account. In addition to obtaining the bounds, a ‘best estimate’ for each factor was also calculated. The factors were then multiplied together. This independent evaluation of the bounds on the acoustic *q* suggested a range of 0.65-2.8, with a best estimate of 1.4. Clearly the *q* from the initial run is almost at the upper bound and probably outside the credible range. When the model was run fixing the acoustic *q* at 0.65 and 2.8, estimates of $B_0$ were 18 000 t and 54 000 t, and estimates of $B_{2000}$ were 8000 t and 48 000 t respectively (Table 23, Figure 8). Within these bounds current biomass is greater than $B_{MAY}$. Assuming the 'best estimate' of *q* of 1.4 gave $B_0$ equal to 22 000 t and $B_{2000}$ equal to 13 000 t.

Based on the range of stock biomass modelled in the assessment, the average catch level since 2002 (380 t) is unlikely to have made much impact on stock size. A more intensive fishery or more consistent catches from year to year would seem to be required to provide any contrast in the biomass indices. This stock has been only lightly exploited since 1993, when over 5000 t was taken in the spawning season.

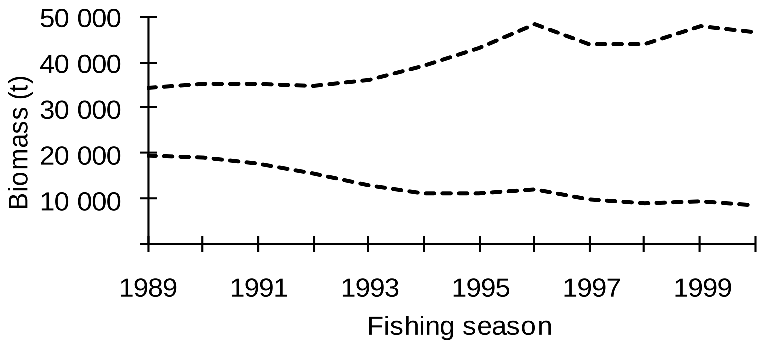



**Figure 8: Mid-season spawning stock biomass trajectory bounds for the Pukaki Rise stock. Bounds based on acoustic *q* of 0.65 and 2.8.**

**Table 23: Parameter estimates for the Pukaki stock as a result of fixing the adult 4+ acoustic *q* at various values. $B_{mid}$, mid-season spawning stock biomass; $N_{2,1992}$ size of the 1990 year class (millions). All values in t x $10^3$.**

| Fixing the acoustic *q* value | $B_0$ | $B_{mid\ 89}$ | $B_{mid\ 00}$ | $N_{2,1992}$ | $B_{mid\ 00}$ (%$B_0$) | $B_{mid\ 00}$ (%$B_{may}$) |
|---|---|---|---|---|---|---|
| *q* = 0.65 | 54 | 36 | 48 | 63 | 88 | 246 |
| *q* = 1.4 | 22 | 22 | 13 | 28 | 58 | 161 |
| *q* = 2.8 | 18 | 19 | 8 | 23 | 44 | 123 |

### (iv) Auckland Islands stock

No estimate of current biomass is available for the Auckland Islands Shelf stock. The acoustic estimate of the adult biomass in 1995 was 7800 t.

## 4.3 Other yield estimates and stock assessment results

### Decision tables

As an alternative to the *CAY* estimates, the results have been presented in the form of decision tables. In the Campbell Island Rise assessment the probability of biomass falling below the limit biomass level (1991 biomass) is presented for a catch level of 30 000 t (Table 15).

## 4.4 Additional stock assessment results for the Bounty Platform

Since the 2010 stock assessment was completed, two aggregation surveys have been carried out on the Bounty Platform in 2010 and 2011. Both surveys appeared to fully cover the spawning aggregation. The estimate of adult biomass from the two surveys was similar to that recorded in 2009 but considerably lower than that for surveys in 2007 and 2008 (see Table 7). O'Driscoll (2011a) explored various reasons for the much lower observed biomass estimates from the surveys in 2009 and 2010 compared with 2007 and 2008, including changes in survey methodology, equipment (including calibration), and changes in timing and extent of survey coverage, but could find no reason for these low estimates. The authors re-iterated the need to adequately survey the entire aggregation, ensure that some snapshots were carried out whilst fish were actively spawning, and recommended that 'wide area' surveys encompassing the likely adult distribution on the spawning grounds be considered. Given the conclusions of O'Driscoll (2011a) and the low biomass estimates in 2009, 2010, and 2011 the Working Group therefore concluded that the estimates of current biomass from the stock assessment were likely to be biased high. In order to provide advice on sustainable yields for the Bounty Platform stock for the 2012-13 fishing year, the Working Group agreed to use the most recent aggregation acoustic survey as the basis for determining yield estimates for management of the fishery.

In making these calculations the Working Group assumed:

a. That the acoustic survey biomass estimate in each year was equal to midseason vulnerable biomass available in each year and had lognormally distributed errors.
b. That the 80% quantiles (i.e., the 10$^{th}$ and 90$^{th}$ percentiles) represent an adequate bound on the sampling uncertainty in the acoustic estimates.
c. That an adequate representation of uncertainty in the target strength of southern blue whiting is ±3 dB, which approximates to a doubling or halving of the resulting biomass calculated from the target strength relationship.
d. That the combined effects of recruitment, the increase or change in mean weight from the growth of individuals, and natural mortality over a one year time frame are negligible and can be ignored.
e. That the biomass was measured after half of the reported catch had been taken.
f. That the maximum exploitation rate possible for the fleet in future years is 100%.

The absolute estimates of southern blue whiting biomass from the 2007-2011 industry acoustic surveys for the 80% intervals and with a ±3 dB uncertainty in the acoustic biomass estimates are given in Table 24.

Assuming that an appropriate exploitation rate for southern blue whiting is 0.20 (i.e., the $U_{CAY}$ that was previously calculated for southern blue whiting on the Bounty Platform in the most recent assessment), and that the total catch taken in 2011 was 6590 then expected *CAY* proxy yields for the biomass estimates in Table 24 for the following year is given in Table 25. Under the assumptions above, the estimate of the *CAY* proxy yield from the 2011 local area aggregation survey projected forward for 2012 was 6460 t with a lower uncertainty bound between 2 901 t and 4 162 t.

The WG noted that there were possible indications of another strong year class (the 2007 cohort) in the 2011 catch at age data. Another acoustic survey is planned for 2012 on the Bounty Platform stock.

**Table 24: Absolute estimates of midseason southern blue whiting vulnerable biomass (±3 dB) from the 2011 local area aggregation acoustic surveys, ignoring any corrections for the potential bias in the catchability coefficient, *q*.**

| Year | Option | TS multiplier | | | Biomass estimate |
|---|---|---|---|---|---|
| | | | 10$^{th}$ percentile | Mean | 90$^{th}$ percentile |
| 2011 | Snapshot | 0.5 | 12 050 | 17 800 | 24 370 |
| | 6 & 7 | 1.0 | 24 110 | 35 600 | 48 750 |
| | | 2.0 | 48 210 | 71 190 | 97 490 |

**Table 25: Approximate *CAY* proxy yields for southern blue whiting biomass from the 2011 local area aggregation acoustic survey, assuming the combined effect on the biomass in the year following the survey from recruitment, change in mean weight, and natural mortality is negligible; and ignoring a correction for the potential bias in the catchability coefficient, *q*.**

| Survey | Yield | Option | TS | | | Biomass estimate |
|---|---|---|---|---|---|---|
| year | Year | | multiplier | 10$^{th}$ percentile | Mean | 90$^{th}$ percentile |
| 2011 | 2012 | Snapshots | 0.5 | 1 752 | 2 901 | 4 216 |
| | | 6 & 7 | 1.0 | 4 162 | 6 460 | 9 090 |
| | | | 2.0 | 8 983 | 13 580 | 18 839 |

## 5. STATUS OF THE STOCKS

**Stock Structure Assumptions**
Southern blue whiting are assessed as four independent biological stocks, based on the presence of four main spawning areas (Auckland Islands Shelf, Bounty Platform, Campbell Island Rise, and Pukaki Rise), and some differences in biological parameters and morphometrics between these areas (Hanchet 1999).

The four main stocks SBW6A (Auckland Islands), SBW6B (Bounty Platform), SBW6I (Campbell Island Rise), and SBW6R (Pukaki Rise) cover the four main bathymetric features in the Subantarctic QMA6. SBW1 is a nominal stock covering the rest of the New Zealand EEZ where small numbers of fish may occasionally be taken as bycatch.

- **Auckland Islands (SBW 6A)**

| **Stock Status** | |
|---|---|
| Year of Most Recent Assessment | - |
| Assessment Runs Presented | - |
| Reference Points | Management Target: 40% $B_0$<br>Soft Limit: 20% $B_0$<br>Hard Limit: 10% $B_0$ |
| Status in relation to Target | Unknown |
| Status in relation to Limits | Unknown |
| **Fishery and Stock Trends** | |
| Recent Trend in Biomass or Proxy | Catches have fluctuated without trend |
| Recent Trend in Fishing Mortality or Proxy | Unknown |
| Other Abundance Indices | No reliable indices of abundance |
| Trends in Other Relevant Indicators or Variables | Catch in 2007 and 2008 dominated by large (40-50 cm long) fish - no sign of recent strong year classes. |

| **Projections and Prognosis** | |
|---|---|
| Stock Projections or Prognosis | N/A |
| Probability of Current Catch or TACC causing decline below Limits | Unknown |

| **Assessment Methodology** | | |
|---|---|---|
| Assessment Type | Level 4 - Low information | |
| Assessment Method | None | |
| Main data inputs | Catch history - erratic catches with no trend<br>Limited catch-at-age data (1993-1998) and 2008. | |
| Period of Assessment | None | Next assessment: |
| Changes to Model Structure and Assumptions | N/A | |
| Major Sources of Uncertainty | No reliable time series of data available. Catches have been erratic for the past 10 years and have been taken as bycatch in other middle depth fisheries so unlikely to provide reliable CPUE indices. | |

| **Qualifying Comments** |
|---|
| There were several years of high catches (700-1100 t) during the mid 1990s but since then annual catches have averaged about 100 t. Good recruitment in southern blue whiting tends to be episodic and |

| |
|---|
| it is likely that the period of high catches was due to the presence of the strong year 1991 year class. Catches will probably remain low until another strong year class enters the fishery. |

| **Fishery Interactions** |
|---|
| The main incidental captures of concern at the Auckland Islands are New Zealand sea lions. There was virtually no fish bycatch when it was a target fishery during the mid 1990s. |

- **Bounty Platform (SBW 6B)**

| **Stock Status** | |
|---|---|
| Year of Most Recent Assessment | 2011 |
| Assessment Runs Presented | A matrix of current biomass estimates was presented based on using acoustic survey estimates as absolute abundance under a range of assumptions. $B_0$ was not estimated. |
| Reference Points | Management Target: 40% $B_0$<br>Soft Limit: 20% $B_0$<br>Hard Limit: 10% $B_0$ |
| Status in relation to Target | Unknown |
| Status in relation to Limits | Unknown if the current biomass is below the Soft Limit<br>Unknown if the current biomass is below the Hard Limit |
| Historical Stock Status Trajectory and Current Status | Unknown |

| **Fishery and Stock Trends** | |
|---|---|
| Recent Trend in Biomass or Proxy | Biomass was Unlikely (< 40%) to have been above the target level from 1993 to 2005 but, with the recruitment of the very strong 2002 year class, the stock increased to be at or above pre-exploitation levels until 2008 but has subsequently declined. |
| Recent Trend in Fishing Mortality or Proxy | Unknown |
| Other Abundance Indices | The assessment is based on estimates of absolute abundance from acoustic surveys conducted on industry vessels. |
| Trends in Other Relevant Indicators or Variables | Recruitment was estimated to be relatively low from 1995 to 2001 but was extremely high in 2002 and has been relatively low since then. The 2007 year class appears to be higher than 2003–2006. |

| **Projections and Prognosis** | |
|---|---|
| Sock Projections or Prognosis | The biomass of the Bounty stock is expected to decrease over the next 5 years at the current catch level as the 2002 year class is fished down |
| Probability of Current Catch or TACC causing decline below Limits | Unknown |

| **Assessment Methodology** | | |
|---|---|---|
| Assessment Type | Level 2 - Partial quantitative stock assessment | |
| Assessment Method | Proxy *CAY* yield based on absolute biomass estimates from the 2011 aggregated acoustic survey | |
| Main data inputs | Absolute biomass estimates from acoustic survey of spawning aggregations conducted in 2011 | |
| Period of Assessment | Latest assessment: 2011 | Next assessment: 2012 |
| Changes to Model Structure and Assumptions | - | |
| Major Sources of Uncertainty | Biomass estimates use an estimate of target strength that is | |

| | |
|---|---|
| | uncertain. The reason for the change in biomass since 2008 is unknown (see below). |

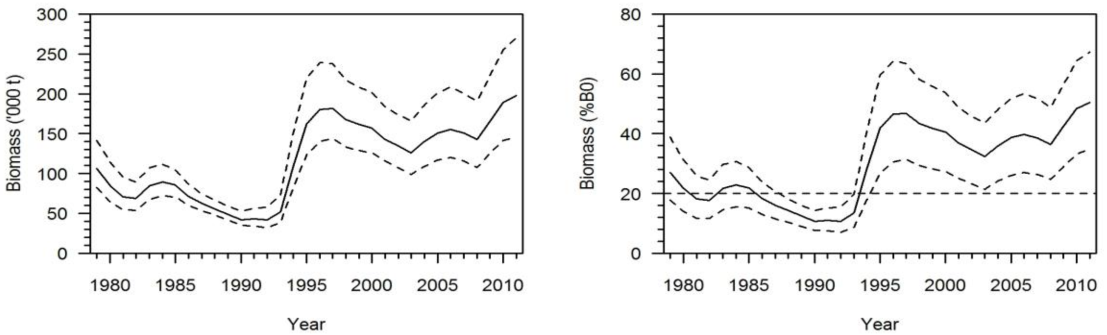
| **Qualifying Comments** |
|---|
| The catch at age data for the last four years have been dominated by the strong 2002 year class. Local area aggregation acoustic surveys carried out in 2007 and 2008 suggested that this was an extremely strong year class, and suggested biomass of 140 000-160 000 t. However, recent surveys in 2009, 2010, and 2011 have suggested a biomass of 25 000 -30 000 t. The observed decline is too great to be explained solely by fishing and average levels of natural mortality of the 2002 year class and it is only possible to speculate on the causes of this decline. Suggested causes include an unusually high natural mortality.<br>Note: The TAC was reduced to 6860 t from 1 April 2011. |

| **Fishery Interactions** |
|---|
| The main incidental capture of concern is of NZ fur seals. There is virtually no fish bycatch in the fishery. |

- **Campbell Island Rise (SBW 6I)**

| **Stock Status** | |
|---|---|
| Year of Most Recent Assessment | 2012 |
| Assessment Runs Presented | Base Case Stock Assessment Model |
| Reference Points | Management Target: 40% $B_0$<br>Soft Limit: 20% $B_0$<br>Hard Limit: 10% $B_0$ |
| Status in relation to Target | $B_{2011}$ was estimated to be 50% $B_0$ and is Likely (> 60%) to be at or above the target |
| Status in relation to Limits | $B_{2011}$ is Exceptionally Unlikely (< 1%) to be below soft or hard limits |

**Historical Stock Status Trajectory and Current Status**




**Trajectory over time of spawning biomass (absolute, and %$B_0$, with 95% credible intervals shown as broken lines) for the Campbell Island stock from the start of the assessment period in 1979 to 2011 (the final assessment year). Years on the x-axis indicate fishing year with "2005" representing the 2004-05 fishing year. Biomass estimates are based on MCMC results.**

| **Fishery and Stock Trends** | |
|---|---|
| Recent Trend in Biomass or Proxy | Biomass was likely to have been below the management target around 1990 and at or above the management target since 2000. With strong recent recruitment the biomass is now increasing. |
| Recent Trend in Fishing Mortality or Proxy | Fishing pressure has reduced with the increase in stock size. |
| Other Abundance Indices | - |

| | |
|---|---|
| Trends in Other Relevant Indicators or Variables | The 2006 and 2007 year classes appear to be exceptionally strong, but slightly less than the 1991 year class. Acoustic estimates of age 2 fish indicate the 2009 year class will likely be strong. |

| **Projections and Prognosis** | |
|---|---|
| Stock Projections or Prognosis | The biomass of the Campbell stock is expected to increase over the next 1-2 years as the strong recent year classes grow and enter the fishery. The TAC was increased to 30,000 t from 1 April 2011. |
| Probability of Current Catch or TACC causing decline below Limits | Soft Limit: Exceptionally Unlikely (< 1%) over next 2-3 years<br>Hard Limit: Exceptionally Unlikely (< 1%) over next 2-3 years |

| **Assessment Methodology** | | |
|---|---|---|
| Assessment Type | Level 1 - Quantitative Stock Assessment | |
| Assessment Method | Age-structured CASAL model with Bayesian estimation of posterior distributions. | |
| Main data inputs | - Research time series based on acoustic indices<br>- Proportions-at-age data from the commercial fisheries and trawl surveys<br>- Estimates of biological parameters | |
| Period of Assessment | Latest assessment: 2012 | Next assessment: 2014 |
| Changes to Model Structure and Assumptions | None | |
| Major Sources of Uncertainty | Uncertainty about the size of recent year classes affects the reliability of stock projections. The data suggest that the 2009 year class is strong, but there is only one observation on this year class. | |

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

| **Fishery Interactions** |
|---|
| The main incidental capture species of concern is the New Zealand sea lion. There is virtually no fish bycatch in the fishery. |

- **Pukaki Rise (SBW 6R)**

| **Stock Status** | |
|---|---|
| Year of Most Recent Assessment | 2002 |
| Assessment Runs Presented | The results of three runs were presented assuming different values for the adult acoustic *q*. |
| Reference Points | Interim Management Target: 40% $B_0$<br>Soft Limit: 20% $B_0$<br>Hard Limit: 10% $B_0$ |
| Status in relation to Target | Current status unknown. Believed to be only lightly exploited between 1993 and 2002 |
| Status in relation to Limits | Current status unknown. Believed to be only lightly exploited between 1993 and 2002 |
| Historical Stock Status Trajectory and Current Status | Unknown |

| **Fishery and Stock Trends** | |
|---|---|
| Recent Trend in Biomass or Proxy | Catches over the last 10 years have fluctuated without trend |
| Recent Trend in Fishing | Unknown |

| | |
|---|---|
| Mortality or Proxy | |
| Other Abundance Indices | No current reliable indices of abundance (wide area surveys were discontinued in 2000) |
| Trends in Other Relevant Indicators or Variables | - |

| **Projections and Prognosis (2002)** | |
|---|---|
| Stock Projections or Prognosis | Unknown |
| Probability of Current Catch or TACC causing decline below Limits | Unknown |

| **Assessment Methodology** | | |
|---|---|---|
| Assessment Type | Level 1 - Full Quantitative Stock Assessment | |
| Assessment Method | Age structured separable Sequential Population Analysis (sSPA) with maximum likelihood estimation | |
| Main data inputs | Abundance indices from wide area acoustic surveys<br>Catch-at-age data | |
| Period of Assessment | Last assessment: 2002 | Next assessment: 2013 |
| Changes to Model Structure and Assumptions | None | |
| Major Sources of Uncertainty | The adult acoustic q was estimated in the model to be 2.7 which the Working Group thought was unrealistically high. A run based on a more plausible value for *q* suggested the 2000 biomass was above 50% $B_0$. | |

| **Qualifying Comments** |
|---|
| Fishers reported large aggregations of fish and made good catches in 2009. However, aggregation surveys by industry vessels in 2009 yielded generally low biomass estimates which were at a level consistent with that during the 1990s. The Subantarctic trawl surveys may provide an index of abundance for this stock, but this has yet to be determined. Catch at age data are available for 2007 and 2009 and suggest the catch is dominated by relatively young fish from the 2003-2006 year classes. |

| **Fishery Interactions** |
|---|
| There is little fish bycatch or marine mammal incidental captures in the target fishery. |

**Table 26: Summary of TACCs and preliminary estimates of landings (t) (1 April-31 March fishing year).**

| Area | 2011-12 Actual TACC | 2011-12 Landings |
|---|---|---|
| SBW 1 (EEZ excluding Sub-Antarctic) | 8 | 2 |
| Campbell Island | 29 400 | 30 840 |
| Bounty Platform | 6 860 | 6 590 |
| Pukaki Rise | 5 500 | 677 |
| Auckland Islands Shelf | 1 640 | 65 |
| Total | 43 408 | 38 174 |

## 6. FOR FURTHER INFORMATION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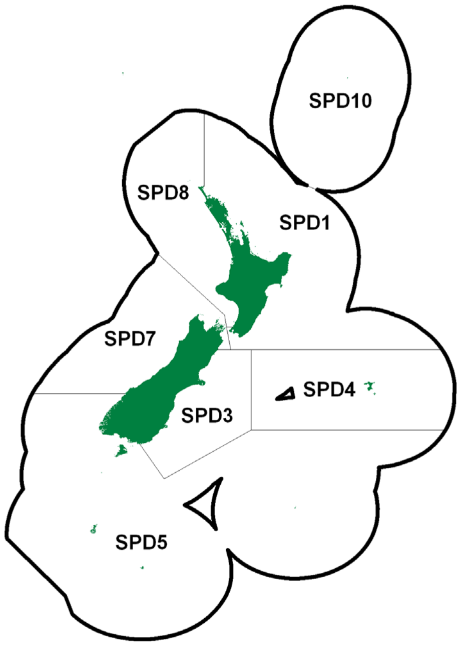
# SPINY DOGFISH (SPD)

(*Squalus acanthias*)
Makohuarau, Pioke, Kāraerae




## 1. FISHERY SUMMARY

### 1.1 Commercial fisheries

Spiny dogfish are found throughout the southern half of New Zealand, extending to East Cape and Manakau Harbour on the east and west coasts of the North Island respectively. A related species the northern spiny dogfish (*Squalus mitsukurii*), is mainly restricted to North Island waters, overlapping with its conspecific in the central west coast area and around the Chatham Islands. Although they have different species codes for reporting purposes it is probable that some misidentification and misreporting occurs - particularly in FMAs 1, 8 and 9.

The best estimate of reported catch from the fishery is shown in the final column in Table 1. For the period 1980-81 to 1986-87 the best estimate of landings is the sum of the FSU data. For the period 1987-88 to 1996-97 this is the sum of the LFRR and the discards from the CELR and CLR. It has been assumed here that all the fish which have been caught and discarded will die, and that all the discarded fish have been recorded. Although neither assumption is likely to be true, and the biases they produce will at least partially cancel each other out, it is likely that the true level of discards is considerably higher. However, these figures are currently the best estimates of total removals from the fishery.

Before 1980-81 landings of rig, and both *Squalus* species were included together and catches of the latter were probably small. Since then the reported catch of spiny dogfish has fluctuated between about 3000 and 7000 t. The reported catch by the deepwater fleet has remained fairly constant during most of the period, averaging 2000-4000 t, with a slight decrease in recent years. Reported catch by the inshore fleet has shown a steady increase throughout the period and is now at a similar level to the catch from the deepwater fleet.

Most of the spiny dogfish caught by the deepwater fleet are taken as a bycatch in the jack mackerel, barracouta, hoki, red cod, and arrow squid fisheries, in depths from 100 to 500 m. Some are packed whole but most are trunked and exported to markets in Asia and Europe.

**Table 1: Reported catches of spiny dogfish (t) by fishing year. FSU (Fisheries Statistics Unit), LFRR (Licensed Fish Receiver Return. Discards reported from CELR (Catch Effort Landing Return), and CLR (Catch Landing Return). Numbers in brackets are probably underestimates. (- no data).**

| | FSU | | | | Best |
|---|---|---|---|---|---|
| | Inshore | Deepwater | LFRR | Discards | Estimate |
| 80-81 | - | (196) | - | - | 196 |
| 81-82 | - | 1 881 | - | - | 1 881 |
| 82-83 | (107) | 2 568 | - | - | 2 675 |
| 83-84 | 309 | 2 949 | - | - | 3 258 |
| 84-85 | 303 | 3 266 | - | - | 3 569 |
| 85-86 | 311 | 2 802 | - | - | 3 113 |
| 86-87 | 870 | 2 277 | 2 608 | - | 3 147 |
| 87-88 | 834 | 3 877 | 4 823 | - | 4 823 |
| 88-89 | (351) | (500) | 3 573 | (16) | 3 589 |
| 89-90 | (14) | 0 | 2 952 | 321 | 3 273 |
| 90-91 | - | - | 5 983 | 333 | 6 316 |
| 91-92 | - | - | 3 274 | 521 | 3 795 |
| 92-93 | - | - | 4 157 | 616 | 4 773 |
| 93-94 | - | - | 6 150 | 1 063 | 7 213 |
| 94-95 | - | - | 4 793 | 628 | 5 421 |
| 95-96 | - | - | 6 230 | 1 920 | 8 150 |
| 96-97 | - | - | 4 887 | 2 572 | 7 459 |

Spiny dogfish are also taken as bycatch by inshore trawlers, setnetters and longliners targeting flatfish, snapper, tarakihi and gurnard. Because of processing problems due to their spines, sandpaper-like skin, and short shelf life, and their low economic value many inshore fishers are not interested in processing and landing them. Furthermore, because of their sheer abundance they can at times severely hamper fishing operations for other commercial species and they are regarded by many fishers as a major nuisance. Trawlers working off Otago during the summer months often reduce towing times and headline heights, and at times leave the area altogether to avoid having to spend hours pulling hundreds of meshed dogfish out of trawl nets. Setnetters and longliners off the Otago coast, and in Tasman Bay and the south Taranaki Bight have also complained about spiny dogfish taking longline baits, attacking commercial fish caught in the nets or lines, and rolling up nets.

The catch by FMA from the FSU, CELR and CLR databases is shown in Table 2. Large catches have been made from FMAs 3, 5, 6, and 7 since 1982-83. Catches from FMA 4 have increased substantially since the mid-1990s. Landings from FMA 5 and 6 were most important in the early 1980s, with 1000-2000 t taken annually by factory trawlers. In more recent years FMA 3, and to a lesser extent, FMA 7 have become more important. The catch in both these areas is taken equally by factory trawlers and inshore fleets. The catch in FMA 1 is unlikely to be spiny dogfish which is considered to be virtually absent from the area, and so these catches should probably be attributed to *S. mitsukurii*.

Competitive quotas of 4075 t for FMA 3, and of 3600 t for FMAs 5 and 6, were introduced for the first time in the 1992-93 fishing year. These quotas were based on yields derived from trawl surveys using a method that is now considered obsolete, and harvest levels which are now considered unreliable. The reported catches exceeded the FMA 3 quota in 1997-98, 2000-01 and 2001-02 and the FMA 5/6 quota in 2002-02.

Spiny dogfish was introduced into the QMS in October 2004. Catches and TACCs are shown in Table 3, while Figure 1 depicts historical landings and TACC values for the main SPD stocks. A breakdown of the TAC for each SPD stock is shown in Table 9.

Prior to their introduction into the QMS spiny dogfish were legally discarded at sea (provided that total catch is reported). Although discard rates increased dramatically through the 1990s (Table 4), this is believed to reflect a change in reporting practise rather than an increase in the proportion of catch discarded.

**Table 2: Reported landings of spiny dogfish by proposed Fishstock. Proportions by area have been taken from CELR and CLR and pro-rated to the best estimate from Table 1. Competitive quotas of 4075 t for FMA 3, and of 3600 t for FMAs 5 and 6, were introduced for the first time in the 1992-93 fishing year.**

| Year | FMA1 | FMA2 | FMA3 | FMA4 | FMA5 | FMA6 | FMA7 | FMA8 | FMA9 | FMA 10 | Other | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1982-83 | 4 | 0 | 151 | 131 | 2 089 | 81 | 145 | 66 | 7 | | | 2 675 |
| 1983-84 | 22 | 18 | 409 | 347 | 565 | 1 700 | 119 | 63 | 16 | | | 3 258 |
| 1984-85 | 21 | 12 | 557 | 481 | 451 | 1 899 | 90 | 48 | 10 | | | 3 569 |
| 1985-86 | 13 | 11 | 892 | 411 | 537 | 1 017 | 120 | 92 | 20 | | | 3 113 |
| 1986-87 | 64 | 18 | 1 048 | 162 | 1 002 | 29 | 501 | 296 | 27 | | | 3 147 |
| 1987-88 | 50 | 9 | 1 664 | 172 | 642 | 16 | 1 402 | 841 | 27 | | | 4 823 |
| 1988-89 | 341 | 16 | 1 510 | 168 | 771 | 7 | 633 | 132 | 11 | | | 3 589 |
| 1989-90 | 36 | 14 | 2 243 | 136 | 241 | 2 | 521 | 80 | 0 | | | 3 273 |
| 1990-91 | 129 | 14 | 2 987 | 513 | 1 708 | 14 | 883 | 67 | 0 | | | 6 316 |
| 1991-92 | 54 | 23 | 1 801 | 66 | 538 | 33 | 1 031 | 249 | 0 | | | 3 795 |
| 1992-93 | 50 | 9 | 2 128 | 218 | 817 | 22 | 1 163 | 366 | 0 | | | 4 773 |
| 1993-94 | 51 | 34 | 3 165 | 358 | 1 158 | 21 | 2 212 | 214 | 0 | | | 7 213 |
| 1994-95 | 84 | 47 | 2 883 | 363 | 606 | 37 | 1 205 | 196 | 0 | | | 5 421 |
| 1995-96 | 68 | 177 | 2 558 | 969 | 1 147 | 152 | 1 205 | 186 | 15 | | | 7 052 |
| 1996-97 | 30 | 159 | 2 428 | 1 287 | 764 | 120 | 1 517 | 235 | 7 | 1 | 1 | 6 555 |
| 1997-98 | 52 | 165 | 5 042 | 917 | 428 | 223 | 2 389 | 1 172 | 34 | 0 | 11 | 10 433 |
| 1998-99 | 45 | 488 | 3 148 | 1 048 | 1 996 | 154 | 1 902 | 74 | < 1 | 0 | < 1 | 8 424 |
| 1999-00 | 15 | 328 | 3 309 | 994 | 1 163 | 189 | 1 505 | 25 | 7 | 0 | 5 | 7 540 |
| 2000-01 | 38 | 336 | 4 355 | 1 075 | 1 389 | 212 | 1 310 | 54 | 16 | 0 | 28 | 8 811 |
| 2001-02 | 12 | 222 | 4 249 | 1 788 | 3 734 | 487 | 961 | 71 | 12 | 0 | - | 11 530 |
| 2002-03 | 10 | 245 | 3 553 | 1 010 | 2 621 | 413 | 772 | 85 | 19 | 0 | 0 | 8 727 |
| 2003-04 | 12 | 91 | 2 077 | 516 | 1 032 | 302 | 423 | 20 | 5 | 0 | 0 | 4 477 |

**Table 3: Reported domestic landings (t) of spiny dogfish by Fishstock and TACC from 2004-05 to 2010-11.**

| Fishstock | SPD 1 | | SPD 3 | | SPD 4 | | SPD 5 | | SPD 7 | |
|---|---|---|---|---|---|---|---|---|---|---|
| FMA | 1&2 | | 3 | | 4 | | 5&6 | | 7 | |
| | Landings | TACC | Landings | TACC | Landings | TACC | Landings | TACC | Landings | TACC |
| 2004-05 | 234 | 331 | 2 707 | 4 794 | 839 | 1 626 | 2 479 | 3 700 | 842 | 1 902 |
| 2005-06 | 186 | 331 | 3 831 | 4 794 | 1 055 | 1 626 | 2 298 | 3 700 | 832 | 1 902 |
| 2006-07 | 239 | 331 | 2 712 | 4 794 | 822 | 1 626 | 2 165 | 3 700 | 1 125 | 1 902 |
| 2007-08 | 156 | 331 | 2 082 | 4 794 | 1 397 | 1 626 | 1 501 | 3 700 | 928 | 1 902 |
| 2008-09 | 229 | 331 | 1 981 | 4 794 | 866 | 1 626 | 2 071 | 3 700 | 929 | 1 902 |
| 2009-10 | 128 | 331 | 1 855 | 4 794 | 667 | 1 626 | 2 205 | 3 700 | 1 116 | 1 902 |
| 2010-11 | 149 | 331 | 1 976 | 4 794 | 825 | 1 626 | 1 443 | 3 700 | 1 413 | 1 902 |

| Fishstock | SPD 8 | | | |
|---|---|---|---|---|
| FMA | 8&9 | | Total | |
| | Landings | TACC | Landings | TACC |
| 2004-05 | 121 | 307 | 7 222 | 12 660 |
| 2005-06 | 108 | 307 | 8 311 | 12 660 |
| 2006-07 | 118 | 307 | 7 181 | 12 660 |
| 2007-08 | 124 | 307 | 6 188 | 12 660 |
| 2008-09 | 150 | 307 | 6 226 | 12 660 |
| 2009-10 | 194 | 307 | 6 166 | 12 660 |
| 2010-11 | 219 | 307 | 6 026 | 12 660 |

**Table 4: Discard rates (% of catch) by QMA and fishing year (after Manning *et al*. 2004).**

| Fishing year | QMA | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Other | Total |
| 1989-90 | 11 | 17 | 18 | 4 | 46 | 100 | 13 | 34 | 0 | 0 | 0 | 18 |
| 1990-91 | 7 | 0 | 6 | 2 | 29 | 11 | 21 | 24 | 0 | 0 | 0 | 11 |
| 1991-92 | 9 | 3 | 8 | 13 | 34 | 90 | 42 | 18 | 0 | 0 | 0 | 20 |
| 1992-93 | 13 | 47 | 5 | 51 | 39 | 43 | 20 | 80 | 0 | 0 | 0 | 21 |
| 1993-94 | 5 | 65 | 13 | 42 | 21 | 34 | 29 | 66 | 0 | 0 | 0 | 23 |
| 1994-95 | 2 | 52 | 8 | 31 | 20 | 74 | 29 | 64 | 98 | 0 | 5 | 19 |
| 1995-96 | 7 | 39 | 18 | 55 | 39 | 94 | 45 | 72 | 100 | 0 | 11 | 36 |
| 1996-97 | 15 | 61 | 26 | 40 | 70 | 68 | 59 | 89 | 93 | 0 | 16 | 44 |
| 1997-98 | 53 | 83 | 51 | 53 | 72 | 86 | 81 | 92 | 100 | 0 | 16 | 64 |
| 1998-99 | 20 | 92 | 57 | 60 | 29 | 78 | 82 | 63 | 0 | 0 | 16 | 58 |
| 1999-00 | 9 | 86 | 60 | 55 | 39 | 68 | 81 | 84 | 35 | 0 | 0 | 62 |
| 2000-01 | 37 | 70 | 60 | 77 | 57 | 77 | 72 | 56 | 29 | 0 | 87 | 64 |
| Total | 15 | 74 | 35 | 53 | 42 | 78 | 54 | 68 | 78 | 0 | 16 | 45 |

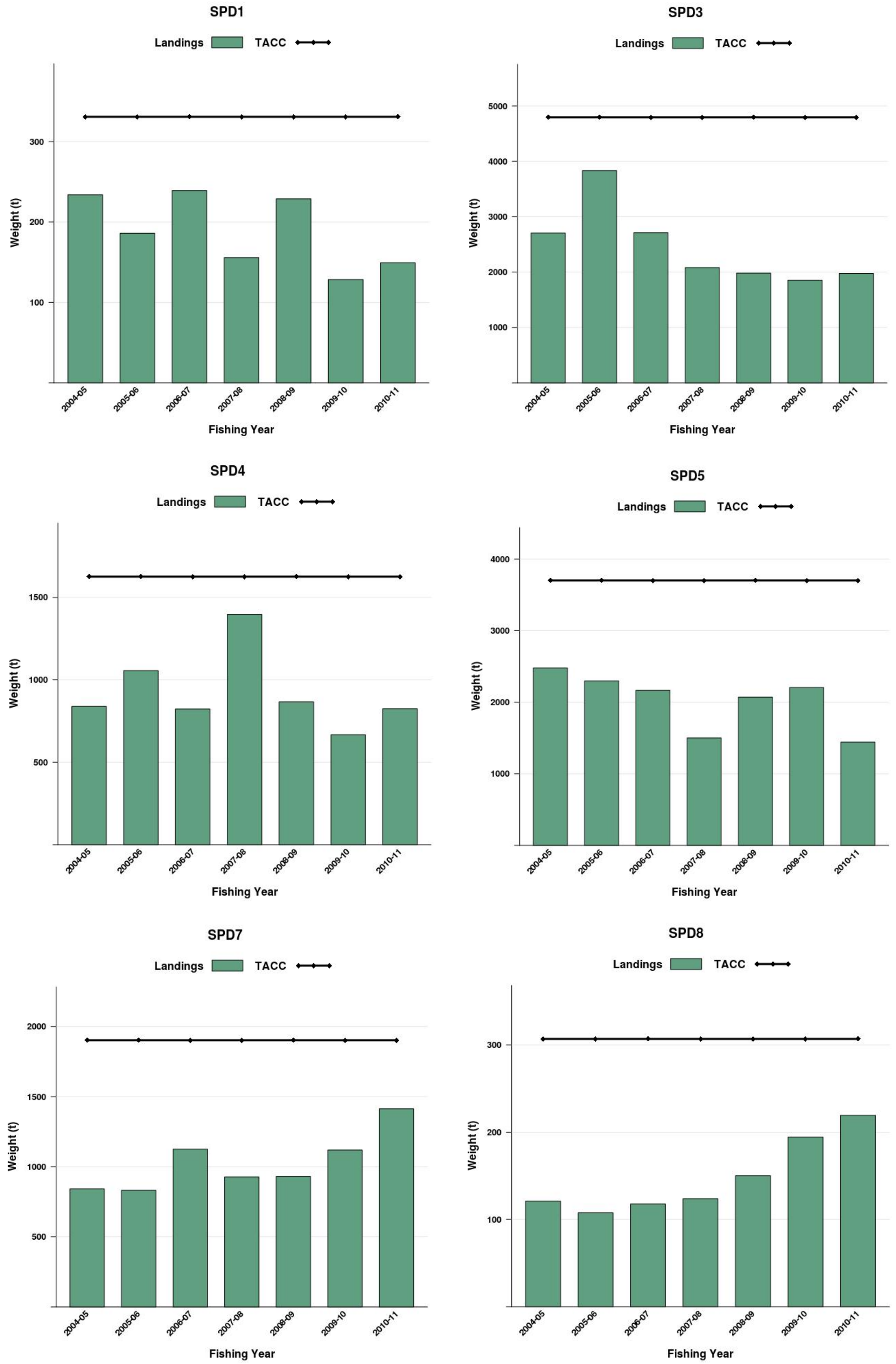



**Figure 1: Historical landings and TACC for the six main SPD stocks. From top left to bottom right: SPD1 (Auckland East, Central East), SPD3 (South East Coast), SPD4 (South East Chatham Rise), SPD5 (Sub Antarctic, Southland), SPD7 (Challenger), and SPD8 (Central Egmont, Auckland West). Note that these figures do not show data prior to entry into the QMS.**

## 1.2 Recreational fisheries

Spiny dogfish are caught by recreational fishers throughout their geographical range in New Zealand. They are mainly taken as bycatch when targeting other more valued species using rod and line and setnet. In many parts of New Zealand, spiny dogfish are regarded by recreational anglers as a pest, often clogging nets and taking baits from hooks. Estimates of recreational landings obtained from three surveys in 1991-92 to 1993-94, 1996 and 1999-00 are given in Table 5. Overall, recreational landings probably comprise only a small proportion (< 10 %) of the total spiny dogfish catch.

**Table 5: Estimated number and weight of spiny dogfish harvested by recreational fishers by Fishstock and survey. Surveys were carried out in different years in the Ministry of Fisheries regions: South in 1991-92, Central in 1992-93, North in 1993-94 (Teirney *et al*. 1997) and nationally in 1996 (Bradford 1998) and 1999-00 (Boyd & Reilly 2005). Survey harvests are presented as a range to reflect the uncertainty in the estimates.**

| Fishstock | Survey | Number | CV% | Harvest Range (t) | Point estimate (t) |
|---|---|---|---|---|---|
| 1991-92 | | | | | |
| QMA 3 | South | | 23 | | 120 |
| QMA 5 | South | | - | | 2 |
| QMA 7 | South | | 92 | | 11 |
| 1992-93 | | | | | |
| QMA 2 | Central | | 42 | | 133 |
| QMA 7 | Central | | 35 | | 46 |
| QMA 8 | Central | | 45 | | 143 |
| 1993-94 | | | | | |
| QMA 1,9 | North | | - | | < 10 |
| 1996 | | | | | |
| QMA 1 | National | 1 000 | - | - | - |
| QMA 2 | National | 5 000 | - | - | - |
| QMA 3 | National | 21 000 | 17 | 25-40 | 33 |
| QMA 5 | National | 9 000 | - | - | - |
| QMA 7 | National | 24 000 | 21 | 30-45 | 37 |
| QMA 9 | National | 15 000 | - | - | - |
| 1999-00 | | | | | |
| QMA 1 | National | 9 000 | 61 | 4.4-17.9 | 11 |
| QMA 2 | National | 22 000 | 37 | 17.3-37.8 | 28 |
| QMA 3 | National | 93 000 | 27 | 83.2-145.9 | 115 |
| QMA 5 | National | 7 000 | 47 | 4.4-12.3 | 8 |
| QMA 7 | National | 25 000 | 35 | 20.4-41.9 | 31 |
| QMA 8 | National | 21 000 | 52 | 12.7-40.3 | 27 |
| QMA 9 | National | 12 000 | 82 | 2.7-26.2 | 14 |

The Recreational Technical Working Group concluded that the harvest estimates from the diary surveys should be used only with the following qualifications: a) they may be very inaccurate; b) the 1996 and earlier surveys contain a methodological error; and c) the 2000 and 2001 estimates are implausibly high for many important fisheries.

## 1.3 Customary non-commercial fisheries

Maori fishers traditionally caught large numbers of "dogfish" during the last century and this included rig, school shark, and spiny dogfish. Quantitative information on the current level of customary non-commercial fisheries take is not available.

## 1.4 Illegal catch

It is unlikely that there is an illegal catch of spiny dogfish as the quota for this species has never been reached, and it has low commercial value.

## 1.5 Other sources of mortality

It is likely that there is a large amount of spiny dogfish discarded by fishers which is never reported on the returns. The level of mortality and any temporal trends from non-reported discards have not been estimated. The introduction of cost recovery charges in 1994-95 may account for the decline in reported discards in that year.

## 2. BIOLOGY

Spiny dogfish are widely distributed around the South Island and extend as far north as Manakau Harbour and East Cape on the west and east coasts of the North Island respectively. They are most abundant on the east coast of the South Island and the Stewart/Snares Shelf. They are found on the continental shelf and upper slope down to a depth of at least 500 m, but are most common in depths of 50-150 m. Schools are strongly segregated by size and sex. The size of fish in the commercial fishery is not known but will depend to a large extent on the method of capture and area fished.

Spiny dogfish are born at a size of 18-30 cm total length (TL). They have been aged using fin spines, and early growth has been validated by following modes in length-frequency and eye lens weight frequency data. Males mature at 58 cm TL at age 6, and females mature at 73 cm TL at age 10. The maximum ages and lengths in a study of east coast South Island dogfish were 21 years and 90 cm TL for males, and 26 years and 111 cm TL for females.

*M* was estimated using the equation $\log_e 100$/maximum age, where maximum age is the age to which 1% of the population survive in an unexploited stock. Using a maximum age of 26 gave an estimate of *M* of 0.18. This has been revised up to 0.2 to reflect the imprecision with which this estimate is known. A similar estimate of *M* was obtained using a survivorship table approach (Hanchet 1986). At an instantaneous mortality rate of 0.2 $\text{year}^{-1}$ an initial population of 1000 females would replace themselves over their lifespan (given their length-at-age, length-at-maturity and fecundity-length relationships).

Female spiny dogfish give birth to young over an extended period between April and September, mainly on the shelf edge in depths of 200-300 m. Mating also occurs in deeper water (coincident with a movement of mature males offshore), after which females with young "candled" embryos move into shallower waters of 100 m or less. They remain there for 12 months until the embryos are 15 cm long after which they return to deeper water. Parturition occurs after a gestation period approaching 24 months, and is closely followed by mating and ovulation and the biennial cycle is repeated. Both the number and the size of young increase linearly with the length of the mother. The number of young per litter ranges from 1 to 19.

Young of the year move inshore into shallower waters shortly after birth. Over the next few years they move steadily into deeper water but remain in size segregated schools comprising up to 2 or 3 age classes. Once maturity is reached both males and females undergo inshore/offshore migrations associated with reproductive activity. A north/south migration along the east coast South Island during autumn/spring has also been postulated but the full extent of this migration is unknown.

Spiny dogfish are found both on the bottom and in mid-water and feed on a very wide range of species, including *Munida*, krill, fish, squid, and crabs.

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

**Table 6: Estimates of biological parameters of spiny dogfish for QMA3 (Hanchet 1986).**

1. Natural mortality (*M*)

0.2

2. Weight = a (length)$^b$ (Weight in g, length in cm fork length)

| | Males | | Females | |
|---|---|---|---|---|
| | a | b | a | b |
| | 0.0027 | 3.05 | 0.0013 | 3.25 |

3. von Bertalanffy growth parameters

| Males | | | Females | | |
|---|---|---|---|---|---|
| $K$ | $t_0$ | $L_\infty$ | $K$ | $t_0$ | $L_\infty$ |
| 0.116 | -2.88 | 89.5 | 0.069 | -3.45 | 120.1 |

4. Maturity ogive

| Age (years) | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **➢ 12** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Males | 0.00 | 0.02 | 0.21 | 0.68 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Females | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.04 | 0.23 | 0.52 | 0.75 | 1.00 | 1.00 |

## 3. STOCKS AND AREAS

No specific research on the stock structure of spiny dogfish has been carried out. Limited tagging has been conducted, so the only available data come from seasonal trawl surveys, and fisheries landings data.

The analysis of *W.J. Scott* and *James Cook* surveys carried out from 1978 to 1983 clearly showed seasonal migrations of spiny dogfish along the east coast of South Island (ECSI). Spiny dogfish were most abundant in the southern part of the coast from October to April, and more abundant to the north in May to September. It is also clear from summer trawl surveys of the area that there is a resident part of the population of spiny dogfish on the Stewart/Snares Shelf over the summer months. However, there have been no comparable series of seasonal surveys there and so it is presently unclear whether the East Coast South Island (ECSI) fish migrate south as far as the Stewart/Snares Shelf. Until more data become available fish from the two areas should be treated as separate stocks.

Seasonal trawl surveys were also carried out on West Coast South Island (WCSI) between June 1981 and April 1983 using the *W.J. Scott.* The catches showed a strong seasonal component being highest in summer and autumn and lowest in winter and spring. It is likely that some fish migrate north in winter, perhaps to the northern and southern Taranaki Bights, and Tasman Bay and Golden Bay. However, it is also clear from summer trawl surveys of the areas that there is a resident part of the population of spiny dogfish in the Taranaki Bights over the summer months. It may therefore be appropriate to treat fish from QMA 7 and 8 as a single stock.

There is little commercial catch in QMAs 1, 2, 4, and 9, and little data on movement in or between the areas. Until more data have been obtained it would seem appropriate to manage spiny dogfish with the following 5 Fishstocks:

SPD 1: QMA 1 & 2
SPD 3: QMA 3
SPD 4: QMA 4
SPD 5: QMA 5 & 6
SPD 7: QMA 7, 8 & 9

## 4. STOCK ASSESSMENT

There are no estimates of current or virgin biomass. This is the first stock assessment for spiny dogfish.

### 4.1 Estimates of fishery parameters and abundance

Biomass indices of spiny dogfish from recent trawl surveys using *Tangaroa* and *Kaharoa* are summarised in Table 7 and Figure 2. Based on a combination of CVs, variability in biomass indices and the time span of each series, it is concluded that surveys only provide reliable indices of dogfish abundance off the west coast of the South Island and on the Chatham Rise. Relative biomass indices suggest that spiny dogfish became more abundant on the Chatham rise during the early to mid 1990s. Apart from a temporary increase during the mid-1990s, the abundance of dogfish off the west coast of South Island appears to have been fairly stable between 1991 and 2003. Although the relevant surveys were discontinued, spiny dogfish appear also to have increased substantially in abundance off the east coast of the South Island and on the Stewart-Snares shelf in the mid 1990s.

**Table 7: Biomass indices (t) and coefficients of variation (CV) from trawl surveys assuming vulnerability, spatial availability and vertical availability equal 1. Note: because trawl survey biomass estimates are indices, comparisons between different seasons (e.g., summer and winter ECSI) are not strictly valid.**

| QMA | Area | Vessel | Trip code | Date | Fishing year | Biomass (t) | CV (%) |
|---|---|---|---|---|---|---|---|
| 2 | East coast North Island | KAH | KAH9304 | Feb-Mar 1993 | 1992-93 | 963 | 78 |
| | | | KAH9402 | Feb-Mar 1994 | 1992-94 | 988 | 47 |
| | | | KAH9502 | Feb-Mar 1995 | 1994-95 | 658 | 25 |
| | | | KAH9602 | Feb-Mar 1996 | 1995-96 | 1 026 | 51 |
| 3 | East coast South Island (*Winter*) | KAH | KAH9105 | May-Jun 1991 | 1990-91 | 12 873 | 22 |
| | | | KAH9205 | May-Jun 1992 | 1991-92 | 10 787 | 26 |
| | | | KAH9306 | May-Jun 1993 | 1992-93 | 13 949 | 17 |
| | | | KAH9406 | May-Jun 1994 | 1993-94 | 14 530 | 10 |
| | | | KAH9606 | May-Jun 1996 | 1995-96 | 35 169 | 15 |
| | | | KAH0705 | May-Jun 2007 | 2006-07 | 35 386 | 24 |
| | | | KAH0806 | May-Jun 2008 | 2007-08 | 28 476 | 22 |
| | | | KAH0905 | May-Jun 2009 | 2008-09 | 25 311 | 31 |
| | East coast South Island (*Summer*) | KAH | KAH9618 | Dec-Jan 1996-97 | 1996-97 | 35 776 | 28 |
| | | | KAH9704 | Dec-Jan 1997-98 | 1997-98 | 29 765 | 25 |
| | | | KAH9809 | Dec-Jan 1998-99 | 1998-99 | 22 842 | 16 |
| | | | KAH9917 | Dec-Jan 1999-00 | 1999-00 | 49 832 | 37 |
| | | | KAH0014 | Dec-Jan 2000-01 | 2000-01 | 30 508 | 34 |
| 4 | Chatham Rise | TAN | TAN9106 | Dec-Feb 1991-92 | 1991-92 | 2 390 | 14 |
| | | | TAN9212 | Dec-Feb 1992-93 | 1992-93 | 2 220 | 11 |
| | | | TAN9401 | Jan-Feb 1994 | 1993-94 | 3 449 | 13 |
| | | | TAN9501 | Jan-Feb 1995 | 1994-95 | 2 841 | 21 |
| | | | TAN9601 | Dec-Jan 1995-96 | 1995-96 | 4 969 | 11 |
| | | | TAN9701 | Jan 1997 | 1996-97 | 9 570 | 14 |
| | | | TAN9801 | Jan 1998 | 1997-98 | 5 724 | 17 |
| | | | TAN9901 | Jan 1999 | 1998-99 | 8 551 | 13 |
| | | | TAN0001 | Dec-Jan 1999-00 | 1999-00 | 8 905 | 9 |
| | | | TAN0101 | Dec-Jan 2000-01 | 2000-01 | 9 586 | 9 |
| | | | TAN0201 | Dec-Jan 2001-02 | 2001-02 | 6 334 | 8 |
| | | | TAN0301 | Dec-Jan 2002-03 | 2002-03 | 6 191 | 17 |
| | | | TAN0401 | Jan 2004 | 2003-04 | 12 289 | 18 |
| | | | TAN0501 | Jan 2005 | 2004-05 | 7 227 | 15 |
| | | | TAN0601 | Jan 2006 | 2005-06 | 5 650 | 14 |
| | | | TAN0701 | Jan 2007 | 2006-07 | 5 906 | 10 |
| | | | TAN0801 | Jan 2008 | 2007-08 | 15 674 | 38 |
| | | | TAN0901 | Jan 2009 | 2008-09 | 5 548 | 11 |
| | | | TAN1001 | Jan 2010 | 2009-10 | 6 698 | 17 |
| | | | TAN1101 | Jan 2011 | 2010-11 | 7 794 | 14 |
| | | | TAN1201 | Jan 2012 | 2012 | 5 438 | 14 |
| 5 | Stewart-Snares Shelf | TAN | TAN9301 | Feb-Mar 1993 | 1992-93 | 36 023 | 13 |
| | | | TAN9402 | Feb-Mar 1994 | 1993-94 | 36 328 | 17 |
| | | | TAN9502 | Feb-Mar 1995 | 1994-95 | 91 364 | 29 |
| | | | TAN9604 | Feb-Mar 1996 | 1995-96 | 89 818 | 29 |
| 6 | Sub-Antarctic (*Spring*) | TAN | TAN9105 | Nov-Dec 1991 | 1991-92 | 8 502 | 55 |
| | | | TAN9211 | Nov-Dec 1992 | 1992-93 | 1 150 | 15 |
| | | | TAN9310 | Nov-Dec 1993 | 1993-94 | 1 585 | 21 |
| | | | TAN0012 | Nov-Dec 2000 | 2000-01 | 4 173 | 12 |
| | | | TAN0118 | Nov-Dec 2001 | 2001-02 | 8 528 | 31 |
| | | | TAN0219 | Nov-Dec 2002 | 2002-03 | 3 505 | 19 |
| | | | TAN0317 | Nov-Dec 2003 | 2003-04 | 2 317 | 17 |
| | | | TAN0414 | Nov-Dec 2004 | 2004-05 | 3 378 | 27 |
| | | | TAN0515 | Nov-Dec 2005 | 2005-06 | 4 344 | 19 |
| | | | TAN0617 | Nov-Dec 2006 | 2006-07 | 3 039 | 19 |
| 6 | Sub-Antarctic (*Autumn*) | TAN | TAN9204 | Apr-May 1992 | 1991-92 | 0 926 | 30 |
| | | | TAN9304 | May-Jun 1993 | 1992-93 | 0 440 | 38 |
| | | | TAN9605 | Mar-Apr 1996 | 1995-96 | 0 207 | 56 |
| | | | TAN9805 | Apr-May 1998 | 1997-98 | 1 532 | 36 |
| 7 | West coast South Island | KAH | KAH9204 | Mar-Apr 1992 | 1991-92 | 3 919 | 15 |
| | | | KAH9404 | Mar-Apr 1994 | 1993-94 | 7 145 | 7 |
| | | | KAH9504 | Mar-Apr 1995 | 1994-95 | 8 370 | 10 |
| | | | KAH9701 | Mar-Apr 1997 | 1996-97 | 5 275 | 13 |
| | | | KAH0004 | Mar-Apr 2000 | 1999-00 | 4 777 | 12 |
| | | | KAH0304 | Mar-Apr 2003 | 2002-03 | 4 446 | 15 |
| | | | KAH0503 | Mar-Apr 2005 | 2004-05 | 6 175 | 12 |
| | | | KAH0704 | Mar-Apr 2007 | 2006-07 | 6 219 | 14 |
| | | | KAH0904 | Mar-Apr 2009 | 2008-09 | 10 270 | 19 |
| | | | KAH1004 | Mar-Apr 2010 | 2010-11 | 6 402 | 13 |
| 9 | West coast North Island | KAH | KAH9111 | Oct 1991 | 1991-92 | 443* | 34 |
| | | | KAH9410 | Oct 1994 | 1994-95 | 381* | 30 |
| | | | KAH9615 | Oct 1996 | 1996-97 | 634* | 68 |
| | | | KAH9915 | Nov 1999 | 1999-00 | 106* | 15 |

Manning *et al*. (2004) recently evaluated the usefulness of commercial CPUE, commercial length composition, trawl survey relative biomass estimates and trawl-survey-catch length-composition for monitoring all major SPD stocks (Table 8).

**Table 8: Catch and effort data sets and analyses evaluated as monitoring tools for major SPD stocks.**

| QMA | Data set and analysis |
|---|---|
| SPD 3 - East coast South Island | 1. Standardised setnet CPUE for core vessels targeting SPD. |
| | 2. Standardised setnet CPUE for core vessels targeting all species. |
| | 3. Standardised bottom trawl CPUE for core vessels targeting all species. |
| | 4. Relative abundance indices from East Coast South Island trawl surveys (discontinued after 2001) |
| SPD 4 - Chatham Rise | 5. Standardised bottom trawl CPUE for core Korean vessels |
| | 6. Standardised bottom trawl CPUE for core domestic vessels |
| | 7. Standardised bottom longline CPUE for core domestic vessels |
| | 8. Relative abundance indices from Chatham Rise trawl surveys. |
| SPD 5 - Stewart Snares Shelf | 9. Standardised bottom trawl CPUE. |
| | 10. Relative abundance indices from Stewart-Snares shelf surveys (discontinued after 1996) |
| SPD 7 - West Coast South Island | 11. Standardised bottom trawl CPUE for core vessels |
| | 12. Relative abundance indices from West coast South Island Trawl Surveys. |

Based on the results of the analyses listed in Table 8, the following methods were recommended for monitoring SPD:

| QMA | Recommended Monitoring Tools |
|---|---|
| SPD 3 - East coast South Island | Standardised setnet CPUE using model 2 (core vessels targeting all species) |
| SPD 4 - Chatham Rise | Chatham Rise Trawl Survey and length composition of commercial catch |
| SPD 5 - Stewart Snares Shelf | *Standardised bottom trawl CPUE and length composition of commercial catch. |
| SPD 7 - West Coast South Island | West coast South Island Trawl survey and length composition of commercial catch |

* Information on historical changes in reporting rates is required before this index can be used.

### 4.2 Biomass estimates

Lack of suitable information has precluded estimation of virgin and current biomass for spiny dogfish. Although most of the necessary biological parameters (Hanchet 1986, 1988, Hanchet & Ingerson 1997), relative indices of abundance and data required to estimate fishing selectivity for most important fisheries (with the exception FMA 4 bottom longline and QMA 3 setnet fisheries) are now available, robust stock assessments will also require estimates of historical, unreported discarding and discard mortality so that an accurate history of fishery related removals can be constructed.

### 4.3 Estimation of Maximum Constant Yield (*MCY*)

*MCY* cannot be estimated.

### 4.4 Estimation of Current Annual Yield (*CAY*)

*CAY* cannot be determined.

### 4.5 Other factors

The ability to withstand harvesting depends on the strength of a number of compensatory mechanisms. For example, under exploitation individuals may grow faster, show increased fecundity, or suffer reduced natural mortality. In elasmobranchs the number of young born is related directly to the number of adult females, and, because of the relatively large size and hence good survival of the young at birth, it is presumed that there is a strong stock recruit relationship for these species.

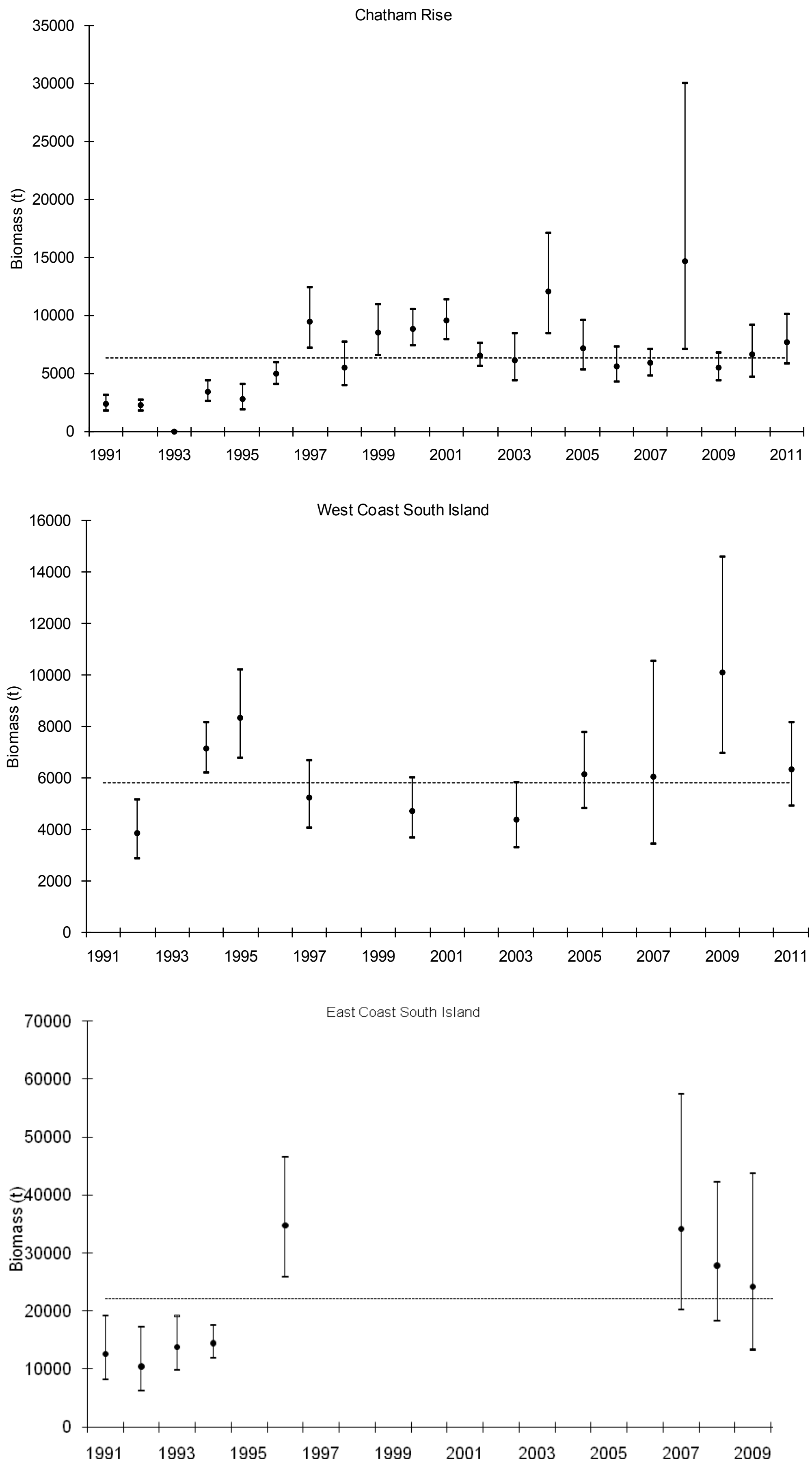



**Figure 2: Spiny dogfish biomass ±95% CI (estimated from survey CVs assuming a lognormal distribution) and the time series mean (dotted line) estimated from the Chatham Rise (Top), West (Middle) and East (bottom) Coast South Island trawl survey.**

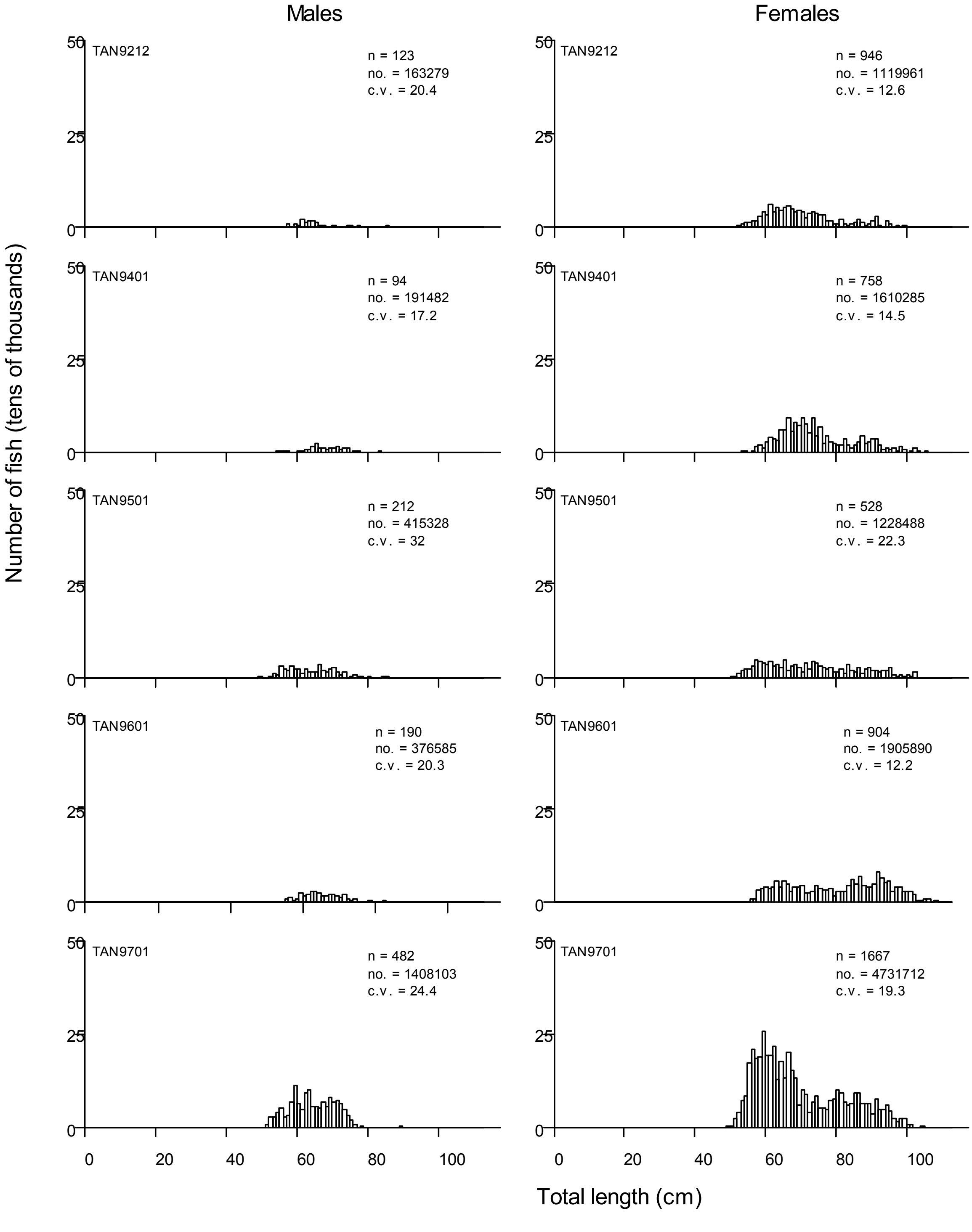



**Figure 3: Scaled length frequency distributions for spiny dogfish, for Chatham Rise surveys. M, males and F, females, (CV) (Stevens *et al.* 2011).**

Several methods of estimating *MCY* involve the multiplication of a harvest level by an estimate of $B_0$ or $B_{av}$. Francis & Francis (1992) used Monte Carlo simulation to estimate harvest levels for calculating *MCY* for a rig stock. No stock-recruitment data were available for elasmobranchs at the time and so they used values for the Beverton & Holt steepness parameter ranging from 0.35 to 0.50, and recruitment variability of 0.4. These values were all at the low range of values used for teleost species and which they considered appropriate for rig. The results of their simulation studies showed that the estimates of *MCY* obtained using the harvest levels given in the equations in the Guide to Biological Reference

Points were overly optimistic for rig. Given that spiny dogfish have a slower growth rate and are less fecund than rig, it seems reasonable to assume that those harvest levels are also unsuitable for spiny dogfish.

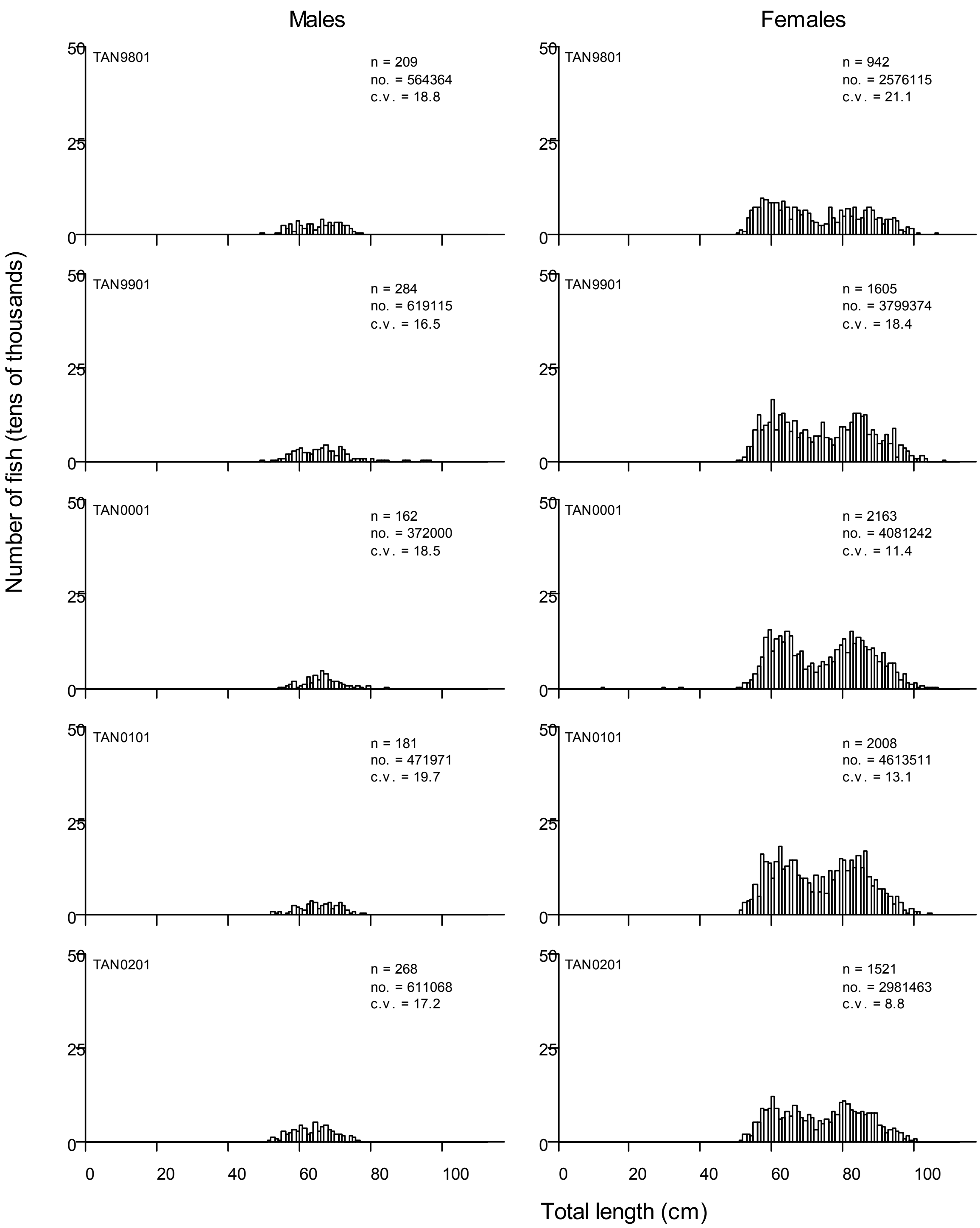



**Figure 3 [Continued].**

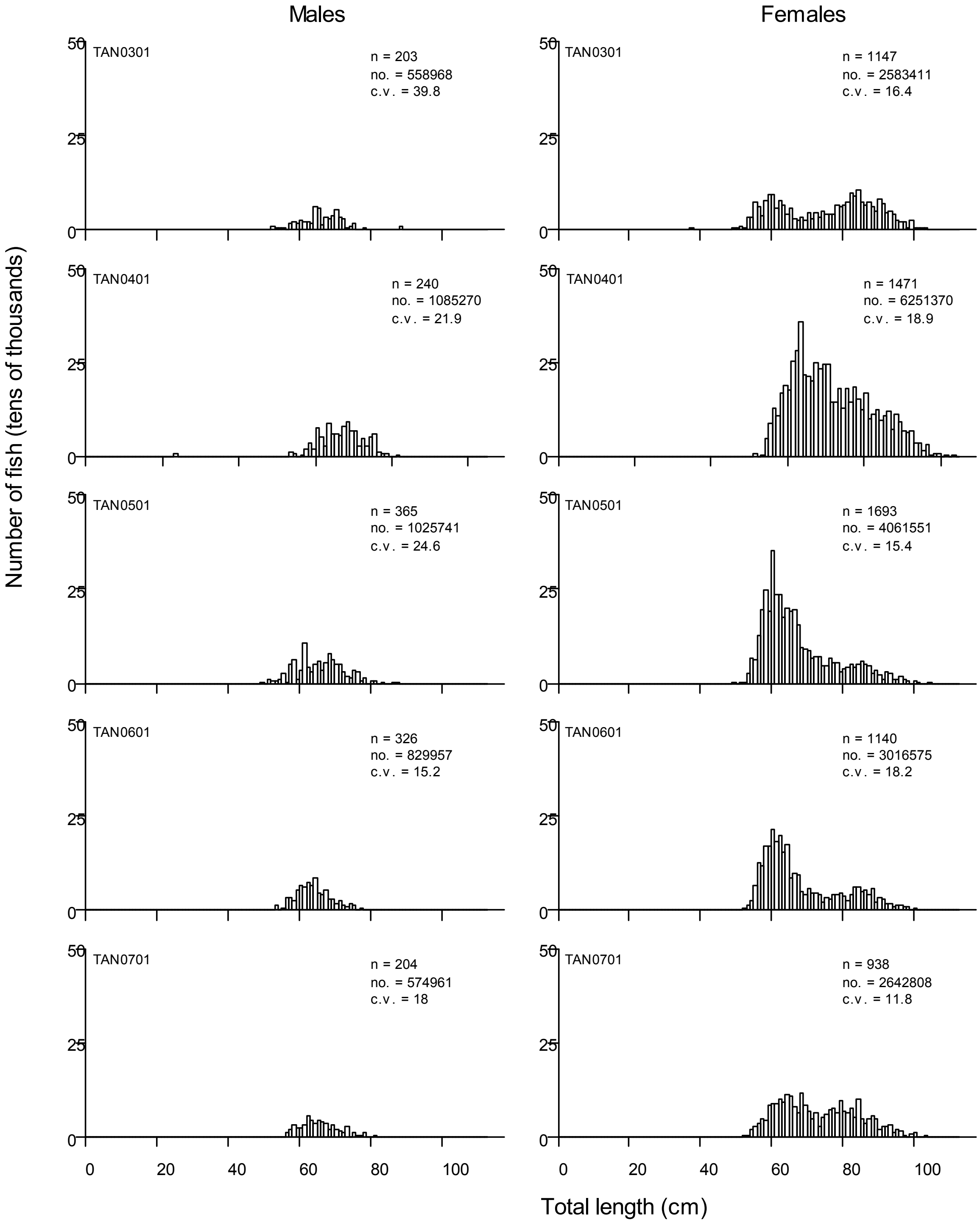



**Figure 3 [Continued].**

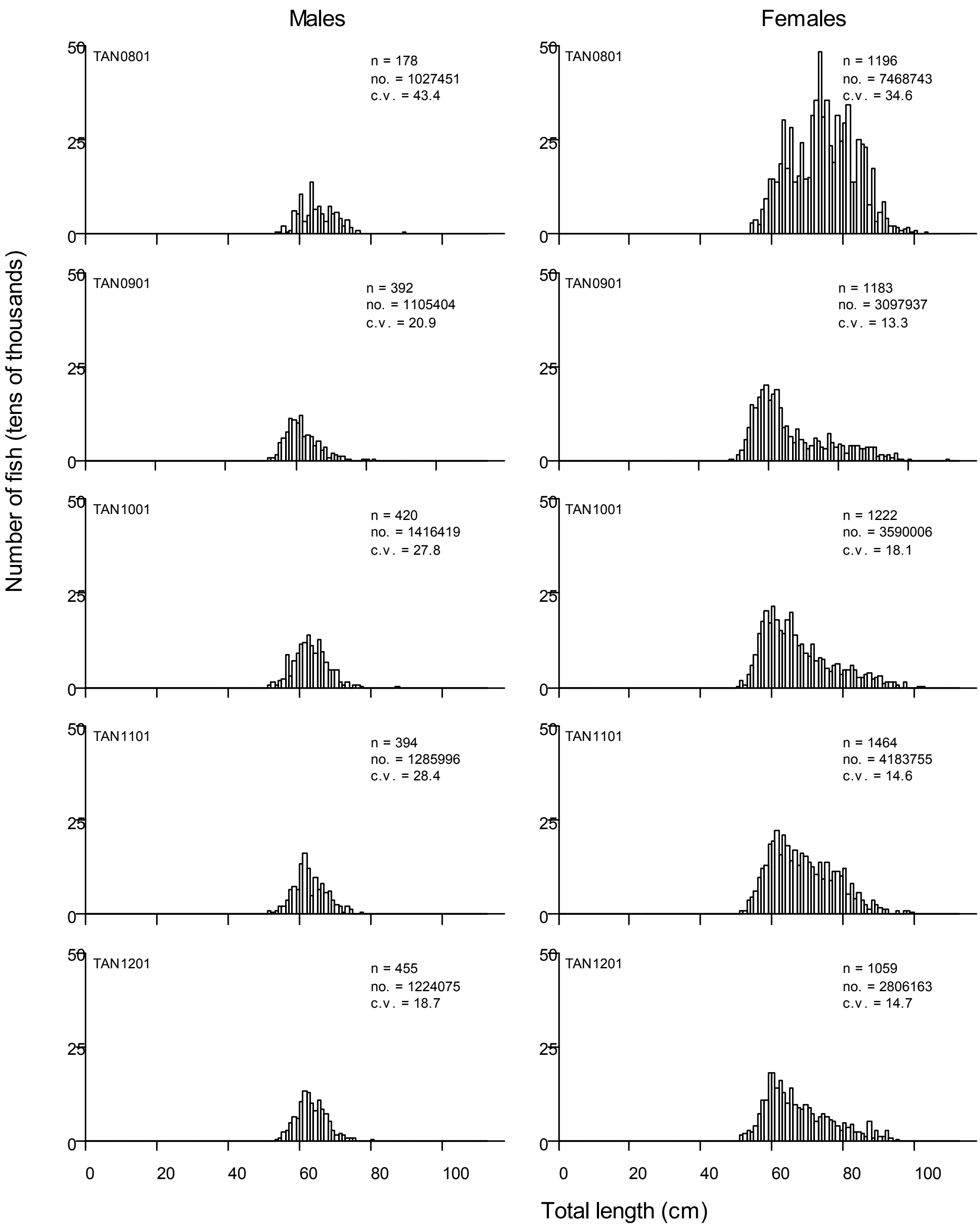



**Figure 3 [Continued].**

# 5. STATUS OF THE STOCKS

No estimates of current or reference biomass are available, but trawl survey estimates of abundances are all at or above the long term average (1991-2009 or 2011).

Although reported commercial catches of spiny dogfish were observed to increase in all major FMAs during the 1990s, the extent to which these increases can be attributed to changes in reporting practice (i.e., more accurate reporting of discards in recent times) is uncertain. Trawl surveys, on the other hand, indicate that there was a general increase in the abundance of spiny dogfish, particularly around the South Island, in the mid 1990s.

Reported landings and TACCs for the 2010-11 fishing year are summarised in Table 9.

**Table 9: Other mortality, recreational, and customary non-commercial allowances (t), Total Allowable Commercial Catches (TACC, t) and Total Allowable Catch (TAC, t), along with reported landings (t) of SPD for the most recent fishing year.**

| Fishstock | | FMA | Other Mortality | Recreational | Customary | TACC | TAC | 2010-11 Reported landings |
|---|---|---|---|---|---|---|---|---|
| SPD 1 | Auckland (East), Central (East) | 1&2 | 4 | 39 | 39 | 331 | 413 | 149 |
| SPD 3 | South east (coast) | 3 | 51 | 115 | 115 | 4 794 | 5 075 | 1 976 |
| SPD 4 | South east (Chatham) | 4 | 16 | 10 | 10 | 1 626 | 1 662 | 825 |
| SPD 5 | Southland, sub-Antarctic | 5&6 | 37 | 8 | 8 | 3 700 | 3 753 | 1 443 |
| SPD 7 | Challenger | 7 | 19 | 31 | 31 | 1 902 | 1 983 | 1 413 |
| SPD 8 | Central (west), Auckland (west) | 8&9 | 3 | 41 | 41 | 307 | 392 | 219 |
| SPD 10 | Kermadec | 10 | 0 | 1 | 1 | 0 | 2 | 0 |
| Total | | | 130 | 245 | 245 | 12 660 | 13 280 | 6 026 |

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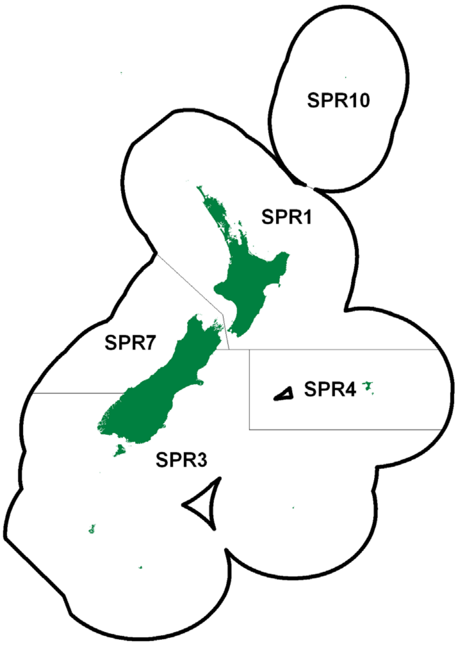
# SPRAT (SPR)

(*Sprattus antipodum, S. muelleri*)
Kupae




## 1. FISHERY SUMMARY

There are two species of sprats in New Zealand, *Sprattus antipodum* (slender sprat) and *S. muelleri* (stout sprat). They can be distinguished by body shape, colour, and some morphological features, but are very similar and it is impractical to separate them in large catches.

Sprats were introduced into the QMS on 1 October 2002, with allowances, TACCs and TACs in Table 1 and have not been changed since.

**Table 1: Recreational and customary non-commercial allowances, TACCs and TACs for sprats by Fishstock.**

| Fishstock | Recreational Allowance | Customary non-commercial Allowance | Other mortality | TACC | TAC |
|---|---|---|---|---|---|
| SPR 1 | 20 | 10 | 0 | 70 | 100 |
| SPR 3 | 10 | 5 | 0 | 285 | 300 |
| SPR 4 | 3 | 2 | 0 | 10 | 15 |
| SPR 7 | 10 | 5 | 0 | 85 | 100 |
| SPR 10 | 0 | 0 | 0 | 0 | 0 |
| Total | 43 | 22 | 0 | 450 | 515 |

### 1.1 Commercial fisheries

The sprat "fishery" is minor and intermittent. There is no information on catches or landings of sprats prior to 1990, although occasional catches were made during exploratory fishing projects on small pelagic species, mainly in the 1960s and 1970s. Sprats have undoubtedly been caught in most years, but were either not reported, reported as "bait" or included in the category "mixed species". The name "sprat" is used in a general sense for several unrelated small fishes, and the juveniles of some larger species. This may have introduced errors into catch records. Reported catches and landings since 1990 have ranged from less than 1 t to 7 t (Table 2). The most consistent (but small) catches have been by bottom trawl. Reported catches by setnet and beach seine could be of true sprats, but may also be of yellow-eyed mullet (*Aldrichetta forsteri*), known colloquially as sprats. This is particularly likely in the upper North Island where the presence of sprats is considerably reduced or non-existent. Sprat was introduced into the QMS in October 2002.

**Table 2: Reported landings (t) of Sprat by fishstock and fishing year. No catches reported for SPR 10, which has a TACC of 0.**

| | SPR 1 | | SPR3 | | SPR 4 | | SPR 7 | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| FMA | 1, 2, 8 & 9 | | 3, 5 & 6 | | 4 | | 7 | | Total | |
| | Landings | TACC | Landings | TACC | Landings | TACC | Landings | TACC | Landings | TACC |
| 1990-91† | 3 | - | < 1 | - | 0 | - | < 1 | - | 3 | - |
| 1991-92† | 1 | - | 0 | - | 0 | - | 0 | - | 1 | - |
| 1992-93† | < 1 | - | < 1 | - | 0 | - | 0 | - | < 1 | - |
| 1993-94† | < 1 | - | < 1 | - | 0 | - | < 1 | - | 1 | - |
| 1994-95† | < 1 | - | < 1 | - | 0 | - | < 1 | - | 1 | - |
| 1995-96† | < 1 | - | 6 | - | 0 | - | < 1 | - | 7 | - |
| 1996-97† | < 1 | - | 1 | - | 0 | - | < 1 | - | 1 | - |
| 1997-98† | < 1 | - | < 1 | - | 0 | - | < 1 | - | < 1 | - |
| 1998-99† | 2 | - | < 1 | - | 0 | - | < 1 | - | 4 | - |
| 1999-00† | < 1 | - | < 1 | - | 0 | - | 1 | - | 2 | - |
| 2000-01† | < 1 | - | < 1 | - | 0 | - | < 1 | - | < 1 | - |
| 2001-02 | < 1 | - | < 1 | - | 0 | - | < 1 | - | < 1 | - |
| 2002-03 | < 1 | 70 | < 1 | 285 | 0 | 10 | 0 | 85 | < 1 | 450 |
| 2003-04 | < 1 | 70 | 3 | 285 | 0 | 10 | 0 | 85 | 3 | 450 |
| 2004-05 | < 1 | 70 | 0 | 285 | 0 | 10 | 0 | 85 | < 1 | 450 |
| 2005-06 | < 1 | 70 | 0 | 285 | 0 | 10 | 0 | 85 | < 1 | 450 |
| 2006-07 | < 1 | 70 | < 1 | 285 | 0 | 10 | 0 | 85 | < 1 | 450 |
| 2007-08 | < 1 | 70 | 0 | 285 | 0 | 10 | 0 | 85 | < 1 | 450 |
| 2008-09 | < 1 | 70 | < 1 | 285 | 0 | 10 | < 1 | 85 | 1 | 450 |
| 2009-10 | < 1 | 70 | 0 | 285 | 0 | 10 | 0 | 85 | 0 | 450 |
| 2010-11 | < 1 | 70 | 0 | 284 | 0 | 10 | 0 | 85 | < 1 | 450 |

† CELR

### 1.2 Recreational fisheries
There is no known recreational fishery, but small numbers are caught in small-mesh setnets and beach seines.

### 1.3 Customary non-commercial fisheries
Quantitative information on the current level of customary non-commercial take is not available.

### 1.4 Illegal catch
Estimates of illegal catch are not available, but this is probably insignificant or nil.

### 1.5 Other sources of mortality
Some accidental captures of sprats by vessels purse seining for other small pelagic species may be discarded if no market is available.

## 2. BIOLOGY

Sprats occur in coastal waters from the Bay of Islands to Stewart Island, and are present at the Auckland Islands. It is not known whether the two species have different distributions. Sprats appear to be most abundant off the southeastern coast of the South Island, where anchovies are absent. Their vertical distribution within the water column is not known.

Spawning occurs in areas of reduced salinity when water temperatures are coolest 9-10.5 $^{o}$C; there are consequently regional differences in spawning season with spawning peaks occurring between June and November (Taylor & Marriott 2004). The eggs are pelagic.

No reliable ageing work has been undertaken. Sprats are assumed to feed on zooplankton, and are preyed upon by larger fishes, seabirds, and marine mammals.

There have been no biological studies that are directly relevant to the recognition of separate stocks, or to yield estimates. Consequently no estimates of biological parameters are available. There is an extensive international literature base on sprats, mainly *Sprattus sprattus*, but the relevance of this to the New Zealand species is unknown.

## 3. STOCKS AND AREAS

There is no biological information on which to make an assessment on whether separate stocks exist. However, there are two species, and their relative distributions are unknown. As presently understood, both species are more common around southern New Zealand. If their distributions do differ, and the biomass of each species fluctuates independently, there are unknown implications for localised stock depletion.

## 4. STOCK ASSESSMENT

There have been no previous stock assessments of sprats. There have been two very general estimates of biomass in the Canterbury Bight region: 50 000 t (Robertson 1978), and 60 000 t (Colman 1979), with a possible yield of 10 000 t. No information on biomass variability is available.

### 4.1 Estimates of fishery parameters and abundance

No fishery parameters are available.

### 4.2 Biomass estimates

No estimates of biomass ($B_0$, $B_{MSY}$, or $B_{CURRENT}$) are available.

### 4.3 Estimation of Maximum Constant Yield (*MCY*)

*MCY* cannot be determined.

### 4.4 Estimation of Current Annual Yield (*CAY*)

Current biomass cannot be estimated, so *CAY* cannot be determined.

Yield estimates are summarised in Table 2.

### 4.5 Other yield estimates and stock assessment results

No information is available.

### 4.6 Other factors

Data from some ichthyoplankton surveys show one or both sprat species to be locally abundant. However, it is unlikely that the biomass is comparable to the very large stocks in the northern hemisphere where there are large sprat fisheries.

It is not known whether the biomass of sprats is stable or variable, but the latter is considered more likely.

In some localities around the South Island, sprats are a major food source for many fishes, seabirds, and marine mammals. Excessive localised harvesting may disrupt ecosystems.

## 5. STATUS OF THE STOCKS

No estimates of current biomass are available. At the present level of minimal catches, stocks are at or close to their natural level. This is nominally a virgin biomass, but not necessarily a stable one.

Yield estimates, reported landings, and TACCs for the 2010-11 fishing year are summarised in Table 2.

**Table 2: Summary of yield estimates (t), TACCs (t), and reported landings (t) for the most recent fishing year.**

| Fishstock | | FMA | *MCY* | 2010-11 Actual TACC | 2010-11 Reported Landings |
|---|---|---|---|---|---|
| SPR 1 | North Island | 1, 2, 8, 9 | – | 70 | 0.01 |
| SPR 3 | South-east + Southland/Subantarctic | 3, 5, 6 | – | 285 | 0 |
| SPR 4 | Chatham | 4 | – | 10 | 0 |
| SPR 7 | Challenger | 7 | – | 85 | 0 |
| SPR 10 | Kermadec | 10 | – | 0 | 0 |
| Total | | | | 450 | 0.01 |

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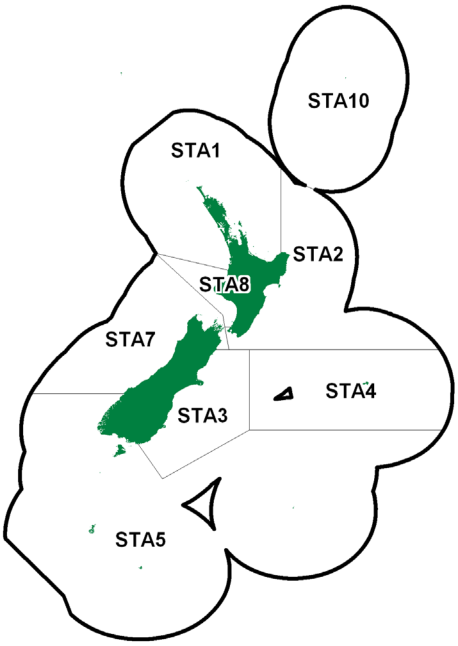
# STARGAZER (STA)

(*Kathetostoma giganteum*)
Puwhara




## 1. FISHERY SUMMARY

### 1.1 Commercial fisheries

Giant stargazer (*Kathetostoma giganteum*, Uranocopidae) is a moderate-sized benthic teleost distributed widely in New Zealand waters. It is found on muddy and sandy substrates to depths of 500 m, but is most common between 50-300 m on the continental shelf around the South Island (Anderson *et al*. 1998), where it supports a moderate-value, commercial trawl fishery. It was incorporated into the QMS on 1 October 1997 and is managed as eight separate Quota Management Areas (QMAs) or Fishstocks at this time: STA 1-5, 7-8, and 10.

It is caught by both directed fishing and as bycatch of fisheries targeting other species. The main target fishery is on the Stewart-Snares shelf west of Stewart Island (statistical areas 029-030). Other target fisheries exist on the west coast of the South Island (WCSI) and off Cape Campbell on the east coast of the South Island (ECSI). It is also caught by small domestic trawl vessels targeting red cod (*Pseuduophycis baccus*), tarakihi (*Nemadactylus macropterus*), flatfishes (*Colistum* spp., *Peltorhamphus* spp., and *Rhombosolea* spp.), and scampi (*Metanephrops challengeri*) on the continental shelf throughout its range, and by larger, foreign-licensed and New Zealand-chartered foreign vessels targeting barracouta (*Thyrsites atun*), jack mackerels (*Trachurus* spp.), and squids (*Nototodarus* spp.) in deeper waters, in particular on the western Chatham Rise and on the continental slope surrounding the Stewart-Snares shelf. Giant stargazer is an important bycatch of scampi fishing in STA 2-4. Catches by methods other than bottom trawling are minimal. Reported landings from 1979 to 1987-88 are given in Table 1.

**Table 1: Reported landings (t) of giant stargazer by vessel flag from 1979 to 1987-88.**

| | New Zealand | | Foreign | | | New Zealand | | Foreign | |
|---|---|---|---|---|---|---|---|---|---|
| Year | Domestic | Chartered | licensed | Total | Year | Domestic | Chartered | licensed | Total |
| 1979* | 387 | 155 | 159 | 701 | 1983-84† | 1 463 | 525 | 360 | 2 348 |
| 1980* | 723 | - | - | 723 | 1984-85† | 1 027 | 321 | 178 | 1 526 |
| 1981* | 1 010 | 314 | 84 | 1 408 | 1985-86† | 1 304 | 386 | 142 | 1 832 |
| 1982* | 902 | 340 | 283 | 1 526 | 1986-87† | 1 126 | 379 | 63 | 1 568 |
| 1983* | 1 189 | 329 | 465 | 1 983 | 1987-88† | 839 | 331 | 26 | 1 196 |

*MAF data. †FSU data.

The total catch between 1979 and 1986-87 was variable, ranging between 701-2348 t and averaging 1481 t. Different trends are apparent for domestic and foreign vessels. The domestic and chartered catch was relatively stable throughout the middle and later half of the series, which probably reflects the stability of effort in the red cod, tarakihi, flatfish, and barracouta fisheries at this time as well as better reporting compliance. However, landings by licensed foreign vessels declined steadily from a high of 465 t in 1983 to a low of 26 t in 1986-87, probably reflecting the declining importance of licensed foreign vessels in New Zealand's deepwater fisheries following the phasing-in of the QMS, which began in 1983 and which was fully implemented by 1986-87. Reported landings since 1983 by Fishstock are given in Table 2, and Figure 1 graphs the historical landings and TACC values for the main STA stocks. The total catches for 1986-87 and 1987-88 in Table 1 are less than those in Table 2 because of under-reporting to the FSU during those years.

After 1983, the catch began to increase rapidly, reaching 3426 t in 1990-91, and averaging 3204 t thereafter. The increase in catch is due to a number of factors, including: (a) increased target fishing in Southland (STA 5); (b) the availability of more quota through the decisions of the QAA; (c) better management of quotas by quota owners; (d) quota trading in STA 3, 4, 5 and 7; (e) changes in fishing patterns in the Canterbury Bight (STA 3) and the west coast of the South Island (STA 7); (f) a possible increase in abundance of stargazer in STA 7; and (g) increases in the STA 3, 5, and 7 TACCs introduced under the Adaptive Management Programme (AMP) in the 1991-92 fishing year.

The AMP is a management regime within the QMS for data-poor New Zealand Fishstocks that are likely to be able to sustain increased exploitation. Under the AMP, quota owners collect additional data from the fishery (typically fine-scale catch-effort data and rudimentary but necessary biological data such as fish length and sex) in return for an increased TACC. Under the AMP, TACCs for five giant stargazer Fishstocks (STA 1-3, 5, and 7) were increased at the start of the 1991-92 fishing year, and a sixth (STA 8) was increased in 1993-94. However, the TACCs for Fishstocks STA 1-3, 5, and 8 reverted to their pre-AMP levels in 1997-98, following the removal of these fishstocks from the AMP in July 1997 because of the failure of quota owners to meet the data-collection requirements of the AMP. In recent years, landings in three of these Fishstocks (STA 1-2 and 5) have exceeded their reduced, post-AMP TACCs; although of these, STA 5 is the only one with a TACC greater than 40 t at this time. STA 3 and STA 7 were reviewed in 1998 and retained in the AMP until the end of the 2002-03 fishing year. The TACC in STA 7 further increased to 997 t at the start of the 2002-03 fishing year with a TAC of 1000 t (which includes a 2 t recreational and a 1 t customary allowance). STA 7 was reviewed again in 2007 (Starr *et al*. 2007) and retained in the AMP, in October of 2010 the TACC was increased to 1 042 t increasing the TAC to 1 072 t. STA 3 was reviewed in 2008 (Starr *et al.* 2008) and retained at the existing TACC of 902 t, a customary and recreational allocation of 1 t and 2 t respectively, totalling a 905 t TAC. All AMP programmes ended on 30$^{th}$ September 2009.

Of the eight Fishstocks, the most important, in terms of the recorded landed catch, are STA 5, STA 7, and STA 3 (where landings since 1990-91 have averaged 1163 t, 883 t, and 748 t, for each stock respectively) with smaller contributions from STA 2 and STA 4, although a high TACC is set for STA 4 compared with the other seven Fishstocks, it has never been approached or exceeded. Most of the STA 4 catch is caught as bycatch of fishing directed at other target species. A high recorded landed catch in 1990-91 (790 t) was due to exploratory fishing for these target species, this has since declined. The recorded landed catch has averaged 278 t per fishing year since then. Increased catches in STA 2 from 1990-91 were due to the development of the scampi fishery in this Fishstock.

As noted, the TACC in STA 7 was increased to 700 t in 1991-92 under the terms of the AMP. The TACC was overcaught in nearly every subsequent fishing year up to 2002-03, when the TACC was further increased to 997 t. Landings reached a high of 1440 t in 2000-01, before dropping back to 800 t in 2001-02. These high recorded landings resulted mainly from the use of bycatch trades with barracouta and flatfishes. With the removal of the bycatch trade system in October 2001, fishers now face the penalty of high deemed-values for any overcatch, and it is likely that these penalties have been the cause of the reduction in the overcatch in this Fishstock.

**Table 2: Reported landings (t) of giant stargazer by QMS Fishstock (QMA) from 1983 to 2010-11. TACCs from 1986-87 to 2010-11 are also provided.**

| Fishstock | STA 1 | | STA 2 | | STA 3 | | STA 4 | | STA 5 | |
|---|---|---|---|---|---|---|---|---|---|---|
| FMA(s) | 1 & 9 | | 2 | | 3 | | 4 | | 5 & 6 | |
| | Landings | TACC | Landings | TACC | Landings | TACC | Landings | TACC | Landings | TACC |
| 1983* | 8 | - | 34 | - | 540 | - | 168 | - | 843 | - |
| 1984* | 5 | - | 24 | - | 588 | - | 143 | - | 1023 | - |
| 1985* | 9 | - | 15 | - | 438 | - | 82 | - | 695 | - |
| 1986* | 12 | - | 24 | - | 415 | - | 95 | - | 566 | - |
| 1986-87 | 10 | 20 | 31 | 30 | 644 | 560 | 72 | 2 000 | 738 | 1 060 |
| 1987-88 | 3 | 20 | 46 | 33 | 783 | 581 | 110 | 2 005 | 886 | 1 144 |
| 1988-89 | 3 | 20 | 41 | 37 | 675 | 591 | 134 | 2 005 | 1 215 | 1 173 |
| 1989-90 | 9 | 21 | 53 | 37 | 747 | 703 | 218 | 2 009 | 1 150 | 1 175 |
| 1990-91 | 8 | 21 | 125 | 37 | 674 | 734 | 790 | 2 014 | 1 061 | 1 239 |
| 1991-92 | 18 | 50 | 105 | 100 | 756 | 900 | 366 | 2 014 | 1 056 | 1 500 |
| 1992-93 | 19 | 50 | 115 | 101 | 811 | 901 | 231 | 2 014 | 1 247 | 1 500 |
| 1993-94 | 8 | 50 | 73 | 101 | 871 | 902 | 113 | 2 014 | 1 327 | 1 500 |
| 1994-95 | 10 | 50 | 74 | 101 | 829 | 902 | 223 | 2 014 | 1 216 | 1 525 |
| 1995-96 | 17 | 50 | 69 | 101 | 876 | 902 | 259 | 2 014 | 1 159 | 1 525 |
| 1996-97 | 22 | 50 | 77 | 101 | 817 | 902 | 149 | 2 014 | 977 | 1 525 |
| 1997-98 | 29 | 21 | 54 | 38 | 667 | 902 | 263 | 2 014 | 544 | 1 264 |
| 1998-99 | 27 | 21 | 46 | 38 | 641 | 902 | 137 | 2 014 | 1 145 | 1 264 |
| 1999-00 | 36 | 21 | 42 | 38 | 719 | 902 | 161 | 2 014 | 1 327 | 1 264 |
| 2000-01 | 26 | 21 | 45 | 38 | 960 | 902 | 233 | 2 014 | 1 439 | 1 264 |
| 2001-02 | 34 | 21 | 58 | 38 | 816 | 902 | 391 | 2 158 | 1 137 | 1 264 |
| 2002-03 | 31 | 21 | 41 | 38 | 863 | 902 | 308 | 2 158 | 967 | 1 264 |
| 2003-04 | 23 | 21 | 27 | 38 | 578 | 902 | 186 | 2 158 | 1 193 | 1 264 |
| 2004-05 | 27 | 21 | 28 | 38 | 646 | 902 | 366 | 2 158 | 1 282 | 1 264 |
| 2005-06 | 34 | 21 | 30 | 38 | 824 | 902 | 359 | 2 158 | 1 347 | 1 264 |
| 2006-07 | 22 | 21 | 31 | 38 | 719 | 902 | 292 | 2 158 | 1 359 | 1 264 |
| 2007-08 | 36 | 21 | 26 | 38 | 572 | 902 | 436 | 2 158 | 1 171 | 1 264 |
| 2008-09 | 35 | 21 | 22 | 38 | 574 | 902 | 139 | 2 158 | 1 137 | 1 264 |
| 2009-10 | 17 | 21 | 26 | 38 | 576 | 902 | 198 | 2 158 | 1 339 | 1 264 |
| 2010-11 | 21 | 21 | 19 | 38 | 570 | 902 | 134 | 2 158 | 1 235 | 1 264 |

| Fishstock | STA 7 | | STA 8 | | STA 10 | | | |
|---|---|---|---|---|---|---|---|---|
| FMA(s) | 7 | | 8 | | 10 | | Total | |
| | Landings | TACC | Landings | TACC | Landings | TACC | Landings | TACC |
| 1983* | 323 | - | 3 | - | 0 | - | 1 919 | - |
| 1984* | 444 | - | 3 | - | 0 | - | 2 230 | - |
| 1985* | 328 | - | 4 | - | 0 | - | 1 571 | - |
| 1986* | 362 | - | 3 | - | 0 | - | 1 477 | - |
| 1986-87 | 487 | 450 | 7 | 20 | 0 | 10 | 1 990 | 4 150 |
| 1987-88 | 505 | 493 | 5 | 20 | 0 | 10 | 2 338 | 4 306 |
| 1988-89 | 520 | 499 | 5 | 20 | 0 | 10 | 2 593 | 4 355 |
| 1989-90 | 585 | 525 | 1 | 22 | 0 | 10 | 2 763 | 4 502 |
| 1990-91 | 762 | 528 | 6 | 22 | 0 | 10 | 3 426 | 4 605 |
| 1991-92 | 920 | 700 | 18 | 22 | 0 | 10 | 3 239 | 5 296 |
| 1992-93 | 861 | 702 | 5 | 22 | 0 | 10 | 3 289 | 5 300 |
| 1993-94 | 715 | 702 | 4 | 50 | 0 | 10 | 3 111 | 5 329 |
| 1994-95 | 730 | 702 | 7 | 50 | 0 | 10 | 3 089 | 5 354 |
| 1995-96 | 877 | 702 | 4 | 50 | 0 | 10 | 3 261 | 5 354 |
| 1996-97 | 983 | 702 | 10 | 50 | 0 | 10 | 3 034 | 5 354 |
| 1997-98 | 564 | 702 | 10 | 22 | 0 | 10 | 2 132 | 4 973 |
| 1998-99 | 949 | 702 | 2 | 22 | 0 | 10 | 2 946 | 4 973 |
| 1999-00 | 1 184 | 702 | 3 | 22 | 0 | 10 | 3 472 | 4 973 |
| 2000-01 | 1 440 | 702 | 4 | 22 | 0 | 10 | 4 146 | 4 973 |
| 2001-02 | 802 | 702 | 4 | 22 | 0 | 10 | 3 238 | 5 117 |
| 2002-03 | 957 | 997 | 4 | 22 | 0 | 10 | 3 171 | 5 412 |
| 2003-04 | 934 | 997 | 6 | 22 | 0 | 10 | 2 947 | 5 412 |
| 2004-05 | 1 028 | 997 | 5 | 22 | 0 | 10 | 3 381 | 5 412 |
| 2005-06 | 1 010 | 997 | 3 | 22 | 0 | 10 | 3 606 | 5 412 |
| 2006-07 | 1 051 | 997 | 4 | 22 | 0 | 10 | 3 478 | 5 412 |
| 2007-08 | 1 014 | 997 | 3 | 22 | 0 | 10 | 3 258 | 5 412 |
| 2008-09 | 1 001 | 997 | 5 | 22 | 0 | 10 | 2 913 | 5 412 |
| 2009-10 | 1 093 | 997 | 6 | 22 | 0 | 10 | 3 247 | 5 456 |
| 2010-11 | 1 037 | 1 042 | 7 | 22 | 0 | 10 | 3 023 | 5 456 |

* MAF data

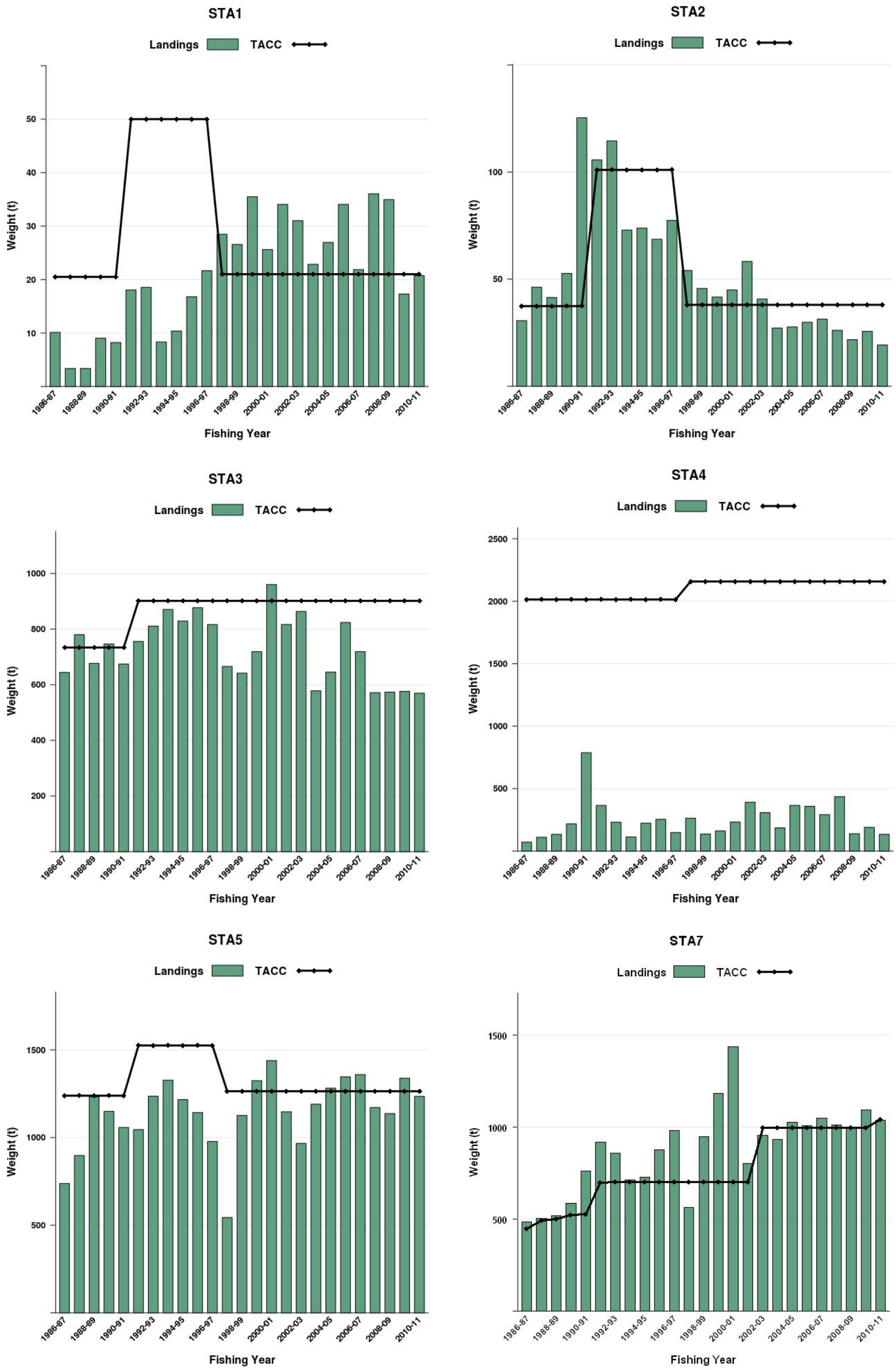



**Figure 1: Historical landings and TACC for the seven main STA stocks. From top left: STA1 (Auckland East), STA2 (Central East), STA3 (South East Coast), STA4 (Chatham Rise), STA5 (Southland), and STA7 (Challenger).** **[Continued on next page].**

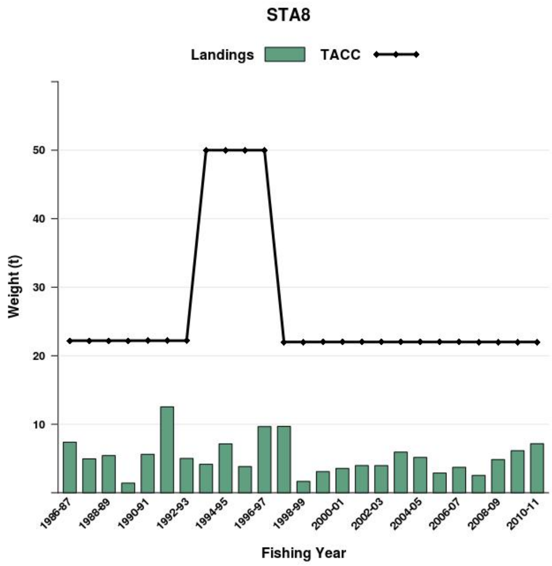



**Figure 1 [Continued]: Historical landings and TACC for the seven main STA stocks. STA8 (Central Egmont). Note that these figures do not contain data prior to entry into the QMS.**

The landings data (Table 1 and Table 2) probably include an unknown quantity of catch from other uranoscopid species misidentified as *K. giganteum*. Fishers in STA 1-3 and 8 have been known to report brown (*Gnathagnus innotabilis*) and spotted stargazer (*Genyagnus monopterygius*) as *K. giganteum* in the past. Landings in STA 4 and 5 probably include an unknown amount of an undescribed sister species, banded stargazer (*Kathetostoma* sp.). Although the true extent of misreporting due to misidentification is unknown, it is likely to be small.

### 1.2 Recreational fisheries
Stargazer were not reported as being caught by recreational fishers in surveys conducted in the Ministry of Fisheries South region in 1991-92, Central region in 1992-93 and North region in 1993-94. In a Ministry of Fisheries national survey in 1996, a few giant stargazer were reported in STA 1 and 3, with an estimated take of 1000 fish in STA 1 and less than 500 fish taken in STA 3 (Bradford 1998). No giant stargazer catch was recorded for the recreational fishers during the 1999-2000 national diary survey (Boyd & Reilly 2005).

### 1.4 Customary non-commercial fisheries
No quantitative information is available on the level of customary non-commercial take.

### 1.5 Illegal catch
No quantitative information is available on the level of illegal catch.

### 1.6 Other sources of mortality
No quantitative information is available on the level of other sources of mortality.

## 2. BIOLOGY

Giant stargazer is found throughout the New Zealand EEZ. It is most plentiful around the South Island (STA 3, 5, & 7) and at the Mernoo Bank on the Chatham Rise (STA 4).

Using data collected from the west coast South Island trawl survey series (Drummond & Stevenson, 1995a, 1995b, 1996; Stevenson 1998; Stevenson & Hanchet 2000; Stevenson 2002, 2004), Manning (2008) found that giant stargazer reach sexual maturity at a length of about 40-55 cm in total length (TL), depending on sex, at an age of between 5-7 years. Age and growth studies suggest that some individuals reach a maximum age of at least 25 years (Sutton 1999; Manning & Sutton 2004; Sutton

2004; Manning & Sutton 2007a, 2007b). Otolith growth zones have not been validated. A number of attempts at growth zone validation have been undertaken unsuccessfully. A tag and release programme was initiated with all released fish being injected with oxytetracycline as part of the East Coast South Island trawl survey. A single fish has been recaptured but the otoliths were not recovered. Andrews (2009) investigated the feasibility of using lead-radium dating of otoliths as a means of validating age. However, the levels of radium-226 in stargazer otoliths were too low (nearly 10 times lower than expected) to generate meaningful results. Using maximum-likelihood methods, Manning & Sutton (2004) found that giant-stargazer growth differs significantly between the east, south, and west coasts of the South Island. They suggested that these differences represented different biological stock units in these areas, although the true stock structure is unclear (Tate 1987). Manning (2005) investigated the effect of assuming alternative growth models with different functional forms on the data and conclusions presented by Manning & Sutton (2004). His results were consistent with the earlier results.

$M$ was estimated using the equation $M = \ln 100 / t_{\max}$, where $t_{\max}$ is the maximum age to which 1% of the population survives in an unexploited stock. Using an unvalidated maximum age of 26 years, yields $M = 0.18$. Preliminary results of the STA 7 quantitative stock that is underway at this time (2008) suggest that 0.18 is an underestimate of the unknown true value. A revised estimate based on applying Hoenig's (1983) regression to the age composition data from the west coast South Island survey series suggested that a value of 0.23 is more reasonable (Manning 2008). Although the west coast South Island age composition data were collected from an exploited stock, 0.23 is considered to be closer to the true value than 0.18.

Stargazer have an annual reproductive cycle with a winter spawning season. Spawning probably occurs in mid and outer shelf waters all around New Zealand. The generalised spawning date assumed in the age and growth studies cited above is 1 July in any given calendar year.

Biological parameters relevant to the stock assessment are given in Table 3.

**Table 3: Estimates of giant stargazer biological parameters**

| Fishstock | | | | | Estimate | Source |
|---|---|---|---|---|---|---|
| 1. Natural mortality ($M$) | | | | | | |
| STA 5 | | | | | 0.20 | Sutton (2004) |
| STA 7 | | | | | 0.18 | Manning (2006a) |

2. Weight = a(length)$^b$ (Weight in g, length in cm fork length).

| | Females | | Males | | All fish | | |
|---|---|---|---|---|---|---|---|
| | a | b | a | b | a | b | |
| STA 3 | - | - | - | - | 0.015 | 3.01 | McClatchie (uppub.data) |
| STA 5 | - | - | - | - | 0.024 | 2.92 | McGregor (unpub. data) |
| STA 7 | 0.018 | 2.97 | 0.013 | 3.07 | - | - | Manning & Sutton (2007a) |

3. Length at maturity (cm total length)

| | Females | | Males | | |
|---|---|---|---|---|---|
| | $L_{50}$ | $L_{95}$ | $L_{50}$ | $L_{95}$ | |
| STA7 | 54.37 | 11.24 | 40.98 | 14.90 | Manning (2008) |

4. Age at maturity (years)

| | Females | | Males | | |
|---|---|---|---|---|---|
| | $A_{50}$ | $A_{95}$ | $A_{50}$ | $A_{95}$ | |
| STA7 | 7.23 | 4.34 | 5.53 | 4.38 | Manning (2008) |

3. von Bertalanffy length-at-age model parameter estimates

| | Females | | | Males | | | |
|---|---|---|---|---|---|---|---|
| | $L_\infty$ | $K$ (yr$^{-1}$) | $t_0$ (yr) | $L_\infty$ | $K$ (yr$^{-1}$) | $t_0$ (yr) | |
| STA 3 | 78.11 | 0.14 | -1.25 | 61.49 | 0.2 | -0.97 | Sutton (1999) |
| STA 5 | 73.92 | 0.18 | -0.22 | 59.12 | 0.19 | -1.19 | Sutton (1999) |
| STA 5 | 72.61 | 0.17 | -0.02 | 60.76 | 0.18 | -1.16 | Sutton (2004) |
| STA 7 | 85.74 | 0.13 | -0.666 | 71.00 | 0.15 | -0.664 | Manning & Sutton (2007a); a revision of earlier results presented by Manning & Sutton (2004) |

## 3. STOCKS AND AREAS

There are no new data that would alter the stock boundaries given in previous assessment documents.

It is not known if there is more than one giant stargazer stock in New Zealand. The present QMAs were used as a basis for Fishstocks, except for QMAs 5 and 6, which were combined (STA 5). The basis for choosing these boundaries was a general review of the distribution and relative abundance of stargazer within the fishery.

As noted, length-at-age differs significantly between the east, south and west coasts of the South Island (Manning & Sutton 2004, Manning 2005). This is consistent with the Fishstock boundaries.

## 4. STOCK ASSESSMENT

There are no new data that are available at this time that would alter the yield estimates of STA 1, 2, 3, 4, 5, and 8 given in the 1997 Plenary Report. The yield estimates are based on commercial landings data.

An integrated assessment for STA 7 was updated in 2008 with data that included the commercial catch, trawl survey biomass and proportions-at-age estimates, and commercial catch proportions-at-age.

### 4.1 Estimates of fishery parameters and abundance

**Trawl surveys**
Indices of relative biomass are available from recent *Tangaroa* and *Kaharoa* trawl surveys (Table 4).

**Table 4: Relative biomass indices of stargazer and coefficients of variation (CV) for east coast North Island (ECNI), east coast South Island (ECSI) - winter and summer, Chatham Rise, west coast South Island (WCSI) and the Stewart-Snares Island survey areas assuming areal availability, vertical availability and vulnerability equal 1.0. Note: because trawl survey biomass estimates are relative indices, comparisons between different seasons (e.g., summer and winter ECSI) are not strictly valid.**

| Species | Region | Fishstock | Year | (Trip Code) | Relative biomass (t) | CV (%) |
|---|---|---|---|---|---|---|
| Giant stargazer | ECNI | STA 2 | 1993 | KAH9304 | 184 | 22 |
| | Inshore | | 1994 | KAH9402 | 58 | 47 |
| | | | 1995 | KAH9502 | 44 | 35 |
| | | | 1996 | KAH9602 | 57 | 17 |
| | ECNI | STA 2 | 1993 | KAH9301 | 250 | 16 |
| | (Scampi) | | 1994 | KAH9401 | 215 | 20 |
| | | | 1995 | KAH9501 | 122 | 17 |
| | ECSI | STA 3 | 1991 | KAH9105 | 600 | 17 |
| | (Winter) | | 1992 | KAH9205 | 669 | 16 |
| | | | 1993 | KAH9306 | 609 | 14 |
| | | | 1994 | KAH9406 | 462 | 15 |
| | | | 1996 | KAH9606 | 465 | 11 |
| | | | 2007 | KAH0705 | 755 | 18 |
| | | | 2008 | KAH0806 | 606 | 14 |
| | | | 2009 | KAH0905 | 475 | 15 |
| | ECSI | STA 3 | 1996 | KAH9618 | 897 | 12 |
| | (Summer) | | 1997 | KAH9704 | 543 | 11 |
| | | | 1998 | KAH9809 | 999 | 10 |
| | | | 1999 | KAH9917 | 472 | 14 |
| | | | 2000 | KAH0014 | 214 | 16 |

**Table 4 [Continued].**

| Species | Region | Fishstock | Year | (Trip Code) | Relative biomass (t) | CV (%) |
|---|---|---|---|---|---|---|
| | Chatham Rise | STA 4 | 1992 | TAN9106 | 2 570 | 11 |
| | | | 1993 | TAN9212 | 2 560 | 13 |
| | | | 1994 | TAN9401 | 2 853 | 12 |
| | | | 1995 | TAN9501 | 1 429 | 13 |
| | | | 1996 | TAN9601 | 3 039 | 16 |
| | | | 1997 | TAN9701 | 2 328 | 15 |
| | | | 1998 | TAN9801 | 1 702 | 14 |
| | | | 1999 | TAN9901 | 1 903 | 13 |
| | | | 2000 | TAN0001 | 2 148 | 13 |
| | | | 2001 | TAN0101 | 1 772 | 16 |
| | Chatham Rise | STA 4 | 2002 | TAN0201 | 2 195 | 16 |
| | | | 2003 | TAN0301 | 1 380 | 15 |
| | | | 2005 | TAN0501 | 3 045 | 13 |
| | | | 2006 | TAN0601 | 2 007 | 19 |
| | | | 2007 | TAN0701 | 1 684 | 12 |
| | | | 2008 | TAN0801 | 4 677 | 40 |
| | | | 2009 | TAN0901 | 3 154 | 24 |
| | | | 2010 | TAN1001 | 1 140 | 17 |
| | | | 2011 | TAN1101 | 3 169 | 28 |
| | | | 2012 | TAN1201 | 1 751 | 13 |
| | WCSI | STA 7 | 1992 | KAH9204 | 1 302 | 12 |
| | | | 1994 | KAH9404 | 1 350 | 17 |
| | | | 1995 | KAH9504 | 1 551 | 16 |
| | | | 1997 | KAH9701 | 1 450 | 15 |
| | | | 2000 | KAH0004 | 1 023 | 12 |
| | | | 2003 | KAH0304 | 827 | 15 |
| | | | 2005 | KAH0503 | 1 429 | 19 |
| | | | 2007 | KAH0704 | 1 630 | 12 |
| | | | 2009 | KAH0904 | 1 952 | 19 |
| | | | 2011 | KAH1004 | 1 645 | 16 |
| | Stewart-Snares | STA 5 | 1993 | TAN9301 | 2 650 | 20 |
| | | | 1994 | TAN9402 | 3 755 | 11 |
| | | | 1995 | TAN9502 | 2 452 | 11 |
| | | | 1996 | TAN9604 | 1 733 | 11 |
| Banded stargazer | Stewart-Snares | BGZ 5 | 1993 | TAN9301 | 409 | 27 |
| | | | 1994 | TAN9402 | 250 | 21 |
| | | | 1995 | TAN9502 | 316 | 29 |
| | | | 1996 | TAN9604 | 232 | 34 |

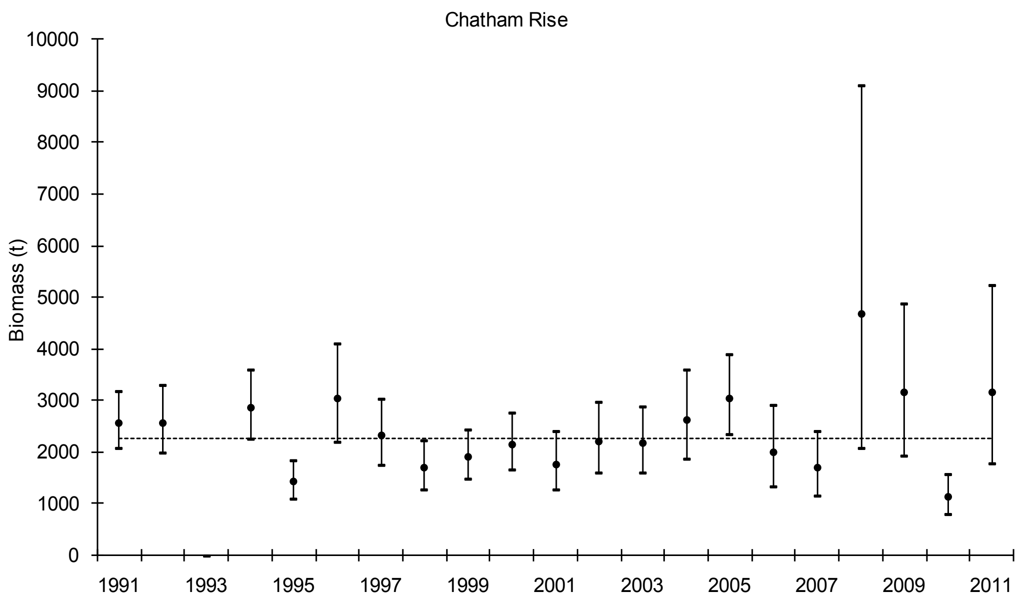



**Figure 2: Stargazer biomass ±95% CI (estimated from survey CVs assuming a lognormal distribution) and the time series mean (dotted line) estimated from the Chatham Rise trawl survey.**

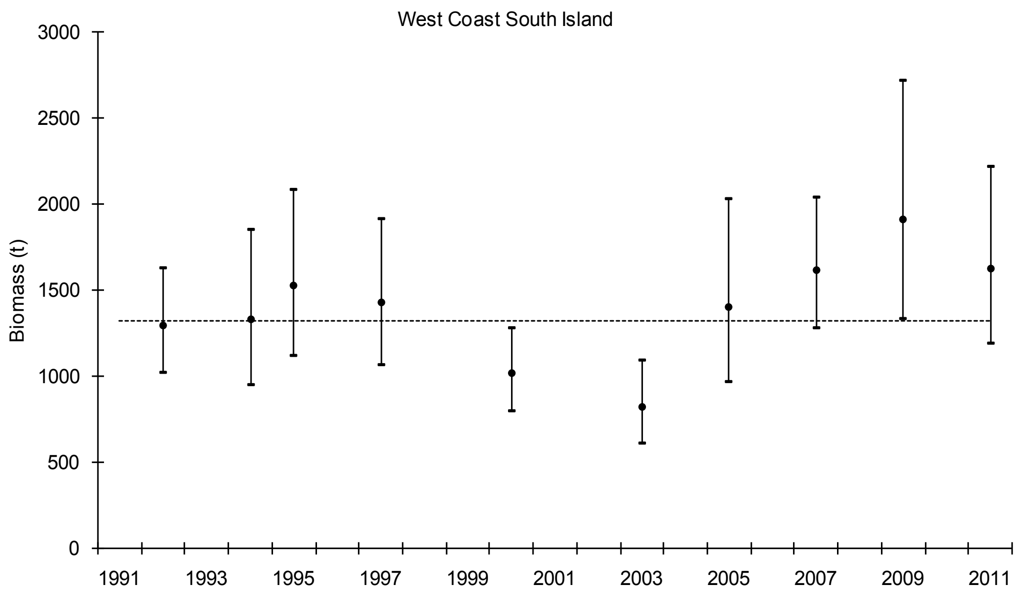



**Figure 3: Stargazer biomass ±95% CI (estimated from survey CVs assuming a lognormal distribution) and the time series mean (dotted line) estimated from the West Coast South Island trawl survey.**

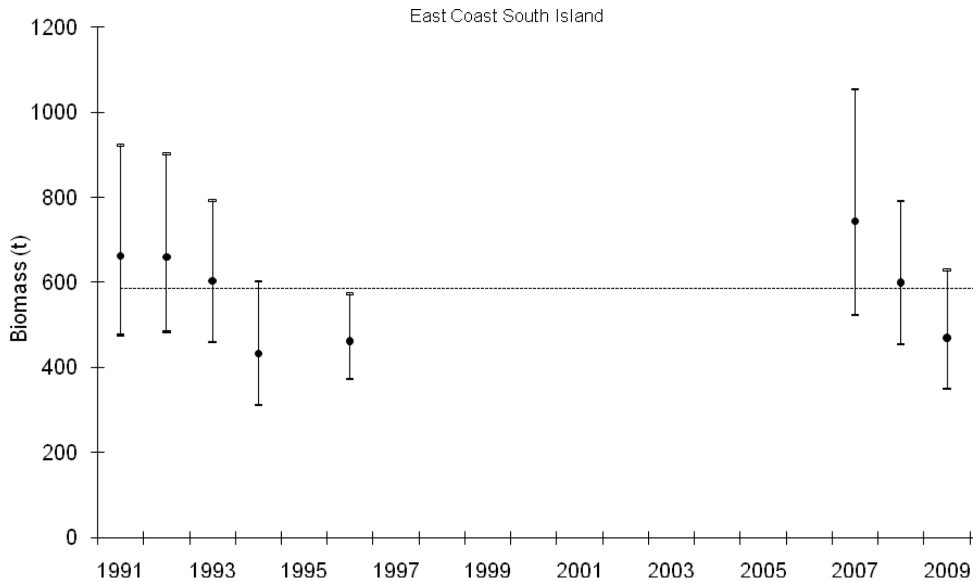



**Figure 4: Stargazer biomass ±95% CI (estimated from survey CVs assuming a lognormal distribution) and the time series mean (dotted line) estimated from the East Coast South Island trawl survey.**

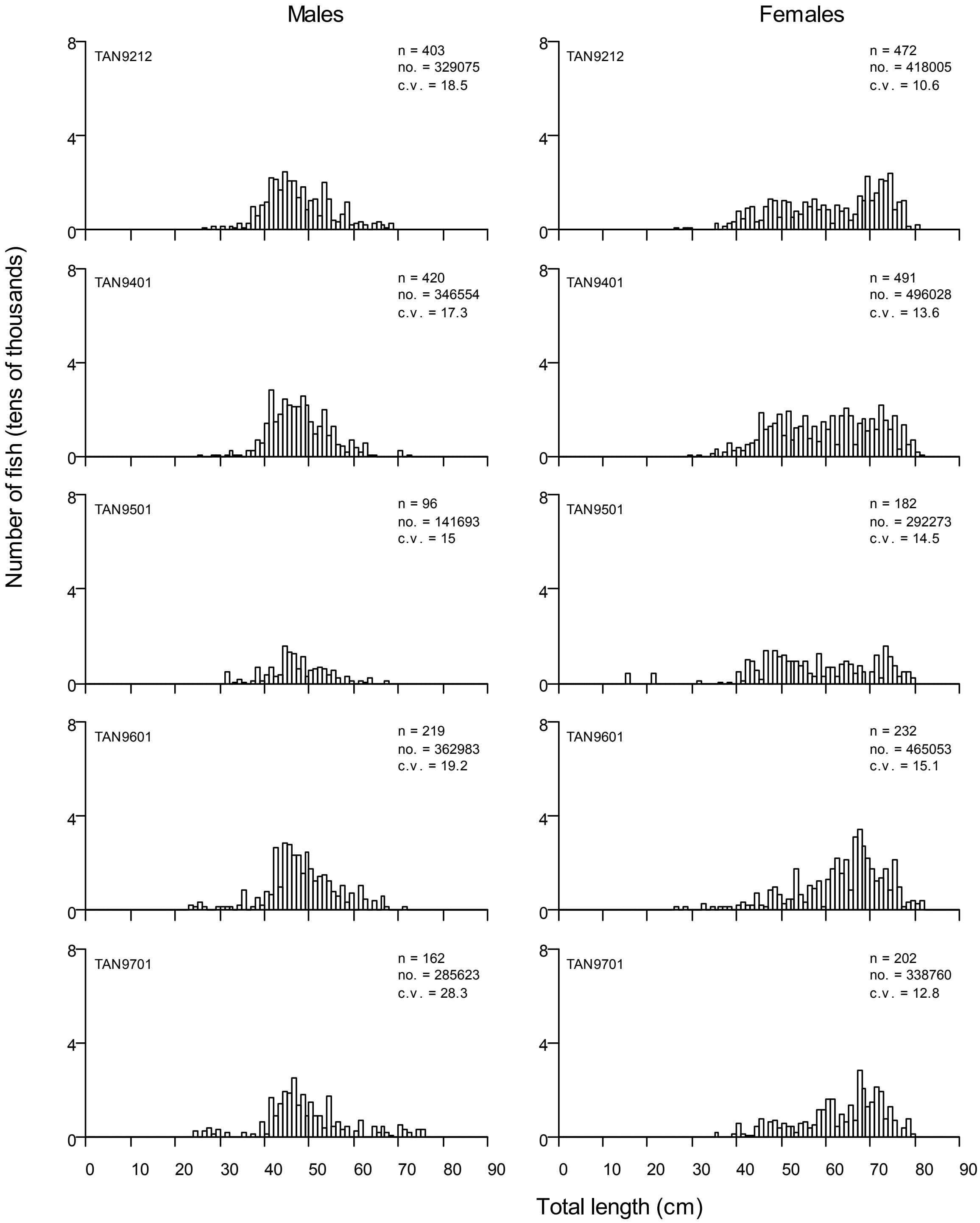



**Figure 5: Scaled length frequency distributions for giant stargazer in 30-400 m, for Chatham Rise surveys. M, males and F, females, (CV) (Stevens *et al.* 2011).**

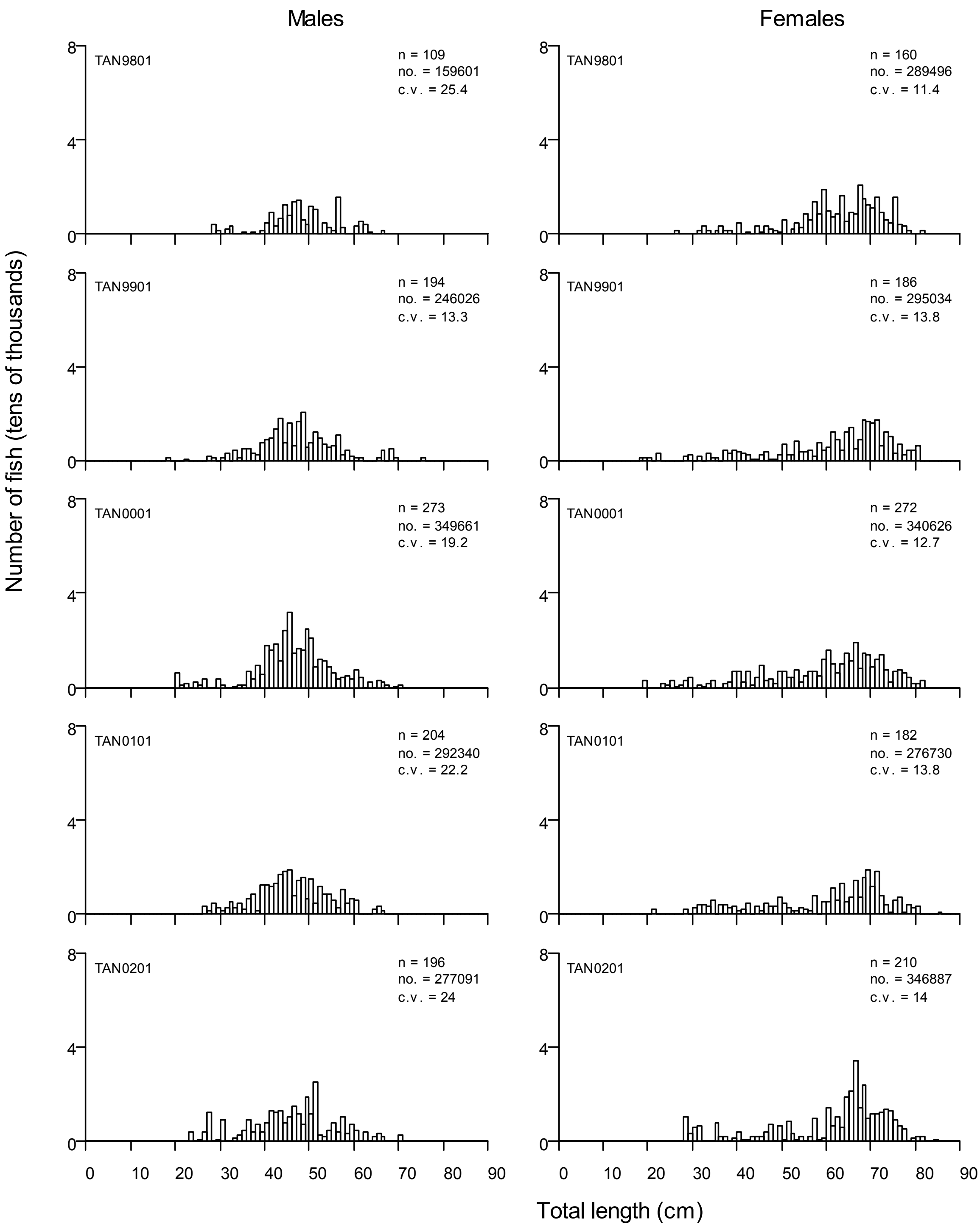



**Figure 5 [Continued].**

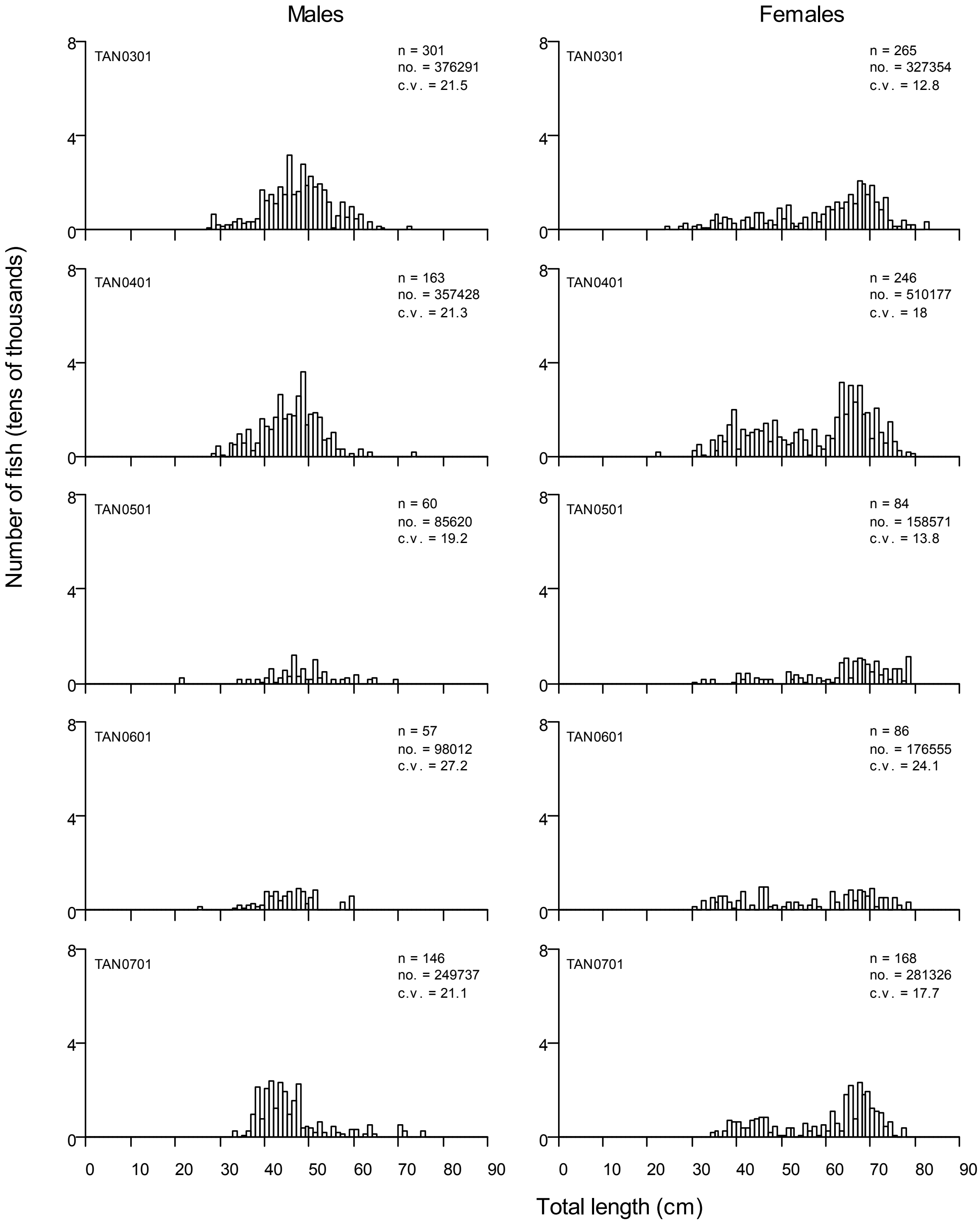



**Figure 5 [Continued].**

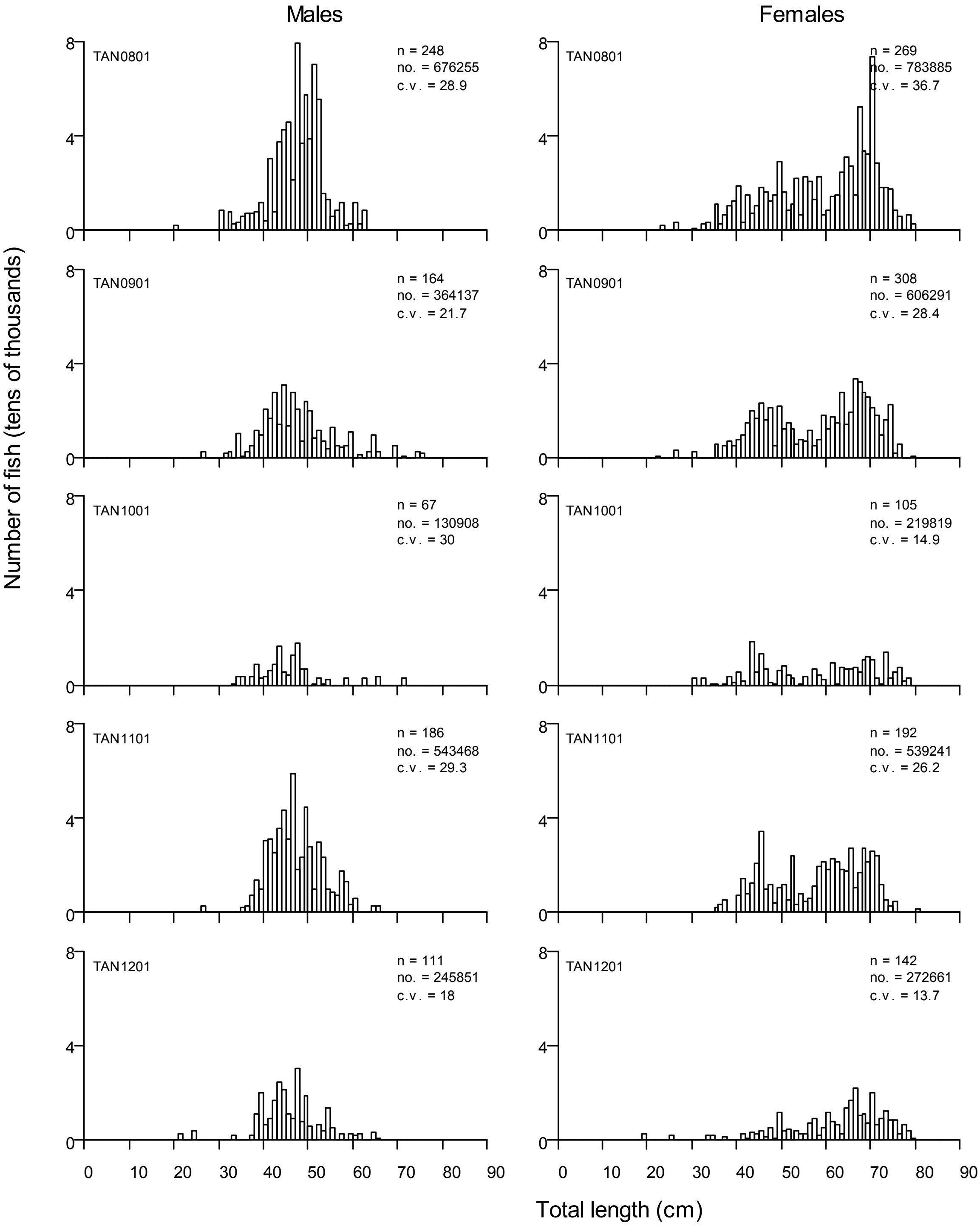



**Figure 5 [Continued].**

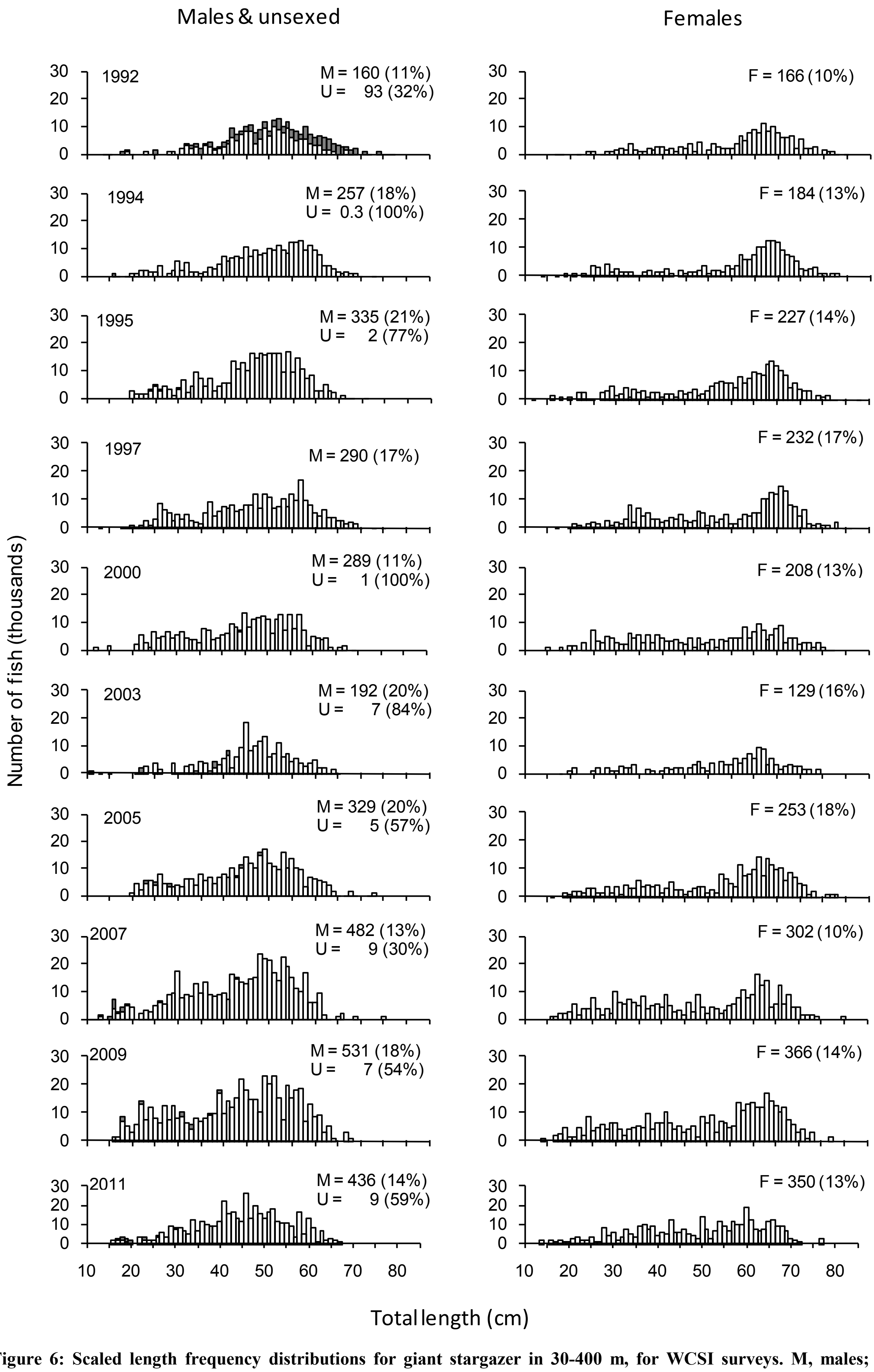



**Figure 6: Scaled length frequency distributions for giant stargazer in 30-400 m, for WCSI surveys. M, males; F, female and u, unsexed, (CV) (Stevenson in press).**

## 4.2 CPUE analysis

### STA 2, 3, and 7

CPUE indices have been calculated for STA 2 (Vignaux 1997) and STA 3 (SEFMC 2002, SeaFIC 2005a, Starr *et al*. 2008). The currently accepted CPUE series for STA 3 (Figure 5) is based on a mixed target species fishery including red cod, barracouta, tarakihi and stargazer and shows no trend since about 2000-01. A CPUE series calculated for STA 7 (SeaFIC 2002, 2003b, 2005b, Starr *et al.* 2007), based on a mixed west coast South Island target species (stargazer, barracouta, red cod and tarakihi) fishery, has not been accepted by the AMP WG as an indicator of STA 7 abundance. The Inshore and AMP Fishery Assessment Working Groups (FAWG) have had concerns over using bycatch fisheries to monitor stargazer abundance in these areas due to possible changes in recording and fishing practices.

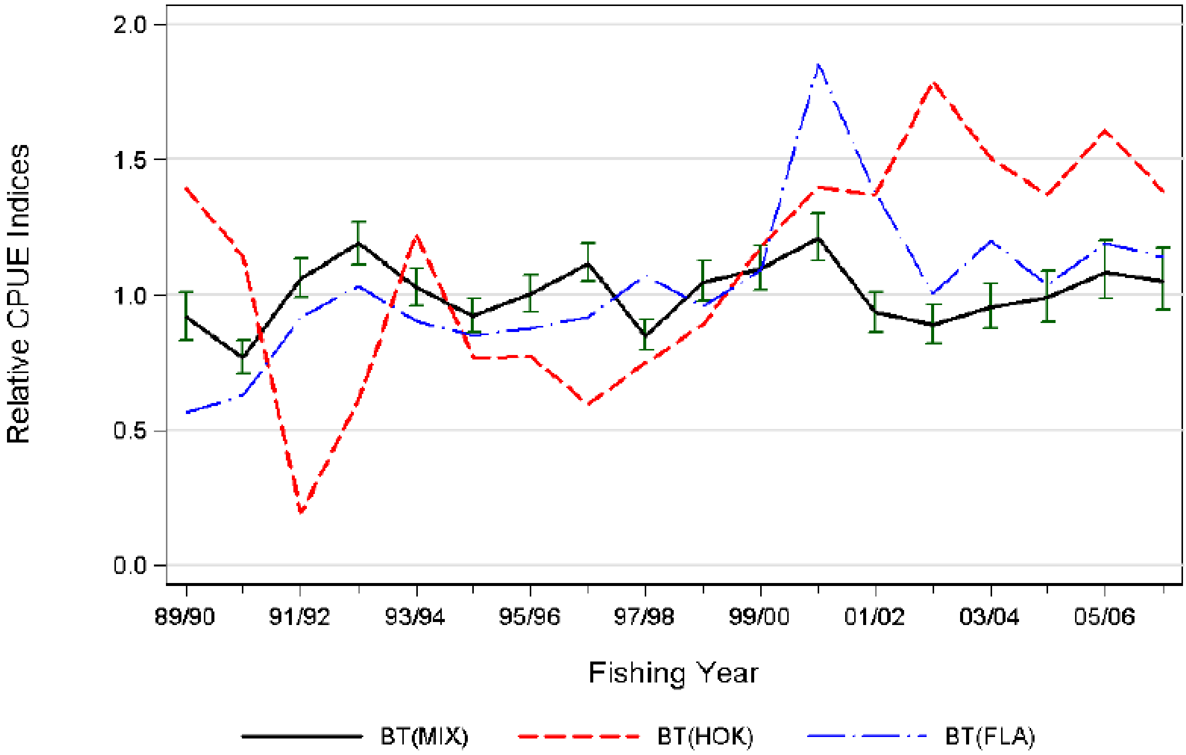



**Figure 7: Comparison of the lognormal indices from the three bottom trawl CPUE series for STA 3; a) BT(MIX): mixed species target trawl fishery; b) BT(FLA): hoki target trawl fishery; c) BT(FLA): target flatfish trawl fishery. Each series is scaled to the geometric mean = 1. (Starr *et al.* 2008).**

### STA 4

Stargazer in STA 4 are taken as a bycatch in the fisheries for hoki, ling, silver warehou, squid, barracouta, red cod and scampi on the Chatham Rise, as bycatch in a barracouta fishery near the Chatham Islands, and in a small targeted stargazer fishery north of the Chatham Islands.

An unstandardised CPUE analysis of stargazer in these fisheries, singly and in appropriate combinations, showed no clear trend (Table 5). The stargazer CPUE is strongly correlated with the stargazer catch, suggesting that it is influenced by being in or out of the top five species reported on fishing returns. The unstandardised CPUE indices of the stargazer bycatch are not considered reliable, and are not used in stock assessment. Further, the Working Group noted the localised nature of the fishing effort in STA 4 and that fishing occurs in two geographically distinct locations, one around the Chatham Islands and the other to the west, adjacent to eastern STA 3. The Working Group agreed that the catch statistics from statistical areas 19, 21 and 23 (in STA 3) should be considered in any STA 4 analysis.

**Table 5: Summary of unstandardised CPUE indices* for stargazer as a bycatch in STA 4† target fisheries.**

| Years | Hoki | Ling | S. warehou | Squid | Barracouta | Red cod | Scampi | Combined‡ |
|---|---|---|---|---|---|---|---|---|
| 1989-90 | 0.14 | 0.72 | 0.31 | 1.00 | 0.29 | 0.86 | - | 0.34 |
| 1990-91 | 0.88 | 0.83 | 1.15 | 1.26 | 0.56 | 1.03 | 0.06 | 0.87 |
| 1991-92 | 0.39 | 0.56 | 0.61 | 0.47 | 0.66 | 0.97 | 0.04 | 0.46 |
| 1992-93 | 0.32 | 0.89 | 0.33 | 0.80 | 0.62 | 0.32 | 0.07 | 0.37 |
| 1993-94 | 0.22 | 0.27 | 0.40 | 0.53 | 0.68 | 0.55 | 0.07 | 0.38 |
| 1994-95 | 0.54 | 2.56 | 0.65 | 0.48 | 0.59 | 0.43 | 0.10 | 0.61 |
| 1995-96 | 0.38 | 0.41 | 0.43 | 0.54 | 0.39 | 0.67 | 0.09 | 0.44 |

* Catch per tow, for tows in which stargazer were reported caught.
† Statistical areas 021 and 023 (STA 3) and 401 and 407 (STA 4), covering the western end of Chatham Rise.
‡ Hoki, ling, silver warehou, squid, barracouta, red cod, but not scampi

**STA 5**

About 80% of the STA 5 catch is caught by small (< 43 m) inshore bottom-trawl vessels targeting giant stargazer. The remainder of the catch is caught mostly by large (≥ 43 m), deepwater bottom-trawl vessels targeting other species such as barracouta, jack mackerels, and squids. Catches by methods other than bottom trawling are very small.

Vignaux (1997) was the first to present standardised CPUE indices for STA 5. Data were analysed from the 1991-92 to 1995-96 fishing years only and the indices she presented showed no trend. Her analysis was superseded by that of Phillips (2001), who analysed data from the 1989-90 to 1999-00 fishing years. He used a log normal generalised linear model to describe non-zero estimated catches reported by both the inshore and deepwater fleets. However, the indices he presented also showed no trend and were rejected as a relative abundance index by the New Zealand Inshore Fisheries Working Group (Inshore FAWG).

Manning (2007) updated Phillips' (2001) analysis with four more fishing years of data and used a different data processing method. His analysis spanned the 1989-90 to 2003-04 fishing years, and he groomed and restratified the catch-effort data in his series tripwise, allocating the groomed landed catch for each trip to the recomputed effort strata using Starr's (2003) method for processing MFish catch-effort and landings data, as implemented by Manning *et al.* (2004). His analysis also rigorously considered and accounted for changes in stargazer conversion factors over time, which neither Vignaux's (1997) nor Phillips' (2001) analyses did.

Manning (2007) fitted a suite of different generalised-linear-models (GLMs) to different subsets of the groomed dataset. The model, accepted by the Inshore FAWG as the best indication of STA 5 relative abundance, was a log normal GLM fitted to non-zero records associated with small, inshore bottom trawl vessels where giant stargazer was recorded as the target species, where the vessels had a consistent presence in the fishery (i.e., those vessels active in the fishery for five years or more with ten or more associated records per fishing year; a so-called "core" vessel subset), and where the response variable was defined as giant stargazer *catch* rather than *catch-per-unit-effort* (model fit 2.4). The canonical indices obtained from this model suggest that stargazer abundance in STA 5 has remained static, or at worst, declined only slightly over the data series (Figure 3). The trend in the standardised CPUE indices between the 1992-93 to 1995-96 fishing years appears consistent with stargazer relative biomass estimates from research trawl surveys of the Stewart-Snares shelf carried out by RV *Tangaroa*, 1993-96 (Figure 6) (Hurst & Bagley 1994, Bagley & Hurst 1995, 1996a, 1996b, Hurst & Bagley 1997). The peak then declined in the standardised CPUE and trawl survey relative biomass indices may, however, reflect a change in catchability rather than in stock abundance.

### 4.3 Biomass estimates

**STA 2**

An age structured model using deterministic recruitment was fitted to the abundance indices from the ECNI inshore and the ECNI scampi trawl surveys results (Table 4). The declines in the indices suggest that the current exploitation rate is very high, but the model results are determined by the choice of maximum allowable exploitation rate. An upper bound of 80% for the catch/biomass ratio was used in the base case, but this is considered unrealistically high, because stargazer is mainly caught as a bycatch of other fisheries and because the ECNI inshore trawl surveys suggest that there are parts of the stock not being fished. The virgin biomass estimated by the model of 563 t is therefore considered a minimum estimate of virgin biomass.

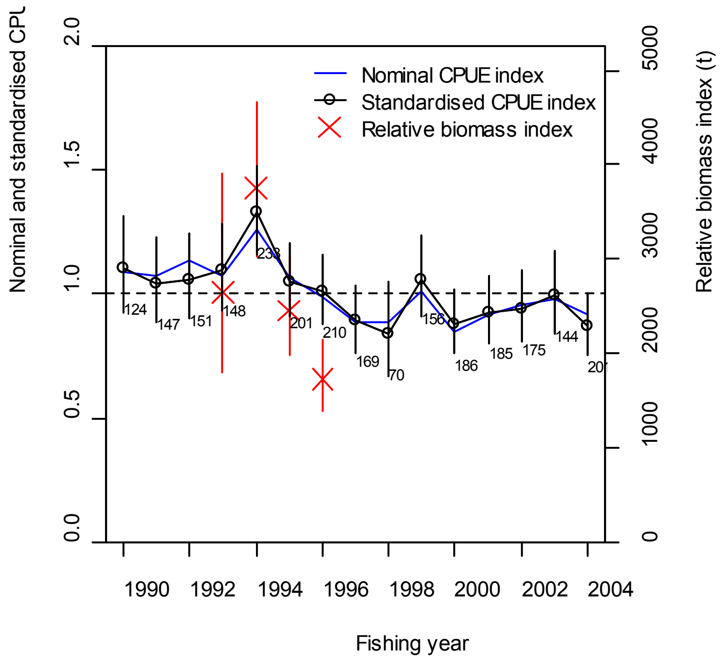



**Figure 8: The standardised CPUE indices from the fit of model 2.4 presented by Manning (2008). The nominal CPUE and trawl survey relative biomass estimates from the SCSI survey series by RV Tangaroa (1993-1996) have been overlaid for comparison. The nominal CPUE and trawl survey relative biomass indices have been rescaled so that all three series can be displayed on the same plot.**

## STA 7

An age-structured model partitioned by age (0-25 years) and sex was fitted to the WCSI trawl survey relative abundance indices (1992-05), WCSI survey proportions-at-age data (1992-05), and WCSI fishery catch-at-age data (2005 only) (Manning 2008). The stock boundary assumed in the model included the west coast of the South Island, Tasman and Golden Bays, but not eastern Cook Strait (a catch history was compiled for the model stock that excluded eastern Cook Strait). A summary of the model's annual cycle is given in Table 6. A preliminary model that included data up to the end of the 2005 year was revised and updated with additional data from 2007 West Coast South Island survey relative biomass, survey proportions-at-age, and fishery proportions-at-age data.

**Table 6: The STA 7 model's annual cycle (Manning 2008). Processes within each time step are listed in the time step in which they occur in particular order (e.g., in time step 3, new recruits enter the model partition first followed by the application of natural and fishing mortality to the partition). *M*, the proportion of natural mortality assumed during each time step. *F*, the nominal amount of fishing mortality assumed during each time step as a proportion of the total catch in the stock area. Age, the proportion of fish growth that occurs during each time step in each model year**

| | | | Proportions | | | |
|---|---|---|---|---|---|---|
| Time step | Duration | Process applied | *M* | *F* | Age | Observations |
| 1 | Oct-Jun | Mortality (*M*, *F*) | 0.75 | 0.77 | 1.00 | Survey relative biomass<br>Survey proportions-at-age Survey length-at-age<br>Fishery catch-at-age<br>Fishery relative abundance |
| 2 | Jun (instantaneous) | Spawning<br>Age incrementation | 0.00 | 0.00 | 0.00 | NIL |
| 3 | Jun-Sept | Recruitment<br>Mortality (*M*, *F*) | 0.25 | 0.23 | 0.00 | Fishery catch-at-age |

**Table 7: MCMC initial and current biomass estimates for the STA 7 model runs R3.1 R3.6 and R3.7 (Manning in prep). $B_0$, virgin or unfished biomass; $B_{2005}$, mid-year biomass in 2005 (current biomass); ($B_{2005}$/ $B_0$) %, $B_0$ as a percentage of $B_{2005}$; Min, minimum; Max, maximum; $Q_i$, ith quantile. The interval ($Q_{0.025}$, $Q_{0.975}$) is a Bayesian credibility interval (a Bayesian analogue of frequentist confidence intervals).**

| | R3.3 | | | R3.6 | | |
|---|---|---|---|---|---|---|
| | $B_0$ | $B_{2007}$ | ($B_{2007}$ / $B_0$) % | $B_0$ | $B_{2007}$ | ($B_{2007}$ / $B_0$) % |
| Min | 7 740 | 1 860 | 24.1 | 8 960 | 2 390 | 25.5 |
| $Q_{0.025}$ | 8 290 | 2 410 | 28.5 | 10 170 | 3 680 | 35.9 |
| Median | 9 210 | 3 580 | 38.8 | 13 750 | 7 490 | 54.2 |
| Mean | 9 250 | 3 640 | 39.1 | 14 630 | 8 330 | 54.5 |
| $Q_{0.975}$ | 10 580 | 5 290 | 50.7 | 24 910 | 18 580 | 76.3 |
| Max | 11 800 | 6 350 | 55.0 | 35 920 | 31 310 | 87.4 |
| | R3.7 | | | | | |
| Min | 7 840 | 1 900 | 24.2 | | | |
| $Q_{0.025}$ | 8 220 | 2 370 | 28.8 | | | |
| Median | 9 190 | 3 580 | 39.0 | | | |
| Mean | 9 220 | 3 640 | 39.1 | | | |
| $Q_{0.975}$ | 10 470 | 5 260 | 50.1 | | | |
| Max | 11 300 | 6 120 | 58.2 | | | |

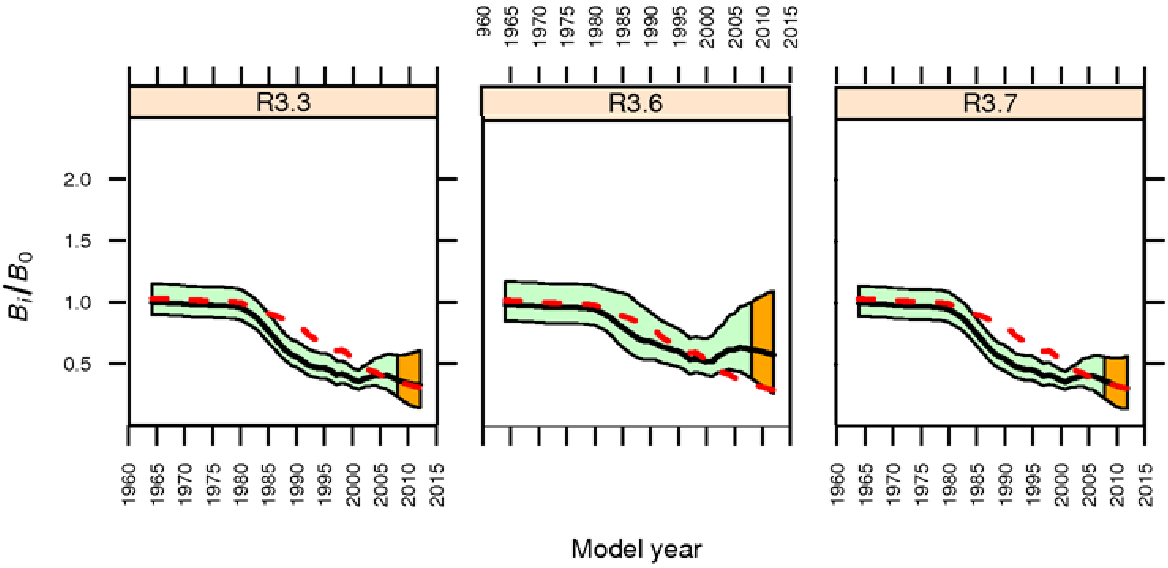



**Figure 9: Relative SSB trajectories (green) and projected status assuming a future constant catch equal to the current catch (orange) calculated from the MCMC runs for model runs 3.3, 3.6, and 3.7 in the quantitative stock assessment of STA 7. The shaded region indicates the 95% credibility region about median SSB (dotted lines) calculated from each model's SSB posterior distribution.**

Monte Carlo Markov chain estimates for three models (3.3, 3.6, and 3.7) are given in Table 7. Sensitivities to the base case model (R3.3) assumed domed survey selectivities (R3.6), and down-weighted the 2000 and 2003 survey indices (R3.7). Spawning stock biomass was estimated as 29-51% $B_0$ for the base case model, and ranged between 29 and 76% $B_0$ for the two model sensitivities (Table 7).

### 4.4 Estimation of Maximum Constant Yield (*MCY*)

(i) Chatham Rise (STA 4) and Southland and Sub-Antarctic (STA 5)

In previous assessments *MCY* was estimated from the absolute biomass estimates from trawl surveys. This method is now considered obsolete and the yield estimates are not reported here.

(ii) Other areas

*MCY* was estimated using the equation, $MCY = cY_{AV}$ (Method 4). The landings data from 1981-86 were relatively stable and were used to estimate $Y_{AV}$. The parameter c was set equal to 0.8 based on the estimate of $M = 0.23$.

The estimates of *MCY* were:

| | | | | | |
|---|---|---|---|---|---|
| STA 1: | 0.8 * | 5.8 t | = | 5 t | |
| STA 2: | 0.8 * | 21.8 t | = | 17 t | (rounded to 20 t) |
| STA 3: | 0.8 * | 492.3 t | = | 394 t | (rounded to 390 t) |
| STA 7: | 0.8 * | 346.6 t | = | 277 t | (rounded to 280 t) |
| STA 8: | 0.8 * | 4.8 t | = | 4 t | (rounded to 5 t) |

These estimates of *MCY* are likely to be conservative because of under-reporting in the past and are highly uncertain. These estimates of *MCY* have not changed since the 1989 Plenary Report.

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

### 4.5 Estimation of Current Annual Yield (*CAY*)

Estimates of current biomass are not yet available and *CAY* cannot yet be estimated for any giant stargazer Fishstock.

Yield estimates are summarised in Tables 8 and 9.

**Table 8: Giant stargazer yield estimates (t) for all stocks except STA 7.**

| Parameter | Fishstock | Yield estimate |
|---|---|---|
| *MCY* | STA 1 | 5 |
| | STA 2 | 20 |
| | STA 3 | 390 |
| | STA 4 | Cannot be determined |
| | STA 5 | Cannot be determined |
| | STA 8 | 5 |
| *CAY* | All | Cannot be determined |

**Table 9: Yield estimates (t) for STA 7**

| | | | Run |
|---|---|---|---|
| Parameter | 3.3 | 3.6 | 3.7 |
| *MCY* | 595 | 649 | 600 |
| $B_{MCY}$ | 6 813 | 11 282 | 6 720 |
| *CAY* | 936 | 2 065 | 938 |
| $F_{CAY}$ | 0.24 | 0.24 | 0.24 |
| MAY | 854 | 1 124 | 852 |
| $B_{MAY}$ | 3 205 | 4 348 | 3 209 |

### 4.6 Other yield estimates and stock assessment results

For STA 2, long-term yields are of the order of 50-60 t based on the minimum virgin biomass estimated by the model. No other yield estimates are yet available.

### 4.7 Other factors

The use of a single conversion factor for deepwater and inshore vessels has resulted in about a 5-10% under-estimate pre 1990-91 of the reported greenweight landings. In 1990-91, separate deepwater and inshore conversion factors were introduced.
The TACC in STA 4 has been under-caught because it is apparently uneconomical to target stargazer except near the Chatham Islands. It is a bycatch in the trawl fisheries for hoki, ling, silver warehou, squid, red cod and scampi on the Chatham Rise.

Stargazer landings have been influenced by changes in fishing patterns and fishing methods in the target species fisheries and indirectly by the abundance of those target species. Landings have also been influenced by changes in reporting behaviour for the different species. Stargazer were also taken historically in large quantities by foreign licensed and chartered trawlers fishing offshore grounds for other species (see Table 1). Because stargazer is mainly a bycatch, there is likely to be under-reporting in these data. Therefore, any estimate of *MCY* based on catch data is likely to be conservative.

## 5. ANALYSIS OF ADAPTIVE MANAGEMENT PROGRAMMES (AMP)

The Ministry of Fisheries revised the AMP framework in December 2000. The AMP framework is intended to apply to all proposals for a TAC or TACC increase, with the exception of fisheries for which there is a robust stock assessment. In March 2002, the first meeting of the new Adaptive Management Programme Working Group was held. Two changes to the AMP were adopted:

- a new checklist was implemented with more attention being made to the environmental impacts of any new proposal
- the annual review process was replaced with an annual review of the monitoring requirements only. Full analysis of information is required a minimum of twice during the 5 year AMP.

**STA 3**

The STA 3 TACC was increased from 734 t to 900 t under the AMP, beginning in the 1991-92 fishing year. The previous 5-year AMP term for STA 3 ended in September 2003 with the current one beginning in October of that year. A formal proposal was not required for the current term as the AMP FAWG supported the continuation of the AMP (March 2003) and no change was requested to the TACC.

**2008 Review of STA 3**

STA 3 was one of the initial stocks to enter an AMP, with a TACC increase from 734 t to 900 t in October 1991. Slight adjustments to this TACC have since occurred. The STA 3 AMP was reviewed in 1998 and retained in the programme until the end of 2002-03. It was further extended for another five years in October 2003. The STA 3 AMP was scheduled to end in September 2008, but will now be retained in an AMP until this Fishstock is incorporated into a Fisheries Plan. STA 3 catches increased quite rapidly in response to the AMP TACC increase from a pre-1991 level of around 600 t to around the new TACC level from 1993-94 to 1995-96. Catches have since fluctuated between about 600 t and 900 t, being below the TACC in all years except 2000-01 (960 t). Catches have averaged 750 t/year over 1996-97 to 2006-07, with 719 t reported in 2006-07. The Working Group noted that:

**Fishery characterisation**

- Most (95%) of STA 3 are caught using bottom trawl (BT), with a few landings in the setnet fishery (5%). About two-thirds of the bottom trawl landings have historically come from the two statistical areas north and south of Banks Peninsula: Area 020 - Pegasus Bay, and Area 022 - Canterbury Bight. The remaining third of the STA 3 BT landings are evenly distributed amongst the remaining inshore statistical areas. Only one offshore statistical area (Area 023) registered any STA 3 landings. Area 018 accounts for three-quarters of the STA 3 setnet landings.
- 40% of the BT landings of STA 3 are taken in the target red cod fishery, with remaining catches coming from the target flatfish, barracouta, hoki and tarakihi fisheries. STA itself only accounts for about 4% of the landings since 1989-90. The small amount of STA 3 setnet landings come from targeting on a range of species, including ling, hapuku/bass, and rig.
- Target species vary by area, with BT fishing for red cod predominating in the northern statistical areas (Areas 018, 020 and 022), and fishing for flatfish in the southern part of the East Coast South Island. Target BT fishing for barracouta is primarily confined to Area 22, while target fishing for hoki and scampi predominate in offshore areas. Ling, hapuku/bass, rig and tarakihi all take stargazer as a setnet bycatch in Area 018 while rig is the predominant setnet target species in Area 024

- There is some monthly variability, but little evidence of seasonality in landings of either bottom trawl or setnet catches of STA 3. Depending on target species, stargazer are caught over a wide depth range, between 50 m and 530 m depth (median 300 m).

**CPUE analysis**

- Three CPUE analyses were conducted for STA 3 catch and effort data, using the following fishery definitions from trips which fished in statistical areas valid for STA 3:
  - BT(MIX): a mixed target trawl fishery targeting a range of species: red cod, barracouta, tarakihi and stargazer.
  - BT(FLA): a target flatfish bottom trawl fishery operating at the shallower end of the stargazer depth distribution.
  - BT(HOK): a target hoki trawl fishery operating at the deeper end of the stargazer depth distribution.

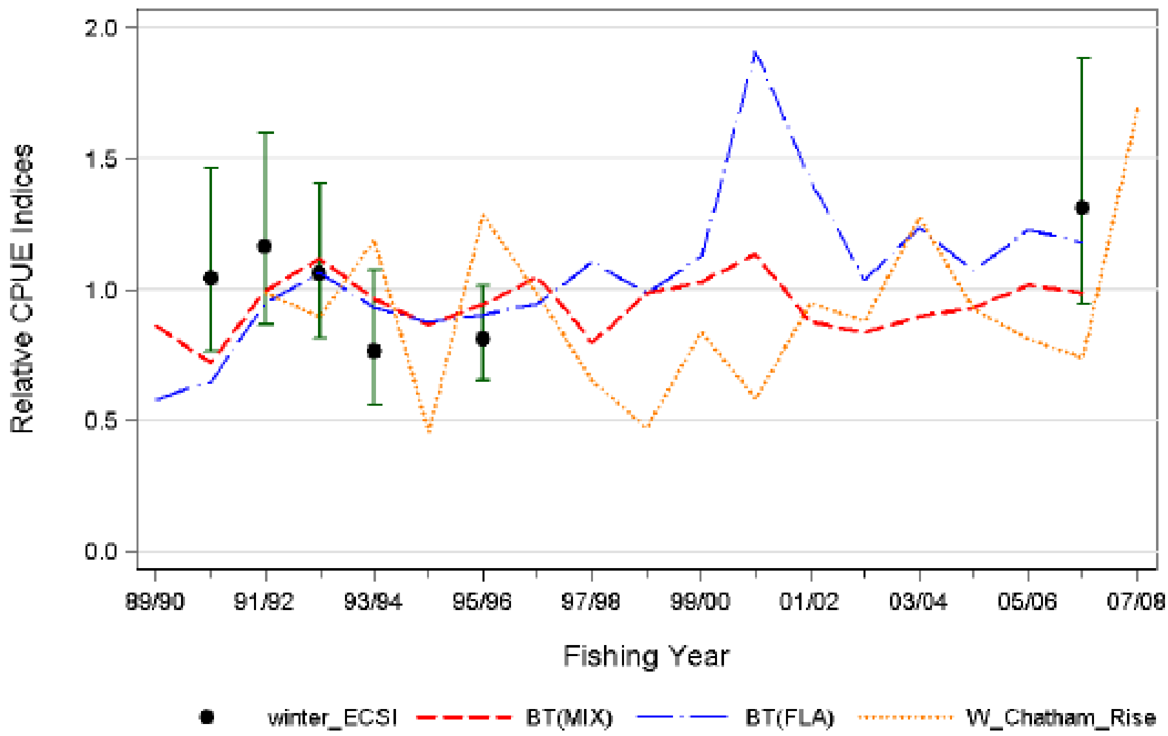



**Figure 10: Comparison plot of two STA CPUE biomass indices [BT(MIX) and BT(FLA)] plotted with the survey biomass indices for stargazer from the winter ECSI and western Chatham Rise trawl surveys. The trawl surveys were assumed to relate to the final year of the fishing year pair. Each series has been standardised to a common geometric mean from 1990-91 to 1993-94, 1995-96 and 2006-07.**

- The lognormal BT(MIX) mixed target bottom trawl fishery model shows only minor inter-annual variability, and no long-term trend since 1989-90 (Figure 8). Unstandardised series for this fishery are very similar to the standardised series, although standardisation does flatten the increasing trend in unstandardised CPUE over past five years.
- The lognormal BT(FLA) flatfish series also shows an increasing trend and, apart from an unexplained doubling of CPUE between 2000-01 and 2001-02, has lower variability than the hoki target fishery index (Figure 7). Unstandardised indices closely match the standardised BT(FLA).
- The lognormal BT(HOK) hoki target trawl series is more variable, with larger error bars, and shows greater deviation from the unstandardised indices. This index shows a generally increasing trend since 1991-92, which may result from the manner that this fishery is conducted. The high variation in this index probably results from the fact that this fishery operates at the deeper end of the stargazer depth range, where STA catch rates are relatively low.

- There appears to be reasonable similarity between the BT(MIX) and BT(FLA) series, particularly in the early to mid-1990s, and an overlay of the three series suggests a slowly increasing trend over the past decade. All three series also show a steady decline in the proportion of records with zero STA landings, which may result either from improved availability of STA, or from changes in fishing practices.

**Trawl survey abundance indices**

- Abundance indices for STA have been summarised for four trawl surveys series: East Coast South Island (ECSI) winter surveys from 1991 to 1996 (five surveys); ECSI winter survey in 2007 (one survey); ECSI summer surveys from 1997 to 2001 (five surveys); and Chatham Rise surveys from 1992 to 2008 (17 surveys) (Figures 2 and 3).
- Annual STA biomass estimates for the ECSI derived from these surveys (Figure 3) have good precision (CVs of 11% to 18%). The initial five winter surveys conducted in the first half of the 1990s did not show any trend, although the last two indices were lower than the first three. This survey was resumed in May 2007, with the most recent estimate similar to the early survey indices and showing no trend over the 11 year gap. These survey indices also correspond well to the three CPUE series discussed in the previous section (Figure 7). The discontinued summer survey series from 1997 to 2001 was highly variable, showing a strong decline in the last three surveys that appeared to be inconsistent with biomass changes, and was judged to be most likely caused by a change in relative catchability/availability of stargazer.
- An index for the western end of the Chatham Rise has been created for stargazer from annual *RV Tangaroa* surveys during December and January. Although this index is likely to be representative of the stargazer population on the western Chatham Rise, it is highly variable and imprecise, particularly in the most recent survey, where the survey CV exceeds 60%. However, there appears to be no overall trend over this series.

**Logbook programme**

- A logbook programme to sample the east coast South Island trawl fishery was implemented in 2003-04. Initially, this programme only sampled elephantfish, but it was gradually extended to sample other AMP species in this fishery, including stargazer.
- As a result of diversity of the fishery and scarcity of stargazer catches in individual tows, this programme has never obtained good coverage. The number of tows reported has ranged from 230 to 905 over all species sampled, but which represents only 300 kg to 3.7 t of estimated stargazer catch. Coverage levels ranged from 0.1 to 0.5% of the total STA 3 trawl catch, based on simple ratios of estimated catches. Coverage has been low, even when only the target stargazer fishery is considered, which achieved coverage from 0% to 8.5%.
- Comparison of the logbook coverage by statistical area with comparable catch/effort data shows that the logbook programme over-sampled Area 022, under-sampled in Area 020 and sampled appropriately in Area 024. The bottom trawl logbook programme has failed to achieve consistent seasonal representation of the stargazer catch in any year.
- Most of the reported logbook data are from the Canterbury Bight, in inner shallow areas, and along the shelf edge. Some tows were reported on the shelf off of Banks Peninsula. The depth range fished ranged from 42 to 125 m (median 55 m, mean 69 m).
- Analyses of length-frequency data showed general consistency between years for each surveys series, with no evidence of trends in mean size. However, females were often larger than males across surveys, and STA in the Chatham Rise surveys were consistently larger than those caught in the ECSI surveys. This raises questions regarding relationships and/or differences between the ECSI and Chatham Rise populations.

**Effects of fishing**

- Low observer coverage and lack of fine scale catch reporting has made it difficult to objectively evaluate the environmental effects of fishing under the STA 3 AMP. The rates of non-fish bycatch are unknown, monitoring is not adequate. Since the last review of STA 3 in 2006:

- The Non-fish/Protected Species Catch Return to be implemented from 1 October 2008 should provide information on the level of non-fish/protected species bycatch for the next review of STA 3. However, adequate observer coverage will still be required to validate reporting rates.
- The draft Hector's and Maui's Dolphin Threat Management Plan (TMP) released for consultation (MFish and DOC 2007) proposes an extension to the existing Banks Peninsula marine mammal sanctuary.
- Under seabird sustainability measures begin on 1 June 2008. Trawlers can not discharge offal or fish on more than one occasion per tow or during shooting or hauling or within 20 minutes before shooting.

**Conclusions**

- A comparison of the most credible abundance indices for the STA 3 stock (BT(MIX) and BT(FLA) CPUE indices, ECSI winter and western Chatham Rise summer trawl surveys) shows fairly good correspondence between the series, suggesting a flat or slowly increasing trend over the history of the fishery, particularly in the preferred BT(MIX) CPUE index (Figure 5).
- These results support the conclusions of the Inshore Fishery Assessment Working Group in 1997 that recent catch levels are probably sustainable. It is not known if the TACC is sustainable because catches have averaged about 15% below the TACC since 1989-90.

**AMP review checklist**

1. The Working Group concluded that the ECSI winter trawl surveys and, in their absence, the BT(MIX) standardised CPUE series, provide reasonable indices of the STA 3 stargazer population. Analyses prepared in 2008 show these two indices to be consistent with one another, and with the BT(FLA) index derived from a fishery operating shallower depths. Together, these indices are considered to monitor abundance of the fished component of the stock reasonably well. However, the full extent of the stargazer population which contributes to the STA 3 fisheries may not be covered by these fisheries, and there are questions about the relationships of the fished population with STA stock components in deeper water, or on the western Chatham Rise.
2. The current logbook programme provides reasonable coverage of the mixed-species bottom trawl fishery in FMA 3. However, its coverage of STA catches in this fishery has been very low, and improvements are needed to improve seasonal and spatial representivity of the fishery, and of variable distribution of STA in the area.
3. Additional analyses recommended by the Working Group included:
   - The relationship between the stargazer populations in STA 3 and STA 4 could be investigated by comparing Chatham Rise trawl survey biological data with equivalent data from the inshore east coast survey and possibly the target hoki fishery to ascertain whether there is a size / depth relationship for STA.
   - It may be possible to perform a stock assessment on the available stargazer data, now that a reasonable set of CPUE biomass indices are available and the winter ECSI trawl survey has been reinstated. Such an assessment would need to understand the relationship between STA 3 and STA 4, as there may be migration between these two areas. Ageing of stargazer from the more recent winter surveys will also be required for such an assessment,
4. Consistency between all of the credible indices for the STA 3 fishery, all of which show a flat, or perhaps slightly increasing, trend across the history of the fishery, indicate that current catches are sustainable.
5. STA 3 remains primarily a bycatch in the mixed-species inshore trawl fishery. At time of entry into the AMP, the STA 3 stock was considered to be most likely above $B_{MSY}$ and views regarding the status of the STA 3 stock have not changed subsequently.
6. Observer coverage levels of the inshore trawl fisheries are low, and the effects of fishing are not currently adequately monitored. Introduction of the '*Non-fish/Protected Species Catch Return*' into the suite of regulated MFish forms from 1 October 2008, may provide a credible source of information on the level of protected species bycatch in STA 3. However, observer coverage will still be required to validate fisher reporting rates.

7. Given the low observer coverage in this fishery, rates of non-fish bycatch are not known with any confidence, and it is not known whether rates of bycatch are acceptable.
8. The Working Group agreed that this stock did not need to be referred to the Plenary for review.

**STA 7**

The STA 7 TACC was first increased under the AMP from 734 t to 900 t, beginning in the 1991-92 fishing year. The TACC was further increased to 997 t (TAC 1000 t) in October 2003, and again in 2010 to 1042 t. The TAC in 2010 therefore increased to 1072 t, which included a 1 t customary and 2 t recreational catch.

**Review of STA 7 AMP in 2007**

In 2007 the AMP FAWG reviewed the performance of the AMP after 5 years (Starr *et al.* 2007b). This report was not updated in 2008. In 2007 the Working Group noted:

**Fishery characterisation**

- The STA7 TACC was increased from 528 t to 700 t in 1991-92 under an AMP. Two proposals were made in 2002 to increase this TACC, and the TACC was increased to 997 t in October 2002, with an additional 3 t for non-commercial catch, giving a total TAC of 1000 t.
- Catches exceeded the TACC in this fishery from entry into the QMS in 1986-87 until implementation of the most recent TACC increase in 2002-03, except in 1997-98 when a decline in the Asian market caused catches to dip below the TACC. In particular, catches escalated dramatically from 1997-98 to reach about double the TACC in 2000-01.
- Active management intervention (stopping of bycatch trading, implementation of the ACE provisions of the Fisheries Act and implementation of ramped deemed values) caused an even more dramatic drop in catches to just above the TACC level in 2001-02. Following the increase in TACC to 997 t in 2002-03, catches have remained near the TACC level.
- The Working Group noted that the ~ 50% drop in catch in 2001-02 in response to changes in the ACE and deemed value systems indicated a particularly strong ability to actively target or avoid stargazer in this fishery. It is certainly clear that the rapid increase in stargazer occurred in the 'barracouta' target fishery, probably due to the fact that barracouta was the cheapest quota to obtain at the time.
- Catch reporting in this fishery is poor, with estimated catches averaging 50% of landed catch, and landings exceeding estimated catches by up to 6 times. The Working Group also noted some unexplainable changes in conversion factors. RDM will be asked whether these are data capture errors, or actual entries on return forms.
- 97% of STA 7 are caught in bottom trawls, with 80% of the trawl landings coming from the southern half of the west coast South Island (Areas 032 to 034). Small amounts of catches are made by setnet or mid-water trawl. The trawl fishery catches STA year-round, whereas setnet fishery catches are mainly made from July to September. Seasons differ by area, with the Cook Strait mainly being fished in summer, whereas the southern areas are fished all year.
- Stargazer are mainly reported from the barracouta targeted trawl fishery, but data presented at previous meetings showed that no barracouta were caught when the large catches of stargazers were made.
- There has been a recent increase in STA catch in the tarakihi, red cod and stargazer targeted trawl fisheries, particularly in the southern areas. The bycatch of stargazer in the barracouta target fishery, has decreased in recent years, possibly due to regulation changes which reduced the incentive to declare this species as the target. Setnet STA catches are mainly made while targeting ling.

**CPUE analysis**

- Three fishery definitions were used in developing standardised CPUE indices for STA7: Trawl fishery targeting STA, BAR, RCO or TAR on the WCSI; the same mixed bottom trawl fishery in the Cook Strait; and the flatfish targeted WCSI trawl fishery.

- CPUE for these fishery definitions was standardised using a lognormal model based on non-zero catches. In addition, a binomial model was used to investigate the effect of changing proportion of non-zero catches.
- Standardisation had very little effect on the indices for the mixed target trawl fisheries relative to the unstandardised index. The standardised WCSI MIX index shows a steady increase to a peak in 2000-01, followed by a sharp drop to near the long-term average, coinciding with the drop in catches. The Cook Strait index shows a flat, stable trend across most of the series, but also with a sharp peak in 2000-01. It seems likely that the CPUE peaks and subsequent drop in catch rates relate more to targeting practices than to abundance.
- The FLA target index shows a steady increase from 1993-94 to a very strong peak in 1999-00, followed by a rapid decline back to the lowest levels by 2003-04. These changes are too large to relate to proportional changes in abundance, and may relate more to changes in availability to the near-shore flatfish fleet, fishing on the inshore edge of the stargazer depth distribution.
- The Working Group noted that the rapid doubling and halving of catch rates in the standardised CPUE indices cannot reflect proportional changes in abundance, and was rather an indication of very strong changes in fleet behaviour and targeting practices. This makes it difficult to decide what confidence to place in the indices.
- The group did note, however, that rapid changes in CPUE in the shallow flatfish fishery could reflect changes in availability of stargazer to this fleet, on the edge of the stargazer depth distribution.
- The strong effect that management changes (the introduction of ACE and changes in deemed values), and targeting responses by the industry, have likely had on CPUE were emphasized. The Working Group considered CPUE after these changes in 2000 to be less reliable and probably not comparable with CPUE prior to 2000.
- The Working Group again noted problems in interpreting reasons for the increase in non-zero catches in many fisheries, and confirmed that the binomial analyses should be accorded very little weight.
- In overview, the overlay of the trawl fishery indices seems to suggest fluctuations (related to targeting?) around a fairly flat trend across the series.

**Trawl surveys**

- The west coast trawl surveys are considered to be more reliable as indicators of abundance than those conducted on the east coast. Eight surveys have now been conducted from 1992 to 2007.
- Trawl survey estimates suggested a substantial decline in STA abundance in 2000, and again in 2003, after a period of stable estimates from 1992 - 1997, prompting concern that the stock was declining.
- However, estimates for 2005 and 2007 are again at or above the average of the 1992 to 1997 historic estimates. These recent estimates indicate that the low levels in 2000 and 2003 may have been due to catchability changes, as has occurred in the east coast survey.
- The overall trawl survey series indicates that the stock has remained stable at a fairly constant level, which seems to support indications in the trawl CPUE indices of a stable long-term trend.

**Logbook programme**

- Coverage of the west coast South Island trawl fishery is good, but no biological data for stargazer are being collected.

**Effects of fishing**

- Hector's dolphins aggregate in two areas of STA 7, Westport and Hokitika. However, there have been no known interactions between these trawl fisheries and dolphins off the WCSI. The Challenger Code of Practice states that trawlers are required not to haul nets when dolphins are present.
- Seabirds do occasionally get caught in BAR targeted fisheries in which STA 7 is caught. During 2005-06, 24 seabird captures were observed on 277 BAR trawls; an incidence rate

was estimated to be 6.5%. However, observer coverage is inadequate to provide reliable estimates of effects of fishing across the fishery.

- The Working Group noted that fishers are able to target stargazer, which has lead to changes in fleet behaviour, probably related to changing fishing area and depth. This suggests that seabed effects, at least, may have changed. Changes such as this need to be measured and reported on.

**Conclusions**

- The results of the trawl surveys indicate that the STA 7 stock has remained stable since 1992.
- The standardised CPUE indices presented do not change that conclusion.

## 6. STATUS OF THE STOCKS

No estimates of current and reference biomass are available.

**STA 1**

The TACC for STA 1 was increased from 21 t to 50 t in the 1991-92 fishing year under the AMP. In 1997, the TACC was reduced to 21 t upon its removal from the programme. Recent catches have exceeded this level. It is not known if recent catch levels and current TACC are sustainable. The status of STA 1 relative to $B_{MSY}$ is unknown.

**STA 2**

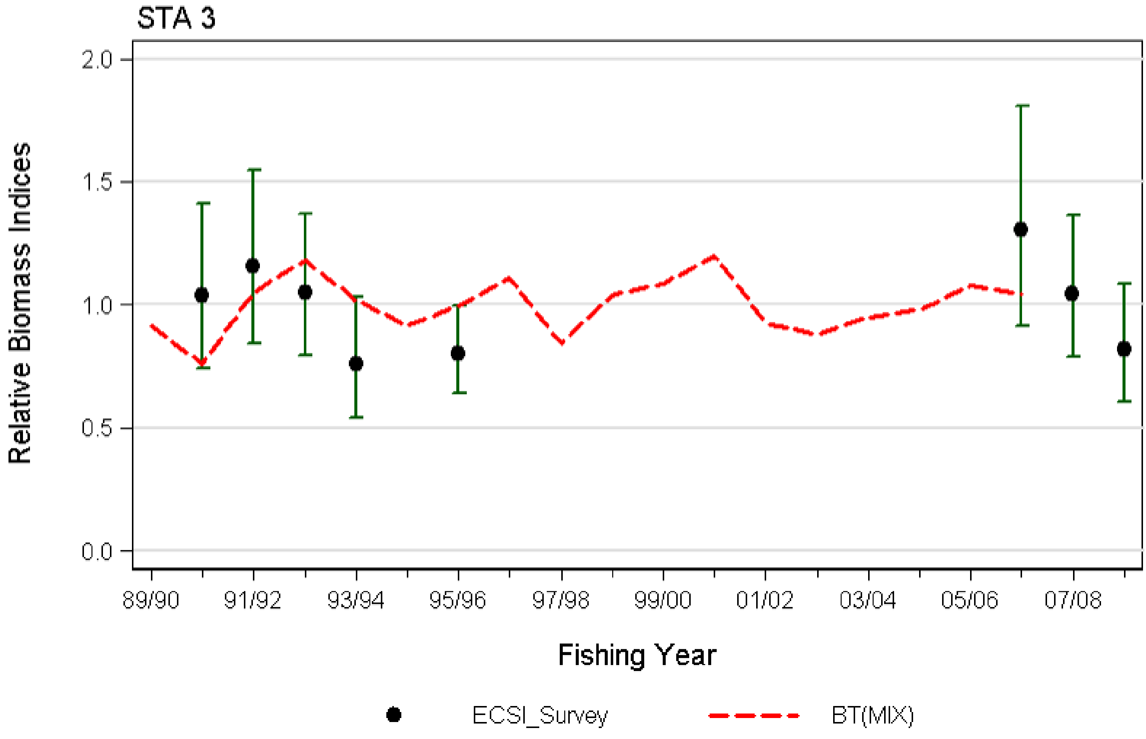
The TACC for STA 2 was increased from 37 t to 100 t in the 1991-92 fishing year under the AMP. Landings in the early 1990s peaked in the range of 105-125 t, but have subsequently declined.

The TACC was reduced to 38 t in the 1997-98 fishing year, upon the removal of STA 2 from the AMP. Landings have been below the TACC since 2003-04. It is not known whether recent catches and the current TACC will cause the STA 2 stock size to decline. The status of STA 2 relative to $B_{MSY}$ is unknown.

**STA 3**

| **Stock Status** | |
|---|---|
| Year of Most Recent Assessment | 2008 (CPUE); 2010 (trawl survey) |
| Assessment Runs Presented | |
| Reference Points | Target: *MSY*-compatible proxy based on the East Coast South Island trawl survey index (to be determined)<br>Soft Limit: 50% of target<br>Hard Limit: 25% of target |
| Status in relation to Target | Unknown |
| Status in relation to Limits | Unlikely (< 40%) to be below both soft and hard limits |

| **Historical Stock Status Trajectory and Current Status** |
| --- |




**Comparison plot of a STA CPUE biomass index with the west coast South Island survey biomass index for. The trawl surveys were assumed to relate to the final year of the fishing year pair.**

| **Fishery and Stock Trends** | |
| --- | --- |
| Recent Trend in Biomass or Proxy | While the CPUE indices have been relatively flat, fluctuating about the long-term mean, the two recent (2008 and 2009) ECSI survey estimates have shown progressive declines from the high in 2007 to just below the long-term mean. |
| Recent Trend in Fishing Mortality or Proxy | Unknown |
| Other Abundance Indices | - |
| Trends in Other Relevant Indicators or Variables | - |

| **Projections and Prognosis** | |
| --- | --- |
| Stock Projections or Prognosis | STA 3 remains primarily a bycatch in the mixed-species inshore trawl fishery. STA 3 stock size is Likely (> 60%) to remain near current levels under current catch (2007-08 and 2008-09). It is Unknown if catches near the TACC would cause the stock to decline. |
| Probability of Current Catch or TACC causing decline below Limits | Soft Limit: Unlikely (< 40%)<br>Hard Limit: Unlikely (< 40%) |

| **Assessment Methodology** | | |
| --- | --- | --- |
| Assessment Type | Level 2 - Partial quantitative stock assessment | |
| Assessment Method | -Trawl survey biomass and standardised CPUE based on lognormal error distribution and positive catches.<br>-Science information quality ranking | <br><br><br><br><br>1 – High Quality |
| Assessment Dates | Latest assessment: 2008 | Next assessment: 2011 (trawl |

| | | |
|---|---|---|
| | (CPUE) 2010 (trawl survey) | survey) |
| Main data inputs | Catch and effort data | |
| Data not used (rank) | N/A | N/A |
| Changes to Model Structure and Assumptions | None | |
| Major Sources of Uncertainty | | |

The Southern Inshore Working Group agreed that both the East Coast South Island trawl survey is a credible measure of relative biomass, and the BT(M)X) CPUE index is credible measures of abundance.

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

| Fishery Interactions |
|---|
| 40% of the bottom trawl landings of STA 3 are taken in the target red cod fishery, with remaining catches coming from the target flatfish, barracouta, hoki and tarakihi fisheries. Target STA has only accounted for about 4% of total landings since 1989-90. |

**STA 4**

Stargazer in this Fishstock occur mainly on the Chatham Rise on the shelf around the Chatham Islands, but are sparsely distributed over the rest of the Rise. In most of this Fishstock they may not be economic to target. However, if fishing is overly concentrated in those areas where stargazer can be targeted, such as close to the Chatham Islands, there are concerns that local depletion may occur.

The 2011 estimate of biomass from the Chatham Rise trawl survey was above the long-term mean (1991-2011). The original TACC of 2014 t for STA 4 was based on a yield estimate from a single trawl survey in 1983. This method is now considered obsolete. The TACC was increased in 2000-01 to 2158 t. Catches have always been substantially less than the TACC. The average catch since the TACC increase has been 300 t. It is not known if catches at the level of the current TACC would be sustainable.

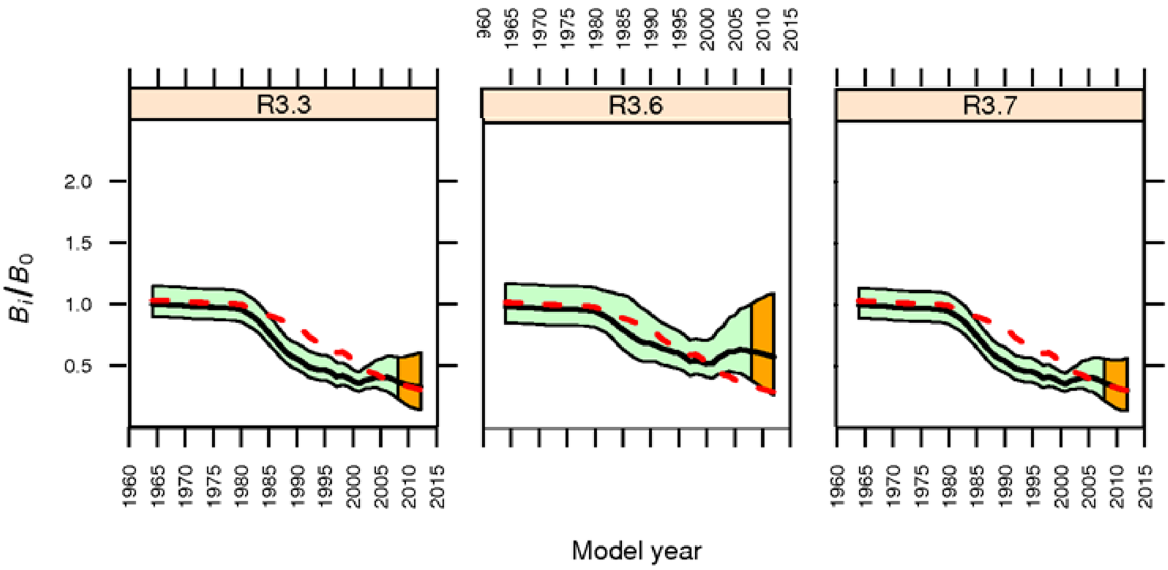
**STA 5**

The TACC for STA 5 was increased from 1239 t to 1500 t in the 1991-92 fishing year under the AMP. Landings increased to 1327 t in 1993-94, declined to 544 t in 1997-98, but have subsequently increased. The TACC was reduced to 1264 t in 1997, upon the removal of STA 5 from the AMP. This new TACC is at the level of recent catches, and is probably sustainable. The status of STA 5 relative to $B_{MSY}$ is unknown.

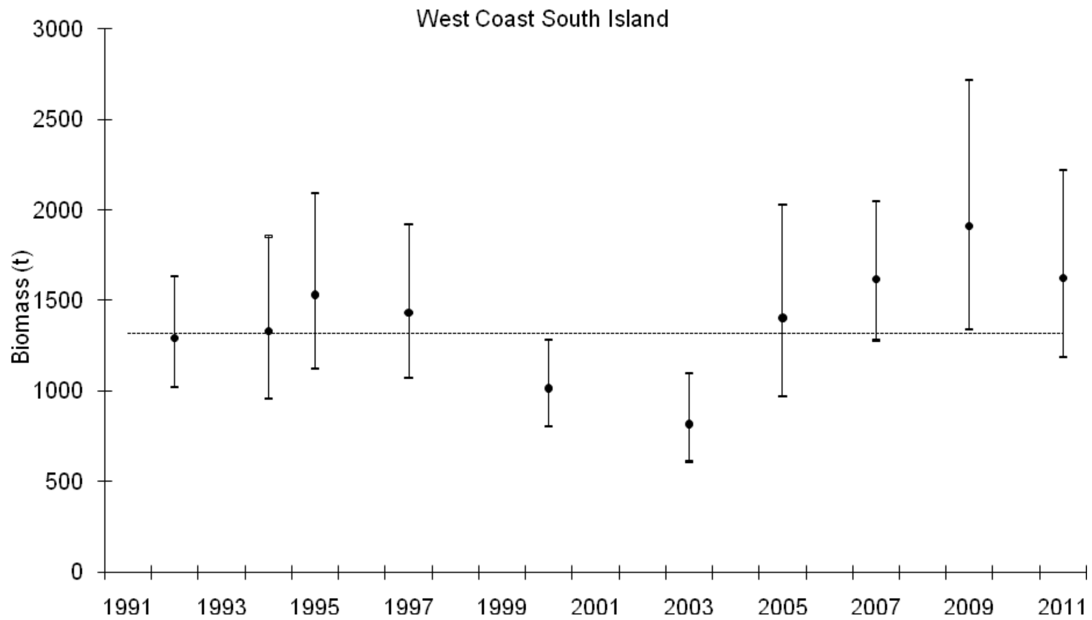
**STA 7**

| Stock Status | |
|---|---|
| Year of Most Recent Assessment | 2008 - Stock assessment<br>2009 - Analysis of survey indices of abundance |
| Assessment Runs Presented | Run 3.3 (base case), 3.6 (domed selectivity) and 3.7 (down weight 2000 and 2003 survey data points) |
| Reference Points | Target(s): Not established but $B_{MSY}$ assumed<br>Soft Limit: 20% $B_0$<br>Hard Limit: 10% $B_0$ |
| Status in relation to Target | The range of model results for STA 7 west coast stock assessment suggests that, given the assumptions about recruitment, the stock is Likely (> 60%) to be at or above $B_{MSY}$. |
| Status in relation to Limits | Soft Limit: Very Unlikely (< 10%) to be below<br>Hard limit: Very Unlikely (< 10%) to be below |

| **Historical Stock Status Trajectory and Current Status** |
|---|




**Relative SSB trajectories (green) and projected status assuming a future constant catch equal to the current catch (orange) calculated from the MCMC runs for model runs 3.3, 3.6, and 3.7 in the quantitative stock assessment of STA 7. The shaded region indicates the 95% credibility region about median SSB (dotted lines) calculated from each model's SSB posterior distribution.**




**Stargazer biomass ±95% CI (estimated from survey CVs assuming a lognormal distribution) and the time series mean (dotted line) estimated from the West Coast South Island trawl survey.**

| **Fishery and Stock Trends** | |
|---|---|
| Recent Trend in Biomass or Proxy | The WCSI trawl survey indices have increased from a low observed in 2003 to the highest in the series in 2009. |
| Recent Trend in Fishing Mortality or Proxy | Unknown |
| Other Abundance Indices | - |
| Trends in Other Relevant Indicators or Variables | - |

| **Projections and Prognosis** | |
|---|---|
| Stock Projections or Prognosis | STA 7 stock is Likely (> 60%) to remain at or above $B_{MSY}$ at current catch levels. |

| | |
|---|---|
| Probability of Current Catch or TACC causing decline below Limits | Soft Limit: Very Unlikely (< 10%)<br>Hard Limit: Very Unlikely (< 10%) |

| **Assessment Methodology** | | |
|---|---|---|
| Assessment Type | Level 1 - Quantitative stock assessment<br>Level 2 - Agreed biomass index (WCSI trawl survey) | |
| Assessment Method | Bayesian Statistical stock assessment model implemented in CASAL.<br>Evaluation of recent trawl survey indices (up to 2009). | |
| Assessment Dates | Latest assessment: 2008 (assessment) 2009 (survey) | Next assessment: 2011 (survey) |
| Main data inputs (rank) | - An age-structured model partitioned by age (0-25 years) and sex was fitted to the WCSI trawl survey relative abundance indices (1992-05), WCSI survey proportions-at-age data (1992-05), and WCSI fishery catch-at-age data (2005 only)<br>- Commercial catch, trawl survey biomass and proportions-at-age estimates, and commercial catch proportions-at-age.<br>- Science information quality ranking | 1 – High Quality; The Southern Inshore Working Group accepted the assessment as a credible means to assess $B_{MSY}$ and the West Coast South Island trawl survey as a credible measure of relative biomass. |
| Data not used (rank) | N/A | N/A |
| Changes to Model Structure and Assumptions | None | |
| Major Sources of Uncertainty | | |

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

| **Fishery Interactions** |
|---|
| Smooth skates are caught as a bycatch in this fishery, and the biomass index for smooth skates in the west coast trawl survey has declined substantially since 1997. There may be similar concerns for rough skates but the evidence is less conclusive. |

**STA 8**

The TACC for STA 8 increased from 22 t to 50 t in the 1993-94 fishing year under the AMP. Landings increased to 18 t in 1991-92 but have since declined to less than 5 t. The TACC was reduced back to 22 t in 1997, upon the removal of STA 8 from the programme. It is not known if recent catch levels and current TACC are sustainable. The status of STA 8 relative to $B_{MSY}$ is unknown.

Yield estimates, TACCs, and reported landings for the 2010-11 fishing year are summarised in Table 10.

**Table 10: Summary of yields (t), TACC (t), and reported landings (t) of giant stargazer for the most recent fishing year.**

| Fishstock | QMA | | *MCY* | *CAY* | TACC | Landings |
|---|---|---|---|---|---|---|
| STA 1 | Auckland (East and West) | 1 & 9 | 5 | - | 21 | 21 |
| STA 2 | Central (East) | 2 | 20 | - | 38 | 19 |
| STA 3 | South-East (Coast) | 3 | 390 | - | 902 | 570 |
| STA 4 | South-East (Chatham) | 4 | - | - | 2 158 | 134 |
| STA 5 | Southland and Sub-Antarctic | 5 & 6 | - | - | 1 264 | 1 235 |
| STA 7 | Challenger | 7 | 595 | 936 | 1 042 | 1 037 |
| STA 8 | Central (West) | 8 | 5 | | 22 | 7 |
| STA 10 | Kermadec | 10 | - | - | 10 | 0 |
| Total | | | - | - | 5 456 | 3 023 |

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