# SCHOOL SHARK (SCH 5)

## REPORT TO THE ADAPTIVE MANAGEMENT PROGRAMME FISHERY ASSESSMENT WORKING GROUP:
## CHARACTERISATION, CPUE ANALYSIS AND LOGBOOK DATA FOR SCH 5

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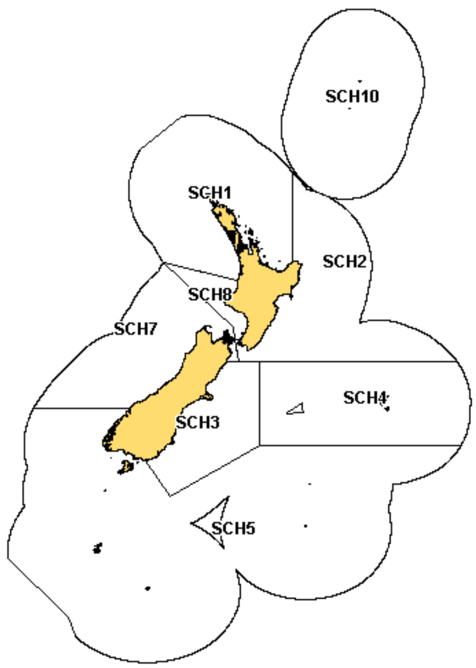


Figure 1. Map of SCH QMAs.

## 1. DESCRIPTION OF THE PROGRAMME

The SCH 5 TACC was raised on 1 October 2004 by 5% from 708 tonnes to 743 tonnes under the conditions of the Adaptive Management Programme (AMP) as specified by the Ministry of Fisheries in the "*Draft Frameworks for Exploratory, Developing, and Established Fisheries under the Adaptive Management Programme*" dated December 1999. Allowances for the combined recreational and customary catches of 51 t per year were also made at the time of the introduction of SCH 5 into the AMP, resulting in a total SCH 5 TAC of 794 t.

This paper is a report to the Adaptive Management Programme Fisheries Assessment Workgroup (AMPWG) on the SCH 5 AMP for the period ending 30 September 2009. The introduction of SCH 5 into the AMP was justified under the adaptive management provision that the "*stock abundance appears to be stable or increasing under current catch levels, i.e. current catch levels appear to be having no effect on stock size*".

## 2. OBJECTIVE OF THE PROGRAMME

To determine the size, geographical extent and long-term sustainable yield of the SCH 5 Fishstock.

## 3. INFORMATION ABOUT CURRENT RESEARCH

The SCH 5 AMP is monitored using catch and effort data from the target shark setnet fishery presently operating in Statistical Areas 025, a small part of 026, most of 027, all of 028 to 031 and part of 032. In addition, data from other fisheries taking school shark, mainly the bottom trawl fisheries operating on the southern end of the South Island, are monitored for trends. This species, given its large size and strong swimming capacity, is unlikely to be adequately monitored using trawl surveys. Biological information is obtained from the shark setnet fishery using a voluntary logbook programme currently operating in QMA 5. Unfortunately, participation in this programme has declined considerably in recent years.

Table 1. Reported landings (t) of school shark for all SCH Fishstocks from 1983–84 to 2008–09 and TACCs (t) from 1986–87 to 2008–09. Data sources: [1983–84 to 1985–86 Fisheries Statistics Unit]; [1986–87 to 2000–01: Quota Management Reports]; [2001–02 to 2008–09: Monthly Harvest Reports]. Note: these data have not been adjusted for changes in conversion factor reporting rates

| Fishing | SCH 1 | | SCH 2 | | SCH 3 | | SCH 4 | | SCH 5 | | SCH 7 | | SCH 8 | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Catch | TACC | Catch | TACC | Catch | TACC | Catch | TACC | Catch | TACC | Catch | TACC | Catch | TACC | Catch | TACC |
| 1983–84 | 1 087 | | 298 | | 630 | | 8 | | 792 | | 1 039 | | 694 | | 4 776 | |
| 1984–85 | 861 | | 237 | | 505 | | 12 | | 995 | | 1 030 | | 698 | | 4 501 | |
| 1985–86 | 787 | | 214 | | 370 | | 23 | | 647 | | 851 | | 652 | | 3 717 | |
| 1986–87 | 416 | 560 | 123 | 162 | 283 | 270 | 19 | 200 | 382 | 610 | 454 | 470 | 224 | 310 | 1 902 | 2 593 |
| 1987–88 | 528 | 602 | 123 | 169 | 320 | 285 | 22 | 200 | 531 | 613 | 516 | 500 | 374 | 345 | 2 413 | 2 724 |
| 1988–89 | 477 | 624 | 136 | 188 | 220 | 294 | 26 | 200 | 501 | 615 | 540 | 522 | 419 | 433 | 2 319 | 2 886 |
| 1989–90 | 585 | 652 | 156 | 197 | 272 | 305 | 27 | 235 | 460 | 635 | 516 | 524 | 371 | 438 | 2 387 | 2 996 |
| 1990–91 | 559 | 664 | 139 | 198 | 227 | 318 | 21 | 239 | 480 | 649 | 420 | 531 | 369 | 441 | 2 214 | 3 049 |
| 1991–92 | 594 | 664 | 161 | 198 | 260 | 318 | 34 | 239 | 599 | 686 | 431 | 531 | 401 | 441 | 2 479 | 3 086 |
| 1992–93 | 820 | 667 | 205 | 199 | 220 | 322 | 38 | 239 | 593 | 686 | 482 | 531 | 482 | 441 | 2 840 | 3 093 |
| 1993–94 | 658 | 667 | 156 | 199 | 202 | 322 | 41 | 239 | 624 | 686 | 473 | 531 | 448 | 441 | 2 603 | 3 093 |
| 1994–95 | 658 | 668 | 159 | 199 | 237 | 322 | 86 | 239 | 656 | 694 | 370 | 534 | 417 | 441 | 2 582 | 3 105 |
| 1995–96 | 800 | 668 | 215 | 199 | 293 | 322 | 216 | 239 | 697 | 694 | 638 | 534 | 521 | 441 | 3 381 | 3 105 |
| 1996–97 | 791 | 668 | 228 | 199 | 289 | 322 | 178 | 239 | 636 | 694 | 545 | 534 | 458 | 441 | 3 127 | 3 105 |
| 1997–98 | 757 | 668 | 210 | 199 | 271 | 322 | 122 | 239 | 621 | 694 | 468 | 534 | 443 | 441 | 2 892 | 3 106 |
| 1998–99 | 784 | 668 | 275 | 199 | 335 | 322 | 106 | 239 | 714 | 694 | 682 | 534 | 533 | 441 | 3 429 | 3 106 |
| 1999–00 | 820 | 668 | 250 | 199 | 343 | 322 | 97 | 239 | 706 | 694 | 639 | 534 | 469 | 441 | 3 324 | 3 106 |
| 2000–01 | 799 | 668 | 178 | 199 | 364 | 322 | 100 | 239 | 724 | 708 | 576 | 534 | 453 | 441 | 3 193 | 3 120 |
| 2001–02 | 670 | 668 | 208 | 199 | 324 | 322 | 93 | 239 | 671 | 708 | 500 | 534 | 448 | 441 | 2 914 | 3 120 |
| 2002–03 | 689 | 668 | 225 | 199 | 410 | 322 | 130 | 239 | 746 | 708 | 512 | 534 | 448 | 441 | 3 161 | 3 120 |
| 2003–04 | 758 | 668 | 187 | 199 | 323 | 322 | 149 | 239 | 727 | 708 | 574 | 534 | 405 | 441 | 3 124 | 3 120 |
| 2004–05 | 695 | 668 | 201 | 199 | 424 | 387 | 206 | 239 | 743 | 743 | 546 | 641 | 554 | 529 | 3 369 | 3 416 |
| 2005–06 | 634 | 668 | 177 | 199 | 324 | 387 | 183 | 239 | 712 | 743 | 568 | 641 | 503 | 529 | 3 101 | 3 416 |
| 2006–07 | 661 | 668 | 200 | 199 | 376 | 387 | 88 | 239 | 738 | 743 | 583 | 641 | 534 | 529 | 3 180 | 3 416 |
| 2007–08 | 708 | 689 | 228 | 199 | 345 | 387 | 134 | 239 | 781 | 743 | 606 | 641 | 497 | 529 | 3 298 | 3 436 |
| 2008–09 | 713 | 689 | 232 | 199 | 364 | 387 | 145 | 239 | 741 | 743 | 694 | 641 | 588 | 529 | 3 478 | 3 436 |

## 4. INFORMATION ABOUT THE STOCK/FISHERY

### 4.1 TRENDS IN COMMERCIAL CATCH

The TACC for school shark in SCH 5 was set at 610 t when this Fishstock was introduced in to the QMS in 1986 but rose gradually to 708 t by 2000–01, most likely due to quota appeals (Table 1; Table 2; Figure 2). Landings exceeded the TACC in 1998–99, along with the other three South Island school shark QMAs and generally remained above the TACC until 2005–06All South Island school shark QMAs, showed a drop in landings in 2001–02, which, for

SCH 5, went below the TACC (Figure 2;Table 2). Landings subsequent to the TACC increase in 2004–05 have fluctuated around the new TACC, remaining within a ± 5% range of 743 t.

Table 2. Reported landings (t), TACC (t) and adjusted landings of school shark in SCH 5 from 1989–90 to 2008–09 (Data sources: QMR [1986–87 to 2000–01]; MHR [2001–02 to 2008–09). $\tilde{SL}_y$ is the sum of landings in a year adjusted for changes in conversion factor (see caption for Table 3) and $SL_y$ is the sum of the same landings without adjustment.

| Year | $QMR_y$ | $TACC_y$ | $R_y = \tilde{SL}_y / SL_y$ | $\tilde{Q}MR_y = QMR_y * R_y$ |
|---|---|---|---|---|
| 1986–87 | 382 | 610 | 0.959[1] | 366 |
| 1987–88 | 531 | 613 | 0.959[1] | 509 |
| 1988–89 | 501 | 615 | 0.959[1] | 481 |
| 1989–90 | 460 | 635 | 0.976 | 449 |
| 1990–91 | 480 | 649 | 0.991 | 476 |
| 1991–92 | 599 | 686 | 0.939 | 562 |
| 1992–93 | 593 | 686 | 0.928 | 550 |
| 1993–94 | 624 | 686 | 1.000 | 624 |
| 1994–95 | 656 | 694 | 1.000 | 656 |
| 1995–96 | 697 | 694 | 1.000 | 697 |
| 1996–97 | 636 | 694 | 1.000 | 636 |
| 1997–98 | 621 | 694 | 1.000 | 621 |
| 1998–99 | 714 | 694 | 1.000 | 714 |
| 1999–00 | 706 | 694 | 1.000 | 706 |
| 2000–01 | 724 | 708 | 1.000 | 724 |
| 2001–02 | 671 | 708 | 1.000 | 671 |
| 2002–03 | 746 | 708 | 1.000 | 746 |
| 2003–04 | 727 | 708 | 1.000 | 727 |
| 2004–05 | 743 | 743 | 1.000 | 743 |
| 2005–06 | 712 | 743 | 1.000 | 712 |
| 2006–07 | 738 | 743 | 1.000 | 738 |
| 2007–08 | 781 | 743 | 1.000 | 781 |
| 2008–09 | 741 | 743 | 1.000 | 741 |

[1] average: 1989–90 to 1991–92

## 4.2 REGULATIONS AFFECTING THE FISHERY

From 1 October 2008, a suite of regulations intended to protect Maui's and Hector's dolphins was implemented for all of New Zealand by the Minister of Fisheries. For SCH 5, commercial and recreational setnetting was banned in most areas to 4 nautical miles offshore, extending from Slope Point in the Catlins to Sandhill Point east of Fiordland and in all of Te Waewae Bay. An exemption which permitted setnetting in harbours, estuaries and inlets was allowed. As well, trawl gear within 2 nautical miles of shore was restricted to flatfish nets with defined low headline heights.

There have been changes to the factors used to convert processed weight to greenweight in the early 1990s and these have been adjusted to a constant conversion factor when preparing the data for the analyses presented in this report (see Section 4.3.2). An exception to this was the change in conversion factor for the state code "GUT", which shifted from 1.1 to 1.65 between 1990–91 and 1991–92. Interviews with fishermen active at that time determined that practices associated with this state code in 1989–90 and 1990–91 likely resulted in an effective conversion factor closer to the value used from 1991–92 onward. Given this observation, it probably would be ill advised to adjust these early landings upward by 50% (=1.65/1.1). It appears that fishermen took advantage of the low conversion factor of 1.1 by cutting off more of the shark than was originally envisioned by the Ministry of Agriculture and Fisheries when it set the conversion factor. Fishermen were taking advantage of an imprecise definition for the state code GUT, which only demanded that "part of the head remain on the trunk". However, by cutting the head in this [perfectly legal] manner, the carcass represented a greater loss from greenweight than the 1.1 conversion factor would suggest. This practice allowed fishermen to land more school shark against their quota than would be possible if the conversion factor had been set in keeping with the actual loss in weight from processing.

This practice was especially prevalent in SCH 5, with nearly 300 t landed in 1990–91 under this state code. As well, nearly 250 t of school shark were landed using the GUT state code in SCH 7 and SCH 8 prior to 1991–92. Adjusting for this shift in conversion factor resulted in raising the overall SCH 5 landings by 28% in 1990–91 (by raising the GUT landings by 50%). The equivalent increase in 1990–91 was 13% for SCH 7 and 9% for SCH 8. These increases seemed excessive and probably unjustified, given that the effective conversion factor would have been greater than the nominal 1.1. This is demonstrated by the observation that the practice disappeared almost immediately after the loophole was removed when the GUT conversion factor was increased to 1.65 in 1991–92.

It was decided to treat landings using the GUT state code prior to 1991–92 (the year that the GUT conversion factor was raised from 1.1 to 1.65) as being equivalent to the landings which followed, making it unnecessary to adjust for the change. This was done for all SCH QMAs. The remaining changes in conversion factors are minor, resulting in small drops of 1 to 7% in the SCH 5 landings compared to the sum of the greenweights declared at the time of landing (Table 2; Figure 2).

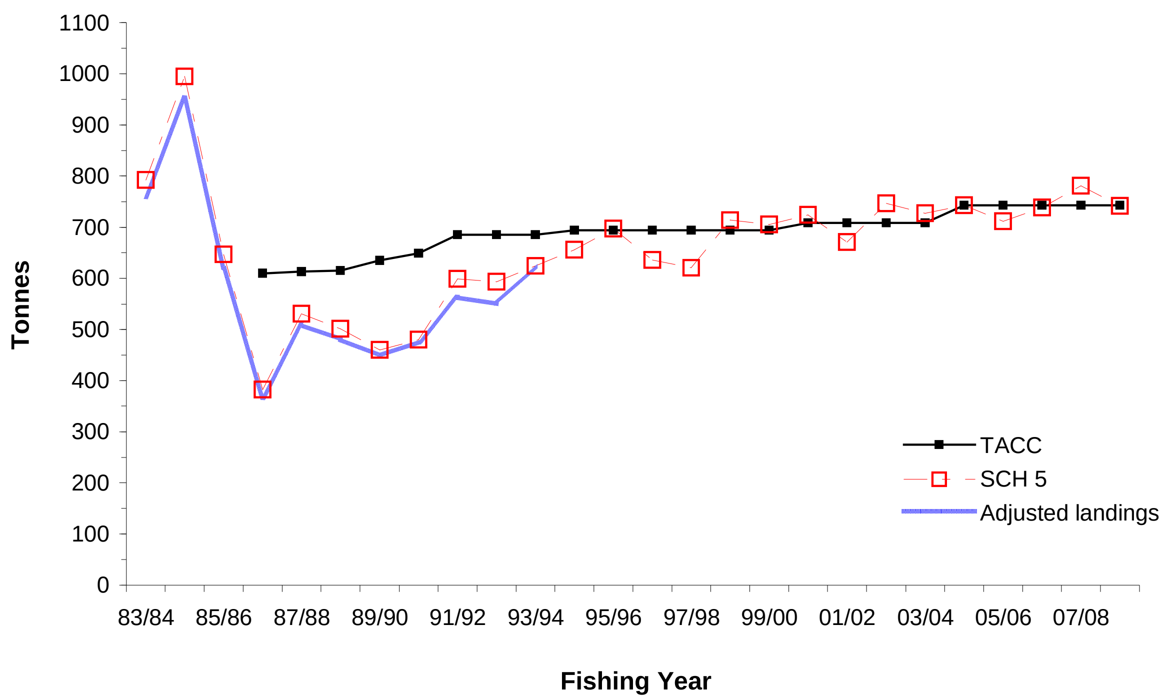


Figure 2 Catch history and TACC (t) for SCH 5 from the 1983–84 to the 2008–09 fishing years (Table 2). Adjusted landings from 1983–84 to 1993–1994 are also plotted (Table 2)

## 4.3 ANALYSIS OF SCH 5 CATCH AND EFFORT DATA

### 4.3.1 METHODS USED FOR 2010 ANALYSIS OF MFISH CATCH AND EFFORT DATA

The methods used to prepare the MFish catch/effort data have remained essentially unchanged since 2002, except for a few refinements. The current methodology used to prepare these data for both the characterisation and the CPUE analyses has been documented elsewhere (Starr 2007).

Table 3. Comparison of the sum of the landed catch totals (t) (bottom part of the MFish CELR form) with the total catch (t) reported by QMR/MHR for SCH 5 by fishing year. Also shown are the total landings from the analysis dataset and the sum of the estimated catches from the trips included in the analysis dataset. $N_y$ =number trips/year in total dataset; $A_y$ =number trips/year in analysis dataset; $S_y$ =number of state codes in year *y*; $\tilde{L}_{i,s,y} = \left(cf_{s,\tilde{y}}/cf_{s,y}\right)L_{i,s,y}$ =adjusted landed catch from trip stratum *i* in year *y* using state code *s* where $cf_{s,y}$ is the conversion factor used in year *y* for state code *s* and $cf_{s,\tilde{y}}$ is the conversion factor for state *s* in the most recent fishing year; $C_{i,y}$ =estimated catch from trip stratum *i* in year *y*

| **Fishing Year** | $\tilde{\text{QMR}}_y$ [Table 2] (t) | $\tilde{SL}_y = \sum_{i=1}^{N_y}\sum_{s=1}^{S_y}\tilde{L}_{i,s,y}$ (t) | $\frac{\tilde{SL}_y}{\tilde{\text{QMR}}_y}$ (%) | $\tilde{AL}_y = \sum_{i=1}^{A_y}\sum_{s=1}^{S_y}\tilde{L}_{i,s,y}$ (t) | $\frac{\tilde{AL}_y}{\tilde{SL}_y}$ (%) | $AC_y = \sum_{i=1}^{A_y}C_{i,y}$ (t) | $\frac{AC_y}{\tilde{AL}_y}$ (%) |
|---|---|---|---|---|---|---|---|
| 89/90 | 449 | 367 | 82 | 347 | 95 | 350 | 95 |
| 90/91 | 476 | 495 | 104 | 484 | 98 | 441 | 89 |
| 91/92 | 562 | 585 | 104 | 550 | 94 | 506 | 87 |
| 92/93 | 550 | 563 | 102 | 559 | 99 | 495 | 88 |
| 93/94 | 624 | 580 | 93 | 573 | 99 | 479 | 83 |
| 94/95 | 656 | 639 | 97 | 631 | 99 | 496 | 78 |
| 95/96 | 697 | 720 | 103 | 652 | 91 | 368 | 51 |
| 96/97 | 636 | 627 | 99 | 592 | 94 | 382 | 61 |
| 97/98 | 621 | 628 | 101 | 574 | 91 | 384 | 61 |
| 98/99 | 714 | 670 | 94 | 660 | 98 | 453 | 68 |
| 99/00 | 706 | 681 | 97 | 649 | 95 | 560 | 82 |
| 00/01 | 724 | 691 | 95 | 642 | 93 | 573 | 83 |
| 01/02 | 671 | 658 | 98 | 632 | 96 | 559 | 85 |
| 02/03 | 746 | 764 | 102 | 731 | 96 | 651 | 85 |
| 03/04 | 727 | 694 | 95 | 675 | 97 | 604 | 87 |
| 04/05 | 743 | 737 | 99 | 673 | 91 | 617 | 84 |
| 05/06 | 712 | 646 | 91 | 621 | 96 | 575 | 89 |
| 06/07 | 738 | 705 | 96 | 660 | 94 | 606 | 86 |
| 07/08 | 781 | 766 | 98 | 732 | 96 | 700 | 91 |
| 08/09 | 741 | 725 | 98 | 698 | 96 | 639 | 88 |

However, there are still shortcomings with analysing the catch and effort data using the procedure described by Starr (2007), because of the following issues:

- Trips which land to more than one Fishstock are discarded if they fish in “straddle” statistical areas which are valid for each of the Fishstocks landed. All trips which land multiple Fishstocks and fish in these ambiguous statistical areas have been dropped from the analysis.
- The most detailed level of area attributable for any trip is the statistical area because of a limitation in the design of the CELR system and the requirement to merge the CELR and TCEPR data for this species. Trips with missing statistical areas have used the predominant (most frequent) statistical area to fill in the missing datum. The few trips which had no statistical area information were dropped.

- Landed greenweight catch is attributed to specific statistical areas, method and target species by assuming that the estimated catches in these categories are distributed correctly. This will lead to error because small catches from some strata are often not included in the estimated catch data. If no estimated catch is available for a trip, the procedure uses the distribution of effort to partition the landed catch for that trip, a procedure which could lead to some bias because it assumes equal catchability in all strata.

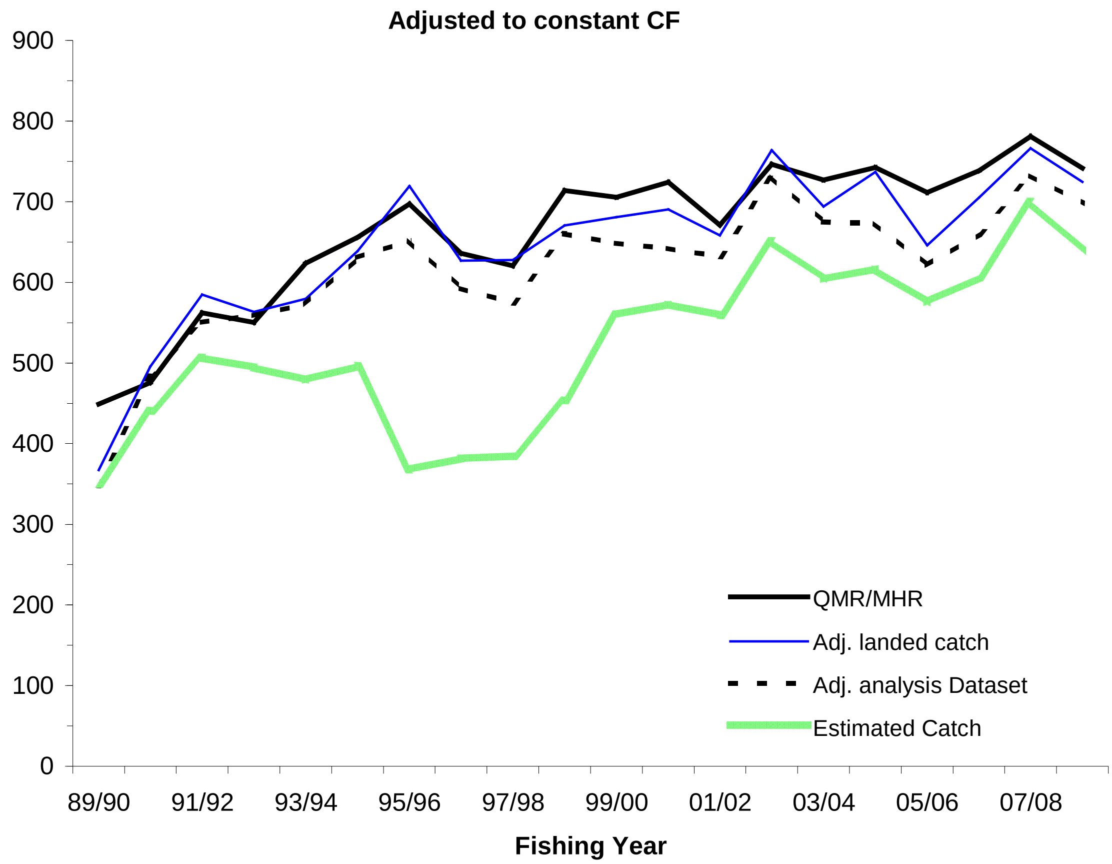


Figure 3. Plot of catch datasets presented in Table 3. The estimated catch total is the sum of the estimated catch in the analysis dataset. The QMR/MHR catches have been adjusted as shown in Table 2, landed and analysis catch plots have been adjusted using $R_y$ , and estimated catches are summed from the trips in the analysis dataset as presented in Table 3.

- Trips with missing method codes are filled in with the method from the remaining events if only one method is reported for that trip. If a trip with a missing method code reports more than one method, the entire trip is dropped.
- Trips which report no target species codes are dropped but events within a trip which have missing target species codes are filled in with the predominant (most frequent) target species for the trip.
- New forms which have been designed to provide more detailed spatial and other information have been introduced: the NCELR (netting catch-effort landing return) on 1 October 2006 and the TCER (Trawl catch-effort return) on 1 October 2007. These forms have been treated similarly to the TCEPR (trawl catch-effort processing returns) by collapsing the information to a level consistent with the CELR forms.

The catch totals (Table 3; Figure 3) resulting from the dataset used for this analysis may not be the same as those reported to the QMS system because the QMS is a separate reporting system than the MFish catch/effort reporting system. One explanation for differences in the annual and monthly totals between the two systems is how the data are aggregated by time: landings are assigned to a fishing year in this analysis based on the date of landing while the QMS assigns landings to a fishing year by the declaration on a separate monthly reporting form. These assignments may differ, especially during the months of September and October which span the changeover between fishing years. The data are further modified during the preparation procedure described above because trips are dropped with a corresponding loss of data, including dropping trips which have large landings of the target Fishstock without sufficient effort to corroborate the large landing. The most important source of data loss in this procedure results from dropping trips which fished in straddling statistical areas and which report more than one valid Fishstock for that statistical area (Table 3).

Table 4. Summary statistics pertaining to the reporting of estimated catch from the SCH 5 analysis dataset. $A_y$, $L_{i,y}$, $AL_y$, and $AC_y$ are defined in Table 3; $L'_{i,y}$ is defined in Eq.1; $Z_y$: number of trips in year $y$ with no estimated catch; 5%: fifth percentile; 50%: median; 95%: ninety-fifth percentile.

| Fishing year | Trips with landed catch but which report no estimated catch | | | Dataset statistics (excluding 0s) for the ratio of landed/estimated catch by trip | | | |
|---|---|---|---|---|---|---|---|
| | $\frac{Z_y}{A_y}$ (%) | $\frac{\sum_{i=1}^{Z_y} L_{i,y}}{AL_y}$ (%) | $\sum_{i=1}^{Z_y} L'_{i,y}$ (t) | $\left(\frac{AL_y}{AC_y}\right)_{5\%}$ | $\left(\frac{AL_y}{AC_y}\right)_{50\%}$ | $\left(\frac{AL_y}{AC_y}\right)_{Mean}$ | $\left(\frac{AL_y}{AC_y}\right)_{95\%}$ |
| 89/90 | 25 | 3 | 12 | 0.59 | 0.99 | 1.28 | 2.65 |
| 90/91 | 25 | 7 | 33 | 0.67 | 1.01 | 1.26 | 2.59 |
| 91/92 | 30 | 3 | 20 | 0.65 | 1.02 | 1.44 | 3.33 |
| 92/93 | 31 | 5 | 29 | 0.72 | 1.00 | 1.46 | 3.15 |
| 93/94 | 27 | 1 | 6 | 0.75 | 1.10 | 1.54 | 2.88 |
| 94/95 | 24 | 3 | 17 | 0.60 | 1.15 | 3.24 | 3.00 |
| 95/96 | 37 | 36 | 248 | 0.61 | 1.07 | 1.53 | 3.21 |
| 96/97 | 38 | 30 | 190 | 0.72 | 1.07 | 1.52 | 3.67 |
| 97/98 | 39 | 30 | 188 | 0.62 | 1.03 | 1.62 | 3.02 |
| 98/99 | 34 | 27 | 195 | 0.68 | 1.10 | 1.64 | 4.10 |
| 99/00 | 30 | 5 | 37 | 0.72 | 1.10 | 1.52 | 3.12 |
| 00/01 | 31 | 3 | 24 | 0.62 | 1.10 | 1.59 | 3.50 |
| 01/02 | 35 | 3 | 21 | 0.60 | 1.13 | 1.68 | 3.51 |
| 02/03 | 35 | 2 | 15 | 0.67 | 1.13 | 1.65 | 3.74 |
| 03/04 | 25 | 2 | 12 | 0.67 | 1.16 | 1.71 | 4.75 |
| 04/05 | 36 | 2 | 18 | 0.69 | 1.13 | 1.63 | 3.97 |
| 05/06 | 33 | 2 | 18 | 0.73 | 1.14 | 1.80 | 5.59 |
| 06/07 | 33 | 2 | 15 | 0.74 | 1.19 | 1.61 | 3.81 |
| 07/08 | 21 | 1 | 6 | 0.70 | 1.16 | 1.49 | 3.20 |
| 08/09 | 21 | 3 | 19 | 0.55 | 1.16 | 1.69 | 3.94 |
| Total | 31 | 8 | 1 121 | 0.67 | 1.10 | 1.65 | 3.50 |

Catch totals in the fishery characterisation tables have been scaled to the QMR/MHR totals reported in Table 2 by calculating the ratio of these catches with the total annual landed catch in the analysis dataset and scaling all the landed catch observations ($i$) within a trip using this ratio:

$$L'_{i,y} = L_{i,y} \frac{\mathbf{QMR}_y}{AL_y} \qquad \text{Eq. 1}$$

where $\mathbf{QMR}_y$, $L_{i,y}$ and $AL_y$ are defined in Table 3.

Annual totals from this dataset compared with the annual QMR/MHR totals in Table 2 are presented in Table 3 and Figure 3. Total landings from the bottom part of the CELR form are similar to the landings in the QMR/MHR system, ranging from 91 to 104% of the official QMR/MHR system over the 20 years of available data (excluding the 82% value in 1989–90 which was the first year of the present catch/effort data collection system and is thought to be data deficient). There is a consistent (and often large) shortfall between the landed and estimated catch by trip for SCH 5 (Table 3; Figure 3), with the sum of the annual estimated catches ranging from 51 to 95% of the annual landed catch for the trips included in the analysis dataset (Table 3). A comparison scatter plot of the estimated and landed catch by trip shows that relatively few trips overestimate the landing total for the trip and that most trips are below the 1:1 line ([left panel] Figure 4). The distribution of ratios of the landed to estimated catch shows that the majority of the ratios are grouped near one, with a subsidiary mode just below 2.0 (Figure 4; [right panel]). There is also a mode at zero, indicating that nearly 10% (by weight) of the trips that landed SCH 5 reported no estimated catch.

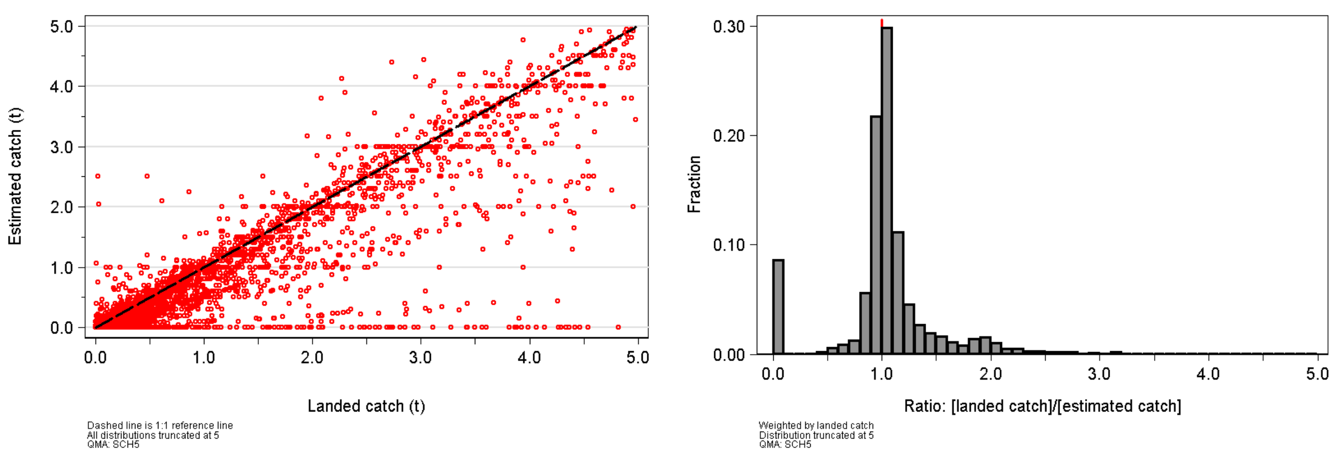


Figure 4. [left panel]: Scatter plot of the sum of landed and estimated school shark catch for each trip in the SCH 5 analysis dataset. [right panel]: Distribution (weighted by the landed catch) of the ratio of landed to estimated catch per trip. Trips where the estimated catch=0 have been assigned a ratio=0.

The 5% to 95% percentiles (excluding trips where there is no estimated catch) for the ratio of landed to estimated catch range from 0.67 to 3.50 for the dataset, with the median ratio of the estimated catch at 110% of the landed catch and the mean ratio at 65% higher than the estimated catch (Table 4). Eight percent of trips by landed weight and 31 % by number estimated no school shark at all, for total landings of over 1 100 t over the 20 years of data (Table 4).

### 4.3.2 DESCRIPTION OF SCH 5 LANDING INFORMATION

Landing data for school shark were provided for all trips which landed any of the six school shark QMAs on the North and South Islands (SCH 1, SCH 2, SCH 3, SCH 5, SCH 7 and SCH 8) at least once, with one record for every reported SCH landing from the trip. Landings from SCH 4 would also be included if one these trips declared that QMA. Each of these records contained a reported green weight (in kg), a code indicating the processed state of the landing, along with other auxiliary information such as the conversion factor used, the number of containers involved and the average weight of the containers. Every landing record also contained a “destination code” (Table 5), which indicated the category under which the landing occurred. The majority of the landings were made using destination code “L” (landed to a Licensed Fish Receiver) (Table 5). However, other codes (e.g., A, O and C) (Table 5) also potentially described valid landings and were included in this analysis. A number of other codes (notably R, Q and T) (Table 5) were not included because it was felt that these landing were likely reported at a later date under the “L” destination category. Two other codes (D and NULL) represented errors which could not be reconciled without making unwarranted assumptions and these were not included in the landing data set.

Table 5. Destination codes in the unedited landing data received for the school shark analysis, restricted to only SCH 5. The “how used” column indicates which destination codes were included in the characterisation and CPUE analyses.

| Destination code | Number events | Green weight (t) | Description | How used |
|---|---|---|---|---|
| L | 15867 | 13,183.1 | Landed in NZ (to LFR) | Keep |
| O | 54 | 10.3 | Conveyed outside NZ | Keep |
| E | 256 | 8.5 | Eaten | Keep |
| A | 67 | 5.6 | Accidental loss | Keep |
| C | 15 | 2.1 | Disposed to Crown | Keep |
| F | 57 | 0.7 | Section 111 Recreational Catch | Keep |
| U | 6 | 0.1 | Bait used on board | Keep |
| R | 796 | 152.8 | Retained on board | Drop |
| T | 80 | 53.0 | Transferred to another vessel | Drop |
| Q | 415 | 19.6 | Holding receptacle on land | Drop |
| D | 34 | 2.2 | Discarded (non-ITQ) | Drop |
| NULL | 11 | 0.6 | Nothing | Drop |
| B | 3 | 0.0 | Bait stored for later use | Drop |

Almost all of the valid landing data for SCH 5 were reported using state codes DRE and HGU with more than 100 t landed using state codes GUT, GGO, GRE, FIL and FIN (Table 6). Reporting problems using state code GUT were discussed in Section 4.2 and state code GGO was only used in the 1989–90 fishing year (Table 7). State codes FIN, FLP, SHK and ROE were treated differently for shark species, where these codes were dropped if the trip also landed DRE or HGU to the same Fishstock. This was done to avoid double counting because these additional landings could have come from the same fish. Landings to these state codes were retained if no other landings were recorded by the trip. About 30 t of invalid landed state code TRU were changed to HGU (“headed and gutted”) (Table 6). The code “TRU” could be a short form of “trunked” and was associated with the same conversion factor (2.0) as was used for the HGU landed state in the same years.

State codes DRE, HGU and GUT have been reported for school shark using variable conversion factors over the data period, with a small shift between 1992–93 and 1993–94 (Table 7). Green weight landings $\left(G'_{i,s,y}\right)$ were adjusted in the CPUE analysis and for some parts of the characterisation analysis for state codes DRE and HGU to consistent conversion factors of 1.95 and 1.85 respectively using the following equation:

$$G'_{i,s,y} = G_{i,s,y} \, {cf_{i,s,lasty}}\big/{cf_{i,s,y}} \qquad \text{Eq. 2}$$

where

$G_{i,s,y}$ is the reported green weight for record *i* using landed state code *s* in year *y*;

$cf_{i,s,y}$ is the conversion factor for record *i* using landed state code *s* in year *y*;

$cf_{i,s,lasty}$ is the conversion factor for record $i$ using landed state code $s$ in the last year

Note that the adjustment for the GUT conversion factor from the 1990–91 value of 1.1 to the 1991–92 value of 1.65 was not done (Section 4.2).

Table 6. Total SCH 5 greenweight reported and number of events by state code in the unedited landing file used to process the SCH 5 characterisation and CPUE data, arranged in order descending landed weight.

| State Code | Number Events | Total reported green weight (t) | Description |
|---|---|---|---|
| DRE | 8 333 | 9 174.9 | Dressed |
| HGU | 3 425 | 2 741.5 | Headed and gutted |
| GUT | 330 | 397.9 | Gutted |
| GGO | 76 | 227.9 | Gilled and gutted tail-on |
| GRE | 475 | 200.1 | Green (or whole) |
| FIL | 242 | 175.1 | Fillets: skin-on |
| FIN | 277 | 160.6 | Fins |
| SKF | 87 | 74.0 | Fillets: skin-off |
| MEA | 110 | 40.4 | Fish meal |
| HGT | 39 | 9.0 | Headed, gutted, and tailed |
| FLP | 1 384 | 7.5 | Flaps |
| NULL | 29 | 1.1 | 0 |
| HGF | 1 | 0.2 | Headed, gutted, and finned |
| SHF | 1 486 | 0.1 | Shark fins |
| DVC | 4 | 0.1 | Dressed-V cut (stargazer) |
| TSK | 4 | 0.1 | Fillets: skin-off trimmed |
| FIT | 19 | 0.0 | Fish tails |
| LIB | 1 | 0.0 | Livers by-product |

A calculated greenweight $\left(\varpi_{i,y}\right)$ was inferred from the landings dataset using the following equation:

$$\varpi_{i,y} = U_{i,y}\, W_{i,y} cf_{i,y} \qquad \text{Eq. 3}$$

where

$U_{i,y}$ is the “unit number” of containers associated with the record;

$W_{i,y}$ is the “unit weight” associated with the record;

$cf_{i,y}$ is the conversion factor associated with the record.

A comparative scatter plot of the calculated greenweight relative to the reported greenweight for the two primary state codes reported in Table 6 (DRE and HGU) illustrates that there is a large amount of scatter around these two quantities (Figure 5 [left panel]). While the majority of the data lie near the 1:1 equality line, there are many observations where the calculated green weight exceeds the recorded green weight by large amounts. A histogram of the ratio of the calculated greenweight relative to the reported greenweight indicates that the central tendency for this ratio for these two landed state codes is near one (median=1.02 and mean=1.25 when the ratio is truncated at 5), but that there is a lot of variation. This analysis indicates that it is probably not possible to reconstruct the greenweights using the detailed data provided in the individual records. The best use of the Eq. 3 calculation would be to corroborate the reported greenweight in situations when the reported greenweight appears to be in doubt.

Table 7. Median conversion factor for the six most important state codes reported in Table 6 (in terms of total landed greenweight) and the total reported greenweight by fishing year in the edited landing file used to process the SCH 5 characterisation and CPUE data. [–]: no landings in indicated cell

| Fishing year | Landed State Code | | | | | | |
|---|---|---|---|---|---|---|---|
| | DRE | HGU | GUT | GGO | GRE | FIN | OTH |
| **Median Conversion Factor** | | | | | | | |
| 89/90 | – | 2 | 1.1 | 1.1 | 1 | – | 2 |
| 90/91 | 2 | 2 | 1.1 | – | 1 | – | 2.3 |
| 91/92 | 2 | 2 | 1.65 | – | 1 | – | 5.6 |
| 92/93 | 2 | 2 | 1.65 | – | 1 | – | 2.3 |
| 93/94 | 1.95 | 1.85 | 1.65 | – | 1 | 30 | 2.15 |
| 94/95 | 1.95 | 1.85 | 1.65 | – | 1 | 30 | 2.15 |
| 95/96 | 1.95 | 1.85 | 1.65 | – | 1 | 30 | 2.15 |
| 96/97 | 1.95 | 1.85 | 1.65 | – | 1 | 30 | 2.15 |
| 97/98 | 1.95 | 1.85 | – | – | 1 | 30 | 1 |
| 98/99 | 1.95 | 1.85 | – | – | 1 | 30 | 2.15 |
| 99/00 | 1.95 | 1.85 | – | – | 1 | 30 | 1 |
| 00/01 | 1.95 | 1.85 | 1.65 | – | 1 | 30 | 2.15 |
| 01/02 | 1.95 | 1.85 | – | – | 1 | 30 | 2.425 |
| 02/03 | 1.95 | 1.85 | 1.65 | – | 1 | 30 | 2.7 |
| 03/04 | 1.95 | 1.85 | 1.65 | – | 1 | 30 | 2.7 |
| 04/05 | 1.95 | 1.85 | 1.65 | – | 1 | 30 | 2.7 |
| 05/06 | 1.95 | 1.85 | – | – | 1 | 30 | 2.7 |
| 06/07 | 1.95 | 1.85 | 1.65 | – | 1 | 30 | 2.425 |
| 07/08 | 1.95 | 1.85 | – | – | 1 | 30 | 2.7 |
| 08/09 | 1.95 | 1.85 | – | – | 1 | – | 2.7 |
| **Total greenweight (t)[1]** | | | | | | | |
| 89/90 | – | 81.7 | 15.7 | 203.0 | 51.5 | – | 15.3 |
| 90/91 | 71.8 | 30.4 | 288.0 | 10.4 | 64.7 | – | 30.0 |
| 91/92 | 36.5 | 455.1 | 90.8 | – | 0.3 | – | 2.4 |
| 92/93 | 29.3 | 530.2 | 2.5 | – | 0.9 | – | 0.5 |
| 93/94 | 178.2 | 398.6 | 0.5 | – | 0.7 | 0.5 | 1.2 |
| 94/95 | 534.3 | 101.1 | 0.0 | – | 1.5 | 1.9 | 1.6 |
| 95/96 | 551.1 | 157.6 | 0.0 | – | 0.4 | 3.5 | 11.1 |
| 96/97 | 446.6 | 151.5 | 0.1 | – | 21.2 | 1.4 | 7.1 |
| 97/98 | 496.6 | 107.9 | – | – | 17.0 | 20.6 | 10.2 |
| 98/99 | 549.1 | 108.4 | – | – | 0.4 | 90.7 | 15.7 |
| 99/00 | 499.2 | 151.4 | – | 14.5 | 4.5 | 2.2 | 12.4 |
| 00/01 | 431.0 | 154.3 | 0.1 | 0.1 | 4.5 | 40.7 | 103.6 |
| 01/02 | 478.3 | 158.8 | – | – | 12.8 | 1.3 | 8.5 |
| 02/03 | 699.4 | 30.5 | 0.0 | – | 8.5 | 0.7 | 25.5 |
| 03/04 | 667.4 | 13.4 | 0.1 | – | 1.0 | 0.3 | 11.7 |
| 04/05 | 700.5 | 8.8 | 0.0 | – | 2.1 | 0.5 | 25.0 |
| 05/06 | 636.8 | 4.3 | – | – | 2.4 | 2.7 | 2.4 |
| 06/07 | 689.1 | 3.1 | 0.1 | – | 2.5 | 3.3 | 10.1 |
| 07/08 | 752.6 | 2.5 | – | – | 1.6 | 3.3 | 9.7 |
| 08/09 | 709.9 | 2.8 | – | – | 1.6 | – | 10.3 |
| Total | 9,157.8 | 2,652.5 | 397.9 | 227.9 | 200.1 | 173.6 | 314.3 |

[1] adjusted to a constant conversion factor consistent with 2008–09

In preparing the landing data for this report, all large reported landing records (single events ranging from 250 kg to 1 000 kg, depending on the QMA and the primary method of capture for the trip) were compared with the total calculated greenweight (Eq. 3) and the total estimated school shark catch for each trip, as well as calculating the trip CPUE for comparison with the empirical distribution of the trip CPUE (Starr 2007). On this basis, 99 trips representing 1 380 t of landings were dropped from the analysis. This is across 3 major fishing methods (setnet, bottom trawl and bottom longline in each of SCH 1, SCH 2, SCH 3, SCH 5, SCH 7 and SCH 8) as well as a number of minor fishing methods for this species (notably bottom longline and Dahn line). Total landings in the full dataset prior to dropping any trips were 60 397 t.

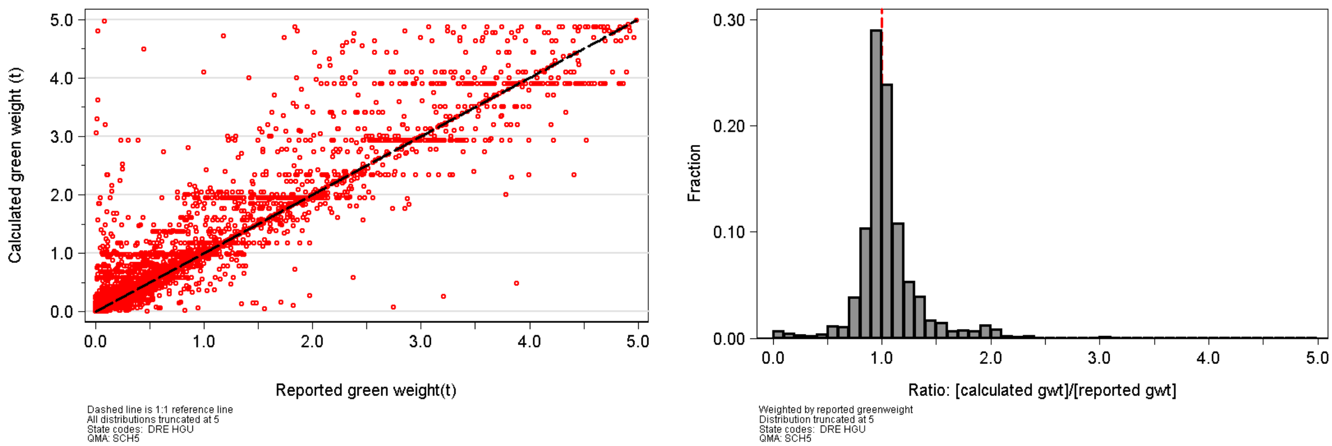


Figure 5. [left panel]: Scatter plot of the calculated greenweight (Eq. 3) for SCH 5 compared to the reported greenweight for state codes DRE HGU; [right panel]: Distribution (weighted by the reported greenweight catch) of the ratio of calculated greenweight relative to reported greenweight for state codes DRE HGU. Records with missing data have been dropped.

Table 8. Distribution of total landings (t) by school shark Fishstock and by fishing year for the set of trips that recorded SCH landings in any of the North or South Island Fishstocks. Landing records with improbable greenweights have been dropped.

| Fishing year | SCH 1 | SCH 2 | SCH 3 | SCH 4 | SCH 5 | SCH 7 | SCH 8 | Total |
|---|---|---|---|---|---|---|---|---|
| 89/90 | 399 | 111 | 216 | 12 | 367 | 454 | 320 | 1 879 |
| 90/91 | 498 | 121 | 204 | 18 | 495 | 397 | 310 | 2 044 |
| 91/92 | 518 | 131 | 229 | 31 | 585 | 382 | 327 | 2 203 |
| 92/93 | 700 | 178 | 200 | 31 | 563 | 460 | 438 | 2 571 |
| 93/94 | 646 | 166 | 205 | 41 | 580 | 454 | 411 | 2 502 |
| 94/95 | 612 | 156 | 249 | 79 | 639 | 393 | 418 | 2 545 |
| 95/96 | 745 | 238 | 289 | 180 | 720 | 638 | 523 | 3 332 |
| 96/97 | 727 | 229 | 263 | 214 | 627 | 537 | 434 | 3 031 |
| 97/98 | 711 | 196 | 267 | 131 | 628 | 453 | 422 | 2 807 |
| 98/99 | 759 | 271 | 323 | 105 | 670 | 666 | 513 | 3 307 |
| 99/00 | 793 | 242 | 332 | 104 | 681 | 637 | 456 | 3 245 |
| 00/01 | 789 | 176 | 374 | 104 | 691 | 581 | 433 | 3 147 |
| 01/02 | 728 | 207 | 325 | 88 | 658 | 497 | 459 | 2 963 |
| 02/03 | 694 | 219 | 405 | 123 | 764 | 527 | 438 | 3 170 |
| 03/04 | 749 | 189 | 334 | 144 | 694 | 566 | 390 | 3 066 |
| 04/05 | 714 | 201 | 418 | 221 | 737 | 539 | 548 | 3 377 |
| 05/06 | 632 | 182 | 306 | 176 | 646 | 561 | 507 | 3 009 |
| 06/07 | 665 | 191 | 375 | 93 | 705 | 581 | 518 | 3 127 |
| 07/08 | 684 | 225 | 325 | 125 | 766 | 619 | 493 | 3 238 |
| 08/09 | 746 | 242 | 385 | 147 | 725 | 695 | 587 | 3 526 |
| Total | 13 509 | 3 870 | 6 023 | 2 169 | 12 941 | 10 635 | 8 944 | 58 092 |

Total landings available in the data set are primarily for SCH 1, SCH 5 and SCH 7, with lesser amounts reported, in descending order, for SCH 8, SCH 3 and SCH 2 (Table 8). Landings for SCH 4 are incidental to the other 6 QMAs. Most SCH 5 landings were reported on CELR forms prior to 2006–07, with only minor amounts of landings reported on CLR forms (Catch Landing Returns; Table 9). These latter forms were used by vessels which reported using effort reporting forms other than the CELR or the NCELR. The CELR form virtually disappeared after 2007–08, after which there was a nearly complete shift away from the CELR form to one of the NCELR, the TCER or the LTCER forms, depending on the primary method of capture (Table 9).

Table 9. Distribution by form type for landed catch by weight for each fishing year in SCH 5. Also provided is the number of days fishing and the associated distribution of days fishing by form type for the effort data using statistical areas consistent with SCH 5. CELR: Catch, effort, landing return; CLR: catch landing return; NCELR: netting catch effort landing return; TCEPR: trawl catch effort processing return; TCER: trawl catch effort return. Forms other than CELR and NCELR report their landings on CLR forms.

| Fishing | Landings[1] | | | Days Fishing (%)[2] | | | | | Days Fishing | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | CELR | CLR | NCELR | CELR | NCELR | TCEPR | TCER | Lining[3] | CELR | NCELR | TCEPR | TCER | Lining[3] | Total |
| 89/90 | 94.5 | 5.6 | 0.0 | 61 | 0 | 39 | 0 | 0 | 1 297 | 0 | 832 | 0 | 0 | 2 129 |
| 90/91 | 92.6 | 7.4 | 0.0 | 55 | 0 | 45 | 0 | 0 | 1 555 | 0 | 1 257 | 0 | 0 | 2 812 |
| 91/92 | 98.7 | 1.3 | 0.0 | 56 | 0 | 44 | 0 | 0 | 1 314 | 0 | 1 018 | 0 | 0 | 2 332 |
| 92/93 | 98.4 | 1.6 | 0.0 | 65 | 0 | 35 | 0 | 0 | 1 406 | 0 | 744 | 0 | 0 | 2 150 |
| 93/94 | 99.8 | 0.2 | 0.0 | 82 | 0 | 18 | 0 | 0 | 1 542 | 0 | 340 | 0 | 5 | 1 887 |
| 94/95 | 99.3 | 0.8 | 0.0 | 66 | 0 | 24 | 0 | 11 | 1 543 | 0 | 558 | 0 | 250 | 2 351 |
| 95/96 | 98.0 | 2.0 | 0.0 | 65 | 0 | 35 | 0 | 0 | 1 522 | 0 | 810 | 0 | 6 | 2 338 |
| 96/97 | 98.9 | 1.1 | 0.0 | 61 | 0 | 35 | 0 | 5 | 1 501 | 0 | 852 | 0 | 116 | 2 469 |
| 97/98 | 99.3 | 0.7 | 0.0 | 70 | 0 | 26 | 0 | 4 | 1 306 | 0 | 487 | 0 | 79 | 1 872 |
| 98/99 | 98.3 | 1.7 | 0.0 | 65 | 0 | 27 | 0 | 7 | 1 634 | 0 | 685 | 0 | 187 | 2 506 |
| 99/00 | 97.7 | 2.3 | 0.0 | 59 | 0 | 39 | 0 | 2 | 1 792 | 0 | 1 179 | 0 | 72 | 3 043 |
| 00/01 | 93.3 | 6.7 | 0.0 | 43 | 0 | 54 | 0 | 3 | 1 855 | 0 | 2 327 | 0 | 123 | 4 305 |
| 01/02 | 93.0 | 7.0 | 0.0 | 41 | 0 | 55 | 0 | 3 | 1 868 | 0 | 2 500 | 0 | 141 | 4 509 |
| 02/03 | 93.3 | 6.7 | 0.0 | 41 | 0 | 56 | 0 | 3 | 2 174 | 0 | 2 963 | 0 | 143 | 5 280 |
| 03/04 | 94.9 | 5.1 | 0.0 | 38 | 0 | 55 | 0 | 7 | 1 797 | 0 | 2 567 | 0 | 337 | 4 701 |
| 04/05 | 91.5 | 8.5 | 0.0 | 33 | 0 | 63 | 0 | 5 | 1 692 | 0 | 3 273 | 0 | 241 | 5 206 |
| 05/06 | 94.4 | 5.6 | 0.0 | 37 | 0 | 59 | 0 | 4 | 1 488 | 0 | 2 382 | 0 | 146 | 4 016 |
| 06/07 | 10.8 | 9.0 | 80.1 | 32 | 9 | 55 | 0 | 4 | 1 262 | 347 | 2 152 | 0 | 167 | 3 928 |
| 07/08 | 0.5 | 14.8 | 84.7 | 4 | 10 | 54 | 21 | 10 | 145 | 379 | 2 004 | 789 | 387 | 3 704 |
| 08/09 | 0.9 | 20.3 | 78.8 | 5 | 9 | 58 | 20 | 8 | 181 | 321 | 2 157 | 740 | 306 | 3 705 |
| Total | 80.7 | 5.6 | 13.6 | 44 | 2 | 48 | 2 | 4 | 28 874 | 1 047 | 31 087 | 1 529 | 2 706 | 65 243 |

[1] Percentages of landed greenweight
[2] Percentages of number of days fishing
[3] combines 814 days for LCER (lining trip >28 m), 198 days for LTCER (lining trip <28 m) and 1 694 days for TLCER (tuna long lining catch effort return)

### 4.3.3 DESCRIPTION OF THE SCH 5 FISHERY

Distributions by statistical area, major fishing method and target species in this section are provided by summarised statistical areas, methods and target species as described in Table 10.

Table 10. Definitions of statistical area (see Appendix A for the locations of the indicated statistical areas), major method codes and target species codes by method of capture used in the distribution tables and plots in this report. Note that there are very few records in the dataset for some of the indicated methods. Number events=number of effort records in analysis dataset; number records=number of records (trip-strata) in analysis dataset after rolling up to trip/statistical area/method/target species.

| Statistical area code | Statistical area definition | Number events | Number records |
|---|---|---|---|
| 025-026 | 025 & 026 | 7 930 | 4 372 |
| 027 | 027, 504, 603–615, 618–622, 624–625 | 17 008 | 2 554 |
| 028-029 | 028, 029, 503, 601-602, 616-617, 623 | 39 010 | 2 666 |
| 030 | 030 & 502 | 24 401 | 6 200 |
| 031 | 031 | 1 727 | 559 |
| 032 | 032 & 501 | 2 815 | 1 078 |

| Method code | Methods included | Number events | Number records |
|---|---|---|---|
| SN | Setnet | 7 159 | 3 972 |
| BT | Bottom trawl | 53 152 | 9 674 |
| BLL | Bottom longline | 11 861 | 1 351 |
| OTH | Other (surface longlining [SLL] is the only remaining method reporting >1 t of SCH 5) | 20 719 | 2 432 |

Table 10. (cont.)

| Species code | Target species definition[1] | Number events | Number records |
|---|---|---|---|
| SCH | School shark | 5 445 | 2 880 |
| SPO | Rig | 1 212 | 811 |
| BUT | Butterfish | 247 | 103 |
| OTH | Remaining target species > 1 t of total setnet landings in ranked descending order: spiny dogfish, elephantfish, scallops, ling, moki, hapuku, bluenose | 255 | 178 |

| Species code | Target species definition[2] | Number events | Number records |
|---|---|---|---|
| STA | Stargazer | 9 891 | 3 333 |
| SQU | Arrow squid | 13 628 | 1 168 |
| FLA | Flatfish (including all related species) | 5 244 | 2 072 |
| HOK | Hoki | 13 182 | 1 017 |
| LIN | Ling | 2 805 | 400 |
| BAR | Barracouta | 1 104 | 260 |
| GUR | Red gurnard | 259 | 147 |
| OTH | Remaining target species > 5 t of total bottom trawl landings in ranked descending order: silver warehou, white warehou, blue warehou, school shark, elephantfish, tarakihi | 7 039 | 1 277 |

| Species code | Target species definition[3] | Number events | Number records |
|---|---|---|---|
| HPB | Hapuku | 1 025 | 389 |
| SCH | School shark | 382 | 204 |
| LIN | Ling | 9 987 | 575 |
| BNS | Bluenose | 410 | 167 |
| OTH | No other species reach 100 kg total landings by this method summed over 20 years | 57 | 16 |

[1] Setnet method
[2] Bottom trawl method
[3] Lining methods

Table 11. Table showing the distribution of total SCH 5 landings (t) by statistical area (Appendix A) and Statistical Area Region (Table 10), grouped by major fishing method (Table 10) and total landings across all fishing methods. Landings have been summed across all fishing years: 1989–90 to 2008–09.

| Statistical Area Region | Fishing Method | | | | | Fishing Method | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | SN | BT | BLL | OTH | Total | SN | BT | BLL | OTH | Total |
| | Landings (t) | | | | | Distribution (%) | | | | |
| 025-026 | 2 699 | 133 | 16 | 29 | 2 877 | 20.2 | 1.0 | 0.1 | 0.2 | 21.5 |
| 027 | 3 387 | 29 | 38 | 21 | 3 475 | 25.3 | 0.2 | 0.3 | 0.2 | 26.0 |
| 028-029 | 799 | 222 | 45 | 73 | 1 139 | 6.0 | 1.7 | 0.3 | 0.5 | 8.5 |
| 030 | 3 864 | 568 | 251 | 32 | 4 714 | 28.9 | 4.2 | 1.9 | 0.2 | 35.3 |
| 031 | 503 | 33 | 165 | 17.4 | 719 | 3.8 | 0.2 | 1.2 | 0.1 | 5.4 |
| 032 | 207 | 4 | 220 | 14 | 445 | 1.5 | 0.0 | 1.6 | 0.1 | 3.3 |
| Total | 11 459 | 988 | 736 | 186 | 13 370 | 85.7 | 7.4 | 5.5 | 1.4 | 100.0 |

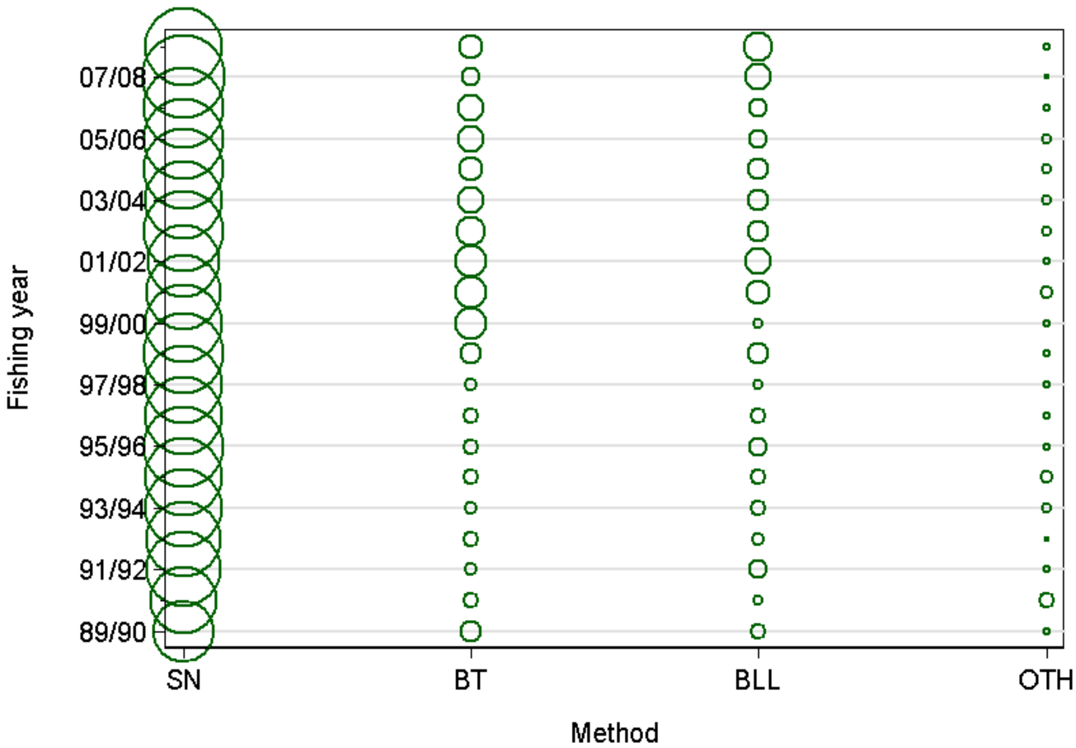


Figure 6. Distribution of catches for the major fishing methods by fishing year from trips which landed SCH 5. Circles are proportional to the catch totals by method and fishing year, with the largest circle = 680 t (07/08 SN)

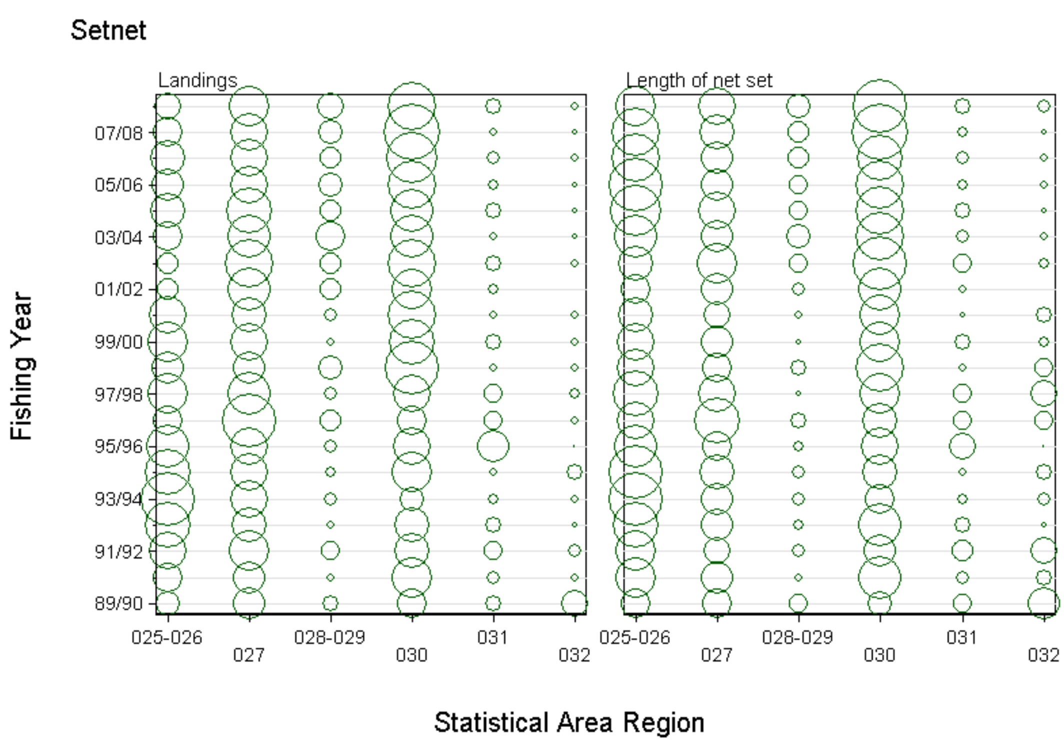


Figure 7. Distribution of landings and length of net set for the setnet method by grouped statistical area (Table 10) and fishing year from trips which landed SCH 5. Circles are proportional within each panel: [catches] largest circle=348 t in 07/08 for 030; [length of net set] largest circle= 439 km in 07/08 for 030.

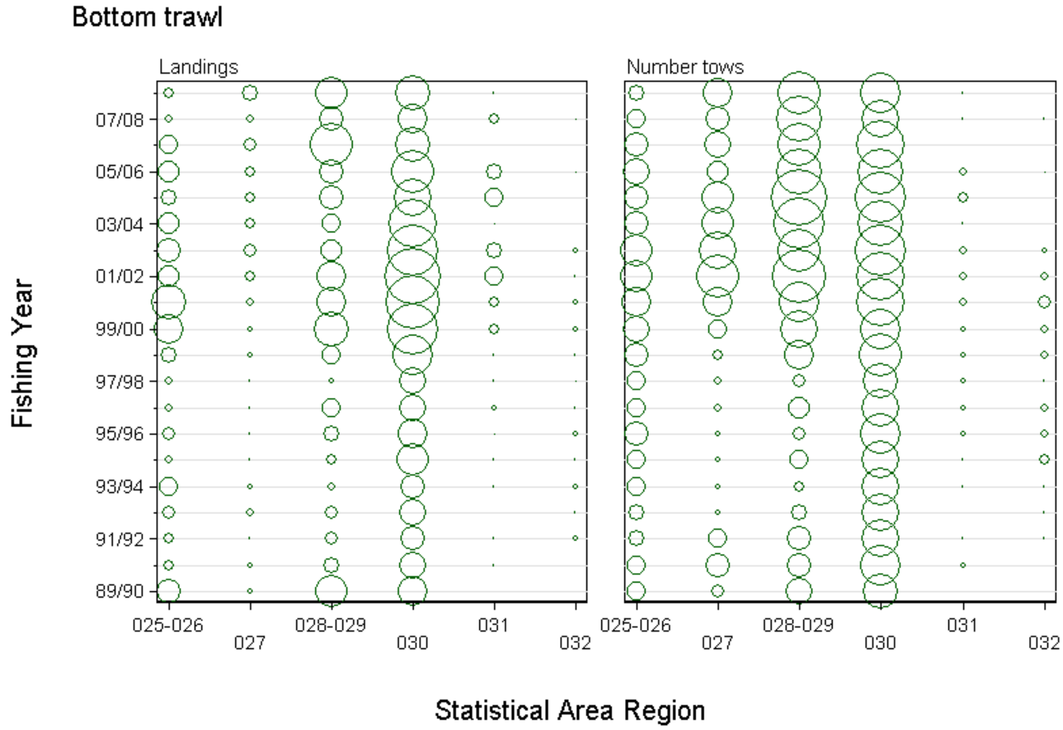


Figure 8. Distribution of landings and number tows for the bottom trawl method by grouped statistical area (Table 10) and fishing year from trips which landed SCH 5. Circles are proportional within each panel: largest circle [catches] = 63 t in 01/02 for 030; [number tows] =3 070 tows in 04/05 for 028-029.

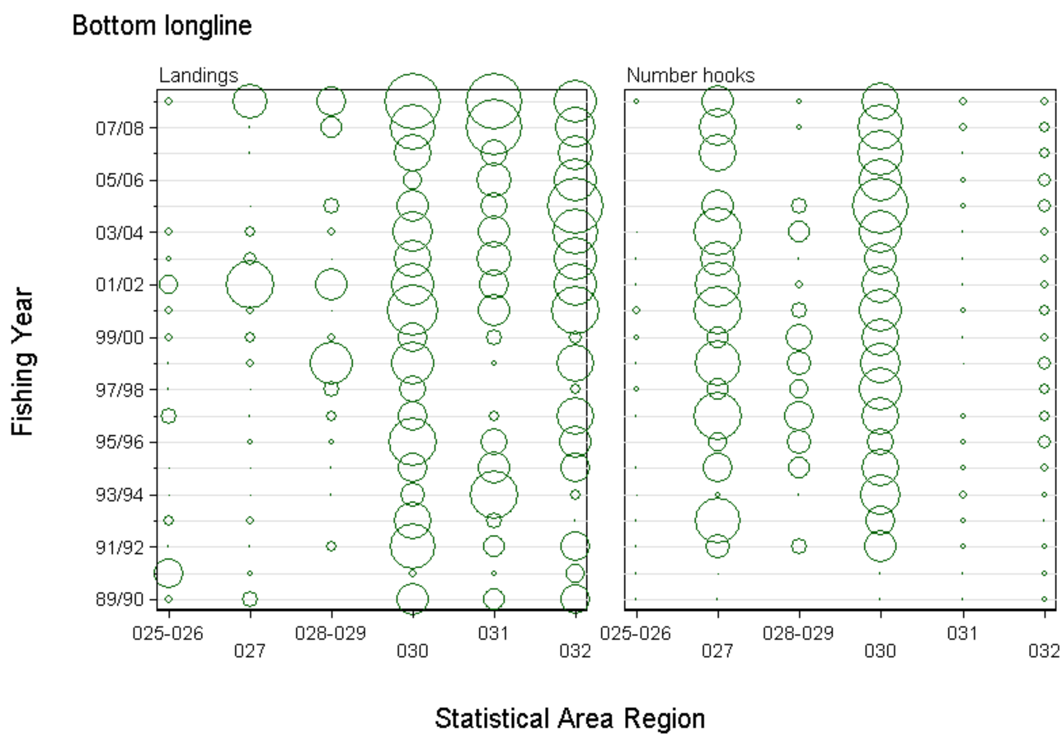


Figure 9. Distribution of landings and number of hooks for the bottom longline method by grouped statistical area (Table 10) and fishing year from trips which landed SCH 5. Circles are proportional within each panel: [catches] largest circle= 28 t in 08/09 for 030; [number hooks] largest circle= 3,447,000 hooks in 04/05 for 030

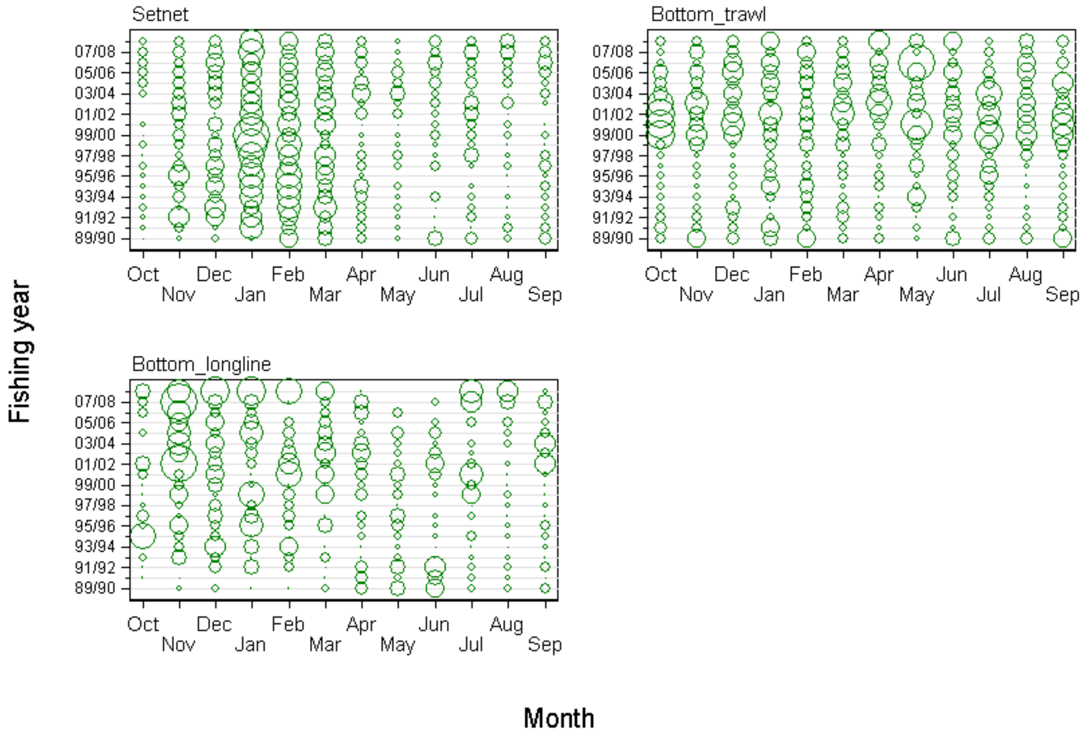


Figure 10. Total landings by month, fishing year and principle method of capture based on trips which landed SCH 5. Circles sizes are proportional within each panel, with maximum values: [setnet] 331 t in 99/00 for Jan; [bottom trawl] 26 t in 06/07 for May; [bottom longline] 26 t in 01/02 for Nov

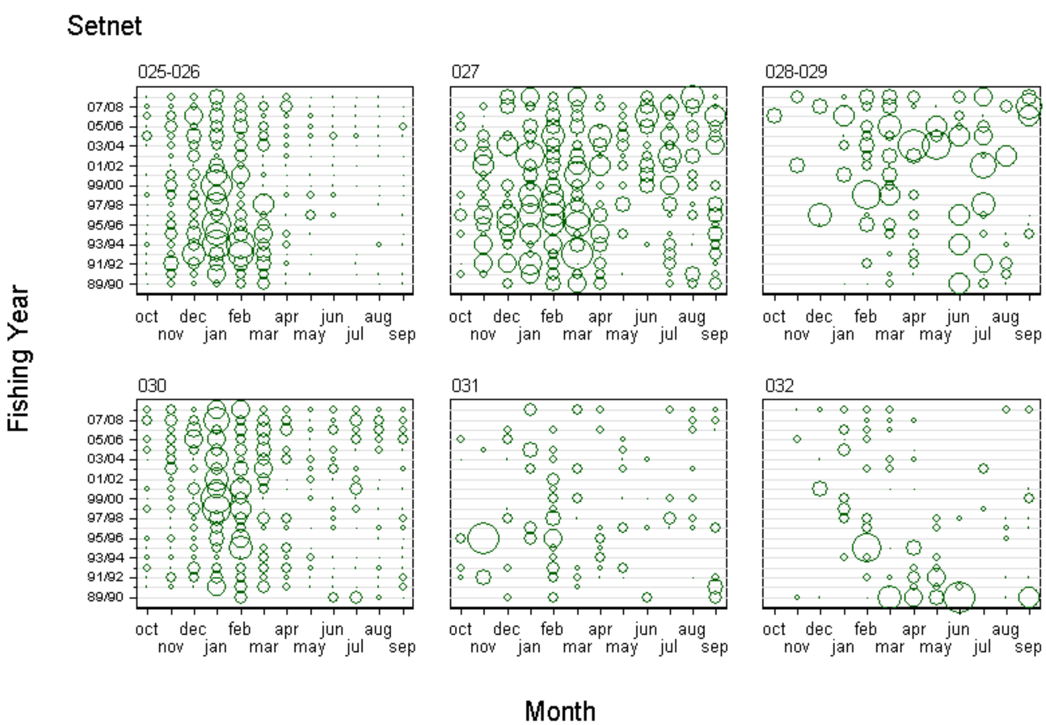


Figure 11. Distribution of landings for the setnet method for grouped statistical areas (Table 10) by month and fishing year from trips which landed SCH 5. Circles sizes are proportional within each panel: maximum values: [025-026] 130 t in 99/00 for Jan; [027] 90 t in 92/93 for Mar; [028-029] 43 t in 03/04 for Apr; [030] 187 t in 99/00 for Jan; [031] 68 t in 95/96 for Nov; [032] 28 t in 89/90 for Jun

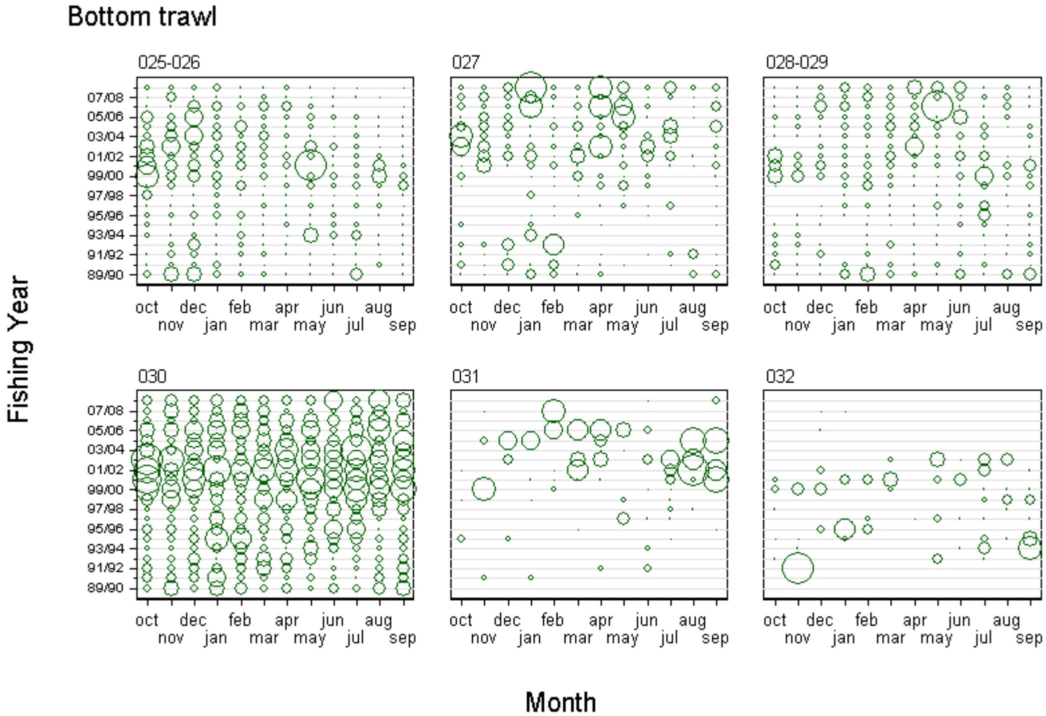


Figure 12. Distribution of landings for the bottom trawl method for grouped statistical areas (Table 10) by month and fishing year from trips which landed SCH 5. Circles sizes are proportional within each panel: maximum values: [025-026] 11 t in 00/01 for May; [027] 2.1 t in 08/09 for Jan; [028-029] 22 t in 06/07 for May; [030] 11 t in 03/04 for Jul; [031] 3.2 t in 01/02 for Aug; [032] 0.7 t in 91/92 for Nov

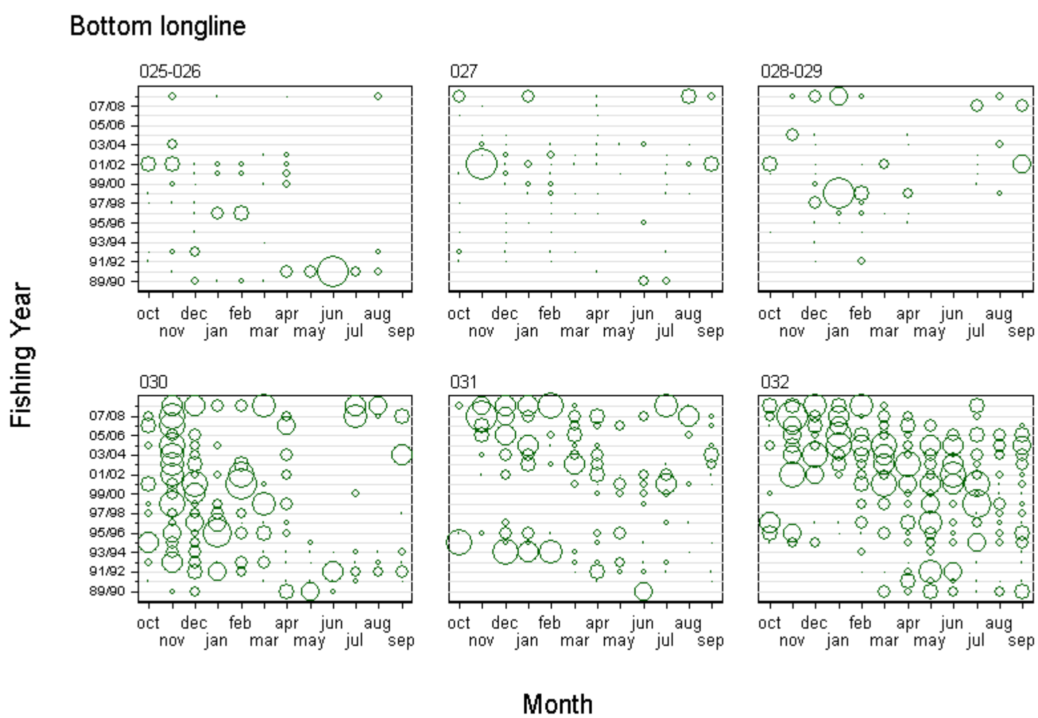


Figure 13. Distribution of landings for the bottom longline method for grouped statistical areas (Table 10) by month and fishing year from trips which landed SCH 5. Circles sizes are proportional within each panel: maximum values: [025-026] 4.2 t in 90/91 for Jun; [027] 14 t in 01/02 for Nov; [028-029] 12 t in 98/99 for Jan; [030] 11 t in 00/01 for Feb; [031] 11 t in 07/08 for Nov; [032] 7.1 t in 07/08 for Nov

SCH 5 shares several statistical areas with other school shark Fishstocks, including Areas 026 and 027 with SCH 3, and Area 032 with SCH 7 (Appendix A). The SCH 5 fishery is taken primarily by the setnet method, but there are minor amounts of landings using the bottom trawl and bottom longline methods (Table 11; Figure 6). About 85% of the landings have been taken by setnet over the 20 years of available catch history, with 7% and 6% of the landings from the bottom trawl and bottom longline fisheries respectively. All other methods account for just over 1% of the total annual SCH 5 catch. About 50% of the total SCH 5 landings come from combined Areas 025 and 027 (eastern Stewart Island and eastern Foveaux Strait) and an additional one-third of the landings from Area 030 (western Foveaux Strait; Table 12).

Setnet landings of school shark are distributed, on average, evenly between the three most important statistical areas, with some inter-year variation (025, 027 and 030; Figure 7;). Bottom trawl landings are primarily made in Area 030, with the eastern statistical areas relatively unimportant in terms of landings (Figure 8; Table 12). Setnet effort shows a similar distribution as do landings, with both Areas 025 and 030 receiving relatively the same amount of effort as landings (Figure 7). There has been an increase in bottom trawl effort in Area 029 but the associated landings are low, except for 2006–07 (Figure 8). Bottom trawl effort nearly disappeared from Areas 027 and 029 in the mid- to late-1990s, but has since recovered (Figure 8). On the other hand, bottom trawl effort in Areas 025 and 030 has been relatively stable over the period of record. Landings of school shark using the bottom longline method are confined almost entirely to the western half of the QMA (Figure 9). The distribution of longline effort does not match well with the landings, with Areas 027 and 029 showing a large amount of effort and relatively small amounts of catch while Areas 031 and 032 have almost no effort and relatively large amounts of landings (Figure 9). Only Area 030 has an equivalent amount of effort and landings.

Table 12. Percent distribution of landings by statistical area region (Table 10) from 1989–90 to 2008–09 for the setnet, bottom trawl and bottom longline methods for trips which landed SCH 5. Annual landings by method are available in Table 13 and rows sum to 100. [–]: no landings in indicated cell

| | **Statistical Area Region** | | | | | | **Statistical Area Region** | | | | | | **Statistical Area Region** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Fishing** | **025-026** | **027** | **028-029** | **030** | **031** | **032** | **025-026** | **027** | **028-029** | **030** | **031** | **032** | **025-026** | **027** | **028-029** | **030** | **031** | **032** |
| **year** | **Setnet distribution (%)** | | | | | | **Bottom trawl distribution (%)** | | | | | | **Bottom longline distribution (%)** | | | | | |
| 89/90 | 14.4 | 28.3 | 7.7 | 22.9 | 7.1 | 19.4 | 21.4 | 1.8 | 40.0 | 36.8 | – | – | 2.8 | 10.7 | – | 37.4 | 18.4 | 30.7 |
| 90/91 | 25.3 | 26.4 | 2.0 | 40.4 | 4.4 | 1.5 | 10.0 | 3.5 | 25.4 | 60.6 | 0.5 | – | 64.1 | 1.3 | – | 5.3 | 1.4 | 27.9 |
| 91/92 | 29.3 | 30.6 | 6.0 | 23.7 | 7.1 | 3.1 | 11.4 | 1.4 | 18.9 | 62.8 | 1.7 | 3.8 | 0.1 | 0.1 | 2.8 | 60.5 | 12.5 | 24.0 |
| 92/93 | 42.3 | 25.2 | 1.3 | 24.9 | 5.9 | 0.5 | 12.6 | 5.9 | 16.2 | 65.0 | – | 0.4 | 5.2 | 4.6 | – | 76.3 | 12.9 | 0.9 |
| 93/94 | 53.4 | 28.3 | 3.9 | 10.8 | 2.6 | 1.0 | 31.5 | 1.9 | 6.9 | 56.4 | 0.4 | 2.9 | 0.0 | 0.0 | 0.2 | 18.1 | 78.4 | 3.2 |
| 94/95 | 38.4 | 24.1 | 2.6 | 28.8 | 1.0 | 5.2 | 6.1 | 0.4 | 8.5 | 83.0 | 0.9 | 1.0 | 0.1 | 0.0 | 0.1 | 32.9 | 36.2 | 30.7 |
| 95/96 | 30.2 | 25.9 | 2.9 | 22.6 | 18.3 | 0.2 | 13.1 | 0.2 | 18.8 | 66.0 | 0.0 | 1.8 | – | 1.0 | 0.6 | 55.9 | 17.8 | 24.8 |
| 96/97 | 14.9 | 53.1 | 9.1 | 16.2 | 5.7 | 1.0 | 6.6 | 0.9 | 29.0 | 60.2 | 2.9 | 0.3 | 8.5 | 0.1 | 3.5 | 34.0 | 5.0 | 48.8 |
| 97/98 | 29.4 | 33.3 | 3.8 | 25.1 | 6.8 | 1.6 | 10.2 | 0.6 | 4.4 | 83.9 | 0.8 | 0.1 | 1.0 | 0.0 | 24.4 | 65.4 | – | 9.3 |
| 98/99 | 16.9 | 19.4 | 10.1 | 51.5 | 0.9 | 1.1 | 13.0 | 0.8 | 16.6 | 68.9 | 0.2 | 0.5 | 0.1 | 1.2 | 34.5 | 36.0 | 0.4 | 27.8 |
| 99/00 | 27.6 | 27.1 | 0.9 | 39.1 | 4.0 | 1.3 | 17.6 | 0.5 | 26.5 | 52.9 | 2.2 | 0.4 | 3.2 | 5.9 | 3.4 | 57.0 | 19.3 | 11.1 |
| 00/01 | 26.0 | 24.4 | 3.5 | 43.9 | 1.0 | 1.2 | 22.7 | 1.3 | 18.3 | 54.4 | 2.8 | 0.5 | 1.5 | 1.1 | 0.0 | 43.1 | 16.2 | 38.1 |
| 01/02 | 10.5 | 41.3 | 9.8 | 35.5 | 2.9 | – | 8.7 | 2.2 | 17.1 | 64.7 | 7.0 | 0.2 | 4.3 | 27.5 | 13.3 | 21.9 | 10.0 | 23.1 |
| 02/03 | 9.1 | 39.1 | 7.8 | 38.9 | 4.1 | 1.1 | 14.9 | 3.9 | 12.1 | 62.7 | 5.9 | 0.5 | 0.4 | 3.6 | 0.0 | 29.7 | 25.2 | 41.2 |
| 03/04 | 15.9 | 31.4 | 16.5 | 34.6 | 1.1 | 0.6 | 13.4 | 3.6 | 10.5 | 72.5 | 0.0 | – | 1.5 | 2.5 | 1.2 | 31.1 | 21.2 | 42.4 |
| 04/05 | 21.2 | 33.7 | 8.0 | 32.1 | 4.4 | 0.7 | 10.1 | 4.6 | 20.3 | 51.1 | 13.9 | – | – | 0.0 | 5.0 | 21.9 | 13.3 | 59.8 |
| 05/06 | 19.9 | 25.5 | 10.6 | 41.3 | 2.2 | 0.5 | 14.1 | 2.9 | 18.8 | 56.1 | 8.1 | 0.0 | – | – | – | 11.4 | 36.2 | 52.4 |
| 06/07 | 21.0 | 23.3 | 8.2 | 43.8 | 3.0 | 0.8 | 9.6 | 5.5 | 48.9 | 36.0 | – | – | – | 0.1 | – | 42.9 | 20.5 | 36.6 |
| 07/08 | 13.7 | 23.5 | 10.0 | 51.1 | 1.4 | 0.4 | 5.3 | 3.7 | 34.6 | 50.3 | 6.2 | 0.0 | – | 0.1 | 6.3 | 29.2 | 41.9 | 22.4 |
| 08/09 | 12.4 | 29.0 | 12.3 | 40.1 | 4.8 | 1.5 | 3.5 | 9.9 | 37.6 | 48.5 | 0.5 | – | 0.6 | 11.0 | 8.4 | 31.5 | 31.3 | 17.1 |
| Mean | 23.6 | 29.6 | 7.0 | 33.7 | 4.4 | 1.8 | 13.4 | 2.9 | 22.4 | 57.5 | 3.4 | 0.4 | 2.2 | 5.2 | 6.2 | 34.1 | 22.4 | 29.9 |

Detailed total SCH 5 landings by important statistical areas (grouped over the Statistical Area Regions defined in Table 10) and method of capture are provided in Table B.1.

Table 13. Percent distribution of landings by month and total annual landings (t) of SCH 5 from 1989–90 to 2008–09 for the setnet, bottom trawl and bottom longline methods for trips which landed SCH 5. Landings (t) have been scaled to the QMR totals $\left(\mathrm{QMR}_y\right)$ using Eq. 1.

| Fishing Year | Month | | | | | | | | | | | | Total (t) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | |
| | **Setnet distribution (%)** | | | | | | | | | | | | |
| 89/90 | 0.0 | 2.8 | 4.4 | 1.4 | 19.1 | 18.5 | 7.0 | 1.7 | 20.0 | 11.4 | 3.9 | 9.9 | 380 |
| 90/91 | 1.8 | 5.7 | 2.8 | 32.5 | 16.4 | 15.6 | 7.1 | 1.6 | 0.7 | 1.1 | 6.1 | 8.7 | 411 |
| 91/92 | 0.9 | 19.9 | 14.1 | 23.1 | 15.5 | 7.8 | 5.8 | 1.7 | 0.5 | 6.1 | 1.6 | 3.0 | 545 |
| 92/93 | 2.9 | 1.9 | 20.5 | 11.0 | 23.3 | 25.5 | 5.6 | 2.4 | 0.0 | 2.9 | 0.7 | 3.4 | 553 |
| 93/94 | 1.4 | 8.2 | 7.2 | 22.9 | 28.0 | 11.8 | 7.9 | 1.9 | 4.1 | 3.0 | 0.9 | 2.5 | 566 |
| 94/95 | 0.9 | 3.9 | 12.9 | 23.6 | 27.7 | 11.4 | 12.3 | 2.0 | 0.0 | 0.9 | 0.0 | 4.4 | 590 |
| 95/96 | 1.7 | 18.6 | 9.0 | 27.7 | 25.5 | 14.6 | 1.3 | 0.0 | 0.0 | 0.0 | 0.4 | 1.1 | 630 |
| 96/97 | 2.5 | 7.1 | 15.8 | 19.8 | 15.6 | 15.4 | 5.6 | 3.3 | 4.4 | 1.1 | 2.9 | 6.5 | 581 |
| 97/98 | 0.1 | 3.0 | 7.3 | 27.4 | 17.2 | 19.3 | 4.5 | 3.8 | 1.3 | 9.2 | 1.5 | 5.4 | 589 |
| 98/99 | 3.2 | 4.8 | 9.3 | 41.7 | 28.5 | 5.6 | 1.7 | 0.9 | 1.5 | 2.6 | 0.1 | 0.1 | 616 |
| 99/00 | 0.0 | 7.8 | 2.8 | 55.8 | 11.7 | 4.7 | 0.8 | 1.7 | 4.5 | 5.3 | 2.7 | 2.1 | 593 |
| 00/01 | 1.3 | 4.6 | 12.0 | 27.0 | 25.0 | 18.6 | 0.0 | 0.1 | 3.7 | 5.2 | 2.2 | 0.4 | 551 |
| 01/02 | 0.0 | 11.8 | 0.4 | 31.1 | 12.5 | 12.4 | 8.4 | 4.5 | 4.3 | 14.5 | 0.0 | 0.0 | 493 |
| 02/03 | 0.0 | 10.7 | 5.9 | 19.7 | 16.8 | 18.2 | 2.8 | 2.5 | 4.5 | 10.7 | 7.2 | 1.2 | 611 |
| 03/04 | 2.5 | 6.2 | 9.3 | 20.6 | 13.1 | 12.3 | 14.1 | 12.0 | 2.6 | 1.5 | 0.0 | 5.8 | 603 |
| 04/05 | 4.9 | 8.3 | 9.8 | 14.9 | 15.3 | 10.2 | 9.5 | 5.3 | 6.6 | 8.2 | 4.1 | 2.6 | 635 |
| 05/06 | 4.1 | 7.2 | 12.0 | 16.8 | 14.9 | 16.3 | 1.0 | 6.1 | 4.7 | 5.7 | 4.5 | 6.7 | 606 |
| 06/07 | 3.4 | 4.9 | 14.7 | 12.1 | 13.2 | 11.1 | 6.1 | 2.8 | 11.8 | 4.1 | 4.3 | 11.5 | 630 |
| 07/08 | 3.4 | 6.5 | 9.2 | 24.8 | 8.7 | 11.0 | 7.5 | 1.2 | 3.6 | 9.0 | 8.1 | 7.1 | 680 |
| 08/09 | 2.6 | 5.5 | 7.0 | 25.7 | 16.1 | 10.0 | 5.7 | 1.0 | 6.2 | 6.0 | 10.1 | 4.1 | 594 |
| Mean | 2.0 | 7.5 | 9.5 | 24.2 | 18.1 | 13.3 | 5.7 | 2.9 | 4.1 | 5.3 | 3.1 | 4.2 | 11 459 |
| | **Bottom trawl distribution (%)** | | | | | | | | | | | | |
| 89/90 | 4.0 | 12.7 | 6.6 | 11.6 | 15.8 | 4.8 | 3.8 | 1.4 | 9.1 | 6.1 | 8.4 | 15.6 | 49 |
| 90/91 | 17.9 | 9.8 | 11.1 | 24.1 | 5.0 | 5.4 | 2.7 | 5.2 | 2.0 | 4.1 | 5.6 | 7.1 | 27 |
| 91/92 | 9.7 | 12.1 | 13.7 | 6.8 | 8.8 | 14.9 | 7.1 | 1.4 | 5.2 | 1.9 | 5.1 | 13.2 | 19 |
| 92/93 | 5.7 | 7.2 | 19.7 | 0.9 | 15.2 | 17.7 | 8.1 | 9.8 | 1.1 | 3.9 | 3.5 | 7.3 | 23 |
| 93/94 | 4.9 | 4.5 | 3.4 | 10.1 | 13.9 | 4.3 | 0.8 | 29.9 | 10.7 | 8.7 | 1.3 | 7.6 | 21 |
| 94/95 | 3.7 | 3.0 | 5.7 | 26.7 | 19.3 | 2.2 | 8.3 | 3.9 | 9.5 | 9.2 | 2.1 | 6.4 | 26 |
| 95/96 | 5.7 | 5.1 | 4.8 | 12.2 | 9.4 | 6.7 | 7.5 | 2.3 | 13.3 | 27.7 | 0.7 | 4.5 | 27 |
| 96/97 | 1.8 | 4.1 | 3.2 | 16.2 | 11.8 | 8.7 | 3.4 | 20.7 | 3.8 | 21.2 | 2.9 | 2.2 | 23 |
| 97/98 | 7.1 | 3.5 | 2.7 | 9.0 | 2.6 | 4.6 | 7.1 | 7.4 | 19.3 | 8.0 | 18.5 | 10.3 | 17 |
| 98/99 | 4.0 | 9.9 | 2.7 | 6.8 | 10.3 | 9.6 | 12.4 | 8.6 | 2.7 | 15.7 | 6.8 | 10.6 | 45 |
| 99/00 | 18.4 | 10.8 | 7.7 | 6.3 | 2.8 | 3.6 | 0.9 | 6.6 | 6.5 | 17.1 | 9.3 | 10.2 | 92 |
| 00/01 | 17.9 | 5.2 | 11.6 | 4.4 | 5.2 | 3.1 | 3.7 | 20.4 | 4.7 | 6.5 | 7.0 | 10.2 | 102 |
| 01/02 | 16.9 | 4.8 | 7.2 | 11.5 | 5.8 | 11.0 | 7.4 | 2.7 | 7.0 | 11.2 | 6.5 | 8.1 | 98 |
| 02/03 | 16.7 | 14.8 | 5.0 | 1.7 | 4.3 | 8.2 | 16.5 | 7.5 | 6.1 | 6.3 | 7.1 | 5.8 | 83 |
| 03/04 | 7.0 | 5.3 | 11.4 | 7.8 | 3.6 | 6.3 | 11.3 | 7.7 | 8.2 | 20.8 | 5.1 | 5.5 | 65 |
| 04/05 | 6.3 | 5.5 | 7.7 | 11.1 | 9.1 | 11.8 | 10.0 | 5.4 | 4.3 | 6.8 | 6.7 | 15.3 | 54 |
| 05/06 | 8.4 | 7.1 | 14.6 | 7.3 | 8.5 | 8.0 | 7.5 | 11.3 | 10.4 | 5.2 | 11.3 | 0.4 | 64 |
| 06/07 | 1.7 | 1.7 | 9.4 | 10.6 | 5.1 | 5.3 | 9.1 | 37.5 | 3.3 | 2.4 | 9.3 | 4.7 | 70 |
| 07/08 | 2.7 | 12.9 | 8.9 | 6.5 | 23.1 | 12.7 | 4.1 | 4.7 | 4.7 | 7.8 | 9.4 | 2.5 | 33 |
| 08/09 | 3.4 | 4.6 | 5.7 | 14.3 | 4.7 | 4.2 | 17.5 | 10.2 | 14.4 | 2.8 | 11.6 | 6.7 | 51 |
| Mean | 10.1 | 7.4 | 8.4 | 9.1 | 7.7 | 7.1 | 7.8 | 10.7 | 6.9 | 9.6 | 7.4 | 7.8 | 988 |

Table 13. (cont.)

| | Bottom longline distribution (%) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 89/90 | 0.0 | 1.8 | 5.8 | 0.3 | 0.6 | 6.3 | 16.0 | 23.7 | 29.5 | 3.9 | 3.9 | 8.2 | 24 |
| 90/91 | 0.5 | 0.2 | 0.0 | 0.0 | 0.0 | 0.6 | 28.5 | 12.9 | 42.6 | 11.5 | 3.1 | 0.2 | 11 |
| 91/92 | 0.2 | 0.0 | 9.5 | 14.3 | 6.4 | 0.0 | 11.1 | 15.7 | 27.4 | 3.9 | 4.1 | 7.3 | 30 |
| 92/93 | 7.0 | 29.8 | 16.6 | 1.0 | 12.6 | 14.5 | 1.9 | 7.9 | 0.4 | 4.1 | 3.5 | 0.7 | 15 |
| 93/94 | 0.0 | 7.8 | 37.3 | 20.2 | 28.0 | 1.1 | 0.1 | 1.8 | 0.0 | 0.8 | 0.1 | 2.8 | 26 |
| 94/95 | 51.9 | 9.7 | 9.7 | 0.8 | 0.0 | 0.0 | 4.2 | 4.4 | 2.3 | 10.2 | 2.1 | 4.6 | 25 |
| 95/96 | 4.7 | 17.1 | 7.3 | 32.9 | 5.1 | 11.7 | 4.4 | 8.8 | 1.2 | 0.0 | 1.1 | 5.6 | 36 |
| 96/97 | 11.8 | 3.5 | 19.2 | 19.6 | 12.3 | 0.5 | 8.6 | 17.5 | 1.7 | 3.9 | 1.1 | 0.4 | 24 |
| 97/98 | 6.4 | 13.1 | 33.7 | 20.1 | 17.2 | 0.0 | 0.0 | 1.0 | 0.0 | 0.2 | 4.9 | 3.4 | 10 |
| 98/99 | 0.6 | 14.8 | 1.7 | 27.4 | 8.6 | 15.8 | 6.9 | 5.0 | 1.6 | 14.4 | 3.0 | 0.3 | 47 |
| 99/00 | 1.5 | 15.0 | 41.9 | 3.2 | 1.8 | 0.6 | 6.4 | 10.4 | 4.7 | 13.4 | 0.6 | 0.6 | 14 |
| 00/01 | 4.6 | 3.7 | 14.6 | 0.2 | 24.2 | 11.0 | 5.5 | 8.6 | 7.1 | 19.0 | 0.4 | 1.1 | 53 |
| 01/02 | 6.4 | 36.3 | 6.7 | 3.3 | 11.3 | 3.4 | 5.5 | 1.3 | 8.2 | 3.7 | 1.2 | 12.6 | 71 |
| 02/03 | 0.0 | 15.7 | 8.6 | 9.7 | 11.1 | 19.7 | 16.5 | 2.7 | 8.5 | 1.2 | 0.0 | 6.3 | 42 |
| 03/04 | 0.0 | 23.5 | 17.0 | 6.4 | 4.4 | 10.9 | 9.8 | 2.8 | 1.3 | 3.0 | 3.0 | 17.9 | 46 |
| 04/05 | 3.5 | 23.7 | 5.5 | 23.4 | 8.0 | 11.6 | 2.8 | 6.4 | 6.5 | 0.0 | 2.9 | 5.7 | 45 |
| 05/06 | 0.0 | 22.1 | 20.9 | 15.8 | 8.9 | 10.5 | 1.6 | 0.0 | 3.4 | 5.7 | 6.3 | 5.0 | 31 |
| 06/07 | 9.0 | 40.3 | 6.2 | 8.7 | 0.0 | 6.5 | 18.1 | 8.7 | 0.0 | 0.0 | 0.0 | 2.4 | 31 |
| 07/08 | 3.6 | 38.6 | 6.8 | 8.1 | 0.4 | 4.3 | 8.4 | 0.0 | 1.9 | 13.2 | 7.5 | 7.2 | 66 |
| 08/09 | 5.9 | 12.9 | 18.3 | 17.5 | 14.5 | 7.6 | 0.0 | 0.0 | 0.0 | 13.4 | 9.0 | 0.9 | 90 |
| Mean | 5.3 | 18.9 | 12.5 | 12.3 | 9.4 | 7.8 | 6.9 | 5.3 | 5.7 | 7.3 | 3.4 | 5.4 | 736 |

While the setnet landings from SCH 5 show a concentration of catch in the first of half of the fishing year, with catch diminishing in the setnet fishery by the end of March (Figure 10), the bottom trawl fishery landings of school shark appear to extend through the entire year (Figure 10; Table 13). Bottom longline landings of SCH 5 are more erratic, but seem to be confined mainly to the spring and summer months (Figure 10). The seasonal pattern of landings of school shark using setnet in each statistical area indicates that school shark landings typically take place in the early part of the fishing year, with the exception of Area 027, which appears to have a longer season (Figure 11). The seasonal distribution of bottom trawl landings by statistical area is sporadic in most areas with the exception of Area 030, where the majority of landings are taken, and where the landings are distributed throughout the year (Figure 12). There was no consistent seasonal pattern in the school shark bottom longline landings by Statistical Area Region, primarily due to the small number of landings when subdivided by method, Region and month (Figure 13)

Table 14. Landings (t) and distribution of landings (%) of school shark from trips which landed SCH 5 by target species and principle fishing methods (Table 10), summed from 1989–90 to 2008–09. Landings (t) have been scaled to the QMR totals $\left(\text{QMR}_y\right)$ using Eq. 1. [–]: no landings in indicated cell

| Target Species | Fishing Method | | | | | Fishing Method | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | SN | BT | BLL | OTH | Total | SN | BT | BLL | OTH | Total |
| | Total landings (t) | | | | | Distribution of landings (%) | | | | |
| SCH | 11 128 | 7 | 214 | 22 | 11 370 | 83.2 | 0.1 | 1.6 | 0.2 | 85.0 |
| STA | 0 | 512 | – | 1 | 512 | 0.0 | 3.8 | – | 0.0 | 3.8 |
| HPB | 1 | 1 | 244.6 | 58 | 305 | 0.0 | 0.0 | 1.8 | 0.4 | 2.3 |
| SPO | 292 | 4 | – | – | 296 | 2.2 | 0.0 | – | – | 2.2 |
| LIN | 3 | 54 | 200.5 | 1 | 257 | 0.0 | 0.4 | 1.5 | 0.0 | 1.9 |
| SQU | – | 112 | – | 58 | 170 | – | 0.8 | – | 0.4 | 1.3 |
| FLA | 0 | 99 | – | 0 | 99 | 0.0 | 0.7 | – | 0.0 | 0.7 |
| BNS | 1 | – | 77 | 10 | 88 | 0.0 | – | 0.6 | 0.1 | 0.7 |
| OTH | 34 | 200 | 0 | 37 | 271 | 0.3 | 1.5 | 0.0 | 0.3 | 2.0 |
| Total | 11 459 | 988 | 736 | 186 | 13 370 | 85.7 | 7.4 | 5.5 | 1.4 | 100.0 |

Table 15. Percent distribution of landings by target species (Table 10) from 1989–90 to 2008–09 for the setnet bottom trawl and bottom longline methods for trips which landed SCH 5. Annual landings by method are available in Table 13. Rows sum to 100 by fishing method and fishing year

| Fishing | Target species | | | | Target species | | | | | | | | Target species | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SCH | SPO | BUT | OTH | STA | SQU | FLA | HOK | LIN | BAR | GUR | OTH | HPB | SCH | LIN | BNS | OTH |
| Year | Setnet distribution (%) | | | | Bottom trawl distribution (%) | | | | | | | | Bottom longline distribution (%) | | | | |
| 89/90 | 98.8 | 0.5 | 0.4 | 0.3 | 55.2 | 6.3 | 3.7 | 0.7 | 1.9 | 20.2 | 1.0 | 11.0 | 61.6 | 26.7 | 1.3 | 10.4 | – |
| 90/91 | 99.0 | 0.5 | 0.1 | 0.4 | 62.3 | 0.7 | 7.4 | 10.1 | 4.1 | 6.1 | 0.3 | 8.9 | 42.1 | 50.2 | 4.4 | 3.3 | – |
| 91/92 | 98.7 | 0.5 | 0.0 | 0.8 | 64.6 | 0.6 | 15.2 | 1.8 | 1.2 | 2.4 | 0.4 | 14.0 | 32.6 | 51.1 | 15.9 | 0.0 | 0.4 |
| 92/93 | 97.9 | 1.9 | 0.0 | 0.1 | 75.5 | 0.0 | 7.6 | – | 1.6 | 6.6 | 0.0 | 8.6 | 22.0 | 40.6 | 37.4 | 0.0 | 0.0 |
| 93/94 | 99.2 | 0.7 | – | 0.1 | 85.4 | – | 5.2 | – | 1.2 | 0.0 | – | 8.3 | 40.6 | 41.4 | 16.8 | 1.2 | – |
| 94/95 | 98.7 | 1.1 | – | 0.2 | 81.1 | 0.2 | 6.4 | 1.7 | 0.8 | 0.0 | – | 9.8 | 70.6 | 0.5 | 24.7 | 4.2 | 0.1 |
| 95/96 | 97.9 | 1.5 | – | 0.6 | 47.7 | 0.0 | 6.8 | 13.8 | 0.1 | 22.2 | 0.3 | 9.1 | 51.6 | 4.6 | 36.2 | 7.2 | 0.3 |
| 96/97 | 99.2 | 0.6 | – | 0.3 | 74.7 | 3.2 | 9.0 | 0.9 | 0.1 | 3.0 | 0.1 | 8.9 | 60.6 | 0.1 | 38.9 | 0.4 | – |
| 97/98 | 99.4 | 0.5 | – | 0.1 | 70.3 | 2.2 | 22.7 | 0.2 | 1.2 | 0.9 | 0.0 | 2.5 | 9.8 | 0.5 | 89.7 | – | – |
| 98/99 | 99.0 | 0.9 | – | 0.2 | 71.3 | 8.1 | 12.7 | 5.1 | 0.0 | 0.0 | 0.8 | 2.0 | 39.0 | 7.7 | 47.4 | 5.9 | 0.0 |
| 99/00 | 99.2 | 0.4 | 0.2 | 0.2 | 75.5 | 2.5 | 10.0 | 3.5 | 0.1 | 0.0 | 5.6 | 2.8 | 25.1 | 6.7 | 66.7 | 1.5 | – |
| 00/01 | 98.9 | 0.7 | – | 0.4 | 62.1 | 4.3 | 14.7 | 15.2 | 1.4 | 0.0 | 0.4 | 1.7 | 38.3 | 11.9 | 45.9 | 3.9 | – |
| 01/02 | 99.3 | 0.6 | 0.1 | 0.1 | 46.7 | 12.0 | 17.0 | 11.4 | 2.9 | 1.6 | 4.5 | 3.8 | 14.2 | 61.6 | 21.1 | 3.1 | – |
| 02/03 | 97.9 | 2.0 | 0.1 | 0.0 | 30.3 | 17.6 | 11.2 | 13.2 | 7.8 | 1.8 | 6.3 | 11.9 | 36.7 | 27.6 | 29.4 | 6.3 | – |
| 03/04 | 93.1 | 6.7 | 0.1 | 0.2 | 51.3 | 23.6 | 9.3 | 4.5 | 4.7 | 2.4 | 0.4 | 3.6 | 27.2 | 26.0 | 28.3 | 18.4 | 0.0 |
| 04/05 | 91.2 | 8.4 | 0.2 | 0.2 | 36.1 | 19.6 | 7.8 | 4.9 | 16.3 | 2.7 | 4.5 | 8.2 | 42.8 | 23.1 | 25.5 | 8.6 | 0.0 |
| 05/06 | 92.3 | 7.6 | 0.1 | 0.1 | 44.6 | 16.9 | 8.8 | 1.8 | 13.8 | 2.0 | 2.3 | 9.7 | 23.9 | 39.1 | 20.8 | 16.1 | – |
| 06/07 | 91.8 | 7.0 | 0.6 | 0.6 | 21.2 | 17.2 | 7.5 | 1.4 | 9.8 | 28.8 | 0.9 | 13.2 | 13.9 | 43.5 | 35.6 | 7.1 | – |
| 07/08 | 95.7 | 4.0 | 0.1 | 0.1 | 39.8 | 22.2 | 4.1 | 1.9 | 13.6 | 3.8 | 0.3 | 14.3 | 21.1 | 43.4 | 18.7 | 16.9 | – |
| 08/09 | 98.0 | 1.7 | 0.2 | 0.0 | 23.1 | 28.7 | 4.2 | 2.3 | 14.7 | 0.9 | 0.1 | 26.1 | 27.8 | 28.4 | 11.0 | 32.8 | 0.0 |
| Mean | 97.1 | 2.5 | 0.1 | 0.2 | 51.8 | 11.3 | 10.0 | 6.1 | 5.4 | 5.0 | 2.2 | 8.2 | 33.2 | 29.1 | 27.2 | 10.5 | 0.0 |

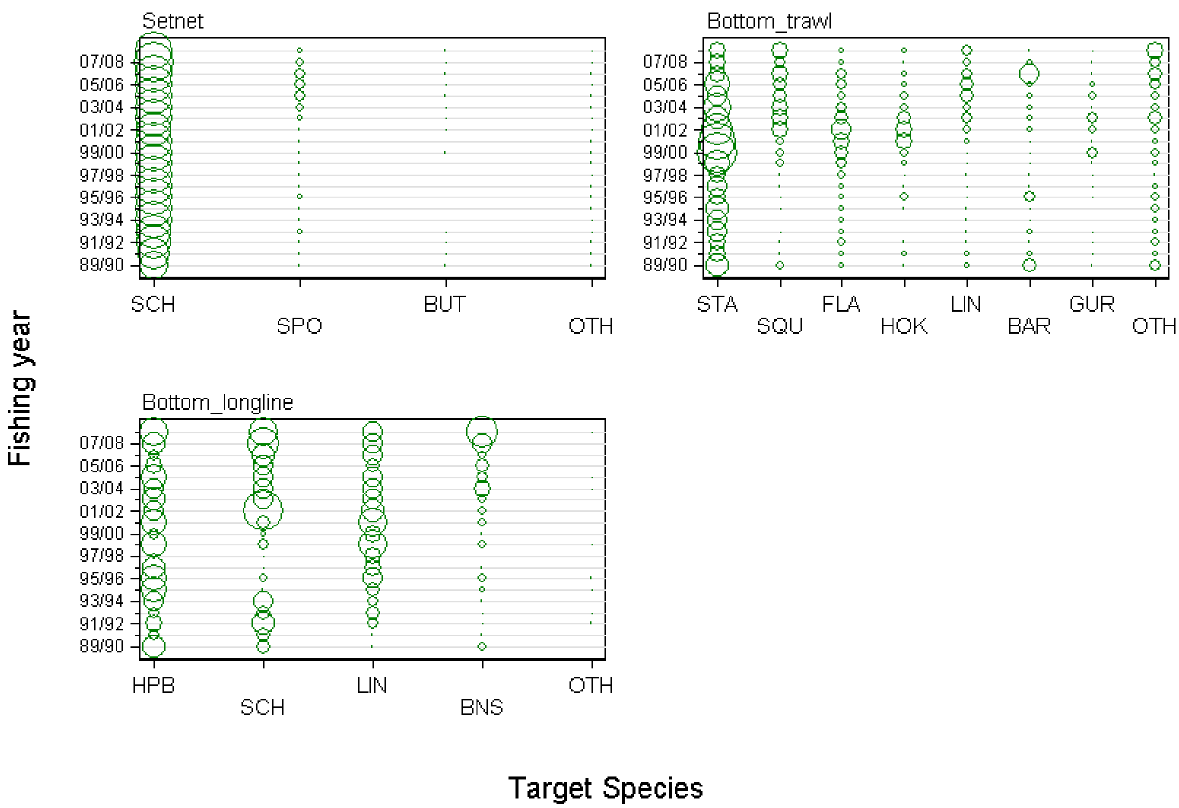


Figure 14. Total landings by target species (Table 10), fishing year and principle fishing methods for trips which landed SCH 5. Circles sizes are proportional within each panel with largest circle: [Setnet] 651 t in 07/08 for SCH; [Bottom_trawl] 70 t in 99/00 for STA; [Bottom_longline] 44 t in 01/02 for SCH

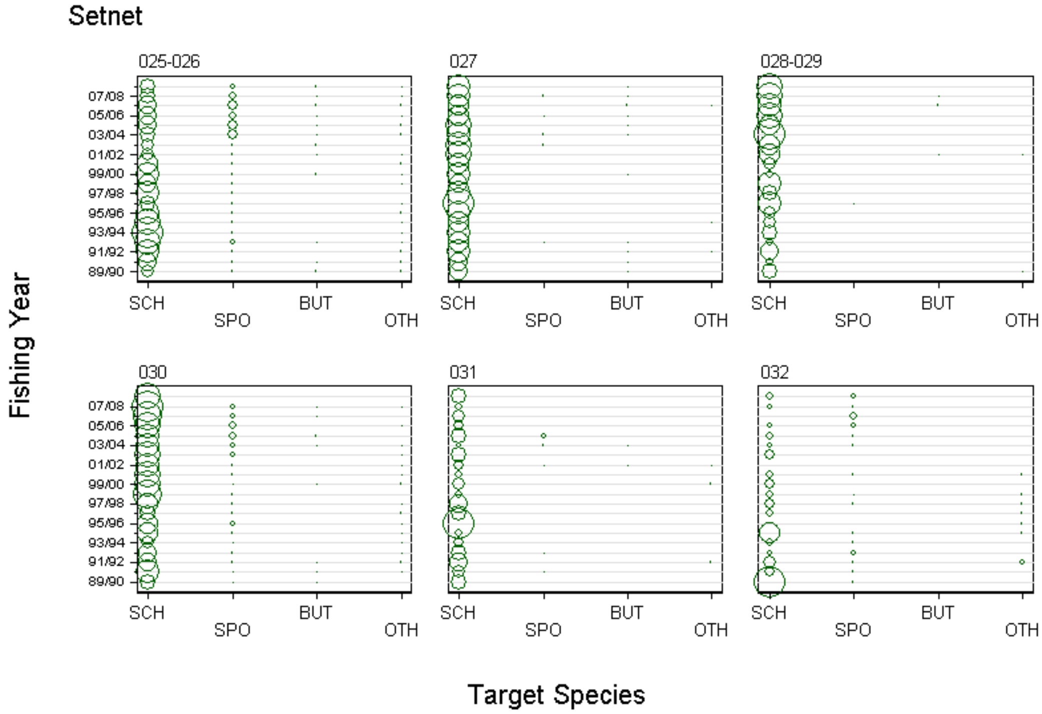


Figure 15. Distribution of landings for the setnet method for grouped statistical areas (Table 10) by target species and fishing year from trips which landed SCH 5. Circles sizes are proportional within each panel: maximum values: [025-026] 298 t in 93/94 for SCH; [027] 309 t in 96/97 for SCH; [028-029] 100 t in 03/04 for SCH; [030] 338 t in 07/08 for SCH; [031] 115 t in 95/96 for SCH; [032] 73 t in 89/90 for SCH

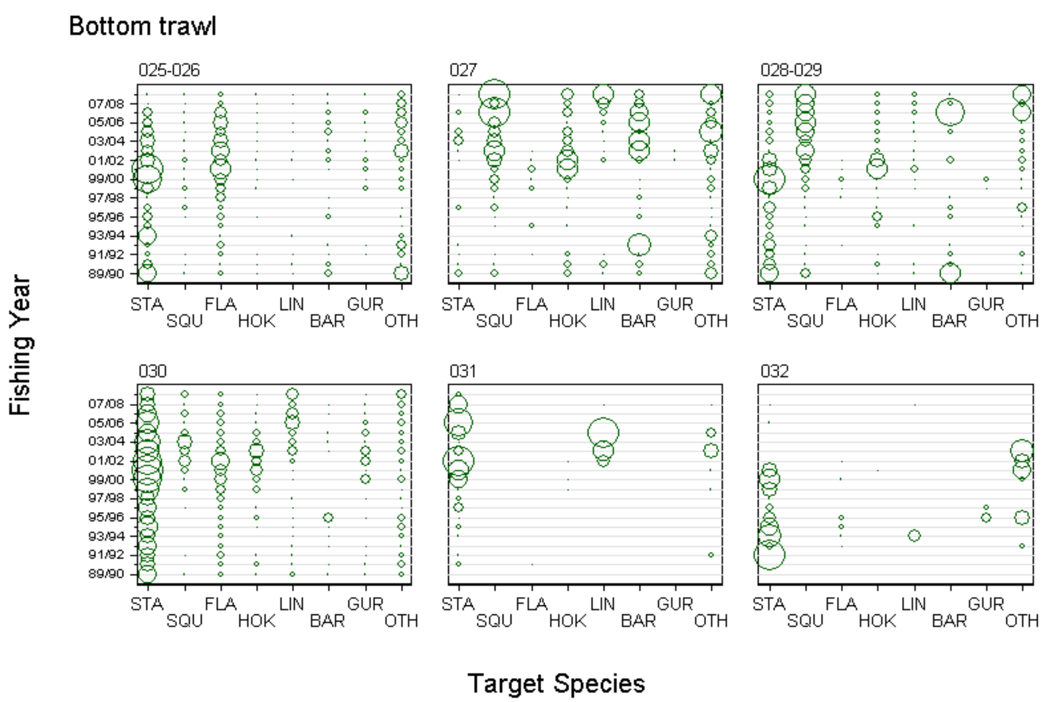


Figure 16. Distribution of landings for the bottom trawl method for the five grouped statistical areas (Table 10) by target species and fishing year from trips which landed SCH 5. Circles sizes are proportional within each panel: maximum values: [025-026] 15 t in 00/01 for STA; [027] 2.4 t in 06/07 for SQU; [028-029] 21 t in 99/00 for STA; [030] 39 t in 00/01 for STA; [031] 5.9 t in 01/02 for STA; [032] 0.7 t in 91/92 for STA

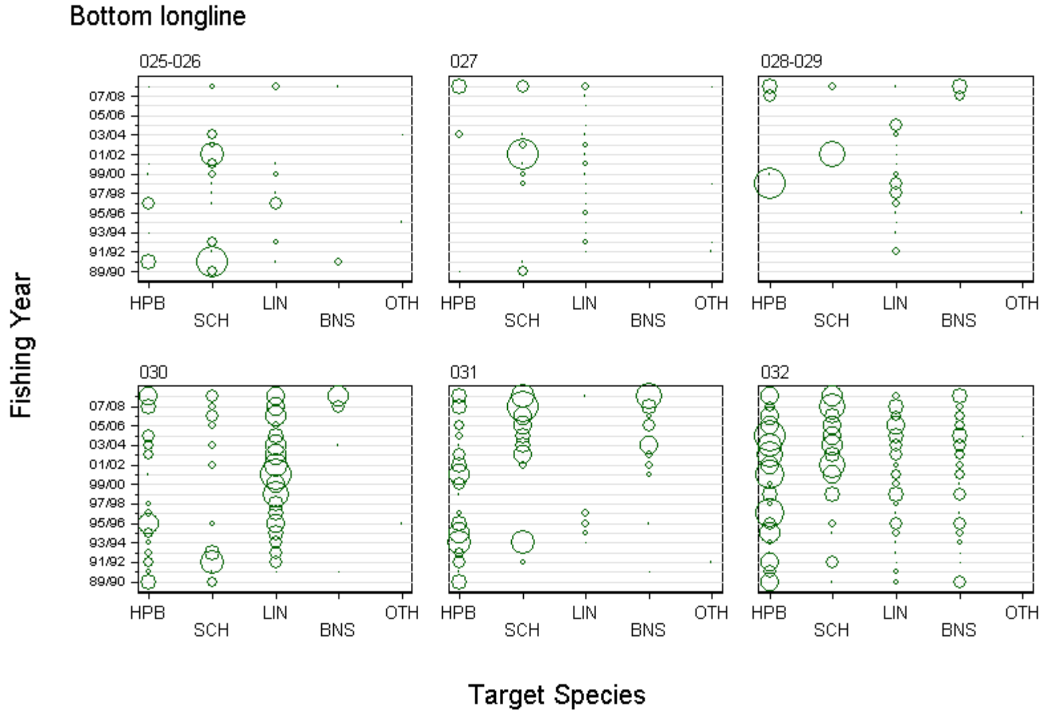


Figure 17. Distribution of landings for the bottom longline method for the five grouped statistical areas (Table 10) by target species and fishing year from trips which landed SCH 5. Circles sizes are proportional within each panel: maximum values: [025-026] 5.1 t in 90/91 for SCH; [027] 19 t in 01/02 for SCH; [028-029] 14 t in 98/99 for HPB; [030] 23 t in 00/01 for LIN; [031] 18 t in 07/08 for SCH; [032] 14 t in 04/05 for HPB

A limited range of target fisheries take school shark in FMA 5, with school shark accounting for 85% of the landed catch and with the remaining species being relatively unimportant (Table 14). The school shark setnet fishery is almost exclusively a target SCH fishery, with SCH declared as the target species for 97% of the landings (Table 15; Figure 14. Just over 50% of the school shark taken in the bottom trawl fishery in QMA 5 appeared to be bycatch to the target stargazer fishery, with the balance taken by a range of target fisheries, including squid, flatfish and hoki (Figure 14). There has been very little change over the years in the predominant target species for the QMA 5 setnet fishery. However, trawl fishery landings of school shark appear to have varied considerably by target species over this period. In particular, note the high trawl catches of school shark in the late 1990s in the target STA fishery. These increased landings coincided with the crash of the Asian market in 1997–98, but have since fallen away again. Afterwards, school shark bycatch increased in the target squid trawl fishery since 2001–02 (Table 15). The bottom longline fishery is almost entirely targeted at hapuku/bluenose, school shark and ling (Figure 14).

The pattern of exclusively target fishing for school shark using setnet gear is common among all the statistical areas within SCH 5, even for those areas where there are small amounts of landings (Figure 15). The distribution of target fisheries by statistical area for the bottom trawl fishery is more variable, with stargazer predominating in all areas, but flatfish target fishing is clearly important in the inshore statistical areas (025 and 030) while there is more squid and hoki target fishing in the outside statistical areas (027 and 029; Figure 16). Almost all of the landings of school shark in the bottom longline fishery come from the most western statistical areas (030, 031 and 032; Figure 17). Ling target fishing predominates in Area 030 while hapuku/bass targeting is more prevalent on the lower west coast of the South Island (031 and

032). There is also some targeting of school shark in this fishery, although landings are small (Figure 17).

Table 16. Summary statistics from distributions of bottom depth from bottom trawl and bottom longline for effort that targeted or caught school shark by target species category in valid statistical areas for SCH 5. This table is based on tows in the dataset from 1989–90 to 2008–09, although the newer TCER, LCER and LTCER forms have been only available relatively recently.

| | | Depth (m) | | | |
|---|---|---|---|---|---|
| **Target species category** | **Number observations** | **Lower 5% of distribution** | **Mean of distribution** | **Median (50%) of distribution** | **Upper 95% of distribution** |
| **Bottom trawl (combined TCEPR and TCER)** | | | | | |
| SQU | 597 | 131 | 207 | 190 | 310 |
| STA | 586 | 49 | 126 | 127 | 160 |
| FLA | 210 | 15 | 43 | 40 | 72 |
| BAR | 169 | 83 | 144 | 147 | 208 |
| HOK | 142 | 246 | 462 | 467 | 670 |
| LIN | 76 | 90 | 362 | 400 | 591 |
| SWA | 42 | 131 | 275 | 268 | 490 |
| TAR | 36 | 40 | 55 | 53 | 95 |
| WWA | 31 | 301 | 458 | 442 | 700 |
| WAR | 29 | 32 | 87 | 87 | 129 |
| SPD | 27 | 27 | 67 | 58 | 118 |
| JMA | 23 | 86 | 139 | 147 | 180 |
| Other | 54 | 13 | 142 | 75 | 420 |
| Total | 2,022 | 28 | 181 | 148 | 471 |
| **Bottom longline (combined LTCER and LCER)** | | | | | |
| LIN | 841 | 320 | 495 | 509 | 638 |
| BNS | 136 | 200 | 337 | 340 | 450 |
| HPB | 72 | 100 | 221 | 200 | 380 |
| SCH | 44 | 63 | 146 | 128 | 320 |
| Total | 1,093 | 150 | 444 | 440 | 635 |

Depth information is available from TCEPR and TCER forms which report bottom or midwater trawl catches pertaining to school shark; similarly, bottom longlining events reporting on the LCER and LCTER forms also record depth information by target species. All depth information which either recorded an estimated catch of school shark or declared school shark as the target species has been extracted.

Bottom trawl events with depth information show that school shark are primarily taken between 28 and 471 m (5$^{th}$ and 95$^{th}$ percentiles), with the median value of 148 m (mean=181 m; note that these values are affected by the large number of squid target records) (Table 16). The distribution of tows which caught or targeted school shark varied according to the target fishery, with fisheries like hoki, squid and tarakihi taking school shark in deeper waters compared to the fisheries like red cod, gurnard, trevally and snapper which tended to fish in shallower depths (Figure 18).

Bottom longline events with depth information show that school shark are primarily taken between 150 and 635 m (5$^{th}$ and 95$^{th}$ percentiles), with the median value of 444 m (mean=440 m; note that these values are dominated by the large number of deeper ling target records) (Table 16). Each target fishery shows a specific depth distribution, with ling being the deepest and the few target sets directed at school shark being the most shallow (Figure 19). Bluenose and hapuku target fishing was done at intermediate depths.

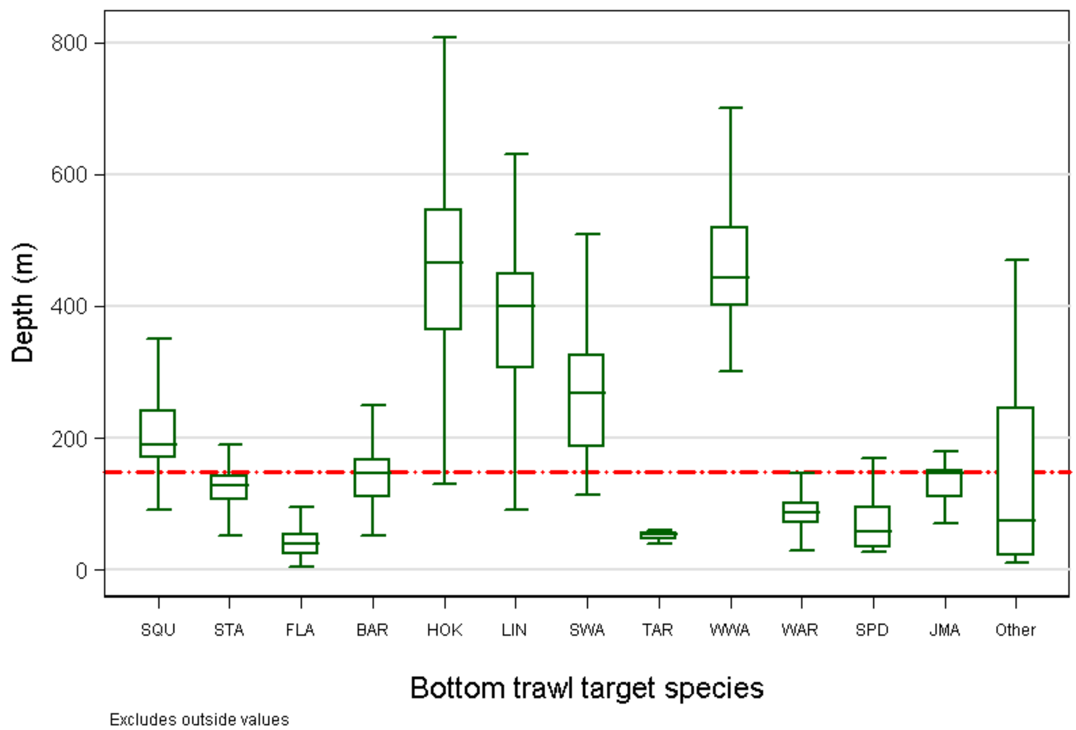


Figure 18. Box plot distributions of depth from SCH 5 bottom trawl effort data (combined TCEPR and TCER forms) for tows that targeted or caught school shark by target species category. Horizontal line indicates the median bottom depth from all bottom trawl tows which caught or targeted school shark.

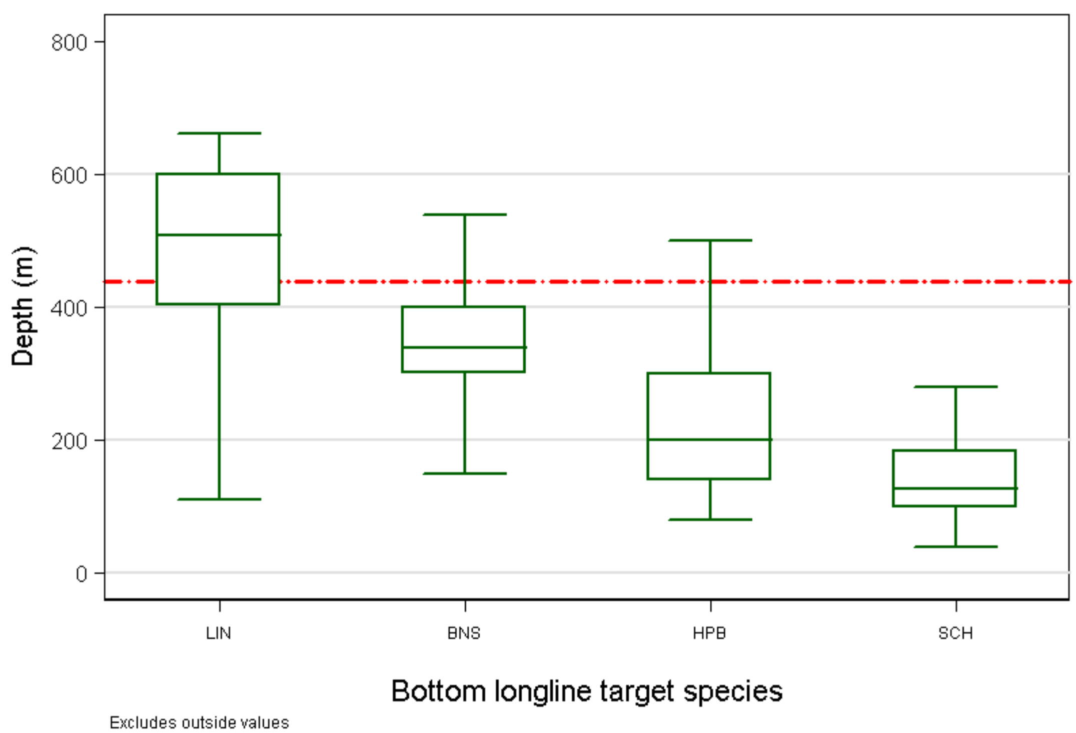


Figure 19. Box plot distributions of depth from SCH 5 bottom longline effort data (combined LTCER and LCER forms) for tows that targeted or caught school shark by target species category. Horizontal line indicates the median bottom depth from all bottom longline sets which caught or targeted school shark.

## 4.4 SCH 5 CPUE ANALYSES

### 4.4.1 INTRODUCTION

A CPUE analysis based on SCH 5 catch and effort data is presented (Appendix C), which repeats and extends the analysis presented to the AMP FAWG when application was made to introduce this Fishstock into the AMP (SeaFIC 2003) and then for its two-year review (Starr et al. 2007). This CPUE analysis is based on setnet catch and effort data in a fishery targeted at school shark.

Data were selected by identifying qualifying events in the target fishery which in turn identified trips from which all associated data were obtained. The methodology used to obtain and process these data is documented elsewhere (Starr 2007). A detailed presentation of the results from the SCH 5 GLM analysis, including summaries of the underlying data, is provided in Appendix C.

### 4.4.2 RESULTS

The series of annual indices estimated by the lognormal standardised model based on successful (positive) catches of SCH 5 declined about 25% from the early 1990s to the series average by the mid-1990s (Figure 20). After holding at this level (with some variation) until the mid-2000s, the index then declined to 50% of the long-term average between 2005–06 and 2008–09, with a particularly large drop from 0.9 to 0.5 between 2007–08 and 2008–09 (Figure 20). However, the annual error bars are quite large for this analysis, indicating likely sensitivity to the small number of vessels currently participating in this fishery and the strong potential for factors other than abundance to affect the estimated annual indices. Model diagnostics are only marginally acceptable, indicating considerable departure from the lognormal distributional assumption and the existence of structure in the data which is unexplained by the available explanatory variables (Figure D.2). The estimated coefficients for the explanatory variables appear to be credible but the plot provided in Figure D.4 indicates that although there 18 vessels selected for this analysis, only 5 or 6 are available in the final 5-6 years of the data series and, of these, only three have significant levels of participation. This small number of vessels may make the CPUE series susceptible to changes in factors other than abundance, such as changes in the port price, the availability of skippers or other factors reflective of the economic situation rather than the abundance of the fish.

The model has relatively high explanatory power (51%; Table C.2) but makes few changes relative to the unstandardised index. There is considerable structure in all the influence plots with large shifts from year to year in the total amount of net set per trip-stratum, the seasonality of fishing, and the statistical areas fished. This is not a fishery that has experienced much stability in the way it has been fished over time, despite (or maybe because of) the small number of vessels involved.

The correspondence between the current standardised model and the model presented in 2007 is reasonable (Figure 21 [left panel]). There is relatively little sensitivity in the estimated year indices to the selection of core vessels, with little change in the series when the analysis was repeated with a more stringent set of core vessel selection criteria (Figure 21 [right panel]).

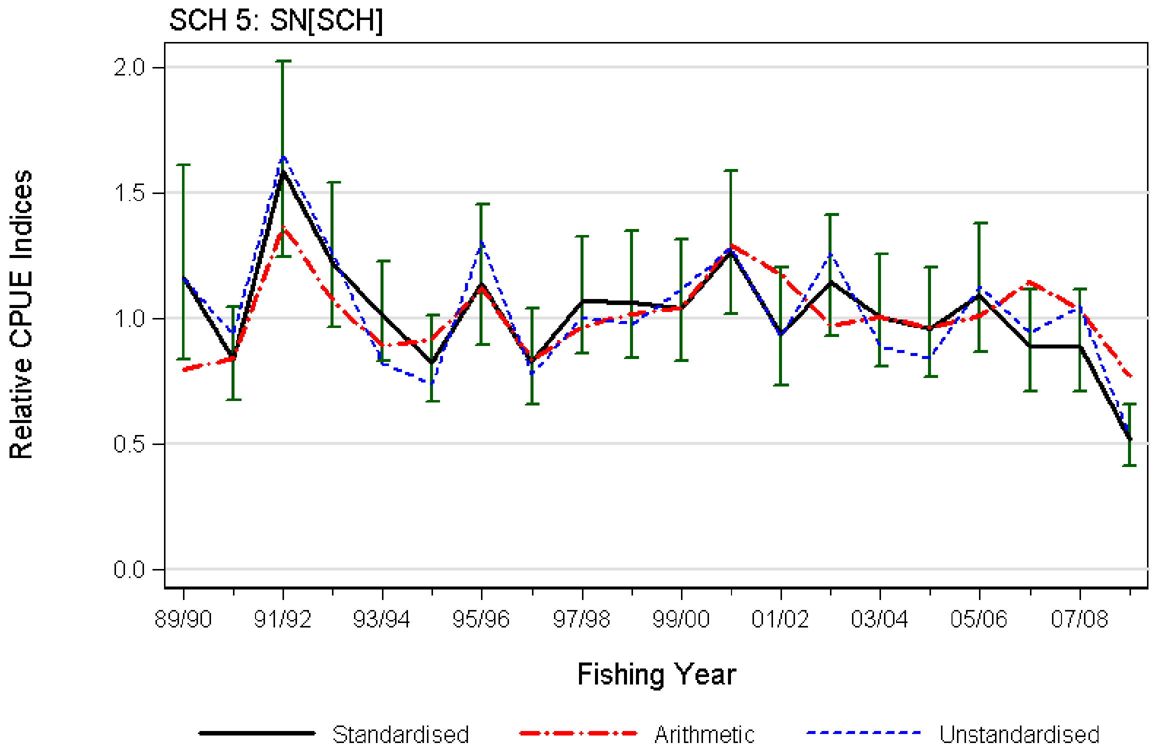


Figure 20. Relative CPUE indices for SCH 5 using the lognormal non-zero model based on the shark setnet fishery described in Appendix C. Error bars are ± 2*SE. Also shown are two unstandardised series from the same data: a) Arithmetic $A_y = \sum_{i=1}^{N_y} C_{i,y} \Big/ \sum_{i=1}^{N_y} E_{i,y}$ and b) Unstandardised $U_y = \exp\left( \frac{\sum_{i=1}^{N_y} \ln\left(C_{i,y}/E_{i,y}\right)}{N_y} \right)$, which is the geometric mean of the observations $C_{i,y}$ =landings in year *y*. $E_{i,y}$ =metres net set in year *y*.

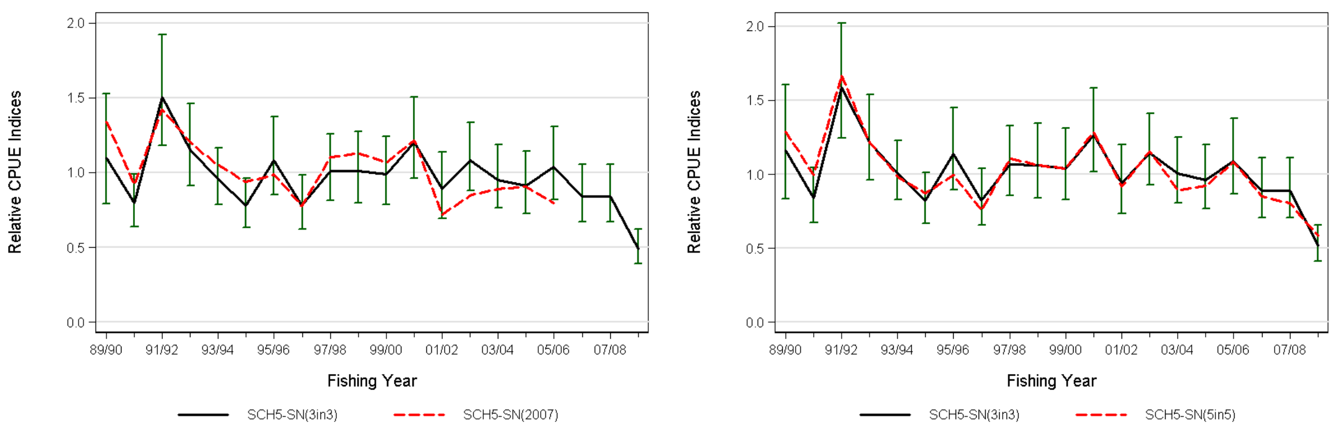


Figure 21. [left panel] comparison of SCH 5 standardised series prepared in 2007 (Starr et al. 2007) with the updated standardised series; [right panel] comparison of selected standardised series (core vessel criteria: at least 3 trips in a minimum of 3 years) with a more stringent set of core vessel selection criteria (at least 5 trips in a minimum of 5 years)

Standardisation of the catch rates does not change the overall trend in the series very much from the unstandardised models, with the exception of emphasising what appears to be a declining trend in the most recent three to four years. Despite accounting for over 50% of the variance, the annual index varies considerably from fishing year to fishing year, indicating possible instability in the index due to the small number of vessels that participate in this fishery. The strong drop in 2008–09 is present in both of the unstandardised indices; thus it is part of the data and not caused by the standardisation procedure.

# 5. SCH 5 SETNET LOGBOOK PROGRAMME

## 5.1 INTRODUCTION

An industry setnet logbook programme was introduced into FMA 3 and FMA 5 in 1994–95 targeted at the three predominant elasmobranch species in this fishery (school shark, rig, and elephant fish) by the Southeast Finfish Management Company (SEFM). This programme was initially begun in support of the SPO 3 and has been run since that year by the Science section of SeaFIC, funded by the SEFM.

The setnet logbook programme has collected data from the inshore set net fisheries off the eastern and southern coast of the South Island for all fishing years from 1994–95 to 2007–08 (only to 2006–07 in FMA 5).

Only the logbook records collected from FMA 5 are presented here. These data are concentrated in Foveaux Strait and Te Waewae Bay (Figure 22) which primarily targets school shark, although some target rig sets have also been recorded.

Table 17. Summary of information from the SEFM setnet logbook programme by fishing year (1994–95 to 2007–08). Target fishing defined as fishing for ELE, SCH, SCH or SPD. Number sampled: number fish measured/ '–': not calculated; NA: not available

| Fishing **Year** | **Number Vessels** | **Sets** | **Sets Targeted** | **Sets SCH caught** | **Net Length (km)** | **Net Length Targeted (km)** | **Catch (t)** | **Catch Targeted (t)** | **Number Sampled** |
|---|---|---|---|---|---|---|---|---|---|
| 95/96 | 5 | 111 | 111 | 111 | 240.6 | 240.6 | 328.4 | 328.4 | 1 092 |
| 96/97 | 3 | 36 | 36 | 36 | 46.8 | 46.8 | 52.8 | 52.8 | 351 |
| 98/99 | 2 | 21 | 11 | 11 | 39.4 | 33.0 | 40.6 | 40.6 | 110 |
| 99/00 | 2 | 34 | 34 | 34 | 66.9 | 66.9 | 64.4 | 64.4 | 340 |
| 00/01 | 3 | 59 | 44 | 47 | 106.6 | 87.0 | 147.9 | 126.9 | 461 |
| 01/02 | 2 | 65 | 64 | 65 | 182.0 | 179.5 | 221.1 | 218.7 | 650 |
| 02/03 | 1 | 65 | 63 | 65 | 187.0 | 181.0 | 170.3 | 164.2 | 649 |
| 03/04 | 2 | 43 | 33 | 33 | 65.5 | 43.0 | 90.0 | 90.0 | 320 |
| 04/05 | 1 | 32 | 32 | 32 | 46.0 | 46.0 | 71.8 | 71.8 | 312 |
| 05/06 | 1 | 49 | 49 | 49 | 49.0 | 49.0 | 49.2 | 49.2 | 490 |
| 06/07 | 1 | 17 | 17 | 17 | 17.0 | 17.0 | 23.4 | 23.4 | 170 |
| Total | – | 532 | 494 | 500 | 1 046.8 | 989.8 | 1 259.9 | 1 230.4 | 4 945 |

## 5.2 DESIGN OF THE DATA COLLECTION

The SEFM setnet logbook records catch and effort data from individual sets and the biological details (length, sex, and maturity stage) from a randomly selected sample of 10 rig, school shark, and elephant fish taken from the catch of each set. Logbook participants are issued with data forms, measuring boards and sampling instructions.

Details pertaining to the fishing effort collected by the programme include the vessel name, skipper name, statistical area, target species, net dimensions, date and time of setting and hauling the gear, and the location and depth of the gear. The estimated greenweight catch of rig, school shark, and elephant fish taken by each set is also recorded.

For each of the three main elasmobranch species, logbook participants are requested to sample 10 fish selected at random from the catch of the set. The length of each fish is determined to the nearest centimetre below the actual length (total length for rig and school shark, fork length for elephant fish), the sex of each sampled fish is determined, as well as the maturity stage of the male fish (based on clasper morphology). The design of the programme, including example forms, is presented in Lydon et al. (2007).

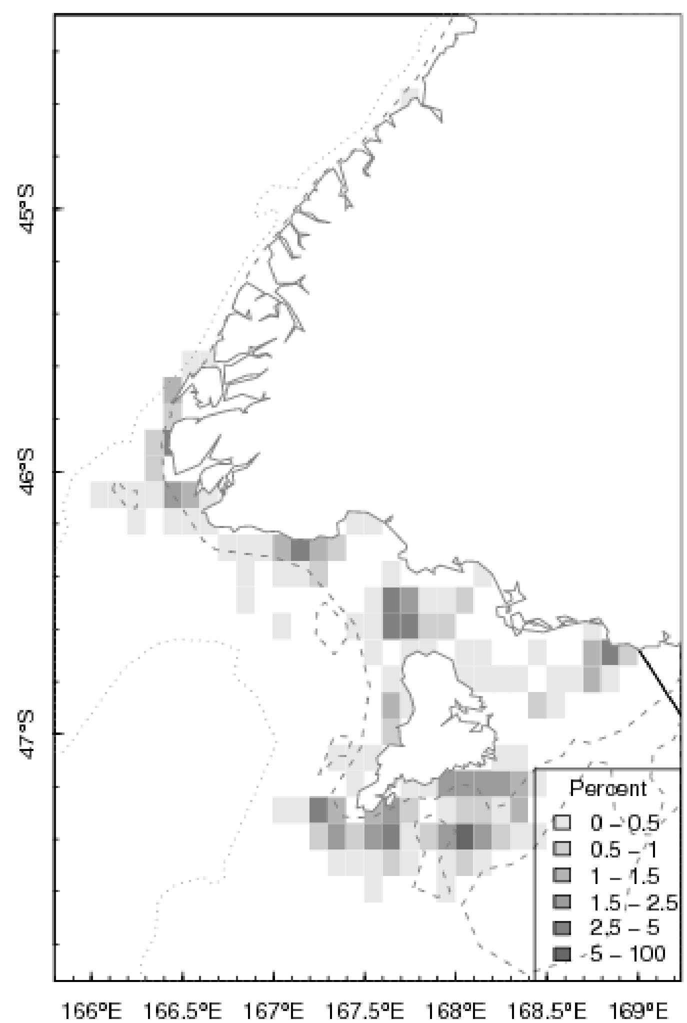


Figure 22. Summary of the spatial coverage of the Industry setnet logbook as it pertains to SCH 5: distribution of the total logbook catch arranged in 0.1 degree cells, shaded as a percentage of the total catch from 1994–95 to 2006–07

## 5.3 LEVEL OF COVERAGE ACHIEVED

Fifty-two sets had no estimated catch of school shark recorded. Of these, 47 had associated length data. For these sets, the sampled lengths were converted to weight using the length-weight relationship for school shark (MFish 2009) and the sum of these sampled weights was used as the estimated catch weight for the set. This procedure only added about 5.4 t (an increase of approximately 0.4% of the total estimated catch) of greenweight catch to the setnet logbook programme.

Using the adjusted catch totals described in the previous paragraph, the SEFM setnet logbook programme obtained coverage of the SCH 5 setnet fishery in each year from 1995–96 to 2005–06, with the exceptions of 1997–98 and 2007–08 to 2008–09. Excluding these years, the number of sets reported has ranged from 17 (2006–07) to 111 (1995–96), representing 23 (2006–07) to 328 t of estimated catch (Table 17). Coverage levels by catch weight for these years have ranged from 4 to 52%, based on simple ratios of estimated catches (Table 18).

Interest in this programme has clearly varied over the years, at first declining considerably by 1997–98. Coverage improved after 1997–98, obtaining reasonable participation from 2000–01 to 2004–05, in terms of catch but not in the number of vessels (Table 17 and Table 18). The number of potential participating vessels is low (Figure D.4), and it is clear from the information in Table 17 that after 2000–01, only one or two vessels participated in the programme. No vessels participated in either 2007–08 or 2008–09.

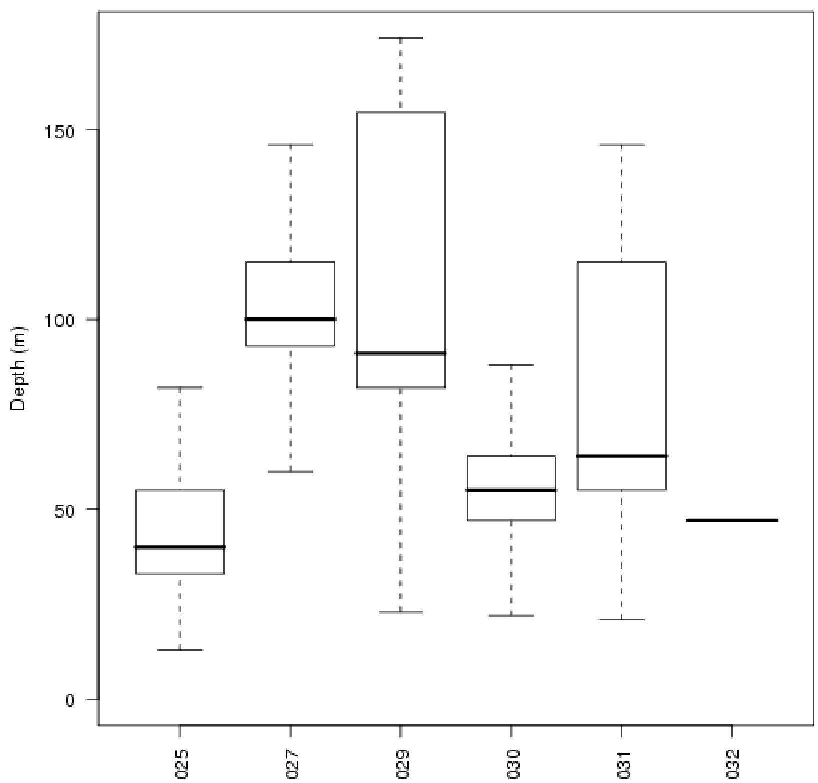


Figure 23. Box plot distributions of depth by Statistical Area Region for the SCH sets with non-zero depth (m) observations summarised over all fishing years.

The reported SCH 5 logbook sets have occurred throughout FMA 5, with catches reported from all around Stewart Island, through Foveaux Strait and around the corner into Fiordland

(Figure 22). The depth range fished varies between statistical areas, with the coastal Areas 025 and 030 showing lower median and mean depths than the more offshore Area 027, 029 and 031 (Table 19). Area 025 appears to be fished at more shallow depths than Area 030, although there are generally not many observations.

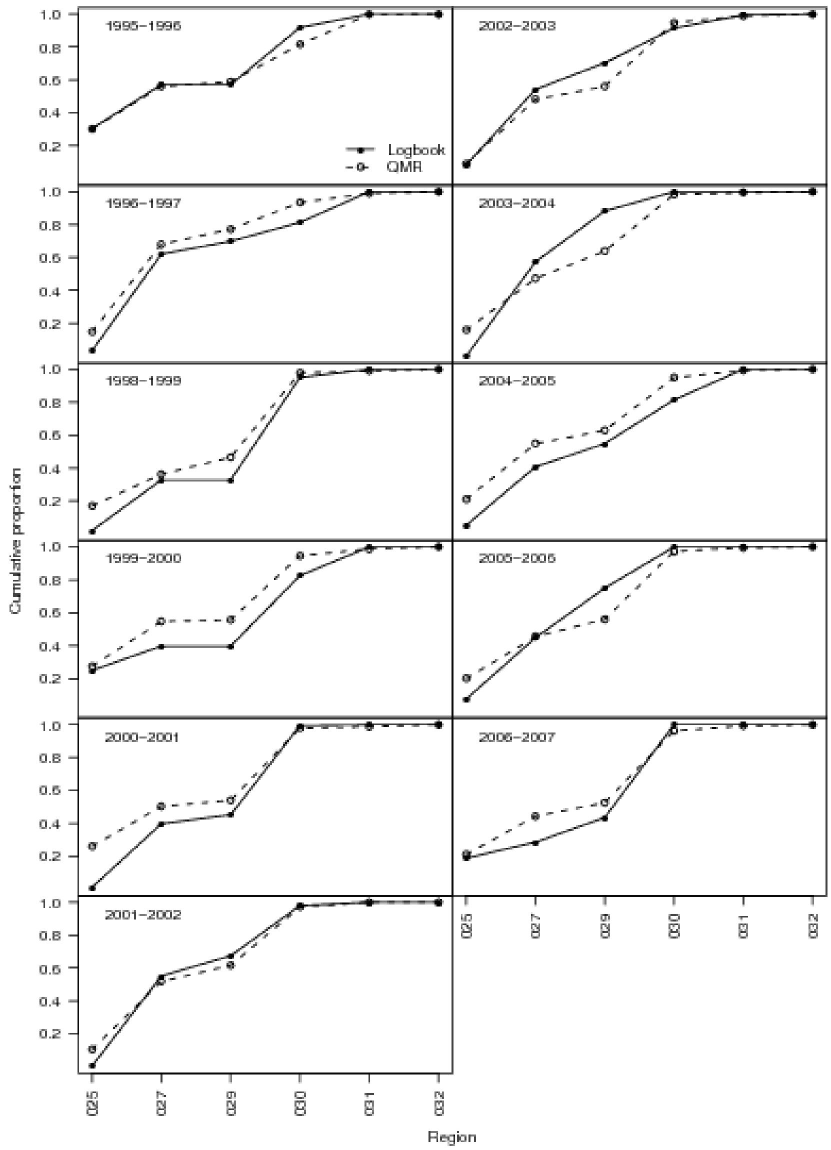


Figure 24. Empirical cumulative distribution of SCH 5 setnet catch by statistical area for the logbook programme and for the MFish setnet QMR for all fishing years.

Comparison of the logbook coverage by statistical area with comparable data from the MFish CELR data shows that the logbook programme has tended to capture the distribution of statistical areas in most years, with relatively minor deviations from the actual distribution (Figure 24; Figure E.1). The SCH 5 logbook programme shows more deviation in the seasonal representation, with relatively large departures from the actual distribution in 1996–97, 2003–04, 2004–05 and 2006–07 (Figure 25; Figure E.2).

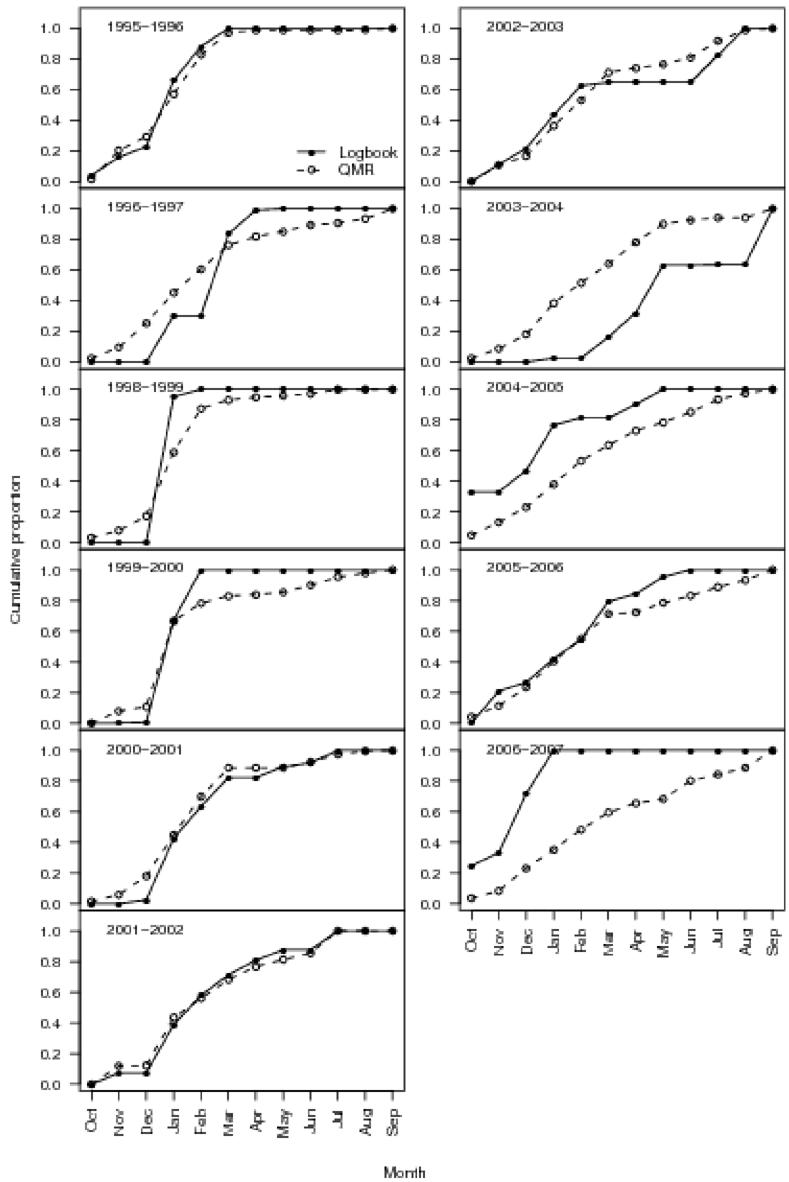


Figure 25. Empirical cumulative distributions of SCH 5 setnet catch by month for the logbook programme and for the MFish setnet QMR data.

Table 18. Comparison of logbook and QMR catches. QMR: total SCH 5 setnet catch; QMR 'represented': total SCH 5 setnet landings from statistical area/month combinations with logbooks; QMR 'targeted': total SCH 5 setnet landings target fishing for ELE, SCH, SCH or SPD

| Fishing Year | QMR (t) | Catch (t) | Coverage (%) | QMR Represented (t) | Coverage Represented (%) | QMR Targeted (t) | Catch Targeted (t) | Coverage Targeted (%) |
|---|---|---|---|---|---|---|---|---|
| 95/96 | 629.7 | 328.4 | 52.2 | 504.8 | 65.1 | 616.6 | 328.4 | 53.3 |
| 96/97 | 581.3 | 52.8 | 9.1 | 224.0 | 23.6 | 576.4 | 52.8 | 9.2 |
| 98/99 | 616.4 | 40.6 | 6.6 | 322.5 | 12.6 | 610.0 | 40.6 | 6.7 |
| 99/00 | 592.7 | 64.4 | 10.9 | 357.4 | 18.0 | 587.9 | 64.4 | 11.0 |
| 00/01 | 551.1 | 147.9 | 26.8 | 439.8 | 33.6 | 545.1 | 126.9 | 23.3 |
| 01/02 | 493.4 | 221.1 | 44.8 | 422.8 | 52.3 | 489.9 | 218.7 | 44.6 |
| 02/03 | 611.0 | 170.3 | 27.9 | 504.3 | 33.8 | 597.9 | 164.2 | 27.5 |
| 03/04 | 603.4 | 90.0 | 14.9 | 346.0 | 26.0 | 561.5 | 90.0 | 16.0 |
| 04/05 | 635.3 | 71.8 | 11.3 | 308.1 | 23.3 | 579.4 | 71.8 | 12.4 |
| 05/06 | 606.4 | 49.2 | 8.1 | 372.2 | 13.2 | 559.5 | 49.2 | 8.8 |
| 06/07 | 629.7 | 23.4 | 3.7 | 132.5 | 17.7 | 578.1 | 23.4 | 4.0 |

Maps of the spatial distribution of logbook coverage have been prepared by year, covering the entire period by fishing year from 1995–96 (Figure E.3) to 2006–07 (Figure E.8). The year 1997–98 has been omitted due to poor participation levels.

Table 19. Depth range statistics by Statistical Area Region (Table 10) for the SCH sets with non-zero depth (m) observations summarised over all fishing years. $P_5$ and $P_{95}$ refer to the 5th and 95th percentiles of the empirical distribution of depth for all setnet events. The 'all areas' total includes records without attributable statistical areas.

| Region | $P_5$ | Median | Mean | $P_{95}$ | N |
|---|---|---|---|---|---|
| 025 | 20 | 40 | 49 | 67 | 58 |
| 027 | 56 | 100 | 101 | 137 | 187 |
| 029 | 26 | 91 | 110 | 164 | 44 |
| 030 | 22 | 55 | 58 | 110 | 178 |
| 031 | 30 | 64 | 78 | 146 | 30 |
| 032 | 47 | 47 | 47 | 47 | 1 |
| Overall | 27 | 73 | 79 | 146 | 498 |

Table 20. Number of length frequencies by sex and fishing year for school shark from the industry setnet logbook programme. The male sex ratio and the mean length by sex have been scaled relative to the MFish QMR catch by month and statistical area

| Fishing Year | Number Male | Number Female | Number Unsexed | Total Sampled | Male Percent | Male Mean (cm) | Female Mean (cm) |
|---|---|---|---|---|---|---|---|
| 95/96 | 738 | 354 | 0 | 1 092 | 68 | 134.3 | 129.3 |
| 96/97 | 217 | 134 | 0 | 351 | 63 | 136.4 | 140.4 |
| 98/99 | 60 | 50 | 0 | 110 | 56 | 127.7 | 122.3 |
| 99/00 | 166 | 173 | 1 | 340 | 51 | 129.9 | 128.2 |
| 00/01 | 253 | 207 | 1 | 461 | 55 | 131.2 | 128.7 |
| 01/02 | 361 | 288 | 1 | 650 | 58 | 127.3 | 125.1 |
| 02/03 | 325 | 322 | 2 | 649 | 52 | 134.9 | 132.5 |
| 03/04 | 150 | 169 | 1 | 320 | 50 | 131.2 | 132.2 |
| 04/05 | 137 | 174 | 1 | 312 | 46 | 131.6 | 132.1 |
| 05/06 | 258 | 230 | 2 | 490 | 55 | 128.8 | 128.4 |
| 06/07 | 120 | 50 | 0 | 170 | 72 | 128.5 | 126.1 |
| All years | 2 785 | 2 151 | 9 | 4 945 | 57 | 131.7 | 130.0 |

## 5.4 BIOLOGICAL DATA

### 5.4.1 SUMMARIES FOR ALL OF SCH 5

Scaled length frequency distributions by sex for sampled school shark from the target QMA 5 shark setnet fishery have been calculated for all fishing years, with the exception of 1997–98, which has been omitted due to small sample size (Figure 26). These length frequencies have shown considerable stability amongst the males for most years, with some shifts in the modal length between 120 and 130 cm. Male distributions are similar to the female distributions, with perhaps fewer fish on the right-hand tail. The female distributions appear to be more variable, with both sexes showing a shift to smaller fish in 1998–99, but this is a year with relatively few samples (Figure 26).

Expressing the length frequencies as cumulative distributions shows that the distributions for male school shark are similar for all fishing years, without any pattern of shifting distributions (Figure 27). The year with the largest fish (1996–97) is early in the series while the smallest fish are in the middle of the series (2001–02). The cumulative distributions of female school shark appear to be more variable between fishing years but again there is no apparent trend, with largest fish again in 1996–97 and smallest in the following year (1997–98). The annual mean lengths by sex demonstrate a stability in mean size for all fishing years, again without trend (Table 20). Unlike for SCH 3, the mean lengths for males and females are similar, mostly ranging between 120 and 132 cm, depending on the year. The length frequency samples have originated mainly from Areas 027 and 030, with about 1 800 lengths from each area (Table 21). Areas 025, 029 and 031 have had smaller numbers of lengths (about 500, 400 and 300 respectively). The sex ratio of school shark sampled from the SCH 5 fishery has been slightly skewed towards males in most years, with the average just below 60% males (Table 20). There was trend towards proportionately fewer males up to 2004–05, but that trend has reversed by the end of the series.

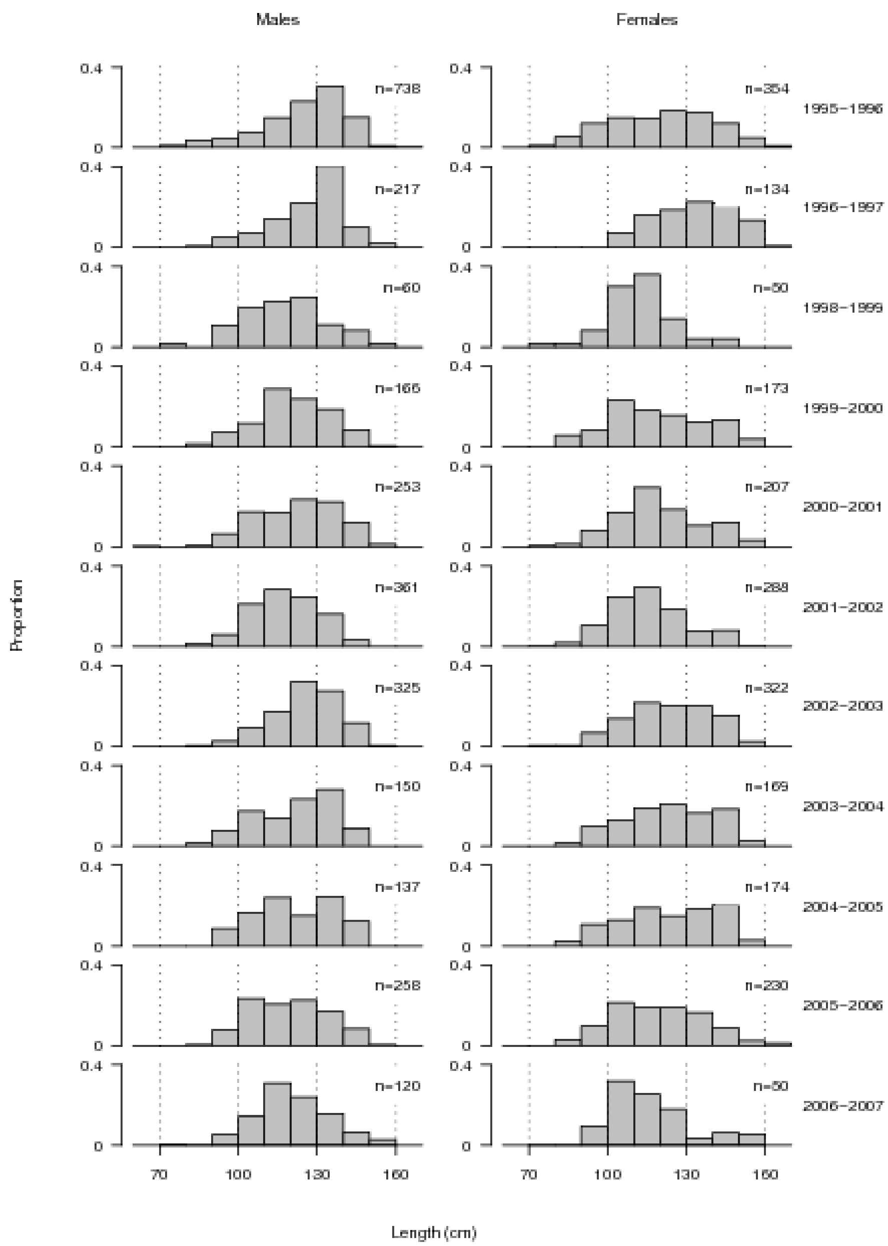


Figure 26. Scaled frequency distributions for male and female school shark sampled from the target shark SCH 5 set net fishery. Length data have been binned into 5 cm length classes. Sample sizes by sex are provided and sampled fish have been scaled relative to the MFish estimated catch by month and statistical area. The combined male and female distributions sum to one.

Table 21. Number of length frequencies by fishing year and Statistical Area Region (Table 10) for school shark from the industry setnet logbook programme; '–': none sampled

| Fishing | Statistical Area Region | | | | | |
|---|---|---|---|---|---|---|
| Year | 025 | 027 | 029 | 030 | 031 | 032 |
| 95/96 | 316 | 239 | – | 437 | 100 | – |
| 96/97 | 30 | 180 | 30 | 63 | 48 | – |
| 98/99 | 10 | 30 | – | 60 | 10 | – |
| 99/00 | 60 | 30 | – | 220 | 30 | – |
| 00/01 | 20 | 160 | 10 | 261 | 10 | – |
| 01/02 | 10 | 370 | 50 | 200 | 20 | – |
| 02/03 | 50 | 299 | 100 | 140 | 50 | 10 |
| 03/04 | 20 | 181 | 69 | 70 | – | – |
| 04/05 | – | 134 | 40 | 88 | 30 | – |
| 05/06 | 30 | 210 | 110 | 140 | – | – |
| 06/07 | 20 | 30 | 30 | 90 | – | – |
| Total | 566 | 1 863 | 439 | 1 769 | 298 | 10 |

Estimates of proportion of immature males based on the morphology of the claspers range from 17 to 55%, calculated from scaled frequencies of staged males (Table 22). The mean value for the proportion immature is near 30% over all reported years (except for 1997–98 where there are insufficient biological data). A plot of the proportion immature by size class shows that the proportion immature drops to below 50% at 120 cm and all but disappear at 130 cm (Figure 28). A similar plot by month across all years shows that immature males are present at rates between 25-35% by number for most months, with the lowest value in April (Figure 29). The low value of about 10% in September is likely a sampling artefact due to low sample sizes.

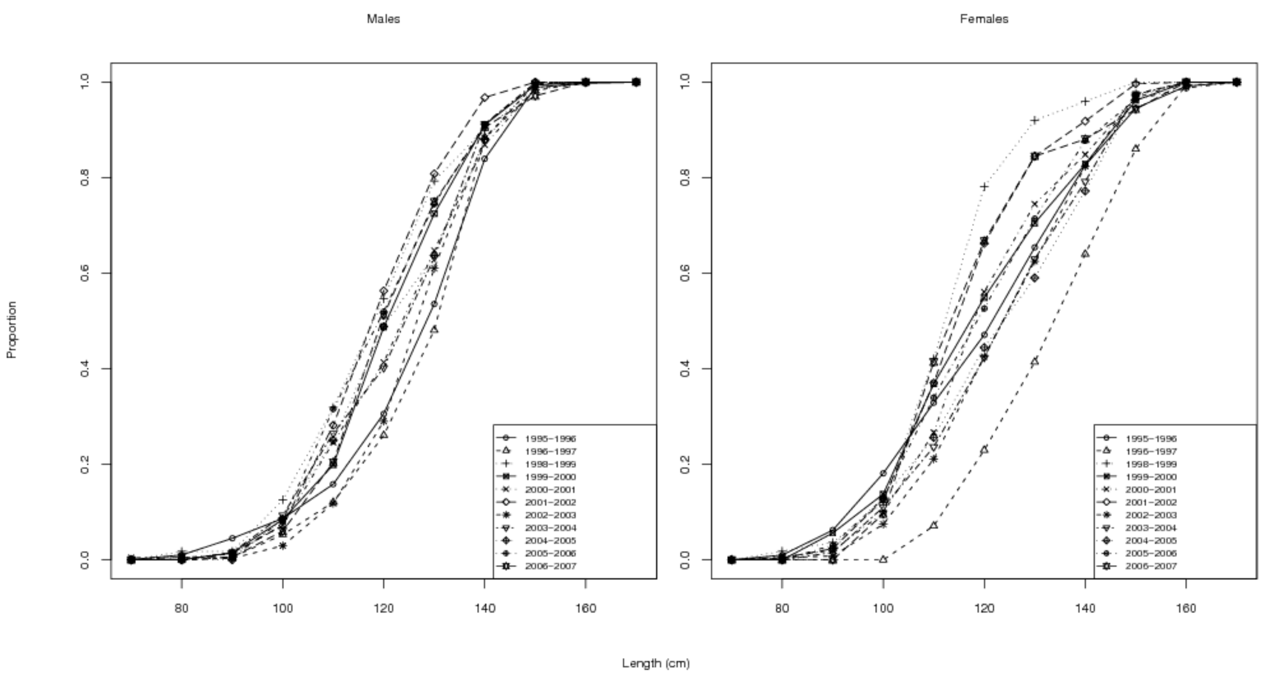


Figure 27. Cumulative frequency distributions for male and female school shark sampled from the target shark SCH 5 setnet fishery. Length data have been binned into 5 cm length classes. Sample sizes by sex are provided in Figure 26 and sampled fish have been scaled relative to the MFish estimated catch by month and statistical area.

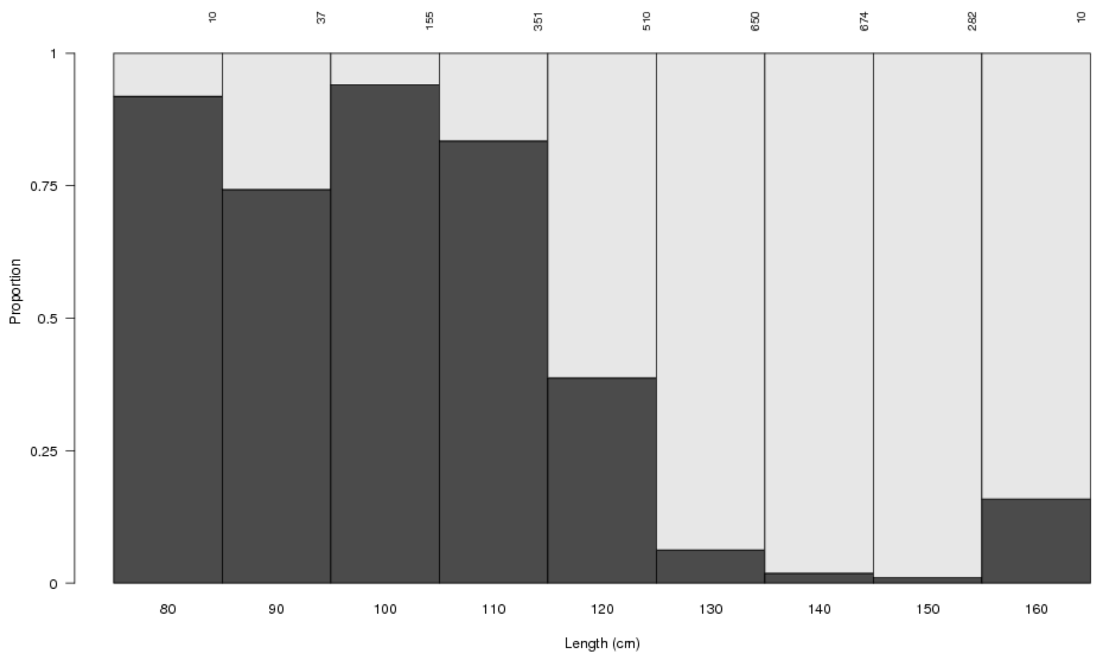


Figure 28. Proportion of males classed as "A" (immature–small claspers) by 5 cm length class bin summed over all years of the Industry setnet logbook programme. The total number of staged males is shown at the top of each bar.

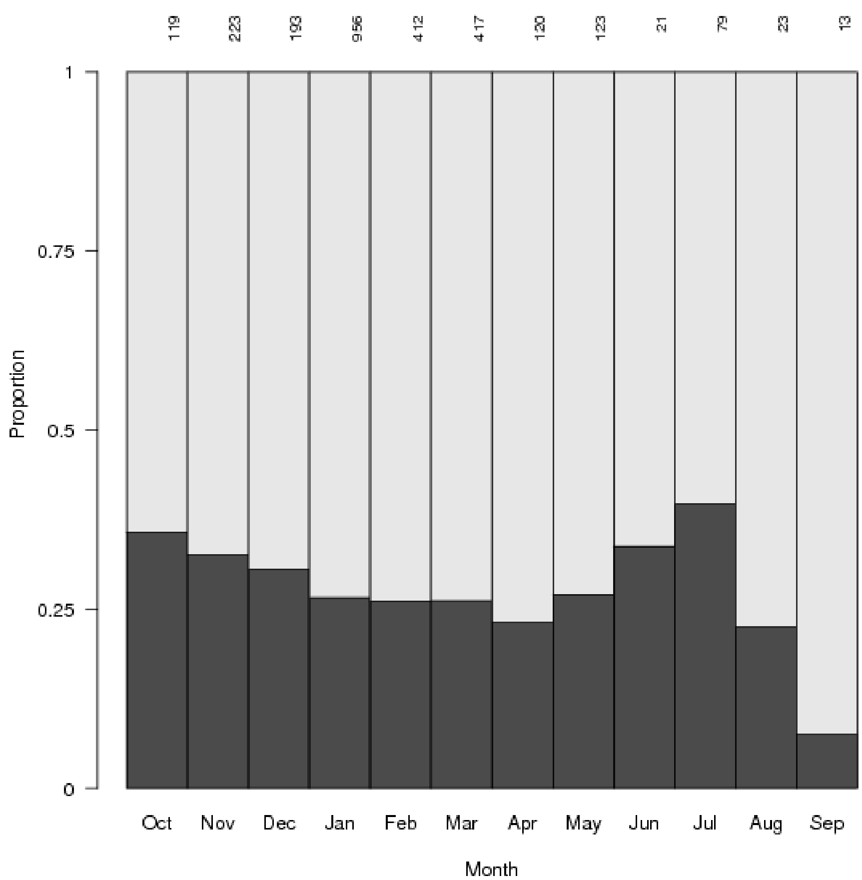


Figure 29. Proportion of males classed as "A" (immature–small claspers: dark bars) by month summed over all years of the Industry setnet logbook programme. The total number of staged males is shown at the top of each bar.

Table 22. Scaled estimates of the proportion of immature males based on clasper identification by logbook participants. Total number of staged males is unscaled and count only males which had been scored as stage A or B [A=immature (small claspers); B= mature (with large claspers)]. The percent `A' has been scaled relative to the MFish estimated catch by month and statistical area; NA: not available

| Fishing Year | Total staged | Number A | Number B | Percent 'A' |
|---|---|---|---|---|
| 95/96 | 719 | 130 | 589 | 17.6 |
| 96/97 | 209 | 40 | 169 | 18.7 |
| 98/99 | 60 | 32 | 28 | 55.0 |
| 99/00 | 166 | 66 | 100 | 40.3 |
| 00/01 | 218 | 62 | 156 | 30.7 |
| 01/02 | 358 | 122 | 236 | 35.3 |
| 02/03 | 319 | 64 | 255 | 21.2 |
| 03/04 | 147 | 45 | 102 | 27.5 |
| 04/05 | 127 | 42 | 85 | 30.7 |
| 05/06 | 257 | 88 | 169 | 35.9 |
| 06/07 | 119 | 26 | 93 | 21.1 |

## 6. STOCK ASSESSMENT CONCLUSIONS

Annual abundance indices estimated by the SCH 5 GLM combined model show a relatively high level from 1989–90 to 1992–93, followed by a drop to about 75-95% of the peak (equivalent to the long-term average) which was maintained from the mid-1990s to the mid-2000s (Figure 20). The index then declined to 50% of the long-term average between 2005–06 and 2008–09, with a particularly large drop from 0.9 to 0.5 between 2007–08 and 2008–09 (Figure 20). Standardisation of the catch rates did not change the overall trend in the series much from the unstandardised models, with the exception of emphasising a declining trend in the most recent three to four years. Despite the model accounting for over 50% of the variance, the annual index varies considerably from fishing year to fishing year, indicating possible instability in the index due to the small number of vessels that participate in this fishery. There is considerable structure in all the influence plots with large shifts from year to year in the total amount of net set per trip-stratum, the seasonality of fishing, and the statistical areas fished. This is not a fishery that has experienced much stability in the way it has been fished over time, despite (or maybe because of) the small number of vessels involved.

Therefore the index produced by this GLM analysis may be indicative of a relatively small fishery operating on a reasonably large stock that is available in this area, with annual variations in the indices relating to short term changes in school shark availability or to variability caused by factors other than abundance. The long period of apparent stability in the catch rates, extending from the mid-1990s to the mid-2000s, is reassuring, but the recent three-year decline observed since 2005–06, particularly the steep drop between 2007–08 and 2008–09 are not. It is important to note that the drop in 2008–09 is present in both of the unstandardised indices; thus it is part of the data and not caused by the standardisation procedure.

It is unknown if these catches are at levels that would allow the stock to move towards a size that would support the maximum sustainable yield.

## 7. INFORMATION ABOUT PARTICIPANTS

| | |
|---|---|
| **Name:** | South East Finfish Management (SEFM) Limited |
| **Representation:** | Stakeholder group which represents finfish quota holders in FMA 3 and FMA 5. Currently this stakeholder company represents 98% of the total SCH 5 quota. |
| **Contact Individual:** | Peter Dawson, Chief Executive |
| **Phone:** | 03-328 9494 |
| **Fax:** | 03-328 9595 |
| **Postal Address:** | PO Box 43<br>Lyttleton |
| **Email Address:** | pete@fishcon.net |
| **Funding Support:** | Voluntary levy from quota owners |

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## Appendix A. MAP OF MFISH STATISTICAL AND MANAGEMENT AREAS

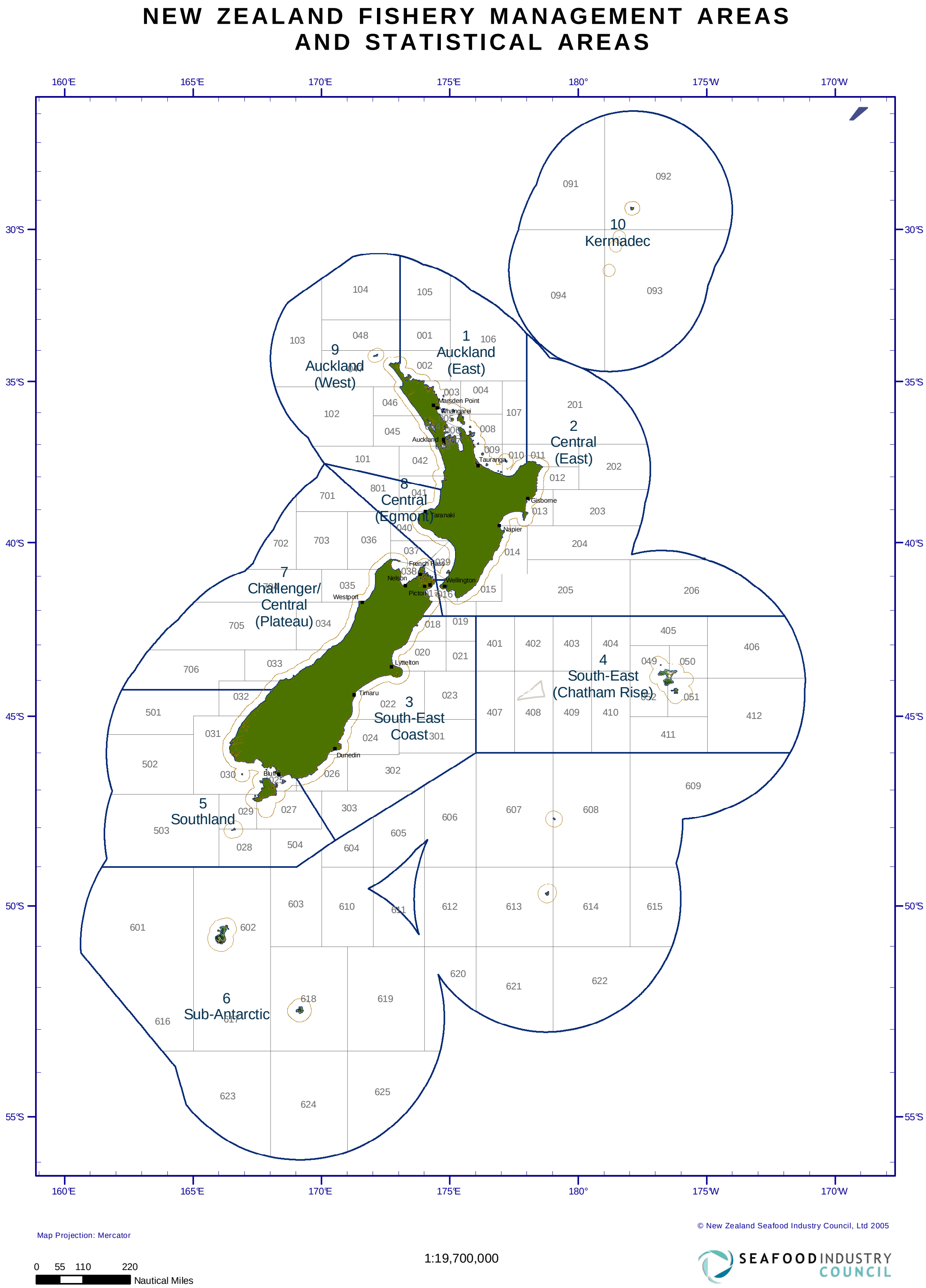



Figure A.1. Map of MFish statistical areas and Quota Management Area (QMA) boundaries, showing locations where QMA boundaries are not contiguous with the statistical area boundaries.

# Appendix B. LANDINGS BY STATISTICAL AREA AND PRINCIPAL FISHING METHODS

Table B.1. Distribution of SCH 5 landings (t) by statistical area (Appendix A), arranged in ranked descending order of total SCH 5 landings, and Statistical Area Region (Table 10), grouped by principal fishing methods (Table 10) as well as all methods combined. Landings have been summed across all fishing years: 1989–90 to 2008–09.

**Setnet (t)**

| Stat_ Area | Statistical Area Region 025-026 | 027 | 028-029 | 030 | 031 | 032 | Total |
|---|---|---|---|---|---|---|---|
| 030 | | | | 3864 | | | 3864 |
| 027 | | 3385 | | | | | 3385 |
| 025 | 2674 | | | | | | 2674 |
| 029 | | | 792 | | | | 792 |
| 031 | | | | | 503 | | 503 |
| 032 | | | | | | 207 | 207 |
| 028 | | | 7 | | | | 7 |
| 026 | 26 | | | | | | 26 |
| 602 | | | | | | | |
| 504 | | 0.1 | | | | | 0.1 |
| 603 | | | | | | | |
| OTH[1] | | 1.7 | | | | | 1.7 |
| Total | 2699 | 3387 | 799 | 3864 | 503 | 207 | 11459 |

**Bottom trawl (t)**

| Stat_ Area | Statistical Area Region 025-026 | 027 | 028-029 | 030 | 031 | 032 | Total |
|---|---|---|---|---|---|---|---|
| 030 | | | | 568 | | | 568 |
| 027 | | 18 | | | | | 18 |
| 025 | 99 | | | | | | 99 |
| 029 | | | 121 | | | | 121 |
| 031 | | | | | 33 | | 33 |
| 032 | | | | | | 4.0 | 4.0 |
| 028 | | | 74 | | | | 74 |
| 026 | 34 | | | | | | 34.0 |
| 602 | | | 25.3 | | | | 25 |
| 504 | | 4.4 | | | | | 4.4 |
| 603 | | 3.1 | | | | | 3.1 |
| OTH[1] | | 3.5 | 0.7 | 0.3 | | | 4.5 |
| Total | 133 | 29 | 222 | 568 | 33 | 4.0 | 988 |

**Bottom longline (t)**

| Stat_ Area | Statistical Area Region 025-026 | 027 | 028-029 | 030 | 031 | 032 | Total |
|---|---|---|---|---|---|---|---|
| 030 | | | | 251 | | | 251 |
| 027 | | 35 | | | | | 35 |
| 025 | 16 | | | | | | 16 |
| 029 | | | 41 | | | | 41 |
| 031 | | | | | 165 | | 165 |
| 032 | | | | | | 220 | 220 |
| 028 | | | 1.3 | | | | 1.3 |
| 026 | 0.7 | | | | | | 0.7 |
| 602 | | | 2.8 | | | | 2.8 |
| 504 | | 0.0 | | | | | 0.0 |
| 603 | | 0.1 | | | | | 0.1 |
| OTH[1] | | 2.7 | 0.1 | 0.5 | | | 3.3 |
| Total | 16 | 38 | 45 | 251 | 165 | 220 | 736 |

**Other (t)[2]**

| Stat_ Area | Statistical Area Region 025-026 | 027 | 028-029 | 030 | 031 | 032 | Total |
|---|---|---|---|---|---|---|---|
| 030 | | | | 32 | | | 32 |
| 027 | | 12 | | | | | 12 |
| 025 | 27 | | | | | | 27 |
| 029 | | | 10 | | | | 10 |
| 031 | | | | | 17 | | 17 |
| 032 | | | | | | 14 | 14 |
| 028 | | | 43 | | | | 43 |
| 026 | 2 | | | | | | 2.1 |
| 602 | | | 19.7 | | | | 19.7 |
| 504 | | 7.9 | | | | | 7.87 |
| 603 | | 0.0 | | | | | 0.0 |
| OTH[1] | | 0.7 | 0.1 | 0.0 | | 0.6 | 1.5 |
| Total | 29 | 21 | 73 | 32 | 17 | 14 | 186 |

**Total (t)**

| Stat_ Area | Statistical Area Region 025-026 | 027 | 028-029 | 030 | 031 | 032 | Total |
|---|---|---|---|---|---|---|---|
| 030 | | | | 4714 | | | 4714 |
| 027 | | 3450 | | | | | 3450 |
| 025 | 2815 | | | | | | 2815 |
| 029 | | | 965 | | | | 965 |
| 031 | | | | | 719 | | 719 |
| 032 | | | | | | 445 | 445 |
| 028 | | | 126 | | | | 126 |
| 026 | 63 | | | | | | 63 |
| 602 | | | 48 | | | | 47.8 |
| 504 | | 12 | | | | | 12.4 |
| 603 | | 3.2 | | | | | 3.2 |
| OTH[1] | | 8.6 | 1.0 | 0.8 | | 0.6 | 11 |
| Total | 2877 | 3475 | 1139 | 4714 | 719 | 445 | 13370 |

[1] Remaining statistical areas in ranked descending order of total SCH 5 landings: 625, 608, 607, 618, 605, 503, 610, 502, 501, 604, 606, 611, 601, 619, 612, 624, 614, 617

[2] see Table 10 for the list of methods included in this category

# Appendix C. SCH 5 CPUE ANALYSIS

## C.1 GENERAL OVERVIEW

School shark are taken in SCH 5 primarily in a target school shark set net fishery. Only minor amounts of this Fishstock are taken using other methods, including bottom trawl, lining and target setnet fishing for other species. Setnet CPUE for all four South Island school shark Fishstocks were evaluated in 2007, including SCH 5 (Starr et al. 2007). On the suggestion of the AMPWG when this analysis was reviewed in 2007, the SCH 5 setnet fishery has been defined on target fishing for school shark only (dropping the broader definition used in the 2007 analysis which also included rig, elephant fish and spiny dogfish). The annual indices from the lognormal model show a decline over the three years since this Fishstock was last analysed, but it is now based on a small number of vessels, the diagnostics are poor and the fishery appears to be driven by factors not able to be modelled.

## C.2 DATA PREPARATION

Candidate trips were identified by searching for all trips which, at least for one event in the trip, fished in a valid statistical area for SCH 5, used the setnet method and targeted one of the four shark species (rig, school shark, spiny dogfish or elephantfish). This produced a list of trips for which all effort and landing records associated with these trips were extracted, regardless of the method or target species.

Extreme values in the effort data were identified as outliers by examining the distribution for each field by vessel and for the whole fleet. All records for a trip with missing or bad effort data were removed. Missing values for vessel ID, statistical area, method, or target species within any trip were substituted with the predominant (most frequent) value for that field over all records for the trip. Trips which were missing in all records for one of these fields were dropped, as were trips which used multiple methods and had a missing method field.

Effort and estimated catch data were summarised by fishing trip, for every unique combination of fishing method, statistical area, and target species, referred to as a “trip stratum”. This reduced both CELR and NCELR format records to lower resolution “amalgamated” data, resulting in fewer records per trip but retaining the original method, area, and target species recorded by the skipper. The daily resolution in the CELR data is lost as is the set-by-set resolution in the NCELR data.

The landed catches of SCH 5 for each trip were allocated to the “trip strata” (defined as statistical area, target species and method) in proportion to the species estimated catch in each “trip stratum”. In the case where there were no estimated catches, the allocation of the landing data was made proportionate to the number of sets. The main assumption made in this allocation procedure is that the reporting of school shark is consistent across statistical areas and target species within a trip. In contrast, if estimated catches were used directly, the assumption must be made that reporting rates are constant across the entire fleet and all statistical areas for all years, as well as making the assumption that the ratio of estimated catch to landed greenweight catch is also consistent across the entire fleet for all years.

The potential data variables available from each trip include estimated and landed catch of school shark, the number of sets, the total length of net set, total duration of fishing, fishing year, statistical area, target species, month of landing, and a unique vessel identifier. Data might not represent an entire fishing trip; just those portions of it that qualified, but the amount of landed catch assigned to the part of the trip that was kept would be proportional to the total landed catch for the trip using the estimated catches to apportion the landings to each trip stratum. Trips were not dropped because they targeted more than one species or fished in more that one statistical area. Trips landing more than one Fishstock of any species from one of the straddling statistical areas were entirely dropped. The statistical area variable used in these models amalgamated some of the offshore statistical areas with adjacent inshore areas because there were few effort observations for school shark from these areas Table C.1. Some of the more offshore areas were dropped altogether, including a few records from the Snares.

Table C.1: Statistical areas used to define the SCH 5 Fishstock areas.

| Statistical Area | Areas Included |
|---|---|
| 25 | 25 |
| 27 | 27, 28, 29 |
| 30 | 30 |
| 31 | 31, 32 |
| 624 | *Not used* |
| 625 | *Not used* |

### C.2.1 DATA SELECTION AND METHODS

Those groups of events that satisfied the criteria of target species, method and statistical areas defining the defined fisheries were selected from available fishing trips. Any effort strata that were matched to a landing of SCH 5 were termed "successful", and included any relevant but unsuccessful effort, so that the analysis of catch rates in successful strata also incorporates much of the relevant zero catch information.

Strata which did not include any landed SCH 5 were assigned a value of zero so that the effort data associated with them could be included in the analysis that considered total effort (as differentiated from successful effort only).

Unstandardised and standardised CPUE analyses were performed on each dataset. Datasets were further restricted to core fleets of vessels for standardised analysis. Two standardised models were applied to each dataset. One model was a lognormal linear model fit to successful catches of SCH 5, excluding zero catches. A binomial model which predicted success or failure of SCH 5 catch was fit to the total dataset, including records that reported a zero catch of school shark. These two models were combined into a single set of indices using the method of Vignaux (1994).

Catch rates were standardised against variation in the explanatory variables using a stepwise multiple regression procedure, selecting until the improvement in model $R^2$ was less than 0.01. The year effects were extracted as canonical coefficients (Francis 1999) so that confidence bounds could be calculated for each year.

The dependent variable for the lognormal model was the log of landed weight of SCH 5 per record (where a record is a trip/statistical area/target species stratum). The range of explanatory variables offered to the model is given in (Table C.2). Fishing year was always forced as the first variable, and month (of landing), statistical area, target species, and a unique vessel identifier were also offered. The total length of net set was included as the measure of effort to explain catch per trip. The dependent variable for the binomial model was a binary variable set to ‘1’ for records which had associated SCH 5 catch and set to ‘0’ for records with no catch. This model was offered the same explanatory variables as the lognormal model.

The two models were combined into a single index using the following equation (Vignaux 1994):

$$C_i = \frac{L_i}{\left(1 - P_0\left[1 - \frac{1}{B_i}\right]\right)}$$

where $C_i$ = combined index for year $i$
$L_i$ = lognormal index for year $i$
$B_i$ = binomial index for year $i$
$P_0$ = proportion zero for base year $0$

It is relatively straightforward to calculate standard errors for the indices $L_i$ and $B_i$. However, this is not the case for the combined index $C_i$ because the standard errors of the two sets of indices are likely be correlated because they come from the same dataset. Francis (2001) suggests that a bootstrap procedure is the appropriate way to estimate the variability of the combined index. This was not done for this study, as the effect of combining the models is often not great, and the additional information incorporated is, in some cases, an artefact of the data amalgamation procedure and may not necessarily add any value to the lognormal indices.

### C.2.2 FISHERY DEFINITIONS FOR CPUE ANALYSIS

**SN (SHK) – Shark set net;** The Fishery is defined from setnet fishing events from any statistical area valid for SCH 5 (excluding the Snares and other outlying southern areas), and targeted at school shark. This definition allowed the use of total effort and not just successful effort in the analysis of catch rates

## C.3 UNSTANDARDISED CPUE

The effort expended in this fishery peaked in 1993-94 at around 170 trips per year, then declined to around 60-70 % of this level during the late 1990s. Effort has since increased to around 140 trips per year. There were some peaks in total trips in recent years that were non-productive for school shark, with no corresponding increase in the number of trips landing school shark (Figure C.1). The annual average catch per day in successful trips has fluctuated around 800 kg/km of net for much of the time series peaking in 2000–01, and is currently at approximately the same level as at the beginning of the series (Figure C.1).

Success rate shows a shift half way through the time series from near complete to around 10% of trips not landing SCH 5 (Figure C.2). The roll-up of data to trip-stratum shows no trend that might affect the apparent success rate (Figure C.2), but an unusually high ratio in the first year of the series. This fishery is defined on target fishing only and is not likely that the percentage of zero catches will provide a meaningful signal.

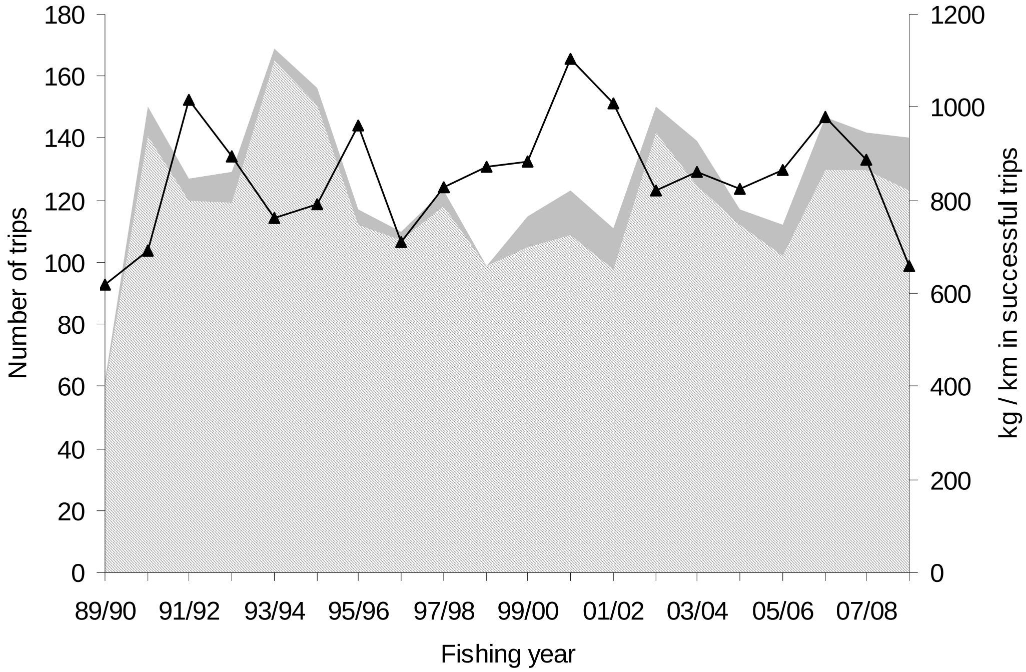



Figure C.1: Number of trips that targeted elephantfish, school shark, rig or spiny dogfish by set net in SN (SHK), (dark area), the number in trips that landed SCH 5 (light area) and the simple catch rate (kg/km) of SCH 5 in successful trips, by fishing year.

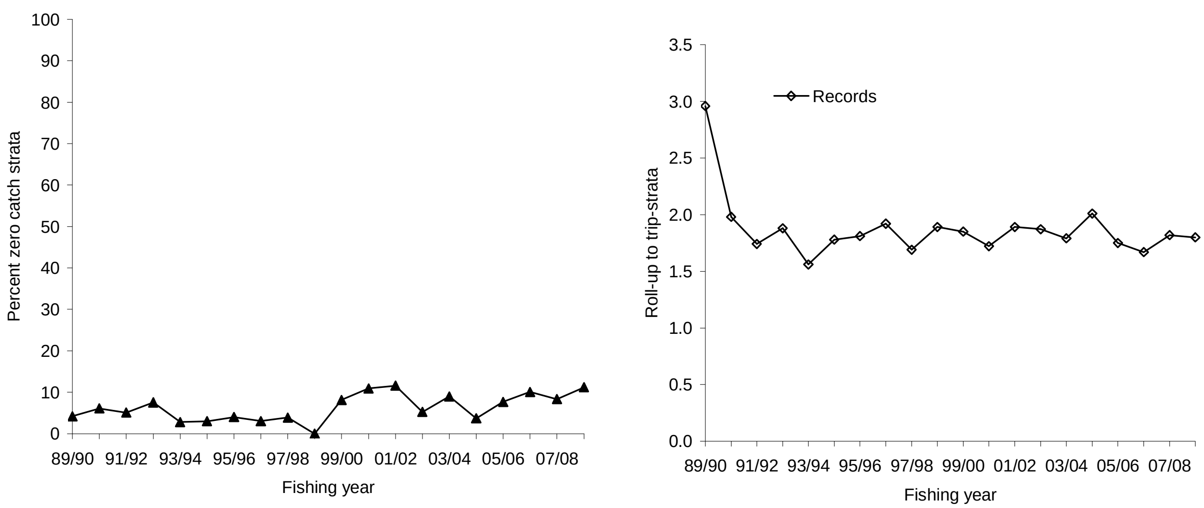



Figure C.2: The proportion of qualifying trips targeted on elephantfish, school shark, rig or spiny dogfish by set net in SN (SHK), that landed zero SCH 5 (left), and the effect of amalgamation of the data to trip-stratum (right), by fishing year.

## C.4 STANDARDISED CPUE ANALYSIS

### C.4.1 CORE FLEET DEFINITIONS

The data sets used for the standardised CPUE analysis were restricted to those vessels that participated with some consistency in the defined fishery. Core vessels were selected by specifying two variables; the number of trips that determined a qualifying year, and the number of qualifying years that each vessel participated in the fishery. The effect of these two variables on the amount of landed school shark retained in the dataset and on the number of core vessels is depicted for each of the defined fisheries in Figure D.1. The core fleet was selected by choosing variable values that resulted in the fewest vessels while maintaining the largest catch of school shark. The selection process usually reduced the number of vessels in the dataset by about 70% while reducing the amount of landed school shark by about 20%.

The final model selected those vessels that had participated in at least 3 trips for a minimum of 3 years. This relaxed core vessel definition had to be adopted so that an important vessel that has recently entered the fishery (vessel 20974) could be included in the analysis. Otherwise, only two vessels would be available to contribute to the final year (2008–09). The number of trips in each fishing year for the selected vessels is provided in Figure D.1. The summary for the data set with the core vessels is presented in Table D.1.

### C.4.2 MODEL SELECTION

The final models selected are described in Table C.2. The lognormal model explained over 50% of the variance observed in catches of school shark in successful trips, attributed in the first instance to the length of net set per trip-stratum, and followed by vessel ID, month and statistical area. Log(duration) also entered the model as a second measure of effort but with little additional explanatory power.

Diagnostic residual plots are presented for the lognormal model in Figure D.2 and show a poor fit of the data to the lognormal assumption, with some departure at the extremes, and some unexplained pattern in the residuals. The residuals are also positively skewed relative to the fitted lognormal distribution.

The first year of the data set has a high value for log(catch/stratum), possibly an artefact of high proportion of trip-strata that were rolled up in that year (Figure C.2 [right panel]; this is the high value seen in the first point in Figure C.3). The high value for catch is offset by a large value for “total length of net set”, resulting in an unstandardised CPUE (catch/[unit net length]) that is nearer average (Table D.2). This effect can be seen in the large offset value for the “length of net” influence plot for 1989–90 (Figure D.3). A gradual trend of increasing length of net set can also be seen in Figure D.3, which the model interprets as a flat or possibly declining CPUE. Changes in the core fleet served to increase observed catch rate in the second half of the time series due to the loss of some poorer performing vessels and increased activity by the better performing vessels (Figure D.4). There is a strong seasonal pattern to predicted catch with highest rates predicted in the summer months. The extension of the season outside this narrow window in recent years means that season has had considerable negative influence on the unstandardised catch rates since the mid 1990s, resulting in lifted catch rates relative to the previous variable (Figure D.5; see Figure C.3). A shift away from the historically important Statistical Area 025 (but with a relatively lower catch rate) into Statistical Areas with higher catch rates has lifted the observed CPUE which is corrected for in the standardisation procedure over the same time period (Figure D.6). Duration has trended downwards over most of the series, but has increased since 2004-05, causing unstandardised CPUE to increase (Figure D.7).

The binomial model explained 41% of the variance in success rate (Table C.2) and included vessel ID, log(duration), statistical area and month as explanatory variables.

There is considerable structure in all the influence plots with large shifts from year to year in the total amount of net set per trip-stratum, the seasonality of fishing, and the statistical areas fished. This is not a fishery that has experienced much stability in the way it has been fished over time, despite (or maybe because of) the small number of vessels involved.

Table C.2: Order of acceptance of variables into the lognormal model of successful catches of SCH 5 and the logistic model of catches (successful or unsuccessful) for core vessels based on the vessel selection criteria of at least 3 trips in 3 or more fishing years) in the SN (SHK) fishery, with the amount of explained deviance ($R^2$) for each variable. Variables accepted into the model are marked with an *, and the final $R^2$ of the selected model is in bold. Fishing year was forced as the first variable.

| | DF | Deviance | AIC | R2 | Final |
|---|---|---|---|---|---|
| **Lognormal Terms** | | | | | |
| None | 0 | 7 232 | 9 925 | 0.000 | |
| Fishing year | 20 | 7 073 | 9 906 | 0.022 | * |
| poly(log(netlength), 3) | 23 | 4 611 | 8 817 | 0.362 | * |
| Vessel ID | 40 | 4 096 | 8 548 | 0.434 | * |
| Month | 51 | 3 881 | 8 432 | 0.463 | * |
| Statistical area | 54 | 3 698 | 8 314 | 0.489 | * |
| poly(log(duration), 3) | 57 | 3 568 | 8 229 | **0.507** | * |
| **Binomial Terms** | | | | | |
| None | 0 | 1 295 | 1 297 | 0.0000 | |
| Fishing year | 20 | 1 241 | 1 281 | 0.0417 | * |
| Vessel ID | 37 | 859 | 933 | 0.3368 | * |
| poly(log(duration), 3) | 40 | 819 | 899 | 0.3678 | * |
| Statistical area | 43 | 798 | 884 | 0.3835 | * |
| Month | 54 | 760 | 868 | **0.4131** | * |

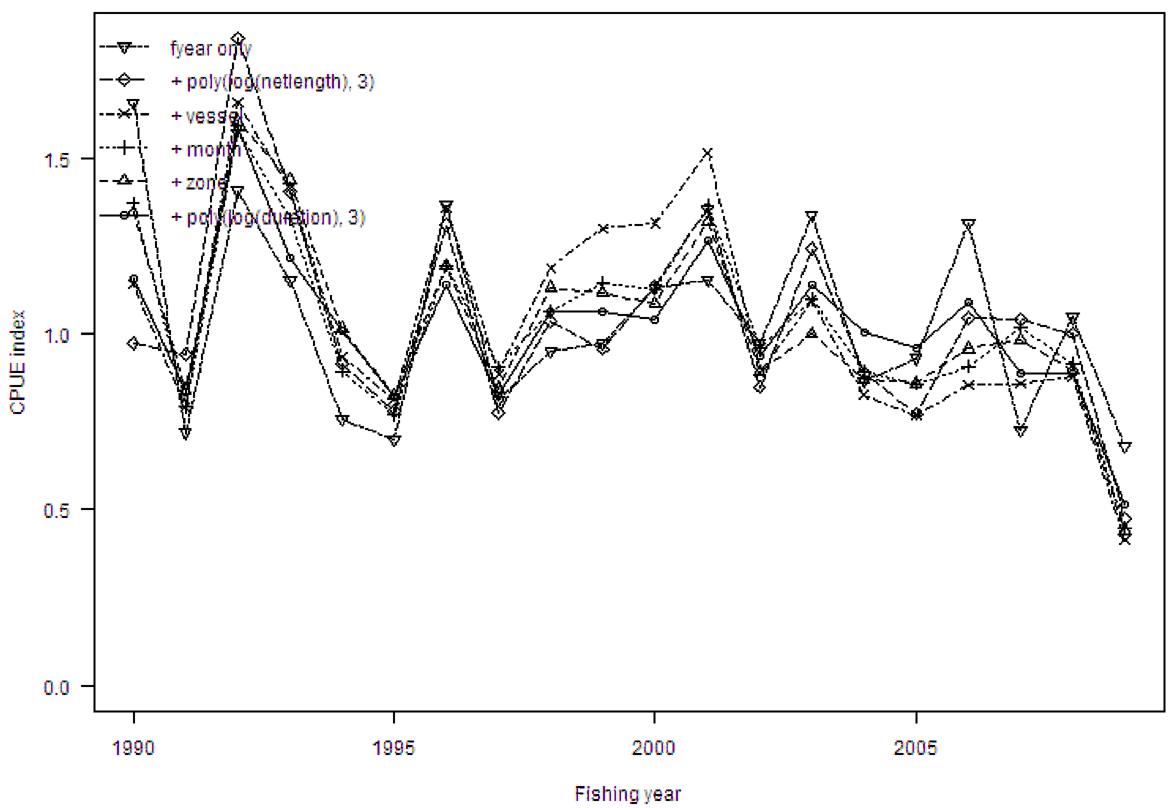



Figure C.3: Annual indices from the lognormal model of SCH 5: SN(SHK) at each step in the variable selection process.

### C.4.3 TRENDS IN MODEL YEAR EFFECTS

Standardisation of the catch rates does not change the overall trend in the series very much from the unstandardised models, with the exception of emphasising what appears to be a declining trend in the most recent three to four years. Despite accounting for over 50% of the variance, the annual index varies considerably from fishing year to fishing year, indicating possible instability in the index due to the small number of vessels that participate in this fishery (Figure C.4). It is likely that other factors unrelated to abundance have a strong influence in this series, which may only serve as an imperfect monitor for this population. Thus the strong drop observed in the most recent year of the series should be interpreted with caution;

The lognormal model indices are flat for most of the time series with wide error bars, but decline in the most recent three years, most markedly in the most recent year. Note that the strong drop in 2008–09 is present in both of the unstandardised indices. Thus it is part of the data and not caused by the standardisation procedure. There is reasonable agreement with the previous series presented in 2007 (Starr et al. 2007), and the differences are likely attributable to the change in target species definition, resulting in the loss of a small amount of data for sets targeting other shark species (Figure C.4).

The recent decline is also seen in the pattern of the year effects from the binomial model, and combining this index with the lognormal model accentuates a drop in the three years since this Fishstock was last analysed in 2007 (Figure C.5).

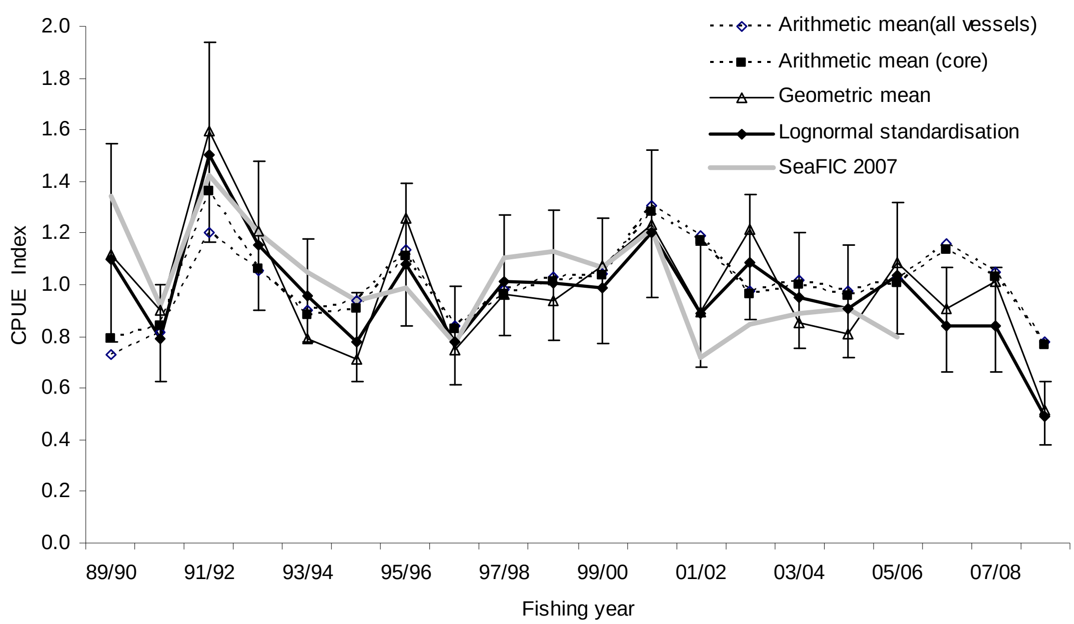



Figure C.4: The effect of standardisation on the raw CPUE of SCH 5 in successful trips by core vessels in the SN (SHK) fishery. Broken lines are the raw CPUE (kg / km ) for all vessels and for the core fleet only, the solid line is the unstandardised CPUE (annual geometric mean), the bold line is the standardised CPUE canonical indices with ± 2 * SE error bars. Grey line is the previous lognormal series presented in 2007 for this fishery. All series are relative to the geometric mean over the years in common.

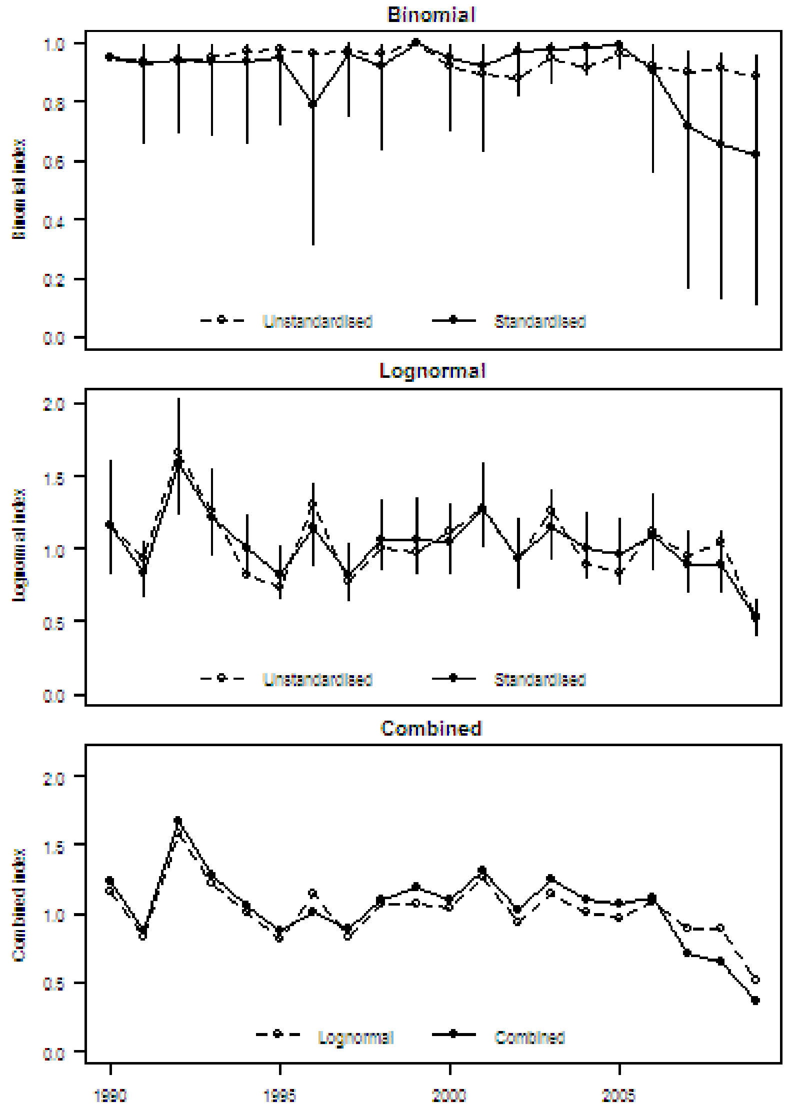
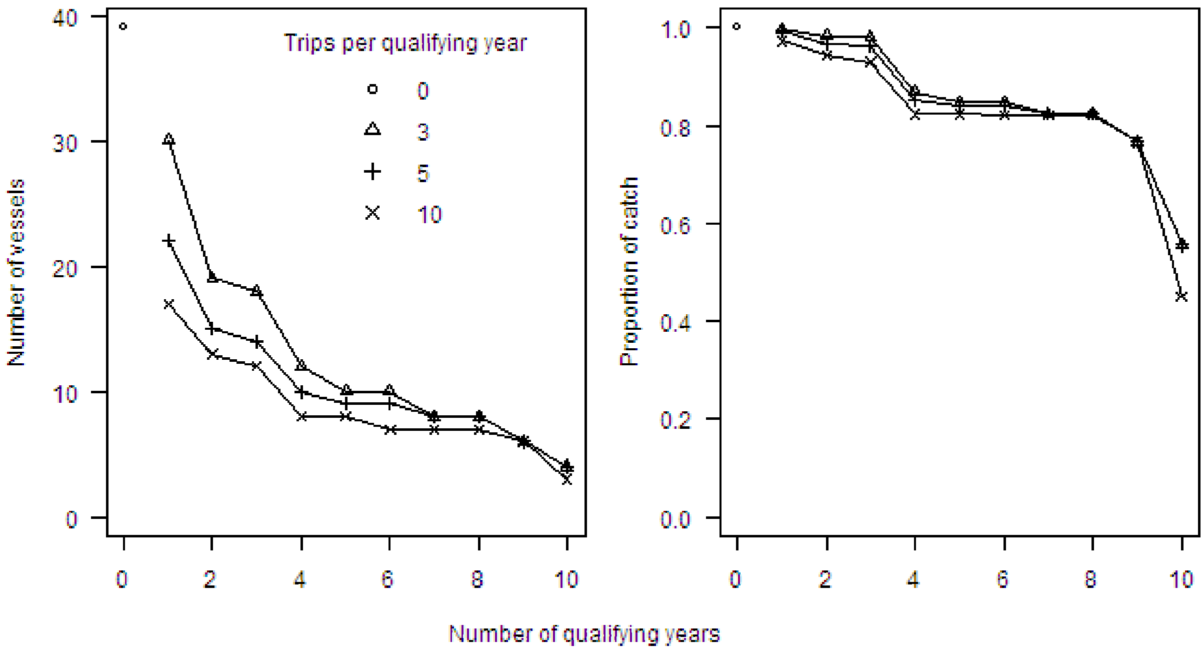



Figure C.5: The effect of standardisation on the raw CPUE of SCH 5 by core vessels in the SN (SHK) fishery. Top: Binomial index of probability of capture. Middle: Lognormal index of magnitude of catch. broken line is the raw CPUE (kg / km) the solid line is the standardised CPUE canonical indices with ± 2 * SE error bars. Bottom: The effect on the lognormal index of combining it with the Binomial index.

# Appendix D. DETAILED DIAGNOSTICS FOR SCH 5 CPUE STANDARDISATIONS

## D.1 CORE VESSEL SELECTION



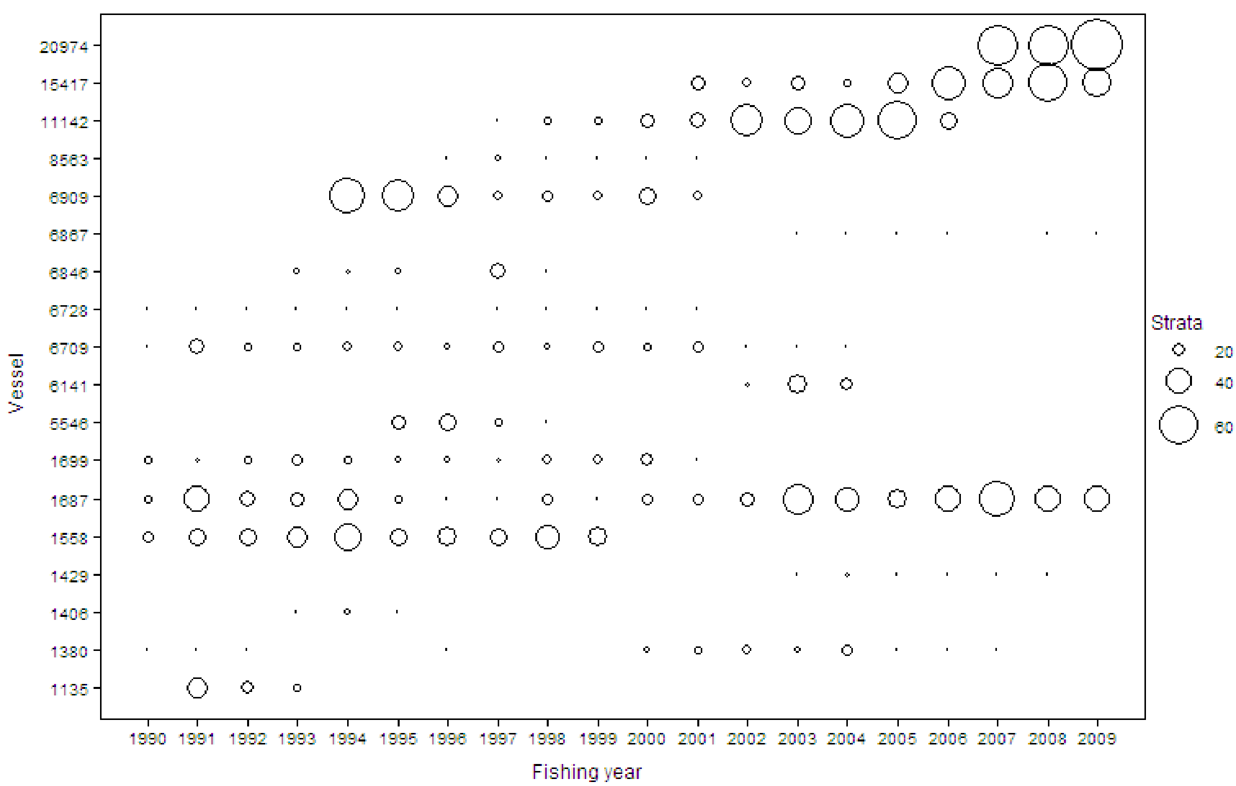




Figure D.1: The total landed SCH 5 [top left] and the number of vessels [top right] retained in the SN (SHK) dataset depending on the minimum number of qualifying years used to define core vessels. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend. The participation of selected core vessels (based on at least 3 trips in 3 or more fishing years); number of records for each vessel in each fishing year [bottom].

## D.2 DATA SUMMARIES

Table D.1: Number of trips, proportion of records in those trips that did not land SCH 5, number of core vessels, and number of tows, landed SCH 5 (t), and simple catch rate for core vessels (based on a minimum of 3trips per year in at least 3 years) in the SN (SHK) fishery, by fishing year.

| Fishing year | Trips | % zero strata | Vessels | Net length (m) | Catch (t) | CPUE kg / km |
|---|---|---|---|---|---|---|
| 89/90 | 47 | 5 | 6 | 327 000 | 220 | 673 |
| 90/91 | 131 | 6 | 7 | 543 800 | 365 | 671 |
| 91/92 | 101 | 6 | 7 | 380 300 | 434 | 1 141 |
| 92/93 | 106 | 5 | 8 | 514 900 | 457 | 888 |
| 93/94 | 168 | 3 | 8 | 675 560 | 506 | 749 |
| 94/95 | 153 | 2 | 9 | 651 070 | 497 | 763 |
| 95/96 | 117 | 4 | 8 | 540 870 | 512 | 947 |
| 96/97 | 110 | 3 | 10 | 553 700 | 383 | 692 |
| 97/98 | 123 | 4 | 10 | 483 820 | 390 | 806 |
| 98/99 | 99 | 0 | 8 | 427 100 | 372 | 871 |
| 99/00 | 114 | 8 | 8 | 473 300 | 412 | 870 |
| 00/01 | 123 | 11 | 9 | 441 200 | 467 | 1 058 |
| 01/02 | 107 | 12 | 6 | 472 280 | 460 | 974 |
| 02/03 | 149 | 5 | 8 | 710 800 | 582 | 819 |
| 03/04 | 139 | 9 | 8 | 624 850 | 521 | 834 |
| 04/05 | 117 | 4 | 6 | 641 820 | 525 | 818 |
| 05/06 | 112 | 8 | 6 | 575 500 | 484 | 841 |
| 06/07 | 147 | 10 | 5 | 551 500 | 515 | 934 |
| 07/08 | 142 | 8 | 5 | 714 110 | 604 | 846 |
| 08/09 | 140 | 11 | 4 | 862 120 | 533 | 618 |

## D.3 RESIDUAL PLOTS

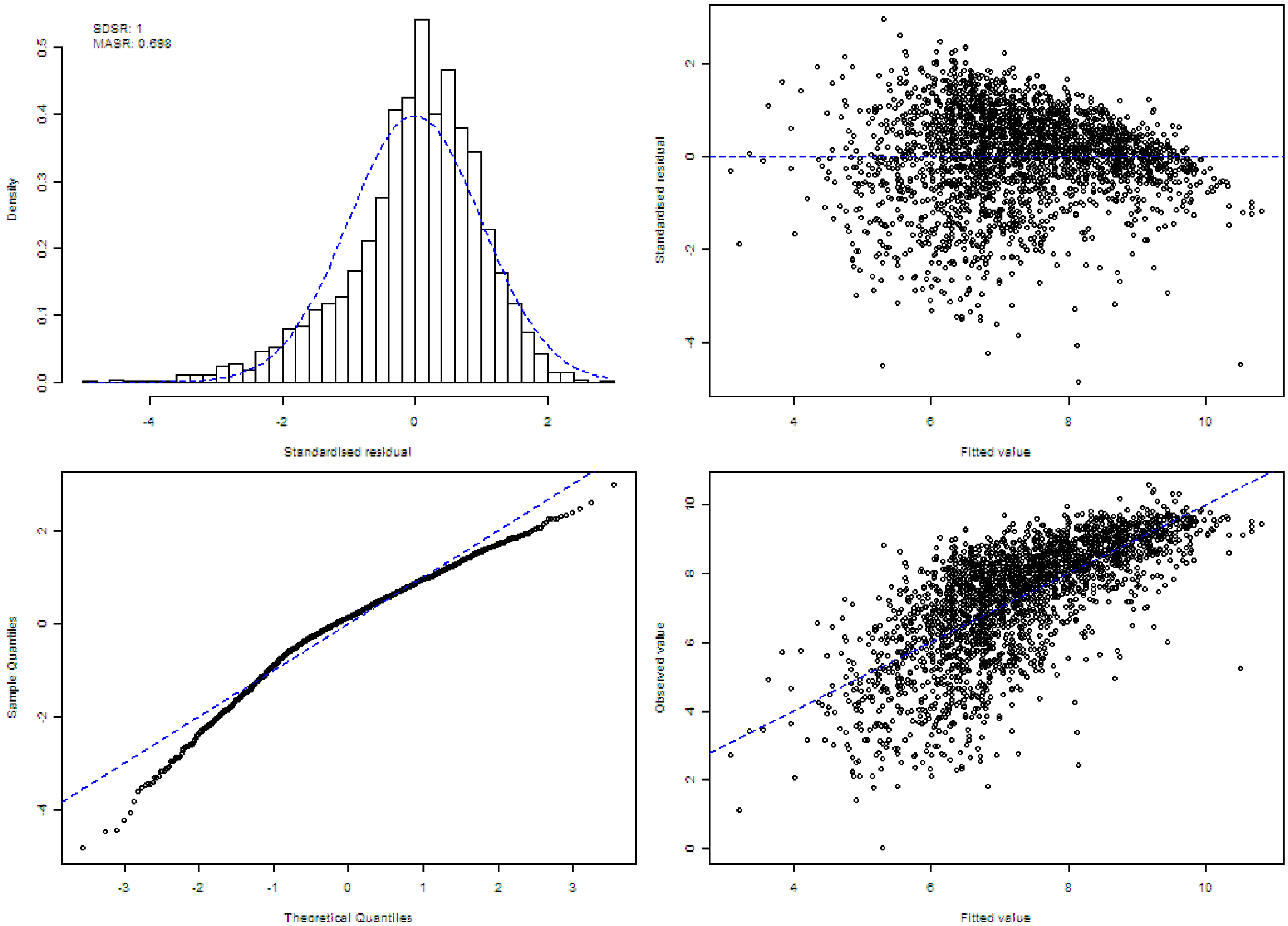



Figure D.2: Plots of the fit of the standardised CPUE model to successful catches of SCH 5 in the SN (SHK) fishery. [Upper left] histogram of the standardised residuals compared to a lognormal distribution (SDSR: standard deviation of standardised residuals. MASR: median of absolute standardised residuals); [Upper right] Q-Q plot of the standardised residuals; [Lower left] Standardised residuals plotted against the predicted model catch per trip; [Lower right] Observed catch per record plotted against the predicted catch per record.

## D.4 MODEL COEFFICIENTS

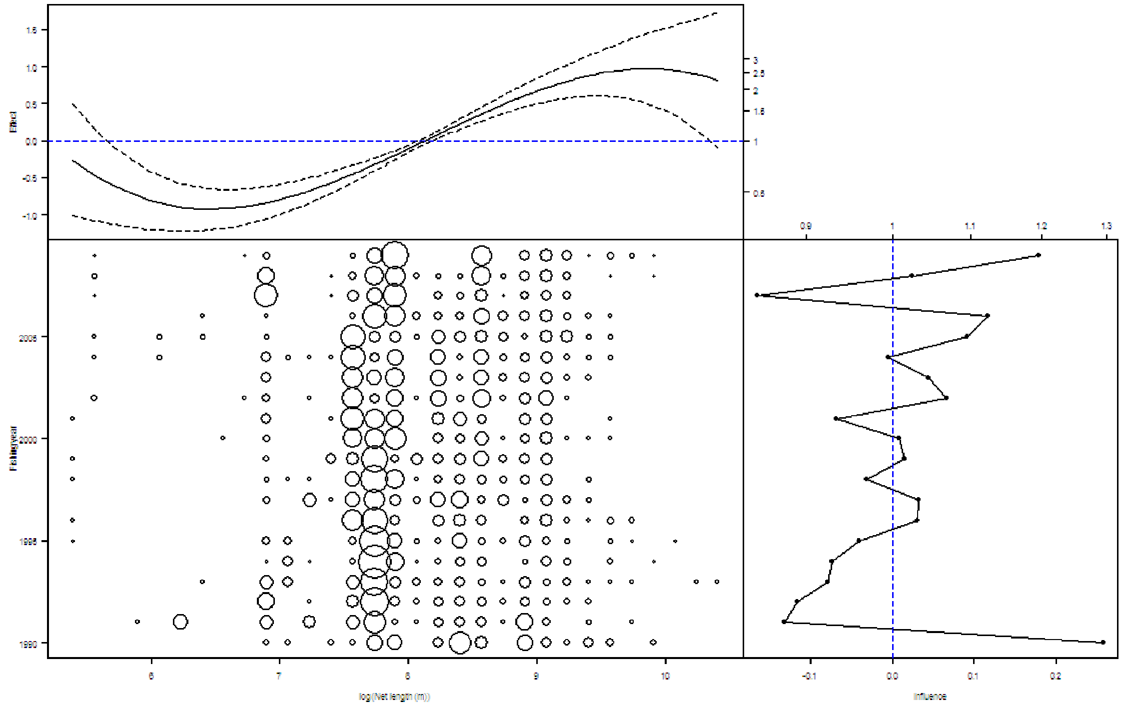


Figure D.3: Effect of **log netlength** in the lognormal model for the SCH 5 **SN (SHK)** fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

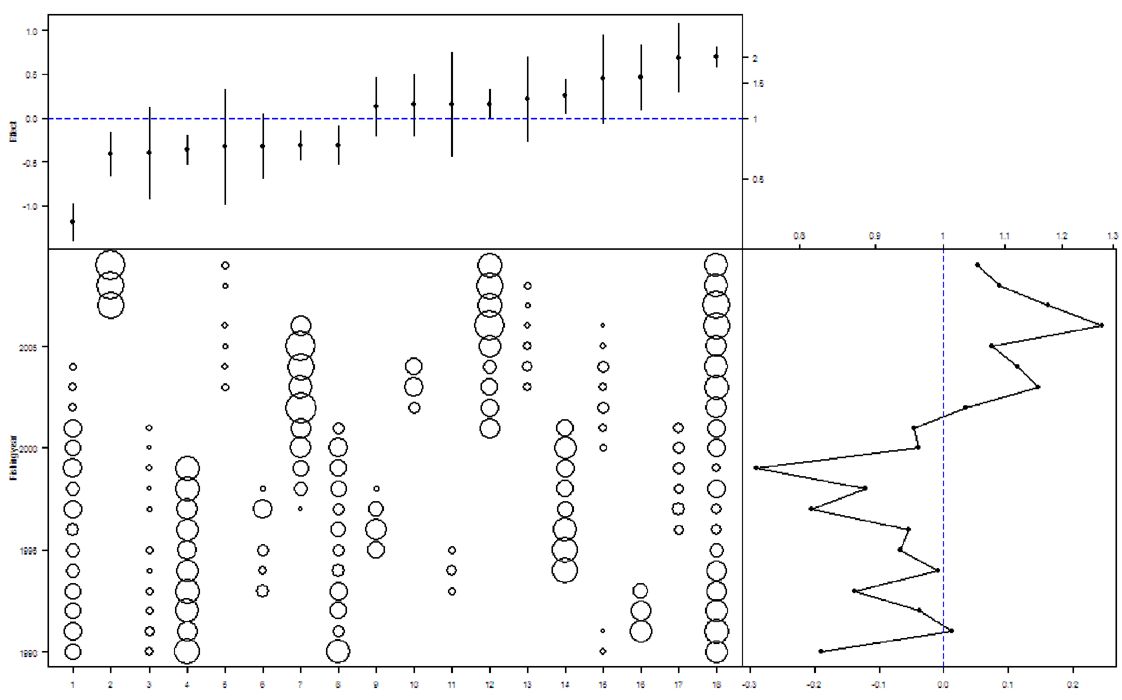


Figure D.4: Effect of **vessel** in the lognormal model for the SCH 5 **SN (SHK)** fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

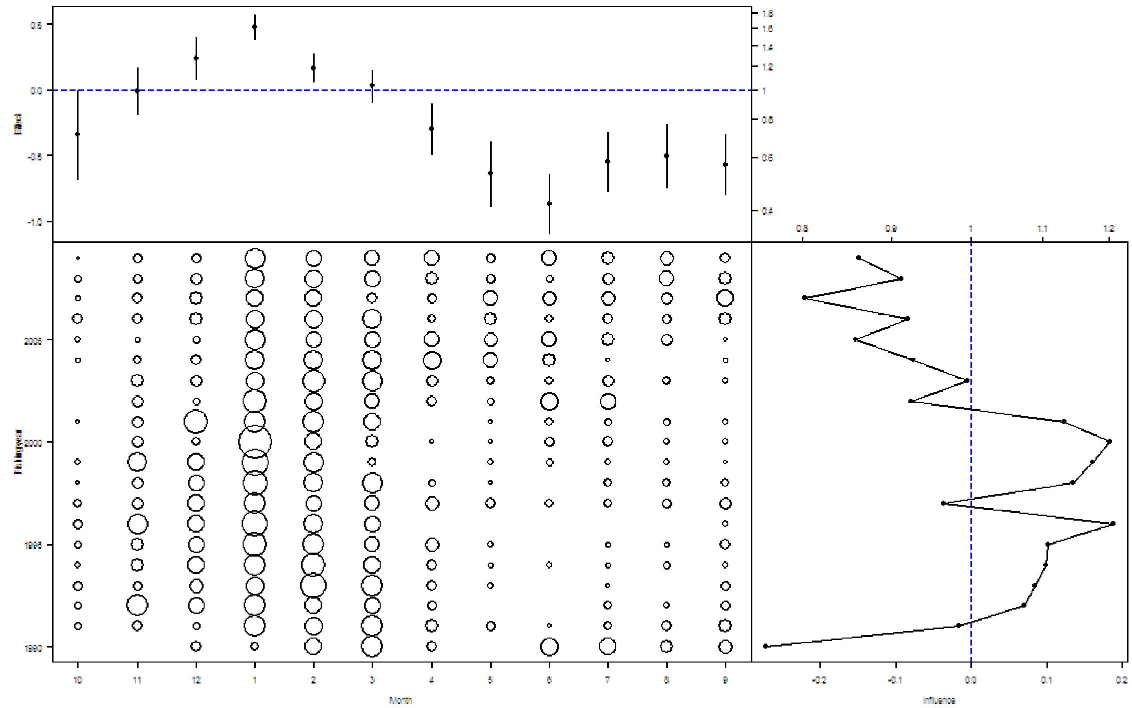


Figure D.5: Effect of **month** in the lognormal model for the SCH 5 **SN (SHK)** fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

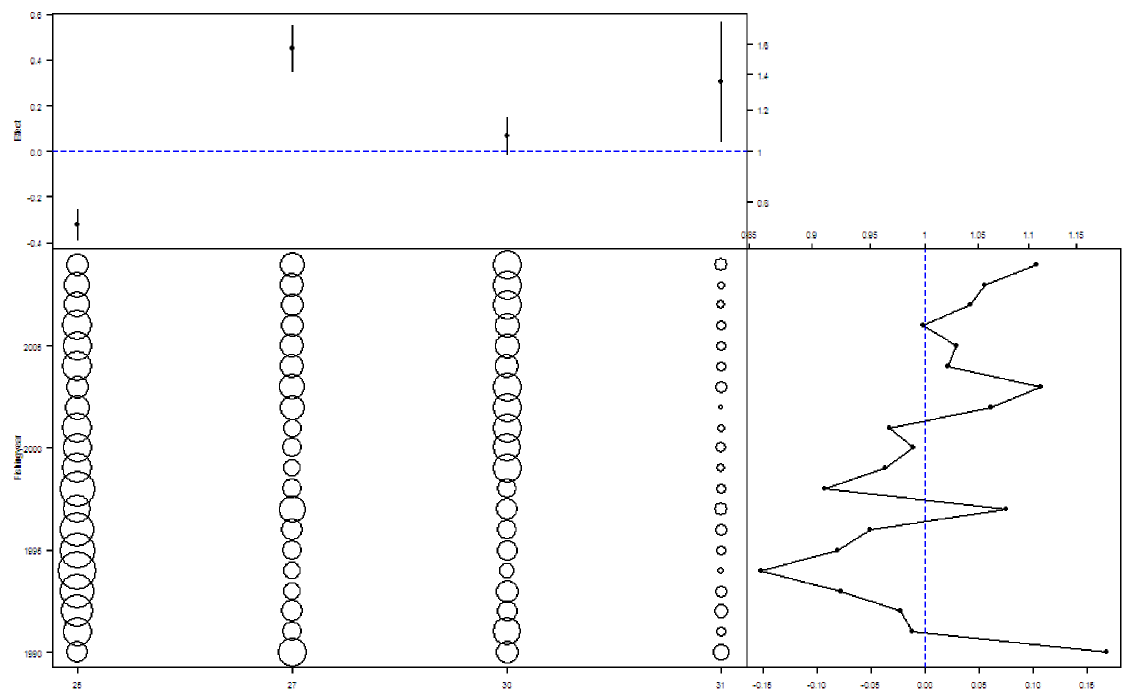


Figure D.6: Effect of **statistical area** in the lognormal model for the SCH 5 **SN (SHK)** fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

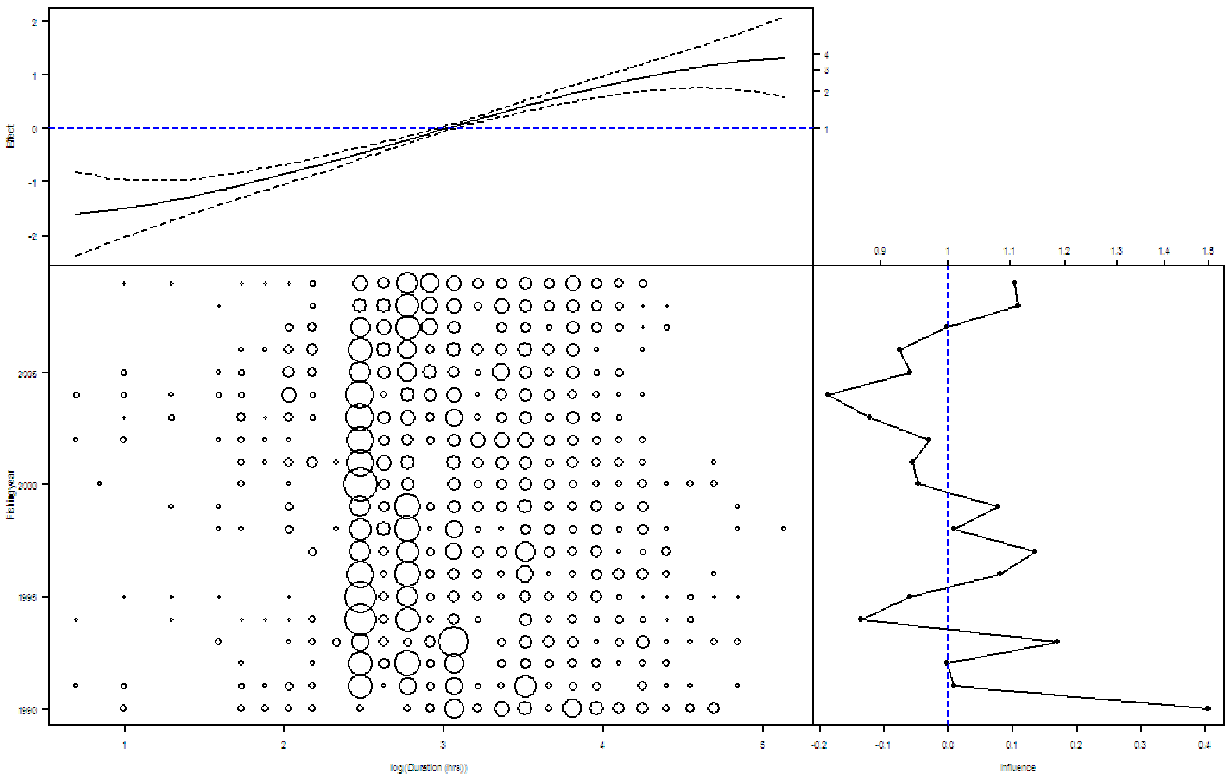



Figure D.7: Effect of **log duration** in the lognormal model for the SCH 5 **SN (SHK)** fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

## D.5 CPUE INDICES

Table D.2: Relative year effects and 95% confidence intervals (in parentheses) for the models fitted to SCH 5 SN(SHK) fishery. Statistics based on core fleet unless otherwise indicated.

| Fishing year | Arithmetic mean(all vessels) | Arithmetic mean | Geometric mean | Lognormal standardisation | Binomial standardisation | Combined standardisation |
|---|---|---|---|---|---|---|
| 1990 | 0.734 | 0.796 | 1.158 | 1.159 (0.836-1.607) | 0.947 | 1.231 (0.888-1.707) |
| 1991 | 0.820 | 0.842 | 0.934 | 0.837 (0.671-1.044) | 0.926 (0.663-0.987) | 0.869 (0.696-1.083) |
| 1992 | 1.204 | 1.370 | 1.654 | 1.587 (1.245-2.023) | 0.941 (0.692-0.991) | 1.675 (1.313-2.135) |
| 1993 | 1.060 | 1.067 | 1.257 | 1.217 (0.962-1.539) | 0.937 (0.687-0.990) | 1.278 (1.010-1.616) |
| 1994 | 0.904 | 0.890 | 0.821 | 1.008 (0.828-1.228) | 0.932 (0.663-0.990) | 1.054 (0.866-1.283) |
| 1995 | 0.938 | 0.915 | 0.738 | 0.822 (0.667-1.012) | 0.951 (0.725-0.993) | 0.877 (0.712-1.080) |
| 1996 | 1.137 | 1.119 | 1.304 | 1.140 (0.897-1.449) | 0.789 (0.313-0.968) | 1.008 (0.793-1.282) |
| 1997 | 0.845 | 0.831 | 0.778 | 0.824 (0.654-1.038) | 0.961 (0.749-0.995) | 0.888 (0.704-1.118) |
| 1998 | 0.982 | 0.966 | 1.001 | 1.066 (0.857-1.326) | 0.921 (0.636-0.987) | 1.101 (0.885-1.370) |
| 1999 | 1.033 | 1.017 | 0.976 | 1.063 (0.840-1.346) | 1.000 (1.000-1.000) | 1.192 (0.942-1.509) |
| 2000 | 1.047 | 1.042 | 1.113 | 1.041 (0.828-1.310) | 0.946 (0.705-0.992) | 1.104 (0.878-1.389) |
| 2001 | 1.312 | 1.291 | 1.281 | 1.268 (1.015-1.584) | 0.923 (0.630-0.988) | 1.312 (1.050-1.639) |
| 2002 | 1.195 | 1.177 | 0.927 | 0.937 (0.732-1.199) | 0.970 (0.821-0.996) | 1.019 (0.796-1.304) |
| 2003 | 0.975 | 0.971 | 1.260 | 1.142 (0.926-1.409) | 0.980 (0.867-0.997) | 1.255 (1.018-1.548) |
| 2004 | 1.022 | 1.005 | 0.888 | 1.004 (0.804-1.253) | 0.982 (0.890-0.997) | 1.106 (0.886-1.380) |
| 2005 | 0.979 | 0.964 | 0.840 | 0.960 (0.767-1.202) | 0.988 (0.912-0.999) | 1.064 (0.849-1.332) |
| 2006 | 1.026 | 1.010 | 1.124 | 1.092 (0.866-1.377) | 0.909 (0.561-0.987) | 1.113 (0.882-1.403) |
| 2007 | 1.162 | 1.144 | 0.941 | 0.887 (0.707-1.112) | 0.715 (0.169-0.969) | 0.711 (0.567-0.891) |
| 2008 | 1.053 | 1.037 | 1.049 | 0.887 (0.708-1.112) | 0.656 (0.133-0.959) | 0.652 (0.520-0.818) |
| 2009 | 0.782 | 0.770 | 0.536 | 0.518 (0.410-0.654) | 0.618 (0.115-0.953) | 0.358 (0.284-0.453) |

# Appendix E. DETAILED INDUSTRY TRAWL LOGBOOK FIGURES

## E.1 ALTERNATIVE COVERAGE PLOTS

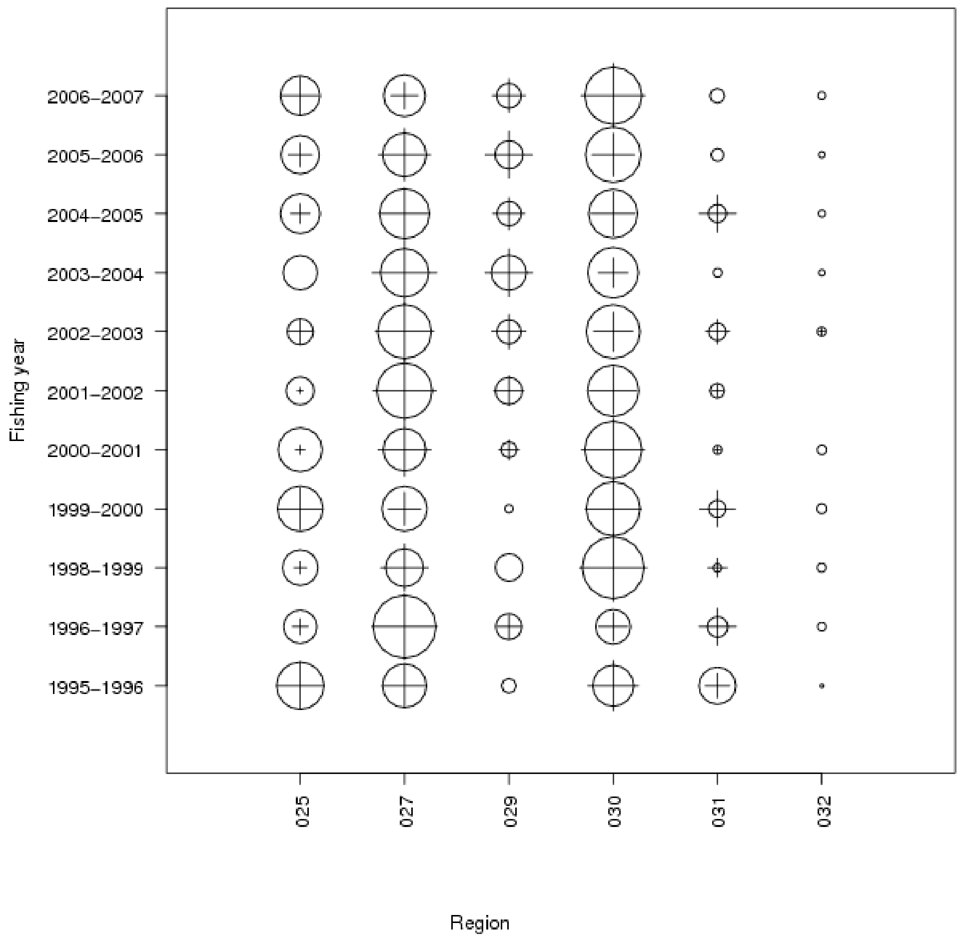



Figure E.1. Comparison of logbook(crosses) and QMR(circles) setnet catches by fishing year and statistical area. For each data source, catches are normalised for each fishing year. The largest circle shown (for Statistical Area Region 027 in 1996–97) represents 53% of QMR catch in that year. Perfect representation is achieved if the arms of the crosses just touch the edge of the circle.

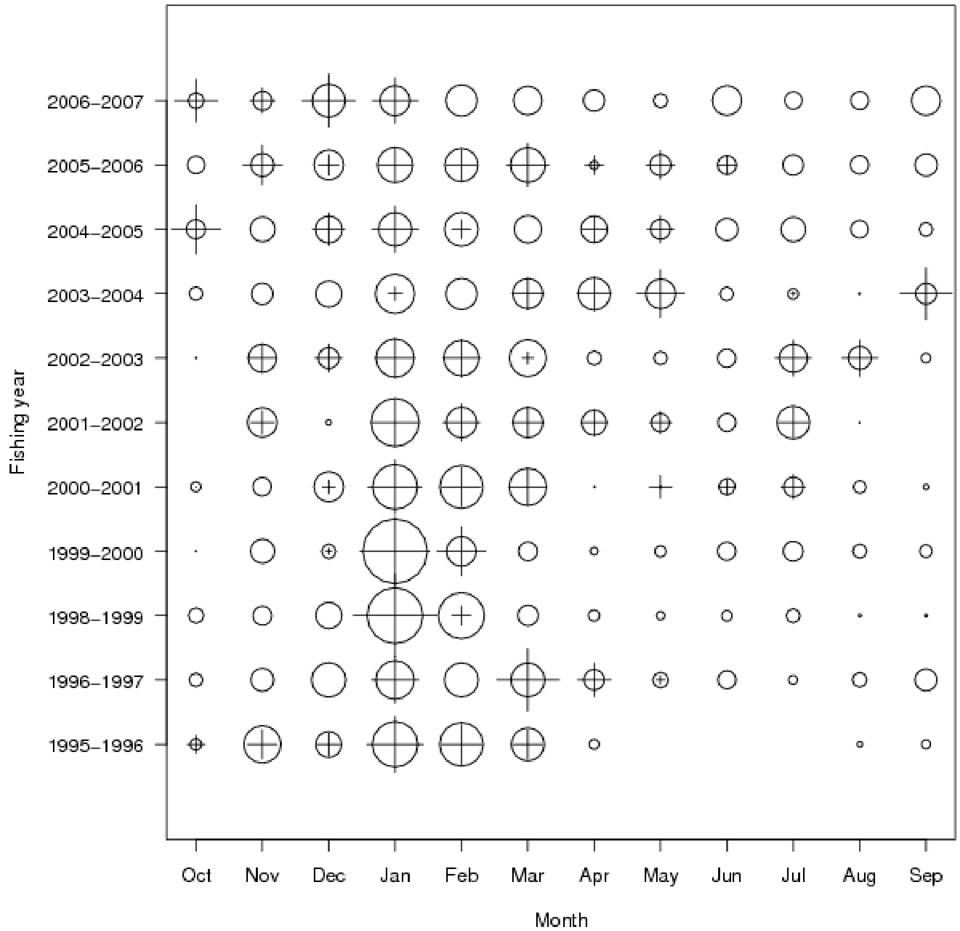



Figure E.2. Comparison of logbook(crosses) and QMR(circles) setnet catches by fishing year and month. For each data source, catches are normalised for each fishing year. The largest circle shown (for month January in 1999–00 ) represents 56% of QMR catch in that year. Perfect representation is achieved if the arms of the crosses just touch the edge of the circle.

## E.2 SPATIAL COVERAGE BY THE INDUSTRY SETNET LOGBOOK PROGRAMME BY FISHING YEAR

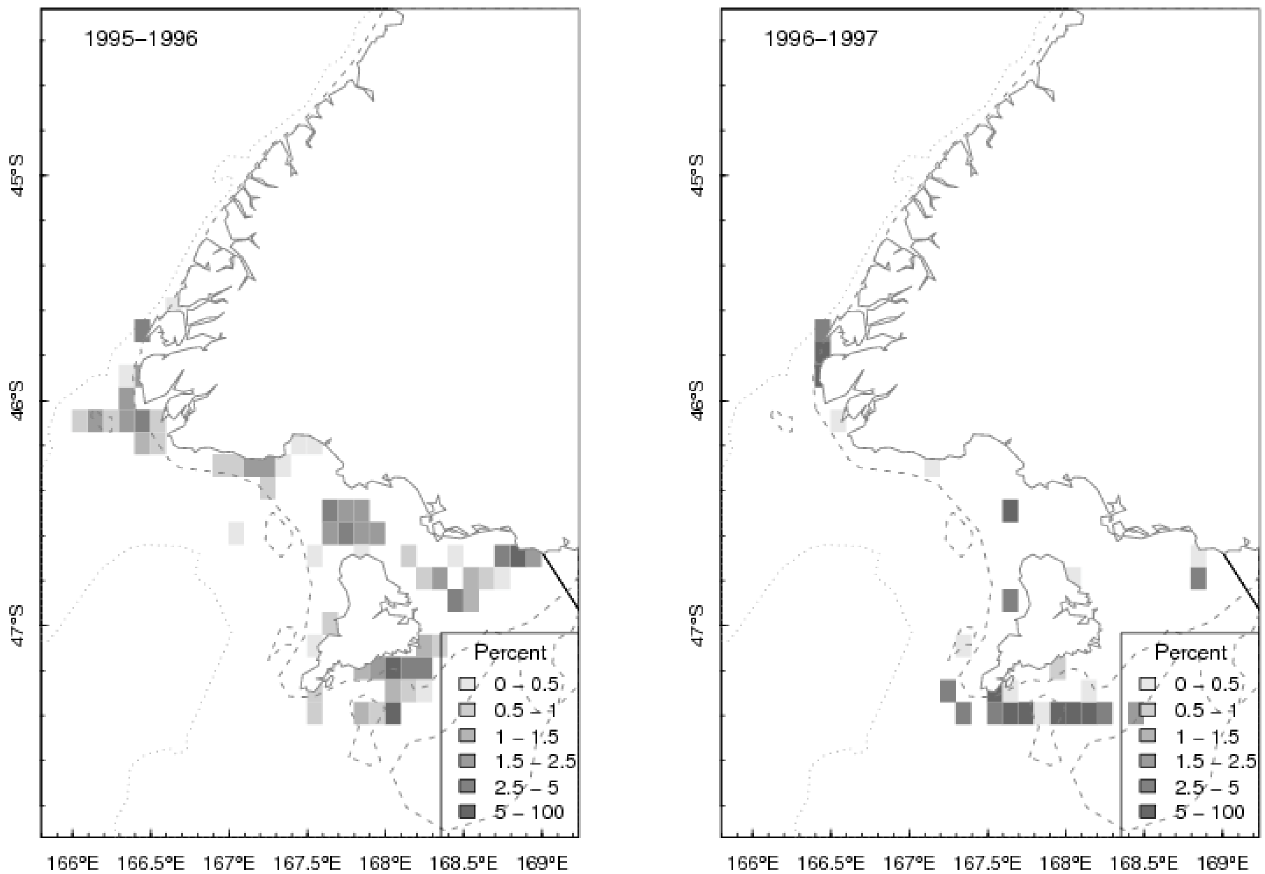



Figure E.3. Distribution of logbook catch in 1995–96 and 1996–97 arranged in 0.1 degree cells, shaded as a percentage of the total annual catch.

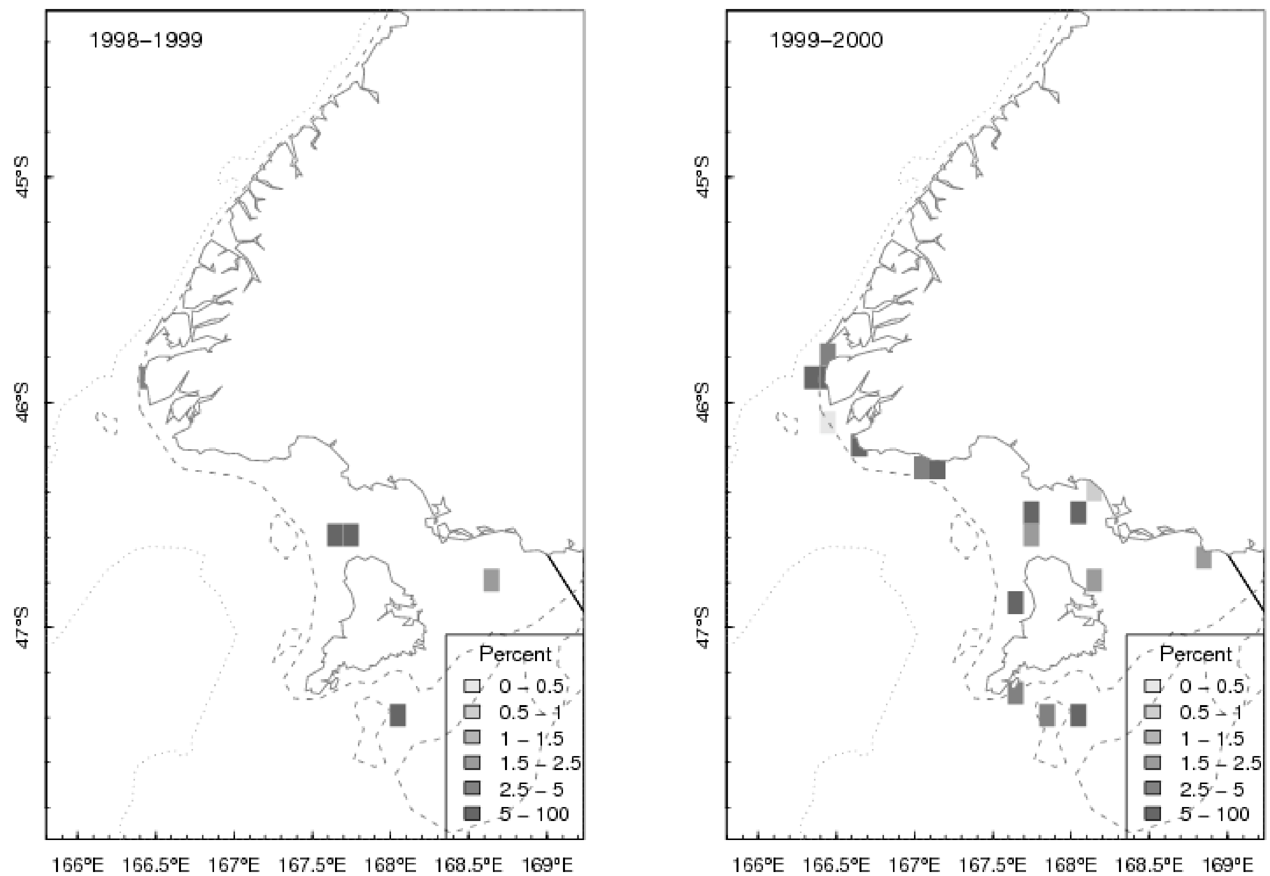



Figure E.4. Distribution of logbook catch in 1998–99 and 1999–00 arranged in 0.1 degree cells, shaded as a percentage of the total annual catch.

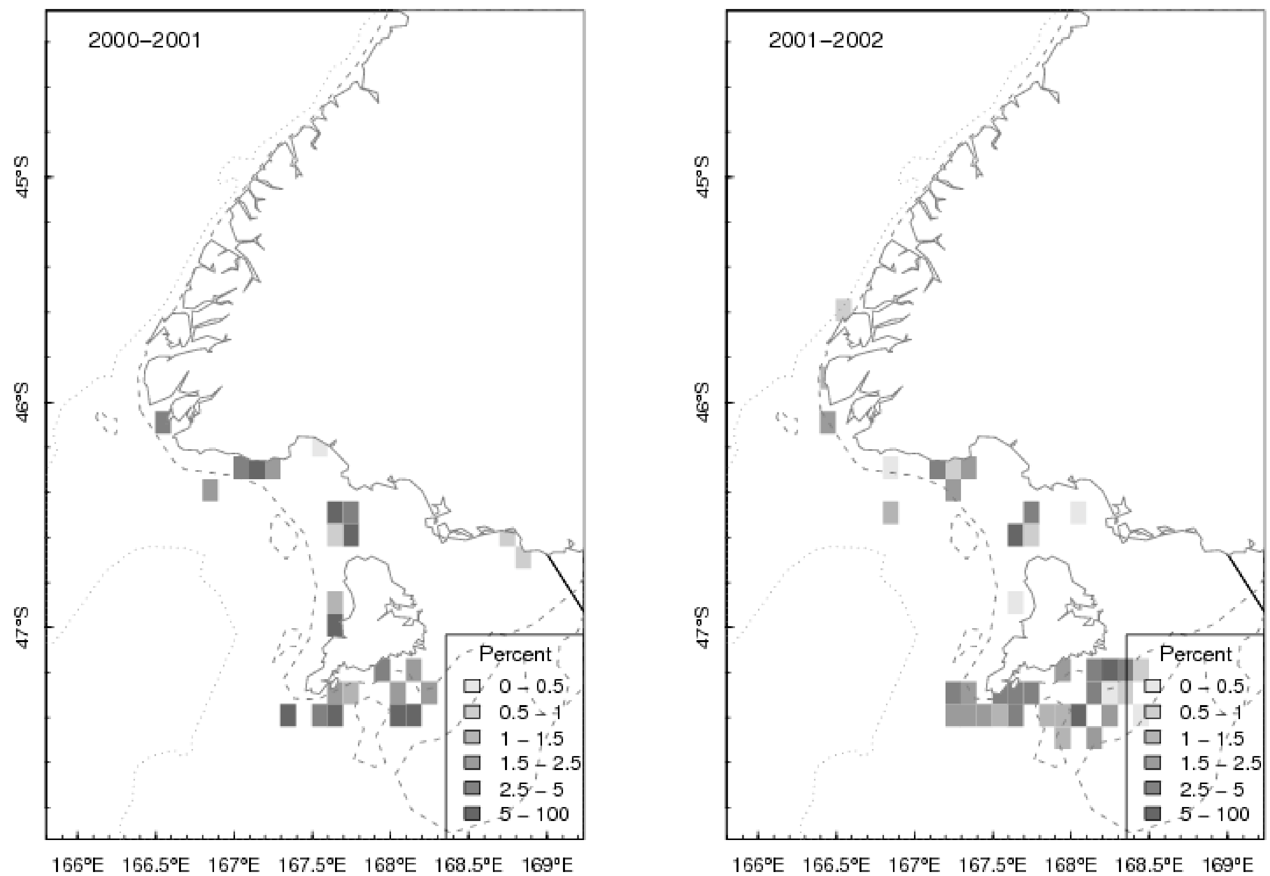



Figure E.5. Distribution of logbook catch in 2000–01 and 2001–02 arranged in 0.1 degree cells, shaded as a percentage of the total annual catch.

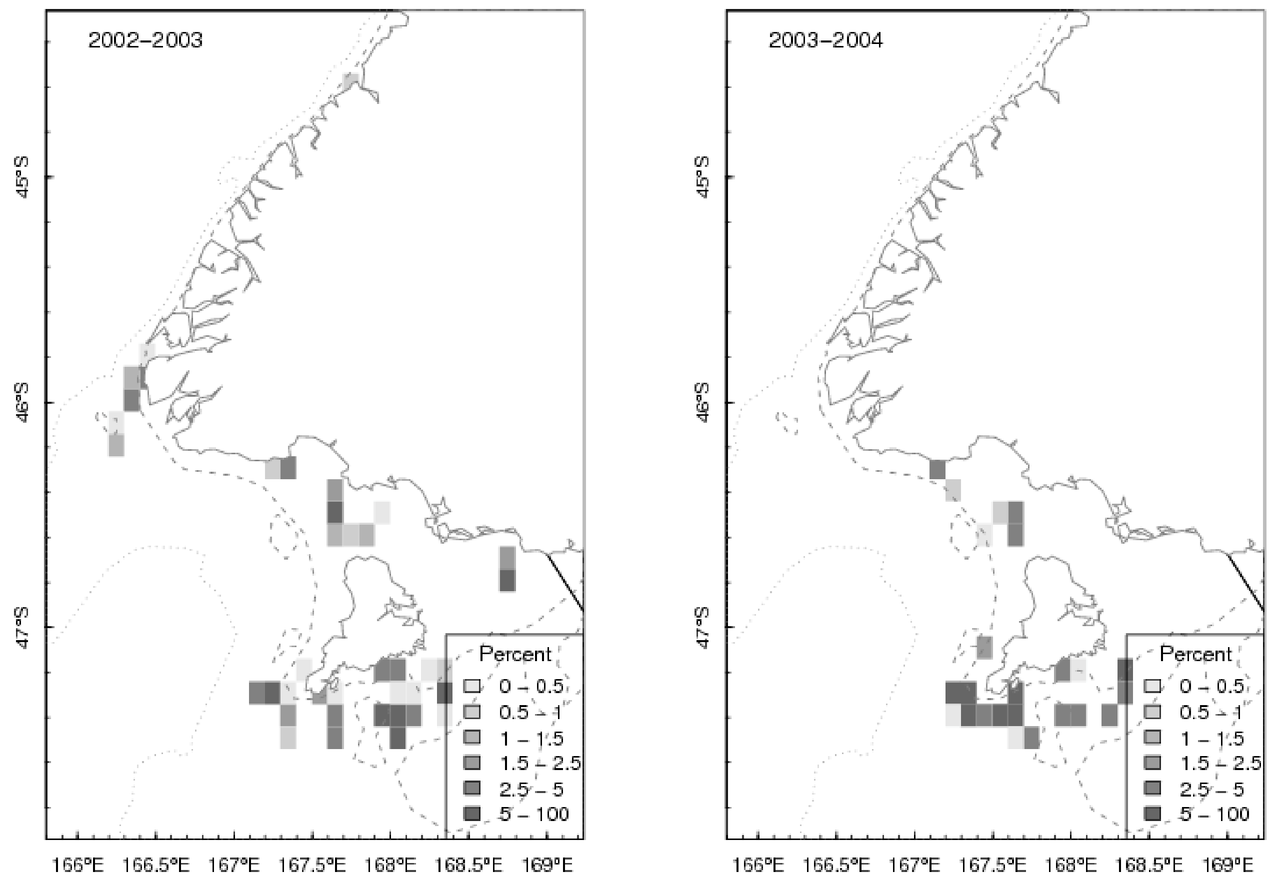



Figure E.6. Distribution of logbook catch in 2002–03 and 2003–04 arranged in 0.1 degree cells, shaded as a percentage of the total annual catch.

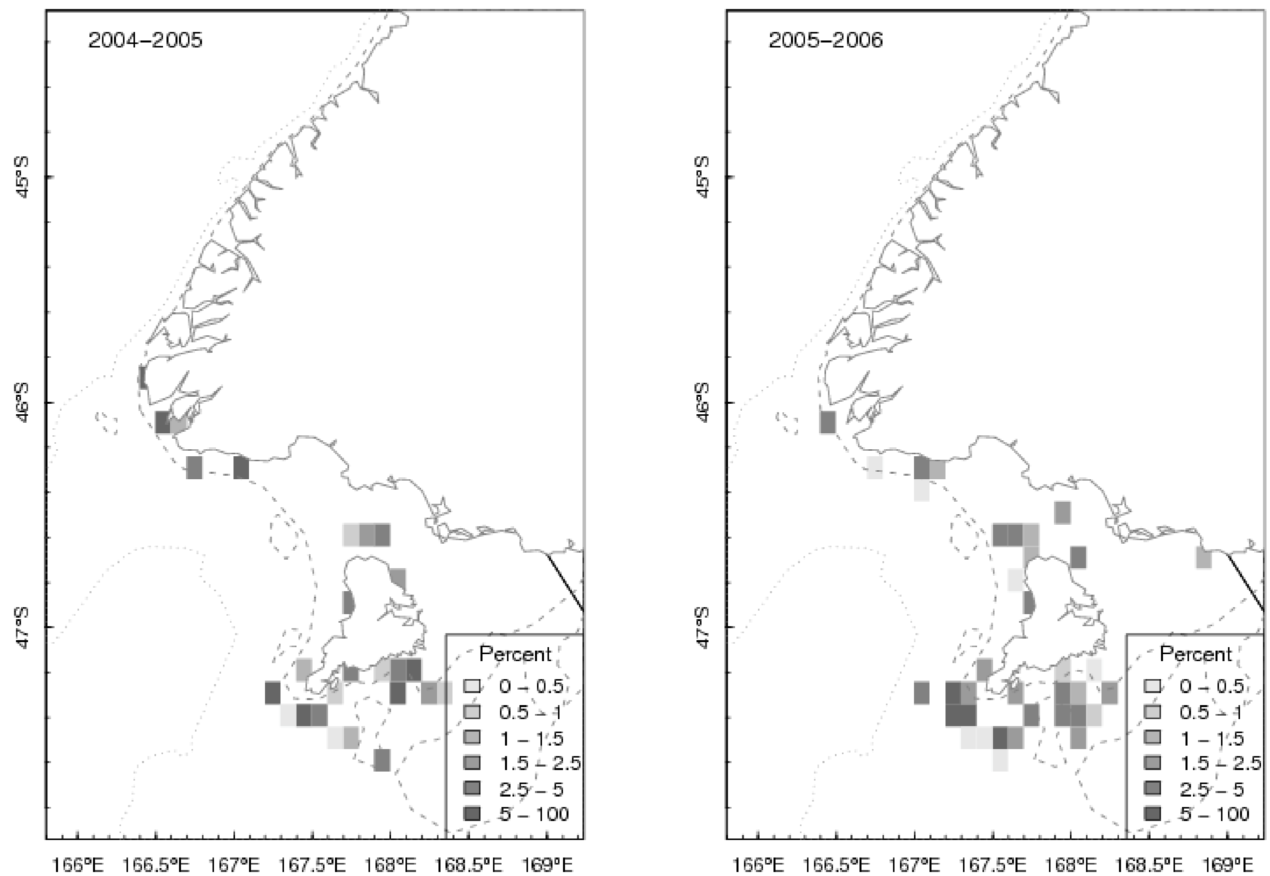



Figure E.7. Distribution of logbook catch in 2004–05 and 2005–06 arranged in 0.1 degree cells, shaded as a percentage of the total annual catch.

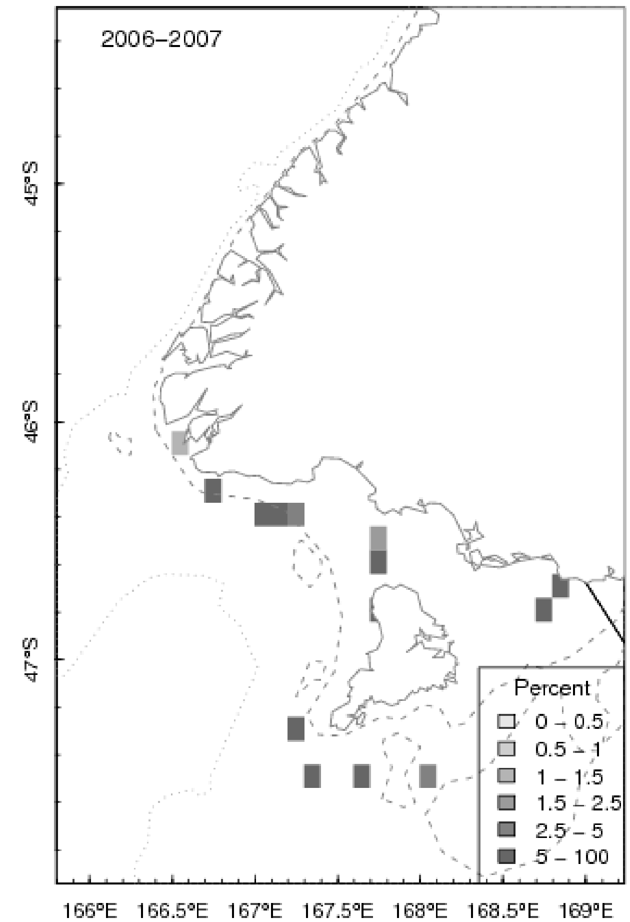



Figure E.8. Distribution of logbook catch in 2006–07 arranged in 0.1 degree cells, shaded as a percentage of the total annual catch.