Summary of blue cod catch and effort data from the BCO 3 and BCO 5 fisheries, 1989–90 to 1999–2000

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EXECUTIVE SUMMARY

This report summarises trends in the catch and effort data from the BCO 3 and BCO 5 fisheries from 1989–90 to 1999–2000. These data were used to determine recent trends in the operation of the two fisheries and the seasonal and spatial distribution of the catch from each fishstock.

The commercial catch from the BCO 5 fishery is almost exclusively taken by the target cod pot fishery operating within Foveaux Strait and around Stewart Island (Statistical Areas 025, 027, 029, and 030). Similarly, the BCO 3 commercial catch is dominated by the target pot fishery, although blue cod is also taken as a small bycatch of the inshore trawl fisheries operating within BCO 3. Most of the catch from BCO 3 is taken in the southern area of the fishstock (Statistical Area 024). Catches from the BCO 3 and 5 fishstocks peak during autumn and winter and the seasonal nature of the fishery is influenced by the operation of the rock lobster fishery as many vessels participate in both fisheries.

The BCO 3 target catch remained relatively constant from 1989–90 to 1999–2000. The total catch from the BCO 5 fishery remained relatively stable from 1982–83 to 1992–93 and subsequently increased to approach the level of the TACC in 1995–96. Catches have remained stable at this higher level in recent years. Since 1989–90, a large proportion of the total catch from the BCO 5 fishery has been taken from Foveaux Strait (Statistical Area 025) and catches from this area remained relatively stable. The recent increase in total catch has been attributable to an increase in catch from the western approaches to Foveaux Strait (Statistical Area 030) and, to a lesser extent, from off eastern Stewart Island (Statistical Area 027).

A standardised CPUE analysis for the main BCO 5 fishery (Statistical Areas 025, 027, and 030) revealed that catch rates remained stable in Statistical Areas 025 and 030 and increased in Statistical Area 027. Insufficient catch and effort data to derive CPUE indices for the other Statistical Areas supporting the BCO 5 commercial fishery. However, the three main areas currently account for about 90% of the total BCO 5 catch.

Within BCO 3, the target blue cod fishery operates in the southern area of the fishstock (Statistical Area 024). Catches and unstandardised catch rates from this area remained relatively stable throughout from 1989–90 to 1999–2000.

The analysis of recent catch and effort data suggests that current commercial catch levels from the main fishery areas of BCO 3 and BCO 5 appear to be sustainable, at least in the short term. The analysis of trends in CPUE from the target blue cod fishery currently represents the most effective method of monitoring trends in the relative abundance in BCO 5. However, the monitoring of the fishery would be improved through the collection of catch and effort data on a finer spatial scale. This would enable the extent of the main fishing areas to be defined and monitor any significant shift in the distribution of fishing effort between years. The collection of these data would be best administered through an industry based logbook programme.

1. INTRODUCTION

Blue cod (*Parapercis colias*) supports important commercial fisheries in both BCO 3 and BCO 5 (Figure 1). Limited information is available concerning recent trends in the distribution and operation of these fisheries. A characterisation of the Southland blue cod fishery was undertaken by Warren et al. (1997) incorporating a summary of the biological information and catch and effort data from the recreational and commercial fisheries. The report documented seasonal and annual trends in the commercial fishery from 1991 to 1996. Recommendations were also made concerning future monitoring of the BCO 5 fishery.

There has been limited monitoring of the blue cod fisheries in the subsequent years, while catches from the BCO 5 fishery have increased (Annala et al. 2001). In 2001, the South East Finfish Management Company contracted the Science Unit of the NZ Seafood Industry Council Ltd to undertake a characterisation of the BCO 3 and 5 commercial fisheries based on recent catch and effort data. The specific objectives of the project are as follows.

a) To determine the annual distribution of blue cod catch by fishing method, target species, Statistical Area, and month.

b) To determine the annual distribution of the bycatch of blue cod for the main target fisheries as defined based on the results of previous objective.

c) To determine trends in the effort (number of pot lifts, number of vessels, number of vessel days, etc) from the main target fishery.

d) To investigate trends in the catch rate from the target fishery (kg/pot lift or other appropriate measure).

This report documents the results of the analysis of the catch and effort data to characterise the commercial fisheries in BCO 3 and 5 for the period 1989–90 to 1999–2000. A standardised CPUE analysis was also undertaken for the target fishery in BCO 5.

2. METHODS

Annual catches from the BCO 3 and BCO 5 fisheries were summarised by month, Statistical Area, fishing method, and target species. Trends in unstandardised catch rates (catch per pot lift) were also investigated for the target blue cod pot fishery operating within each of the main Statistical Areas fished. These catch and effort data also formed the basis for the data set included in a standardised CPUE analysis of the BCO 5 fishery.

2.1 Data set

The analysis included all catch and effort data from the BCO 3 and 5 fishstocks for 1989–90 to 1999–2000. These data were provided by the Ministry of Fisheries Client Services Reporting Group (Report No. 3655). The dataset included the following components.

1. All effort records recorded in Catch Effort Landing Return (CELR) format where blue cod was caught or targeted (66 495 records). These records include the recorded fishing effort for each day of fishing during a trip and the estimated catch (greenweight) of the main species caught.

2. All landing records from the CELR format where landings of BCO 3 or BCO 5 were reported (73 709 records). These records include the weight of catch landed from the trip by processing type calculated as greenweight.

3. All trawl records recorded in Trawl Catch Effort Processing Return (TCEPR) format where blue cod was caught or targeted (383 records). These records are from larger trawl vessels and record the details of individual trawls and the estimated catch associated with the trawl.

An initial examination of the TCEPR data revealed only a few trawls reporting a catch of blue cod, representing an annual catch of 5–10 t. However, many of the records were from target fisheries operating beyond the normal habitat range of blue cod (oreo, orange roughy, and squid) and a number of records included large individual catches of blue cod. It was concluded that these data were unreliable, and all TCEPR records were excluded from the subsequent analysis. The relatively small number of records involved meant that the exclusion of these records would not unduly affect the overall summary of the catch and effort data.

For 19% of the CELR records, Statistical Area fished was reported based on the Rock Lobster Statistical Areas (see Appendix 1), mostly when the vessel caught blue cod as a bycatch from the rock lobster fishery or targeted blue cod in conjunction with the rock lobster fishery. The records were assigned to the corresponding General Statistical Area (see Appendix 2)(Table 1). For the purpose of the analysis catch from Statistical Area 026 was assumed to be from BCO 5.

For the two fishstocks, total annual catch data from the effort and landed sections of the CELR were compared with the total annual catch from the Quota Management Returns (QMR). The comparison initially identified some CELR landing records that had recorded a very large greenweight catch of blue cod. It was assumed that these records had incorrectly recorded the *Purchase Tax Invoice number from LFR* in the *Greenweight* field of the CELR and these records were excluded (4 records).

In general, the CELR estimated catch represented about 90–100% of the QMR catch from the BCO 3 fishery and 80–90% of the QMR catch from BCO 5 (Tables 2 and 3). The CELR landed catches were generally comparable with the QMR totals for both fishstocks, although in most years the CELR totals were higher than the QMRs.

2.2 Standardised CPUE analysis

A standardised CPUE analysis of the BCO 5 target potting fishery was conducted based on the methods of Vignaux (1992, 1994). The data set included all days targeting blue cod within Statistical Areas 025, 027, and 030 between 1989–90 and 1999–2000. Only the core vessels in the fishery were included in the analysis, i.e., those completing at least 3 years and 50 days (in total) in the fishery. A few records with a zero catch of blue cod were excluded from the analysis.

The standardised CPUE model included the natural logarithm of the daily blue cod catch (non-zero) as the dependent variable. The following variables were included as potential predictive variables; month, Statistical Area, unique vessel code, fishing year (all categoric variables), the number of pot lifts, and the vessel length (both as third order polynomial functions) (Table 4). Variables were included in the CPUE model in a step-wise procedure until the increase in the explanatory power of the model with the inclusion of an additional variable was less than 0.5%.

Annual indices and the associated standard error were determined following Francis (1999).

3. RESULTS

3.1 Fishery summary

Annual reported landings from the BCO 3 fishery in the early 1980s were about 80 t (Figure 2). The fishery was introduced to the Quota Management System in 1986–87 with an initial TACC of 120 t and over the subsequent years the TACC was gradually increased to reach the current level of 162 t in 1993–94 (Figure 2). Annual catches from BCO 3 have remained around the level of the TACC, or slightly below, since introduction to the QMS.

Annual catches from the BCO 5 fishery in the early 1980s were between 600 and 1000 t and the initial TACC for the fishstock was established at 1190 t in 1986–87 (Figure 2). The TACC was increased over the subsequent years to 1536 t in 1991–92 and was maintained at this level from 1991–92 to 1999–2000. Annual catches from the fishery were about 800–900 t between 1984–85 and 1991–92 and steadily increased in the subsequent years to reach the level of the TACC in 1995–96. Annual catches remained at slightly below the level of the TACC from 1996–97 to 1999–2000 (Figure 2).

Most of the catch from BCO 3 is taken from the southern region of the fishstock, within Statistical Area 024 (Table 5). This area annually accounted for 70–75% of the total catch from BCO 3 between 1989–90 and 1999–2000.

For BCO 5, most of the catch is taken within Statistical Areas 025, 030, and 027 (Table 6). From 1989–90 to 1999–2000, the former area accounted for 52% of the total BCO 5 catch. The annual catch from this area remained relatively constant throughout the period. However, the proportion of the total annual catch declined from 63% in 1993–94 to 42% in 1999–2000 with the increase in the total catch from the fishery. Most of the increase in catch occurred in Statistical Area 030 and in recent years this area accounted for about 25% of the annual BCO 5 catch. Statistical Area 027 accounted for about 15–25% of the annual catch from BCO 5 from 1989–90 to 1999–2000 (Table 6).

Most of the catch from the BCO 3 fishery is taken by cod pot, accounting for about 70% of the annual catch (Table 7). The remainder of the catch is principally taken by bottom trawl (10–20%) with a small proportion of the catch taken by line methods and from rock lobster pots.

The BCO 5 catch was almost exclusively taken by the target cod pot fishery (Tables 8 and 10) and most of the catch from BCO 3 was also taken by the target fishery (Table 9).

The BCO 3 fishery typically operates between February and May (Table 11) and the main BCO 5 fishery begins in February and extends through until July (Table 12).

3.1.1 Target fishery

From 1989–90 to 1999–2000, the target blue cod pot fishery accounted for 71% and 98% of the catch from BCO 3 and BCO 5 fisheries, respectively. These two fisheries also accounted for 74% of the CELR effort records where blue cod was reported to have been caught. These records were examined in further detail and considerable problems were identified in the reporting of fishing effort from the target fishery. For the cod pot method, fishers are required to record:
a) The total number of pot lifts in the day (effort a), and
b) The number of pots in the water at midnight at the start of the day (effort b).

A significant proportion (26%) of CELR effort records did not include the number of pots in the water at midnight and it is assumed that the null records were actually zero. There was also some apparent confusion in the completion of the recording of the effort data with the two fields transposed. This was evident in records where the number of pot lifts was significantly less (usually a multiple) of the number of pots in the water at midnight (7732 records). These records were amended, updating the number of pot lifts to the number of pots in the water at midnight.

No effort data were recorded for 280 records and 123 records did not record the catch of blue cod (null). In addition, records with more than 70 pot lifts were excluded from the target fishery data set. These records were at the upper extreme of the number of pot lifts conducted in a day of fishing.

Most of the catch from the target BCO 3 and BCO 5 fisheries is landed in the processed form, either head-and-gutted (HGU) and fillet (FIL) which collectively accounts for 70% of the total landed catch. In a number of other fisheries, the processed catch is incorrectly reported as the estimated catch in the effort section of the CELR form (). However, for the BCO 3 and BCO 5 target fisheries there is a strong correlation between the estimated greenweight catch and the landed blue cod catch (Figure 3). For target fishing trips catching at least 100 kg of blue cod, 52% of the trips recorded a combined estimated greenweight within (+/-) 10% of the total landed weight for the trip. This observation indicates that there is no consistent missreporting of the catch of blue cod in the estimated catch section of the CELR form.

The target fisheries principally operate within Statistical Areas 024, 025, 027, and 030. Catch and effort data from each of these areas were investigated in detail. The total catch and fishing effort, the number of pot lifts, days fished, and vessels was determined for each year and the annual catch rate (expressed as the average catch (kg) per pot lift for each day of fishing) was also determined (Table 14). Only vessels completing at least 3 years and 50 days fishing in the Statistical Area during the study period were included and used to calculate the annual catch rate.

Between 1989–90 and 1999–2000, the target fishery operating in Statistical Area 024 has been conducted by 16–18 vessels, although only a few vessels complete a large number of pot lifts in each year (more than 1000) (Table 14). In total, the entire target fleet conducts about 500–600 fishing days per year, representing 6000–10 000 pot lifts annually, and catches 70–80 t of blue cod. The number of pot lifts and days fished declined since 1995–96, while the target catch also declined. Annual catch rates (kg per pot lift) from the fishery were relatively constant between 1989–90 and 1994–95, but steadily increased in the subsequent years to the highest level in 1999–2000 (Figure 4).

Statistical Area 025 supports the main target blue cod fishery and accounted for an annual catch of 450–600 t between 1989–90 and 1999–2000 (Table 14). The fishery supports a core fleet of 20–30 vessels and an entire fleet of up to about 60 vessels per year. These vessels annually completed about 2000–2500 days fishing and 50 000–70 000 pot lifts during the study period. Annual catch rates were relatively constant between 1989–90 and 1995–96, increased by about 20% in 1996–97, and were maintained at the higher level until 1999–2000 (Figure 4).

Annual catches from Statistical Area 027 generally increased from about 120 t in 1991–92 to 250 t in 1999–2000 (Table 14). The fishery comprised a core fleet of about 5 vessels and a total fleet of about 20 vessels, annually. The fleet annually completed about 500 days of fishing and 12 000–20 000 pot lifts. There was a general increase in the average annual catch rate from the fishery between 1994–95 and 1999–2000, with the catch per pot lift increasing by about 200% (Figure 4).

The level of catch from the target fishery operating in Statistical Area 030 has also increased in recent years from about 100 t in 1991–92 to 250–300 t (Table 14). Before 1992–93, three vessels accounted for a significant proportion of the total annual fishing effort. In the following years 5–8 vessels have conducted at least 1000 pot lifts annually in the area. Since 1991–92, the number of days fished by the entire fleet has increased from about 400 to about 600–700 annually. There was a corresponding increase in the annual number of pot lifts, with effort peaking in 1993–94 at about 20 000 lifts and stabilising at 16 000 lifts per annum between 1997–98 and 1999–2000 (Figure 4). Annual average catch rates were relatively stable between 1989–90 and 1993–94, before increasing rapidly to peak in 1997–98 and 1998–99, before dropping in 1999–2000. The annual catch rates observed in 1997–98 and 1998–99 were substantially higher than catch rates from any of the other Statistical Areas examined.

3.2 CPUE analysis

The CPUE data set included a fleet of 117 core vessels. Most of the core vessels are within the 10–15 m length range and typically completed 15–40 pot lifts per day (Figure 5). Each fishing day typically yielded a catch of less than 250 kg of blue cod, although there was a slight increase in the proportion of larger catches (exceeding 400 kg) after 1995–96.

The step-wise regression procedure included the variables vessel code ($r^2 = 38.1\%$), number of pot lifts ($r^2 = 54.2\%$), and fishing year ($r^2 = 55.7\%$) (Table 15).

The polynomial function predicting the relationship between daily catch and the number of pot lifts approximated a positive linear relationship between the two variables.

The annual indices derived from the model were relatively constant from 1989–90 to 1994–95 period, increased by about 50% between 1994–95 and 1997–98, and were maintained at the higher level during the remainder of the study period (Table 16 and Figure 6). The model residuals reveal a reasonable fit to the data although the extreme values depart from the assumption of normality (see Figure 8)

There was some concern that the large increase in recent years may be influenced by changes in the spatial distribution of the fishery. This was examined in the context of the CPUE model by the inclusion of the Statistical Area variable. The resulting CPUE model yielded considerably different annual indices from the previous model. The annual indices showed only a slight increase in catch rates (about 2%) over the entire period, although the extent of the increase was not statistically significant. The interaction between Statistical Area and fishing year was also examined, and revealed that the slight increase in catch rate was consistent over the three Statistical Areas included in the analysis.

However, when the data from the three Statistical Areas were fitted in separate models there was a clear difference in the annual indices derived for Statistical Area 027 compared with the other two areas. Standardised catch rates from both 025 and 030 remained relatively constant during

the period, while catch rates from 027 almost trebled between 1989–90 and 1999–2000 (see Figure 7). The differences in annual indices from the combined CPUE model indicates differences in the paramaterising of the significant variables between the separate models.

This result indicates that considerable caution is required before amalgamating the data by Statistical Areas as the operation of the fishery may vary between areas. The recent increase in standardised catch rates in Statistical Area 027 corresponds with a small increase in the duration of target BCO 5 fishing trips since 1993–94 (Table 17). This suggests that the spatial distribution of the fishery has expanded in recent years and has contributed to the increase in catch rates.The lack of spatial definition of the catch and effort data in the CELR format prevents such trends from being examined in greater detail.

4. DISCUSSION

The BCO 3 and BCO 5 fisheries are dominated by the target pot fishery. The analysis of trends in CPUE from the target blue cod fishery currently represents the most effective method of monitoring trends in the relative abundance of BCO 5.

The current analysis reveals standardised CPUE within BCO 5 has remained stable in Statistical Areas 025 and 030 and increased in Statistical Area 027. There are insufficient catch and effort data to derive CPUE indices for the other Statistical Areas supporting the BCO 5 commercial fishery. However, the three main areas currently account for some 90% of the total BCO 5 catch.

The analysis indicates that it is appropriate to monitor the fishery at the spatial scale of a Statistical Area. However, significantly different trends in catch rate may exist between Statistical Areas. This inference is supported by results from a tagging study of blue cod in Foveaux Strait that revealed relatively low rates of movement of tagged fish between Statistical Areas, although considerable movement of tagged fish was observed within an individual Statistical Area (Carbines & McKenzie 2001).

There may also be an opportunity to use CPUE data to monitor trends in relative abundance for the southern area of BCO 3 (Statistical Area 024), although the target fishery in the area is considerably smaller than BCO 5 and, consequently, less data are available. Nevertheless, catches and unstandardised catch rates from this area remained relatively stable from 1989–90 to 1999–2000.

The analysis of recent catch and effort data suggests that current commercial catch levels from the main fishery areas of BCO 3 and BCO 5 appear to be sustainable, at least in the short term.

Trends in CPUE from the blue cod fishery may be influenced by changes in the distribution of fishing effort, in particular the extension of the fishery to new areas that were previously unfished. This may explain the recent large increase in catch rates from BCO 5 within Statistical Area 027. Trends in catch rate will also be influenced by changes in the efficiency of the fishing operation due to improvements in fishing gear and fishing experience. There have also been recent changes in the management of the BCO 5 fishery with the introduction of a minimum mesh size (of 48 mm) for cod pots in 1994 (Warren et al. 1997).

The current level of reporting for the blue cod fishery (CELR format) does not have sufficient spatial definition to determine changes in the distribution of fishing below the level of the broad Statistical Areas. The credibility of any CPUE analysis would be increased with the collection of

catch and effort data on a finer spatial scale. This would enable the extent of the main fishing areas to be defined and monitor any significant shift in the distribution of fishing effort between years. The collection of these data would be best administered through an industry based logbook programme.

5. ACKNOWLEDGMENTS

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Table 1: Assignment of blue cod CELR records from Rock Lobster Statistical Areas to General Statistical Areas.

Rock Lobster Statistical Area	General Statistical Area
917	018
918	022
919	022
920	024
921	026
922	026
923	025
924	027
925	029
926	030
927	031

Table 2: Annual catch (tonnes) reported from the BCO 3 fishery from CELRs (estimated catch and landed catch) and QMRs. The estimated catch from the CELRs is also presented as a percentage of the total QMR catch.

Fishing year	Total catch (t)			Percent
	Est. Catch	Landed	QMR	
1989–90	93	122	121	77
1990–91	125	146	144	87
1991–92	141	158	135	104
1992–93	148	189	171	87
1993–94	137	158	142	96
1994–95	154	214	155	99
1995–96	154	183	158	97
1996–97	144	180	156	92
1997–98	154	199	163	94
1998–99	139	197	150	93
1999–2000	145	174	168	86

Table 3: Annual catch (tonnes) reported from the BCO 5 fishery from CELRs (estimated catch and landed catch) and QMRs. The estimated catch from the CELRs is also presented as a percentage of the total QMR catch.

Fishing Year	Total catch (t)			Percent
	Est. catch	Landed	QMR	
1989–90	813	927	928	88
1990–91	946	1103	1096	86
1991–92	754	890	873	86
1992–93	883	1024	1029	86
1993–94	976	1112	1132	86
1994–95	1050	1247	1218	86
1995–96	1218	1603	1503	81
1996–97	1079	1423	1326	81
1997–98	1132	1413	1364	83
1998–99	1179	1673	1470	80
1999–2000	1135	1377	1357	84

Table 4: Summary of the variables tested in the regression model. The numbers in parentheses are the number of categories.

Variable	Type	Description
Month	Categorical (12)	Month of the year
Vessel	Categorical (117)	Vessel code number
Fishing year	Categorical (11)	Fishing year
Stat area	Categorical (3)	Statistical Area fished
Pot lifts	Polynomial	Number of pot lifts completed in day

Table 5: Percentage distribution of BCO 3 catch by Statistical Area and fishing year from 1989–90 to 1999–2000.

Fishing Year	018	019	020	021	022	023	024	Catch (t)
1989–90	15.5	1.1	2.8	5.4	6.5	0.4	68.3	93
1990–91	4.9	1.6	0.6	4.2	6.4	0.0	82.4	125
1991–92	8.5	0.0	12.5	3.5	8.1	0.8	66.5	141
1992–93	15.7	1.2	3.1	1.0	1.8	7.8	69.5	148
1993–94	7.7	0.7	1.7	0.4	5.9	4.8	78.8	137
1994–95	6.5	0.4	6.6	1.6	10.0	7.5	67.4	154
1995–96	7.6	2.1	11.6	1.2	2.0	0.7	74.8	154
1996–97	8.1	0.0	8.7	2.5	0.7	1.4	78.6	144.
1997–98	10.2	0.3	10.3	4.5	2.0	0.6	72.1	154
1998–99	11.4	0.7	8.2	5.0	5.2	1.0	68.5	139
1999–2000	12.5	8.9	13.6	2.2	3.3	0.3	59.1	145
Total	9.7	1.6	7.5	2.8	4.6	2.4	71.4	

Table 6: Percentage distribution of BCO 5 catch by Statistical Area and fishing year from 1989–90 to 1999–2000.

Fishing Year	025	026	027	028	029	030	031	032	Catch (t)
1989–90	57.1	1.2	24.1	0.1	2.3	15.0	0.3	0.0	813
1990–91	62.5	2.6	22.5	0.0	0.8	11.4	0.1	0.1	946
1991–92	58.9	2.5	16.5	0.1	6.1	15.6	0.4	0.0	754
1992–93	60.1	2.4	15.9	0.0	2.6	18.2	0.3	0.6	883
1993–94	62.8	1.8	13.5	0.0	1.1	20.1	0.6	0.1	976
1994–95	54.2	2.0	14.9	0.1	3.1	23.8	2.0	0.1	1 050
1995–96	48.8	2.8	19.4	0.0	3.9	21.7	3.3	0.1	1 218
1996–97	48.4	3.9	17.6	0.8	4.8	21.7	2.2	0.6	1 079
1997–98	42.1	1.7	22.6	0.3	2.6	26.3	4.0	0.4	1 132
1998–99	45.1	1.5	18.4	0.2	3.4	29.3	1.7	0.5	1 179
1999–2000	43.7	1.1	23.7	0.4	3.2	22.8	4.5	0.7	1 135
Total	52.2	2.1	19.1	0.2	3.1	21.1	1.9	0.3	

Table 7: Percentage distribution of BCO 3 catch by fishing method and fishing from 1989–90 to 1999–2000. Line methods include hand lines, bottom longlines, and drop lines.

| Fishing Year | | | | Fishing method | | Catch |
	Bottom trawl	Cod pot	Rock lobster pot	Line	Other	(t)
1989–90	16.7	59.4	16.9	5.8	1.2	93
1990–91	10.5	73.7	7.5	6.4	2.0	125
1991–92	16.7	68.9	6.3	3.9	4.2	141
1992–93	16.2	63.2	7.7	5.8	7.1	148
1993–94	19.3	69.7	3.7	3.3	4.1	137
1994–95	18.3	68.5	4.8	4.3	4.1	154
1995–96	8.0	79.6	7.0	3.1	2.3	154
1996–97	11.9	78.0	6.9	1.3	1.9	144
1997–98	20.4	70.5	4.2	1.8	3.2	154
1998–99	18.7	69.2	3.3	6.9	1.9	139
1999–2000	20.8	68.6	3.2	4.1	3.4	145
Total	16.1	70.3	6.1	4.1	3.3	

Table 8: Percentage distribution of BCO 5 catch by fishing method and fishing year from 1989–90 to 1999–2000. Line methods include hand lines, bottom longlines, and drop lines.

| Fishing Year | | | | Fishing method | | Catch |
	Bottom trawl	Cod pot	Rock lobster pot	Line	Other	(t)
1989–90	0.8	94.4	2.4	2.3	0.1	813
1990–91	0.6	96.6	1.1	1.5	0.2	946
1991–92	0.5	96.4	2.1	0.9	0.0	754
1992–93	0.6	97.5	1.3	0.5	0.0	883
1993–94	1.0	97.6	0.8	0.6	0.0	976
1994–95	0.2	99.1	0.4	0.2	0.1	1 050
1995–96	0.6	97.3	1.5	0.4	0.2	1 218
1996–97	0.6	97.4	1.6	0.4	0.0	1 079
1997–98	1.4	96.8	1.4	0.4	0.0	1 132
1998–99	0.6	96.9	1.9	0.5	0.1	1 179
1999–2000	0.4	98.6	0.7	0.3	0.0	1 135
Total	0.7	97.2	1.4	0.7	0.1	

Table 9: Percentage distribution of BCO 3 catch by target species and fishing year from 1989–90 to 1999–2000. The target species codes are as follow: BCO, blue cod; CRA, rock lobster; FLA, flatfish; LIN, ling; RCO, red cod.

| Fishing | | | | | Target species | | Catch |
Year	BCO	CRA	FLA	LIN	RCO	Other	(t)
1989–90	63.8	16.5	7.1	1.1	0.9	10.6	93
1990–91	73.0	6.2	2.4	8.0	5.8	4.6	125
1991–92	62.7	6.2	3.5	10.1	10.0	7.5	141
1992–93	70.7	7.6	8.1	3.0	3.7	7.0	148
1993–94	72.0	3.6	8.6	1.0	7.6	7.2	137
1994–95	71.6	4.7	4.4	1.5	11.8	5.9	154
1995–96	79.8	6.8	4.1	0.7	2.8	5.9	154
1996–97	75.7	4.5	8.1	5.9	1.8	4.1	144
1997–98	68.2	3.7	9.5	5.5	7.0	6.0	154
1998–99	70.3	4.1	9.6	5.2	3.4	7.4	139
1999–2000	67.1	3.1	8.6	3.5	2.3	15.3	145
Total	70.7	5.8	6.8	4.1	5.3	7.3	

Table 10: Percentage distribution of BCO 5 catch by target species and fishing year from 1989–90 to 1999–2000. The target species codes are as follow: BCO, blue cod; CRA, rock lobster; FLA, flatfish; LIN, ling; RCO, red cod.

| Fishing | | | | | Target species | | Catch |
Year	BCO	CRA	FLA	LIN	RCO	Other	(t)
1989–90	97.0	2.3	0.2	0.0	0.0	0.5	813
1990–91	98.3	1.1	0.0	0.1	0.0	0.5	946
1991–92	97.7	1.9	0.0	0.0	0.0	0.3	754
1992–93	98.2	1.2	0.1	0.0	0.0	0.5	883
1993–94	98.3	0.7	0.2	0.0	0.0	0.9	976
1994–95	99.2	0.4	0.0	0.0	0.0	0.4	1 050
1995–96	98.7	0.4	0.1	0.0	0.0	0.7	1 218
1996–97	98.2	0.9	0.2	0.0	0.0	0.7	1 079
1997–98	97.5	0.7	1.2	0.0	0.0	0.5	1 132
1998–99	98.0	1.1	0.4	0.0	0.1	0.4	1 179
1999–2000	98.7	0.6	0.2	0.0	0.1	0.4	1 135
Total	98.2	1.0	0.3	0.0	0.0	0.5	

Table 11: Percentage distribution of BCO 3 catch by month and fishing year, 1989–90 to 1999–2000.

Fishing Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Month Sep
1989–90	1.9	7.7	4.8	7.8	9.4	17.5	14.5	13.4	4.7	5.4	5.3	7.6
1990–91	6.8	2.4	1.8	3.5	8.1	14.1	28.8	20.8	3.3	2.9	2.9	4.7
1991–92	4.1	2.7	2.2	4.9	16.8	14.3	16.4	11.6	13.4	7.4	2.2	4.0
1992–93	2.8	2.7	1.7	3.4	7.3	8.2	27.6	19.1	12.8	7.8	1.8	4.9
1993–94	3.8	1.7	5.6	6.4	10.6	12.5	17.4	17.2	5.3	2.7	5.6	11.2
1994–95	3.1	5.2	5.3	8.0	10.5	24.5	8.7	15.9	2.6	2.4	6.2	7.8
1995–96	3.8	3.7	2.7	2.2	8.3	16.3	24.9	17.5	4.3	3.9	5.4	7.0
1996–97	2.8	2.8	3.7	4.4	5.0	12.9	19.5	21.8	8.6	9.2	4.0	5.3
1997–98	2.5	5.1	2.4	8.7	10.5	10.2	12.8	15.8	10.1	8.4	4.9	8.5
1998–99	3.3	2.4	4.5	5.0	13.6	14.6	15.6	10.1	8.9	5.5	7.2	9.3
1999–2000	4.3	7.2	9.2	10.7	8.0	15.3	13.4	14.1	4.1	5.5	2.9	5.3
Total	3.6	3.9	4.0	5.9	9.8	14.5	18.1	16.2	7.2	5.6	4.4	6.9

Table 12: Percentage distribution of BCO 5 catch by month and fishing year, 1989–90 to 1999–2000.

Fishing Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Month Sep
1989–90	1.5	2.4	2.2	2.2	6.5	7.6	12.8	7.4	19.5	19.4	11.3	7.2
1990–91	3.2	5.1	1.4	4.5	4.6	18.1	12.2	13.4	14.2	12.4	5.4	5.6
1991–92	3.5	6.0	5.5	5.4	4.4	3.6	14.9	14.1	18.2	10.3	5.7	8.4
1992–93	3.5	4.5	2.8	2.4	9.6	9.0	15.4	10.7	8.3	19.3	7.7	6.8
1993–94	4.9	5.6	4.5	7.3	13.6	10.7	8.3	13.6	12.7	7.3	4.2	7.1
1994–95	3.6	2.3	3.7	6.3	7.1	8.7	13.6	14.3	11.3	13.5	8.4	7.2
1995–96	3.1	5.2	4.6	8.0	7.2	13.5	15.1	7.7	13.8	10.3	5.3	6.3
1996–97	2.5	3.3	5.3	9.4	9.7	11.3	9.8	15.1	10.0	9.3	7.2	6.9
1997–98	2.7	1.4	4.2	6.2	9.6	8.4	10.3	12.8	16.9	13.6	7.5	6.3
1998–99	3.5	7.1	3.1	9.5	12.0	10.3	14.1	6.0	9.2	12.6	5.4	7.5
1999–2000	4.5	5.0	4.1	8.7	5.0	12.5	8.5	13.7	12.8	14.8	5.4	5.2
Total	3.3	4.4	3.8	6.6	8.2	10.6	12.2	11.6	13.1	12.8	6.6	6.7

Table 13: Percentage of the BCO 3 and BCO 5 landed catch (green weight equivalent) landed from the target fishery by the main processing types for the 1989–90 to 1999–2000 fishing years combined. The current conversion factor for each processing type is also given.

State code	Conversion factor	Fishstock		Total
		BCO 3	BCO 5	
HGU	1.4	66.8	44.4	46.0
FIL	1.7	6.6	24.9	23.6
GUT	1.15	8.8	10.8	10.7
DRE	1.7	5.3	9.8	9.4
GGU	1.15	4.0	4.2	4.2
GRE	1	5.9	3.8	4.0
Other		2.6	2.2	2.2

Table 14: Summary of catch (t), number of pot lifts, number of days fished for the target blue cod cod pot fishery for the main Statistical Areas fished. The number of vessels completing at least 100 pot lifts and at least 1000 lifts in each Statistical Area is also given.

Stat area	Fishing year	Catch	No. of pot lifts	Days fished	Number of vessels 100+ lifts	Number of vessels 1000+ lifts	Catch rate kg/lift	Catch rate Std. dev	n.
024	1989–90	47.1	6848	416	18	0	10.2	15.0	321
	1990–91	81.0	10723	498	23	1	12.1	18.1	369
	1991–92	69.1	9098	461	19	1	10.1	15.1	404
	1992–93	78.9	9819	526	18	1	9.5	12.1	514
	1993–94	88.8	12791	585	18	4	9.2	15.0	543
	1994–95	87.7	9604	590	17	2	9.8	9.9	573
	1995–96	104.7	9546	684	18	1	12.3	18.1	656
	1996–97	87.4	8368	637	17	1	10.6	10.4	606
	1997–98	79.6	8303	627	14	2	11.8	29.2	595
	1998–99	73.5	6489	492	16	0	13.0	19.4	415
	1999–2000	60.7	6189	505	12	1	14.0	19.0	359
025	1989–90	447.7	50596	1989	50	20	10.0	11.9	1839
	1990–91	579.2	74537	2922	62	28	8.7	8.8	2742
	1991–92	442.9	61398	2346	62	21	8.3	8.4	2259
	1992–93	527.4	71476	2681	64	27	8.7	9.6	2585
	1993–94	606.8	78865	2923	66	33	8.8	9.7	2739
	1994–95	567.7	69799	2654	61	23	8.6	11.1	2426
	1995–96	585.0	66661	2667	56	28	9.2	13.0	2478
	1996–97	515.8	54821	2333	54	20	11.9	14.6	2159
	1997–98	466.0	48039	1913	46	20	11.6	14.4	1793
	1998–99	524.1	54808	2185	49	20	12.2	14.5	2072
	1999–2000	492.1	52422	2194	42	16	12.3	13.7	2158
027	1989–90	187.2	16345	632	22	7	14.7	23.9	429
	1990–91	211.5	21731	750	21	7	9.5	7.3	637
	1991–92	122.9	10303	479	22	3	10.4	9.4	411
	1992–93	139.3	12396	520	23	2	12.0	12.1	480
	1993–94	130.3	12703	436	16	4	11.4	9.9	330
	1994–95	155.0	12559	464	19	4	10.3	6.2	325
	1995–96	231.1	15767	565	19	5	14.8	19.5	456
	1996–97	186.3	12155	438	22	4	17.0	19.3	385
	1997–98	253.5	18866	630	20	7	13.2	14.6	537
	1998–99	211.6	15435	561	21	5	16.2	15.4	477
	1999–2000	268.6	16205	545	21	5	20.6	43.0	488
030	1989–90	108.8	8560	286	16	3	13.7	12.2	213
	1990–91	95.0	9791	378	17	3	12.6	16.6	307
	1991–92	95.2	11950	408	20	3	10.3	11.2	324
	1992–93	149.9	18240	679	23	5	10.9	12.8	492
	1993–94	185.1	20803	733	23	8	11.5	10.3	536
	1994–95	244.8	20564	774	22	7	18.6	19.5	595
	1995–96	250.4	19354	705	25	6	18.3	18.6	576
	1996–97	225.0	15038	546	18	5	22.9	26.2	481
	1997–98	283.2	16396	615	26	5	28.2	29.4	505
	1998–99	325.1	16364	664	27	6	28.5	33.5	497
	1999–2000	250.4	16360	577	22	7	19.6	20.0	456

Table 15: Variables included in the stepwise regression for the CPUE model in order of importance.

Variable	Percent of deviance
Vessel	38.1
Pot lifts	54.2
Fishing year	55.7

Table 16: Year indices with standard deviation and regression coefficients for the BCO 5 CPUE model, n = number of records.

Fishing year	n	Regression coefficient	Canonical index	Std error	Year index	Lower bound	Upper bound
1989–90	2 468	0.10	-0.086	0.013	0.918	0.89	0.94
1990–91	3 673	0.00	-0.184	0.011	0.832	0.81	0.85
1991–92	2 984	0.04	-0.147	0.012	0.863	0.84	0.88
1992–93	3 544	0.07	-0.113	0.011	0.893	0.87	0.91
1993–94	3 589	0.06	-0.119	0.011	0.888	0.87	0.91
1994–95	3 327	0.10	-0.087	0.011	0.916	0.90	0.94
1995–96	3 349	0.21	0.029	0.011	1.029	1.01	1.05
1996–97	2 892	0.32	0.138	0.012	1.148	1.12	1.18
1997–98	2 608	0.39	0.205	0.012	1.228	1.20	1.26
1998–99	2 882	0.37	0.190	0.012	1.210	1.18	1.24
1999–2000	3 020	0.36	0.172	0.012	1.188	1.16	1.22

Table 17: Mean duration (days) of target fishing trips within the BCO 5 fishery by fishing year. Trip duration is defined as the number of days between the start and end of fishing. The number of records represents the number of qualifying fishing trips.

Fishing year	Trip duration (days)	Number of records
1989–90	1.27	2 027
1990–91	1.23	3 111
1991–92	1.28	2 456
1992–93	1.26	2 802
1993–94	1.24	2 853
1994–95	1.34	2 599
1995–96	1.35	2 664
1996–97	1.35	2 337
1997–98	1.35	2 004
1998–99	1.36	2 302
1999–2000	1.38	2 270
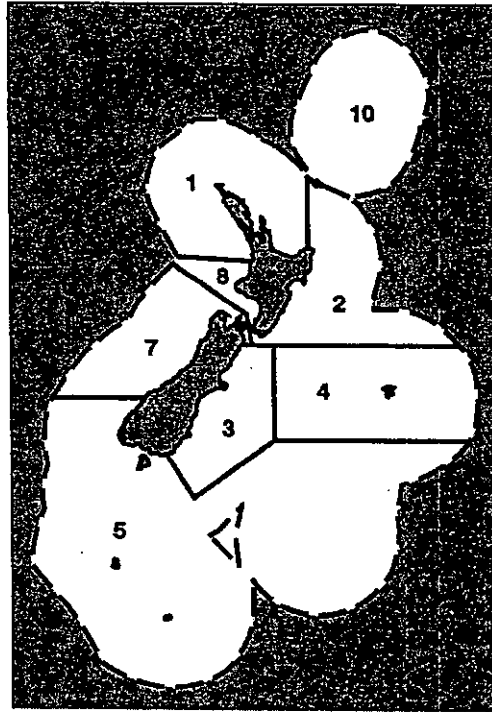
Figure 1: Fishstock areas for blue cod (source, Annala et al. 2001).
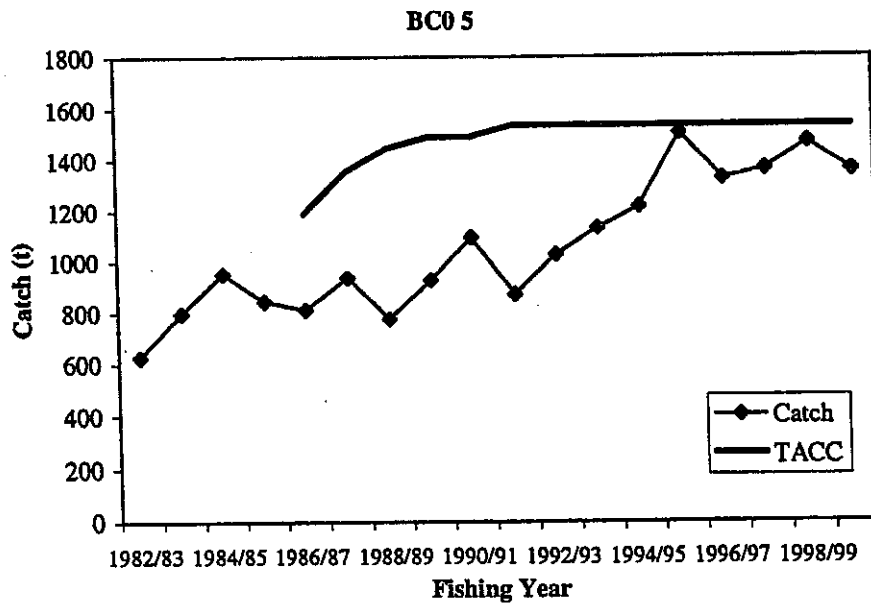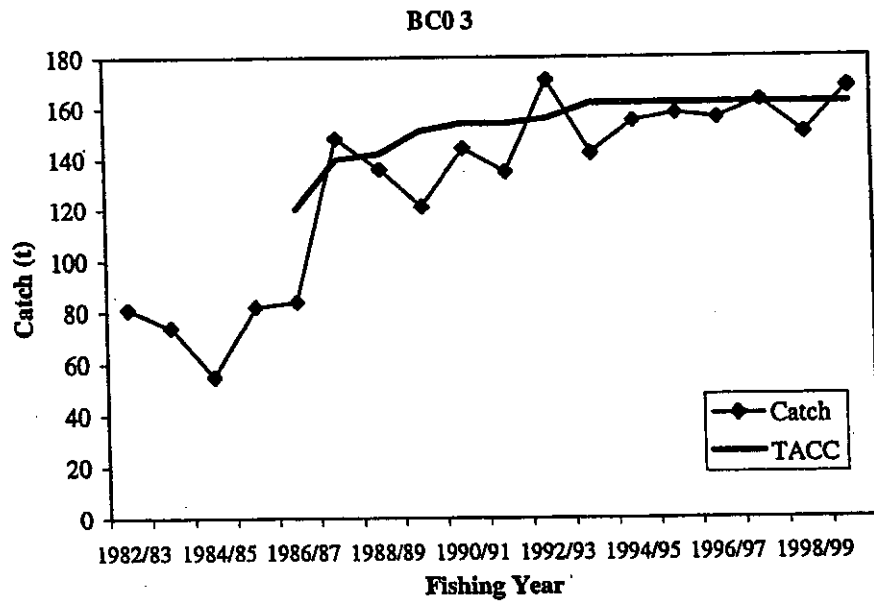
Figure 2: Annual catch and TACC for the BCO 3 (top) and BCO 5 (bottom) fishstocks.
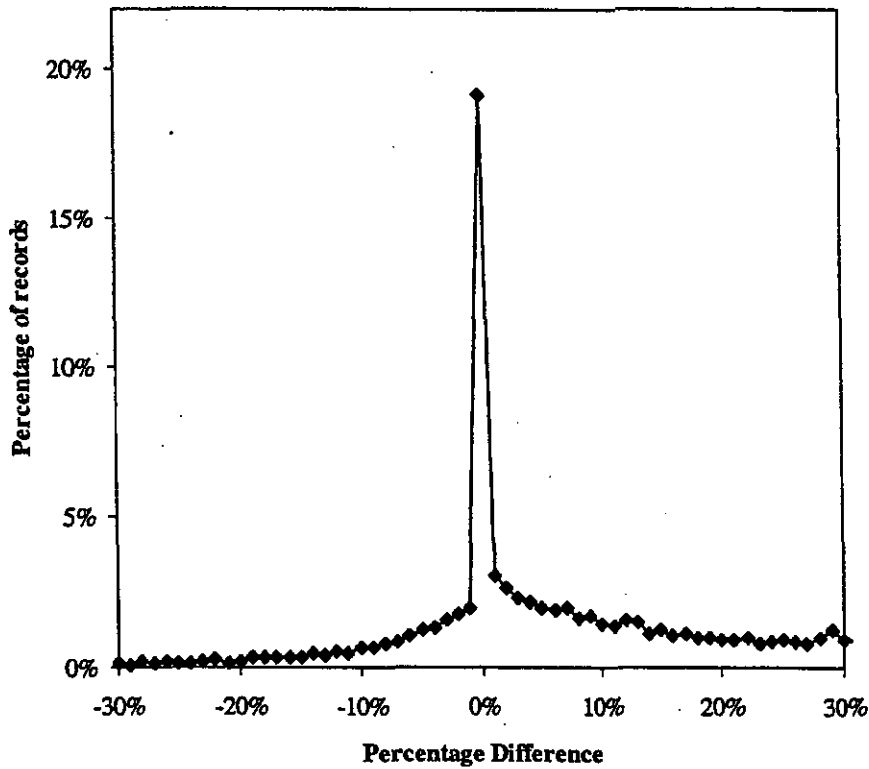
Figure 3: Percentage difference between the landed green weight of blue cod and the cumulative estimated green weight for an individual fishing trip for all target cod pot (CP) fishing trips where at least 100 kg blue cod landed and recorded as estimated catch. Includes all trips between 1989–90 and 1999–2000, BCO 3 and BCO 5 combined (number of trips, 24 316). The percentage difference was calculated as 1- estimated catch/landed catch.
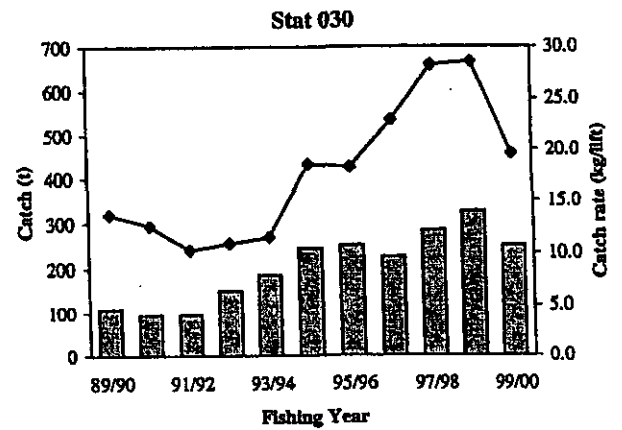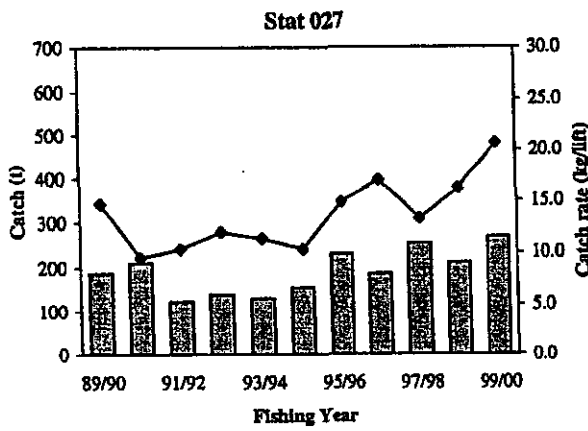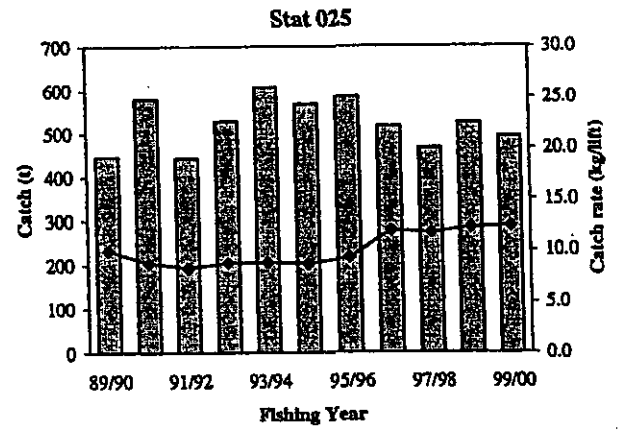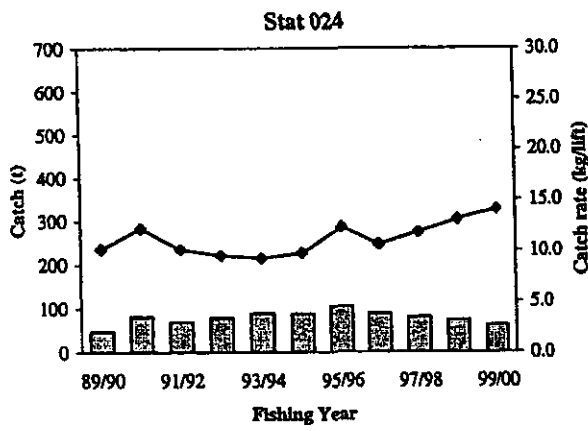
Figure 4: Annual trends in total catch and catch rate (average weight per pot lift) from the target blue cod fishery operating in the main Statistical Areas within BCO 3 and BCO 5, 1989–90 to 1999–2000. The bar represents the annual catch (t) and the line represents the catch rate.
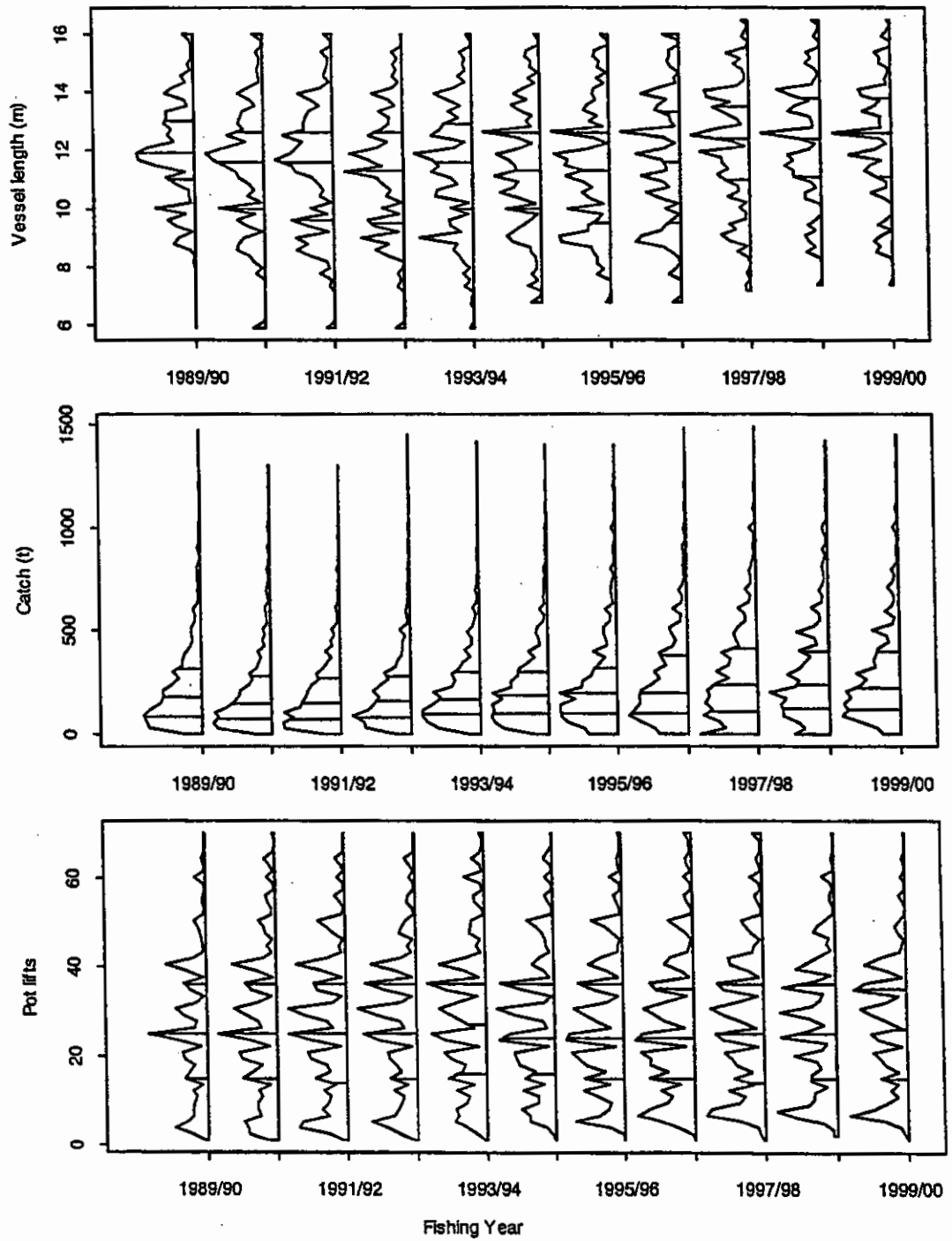
Figure 5: Summary of CPUE data from the target blue cod fishery operating in Statistical Areas 025, 027, and 030 for core vessels in fishery.
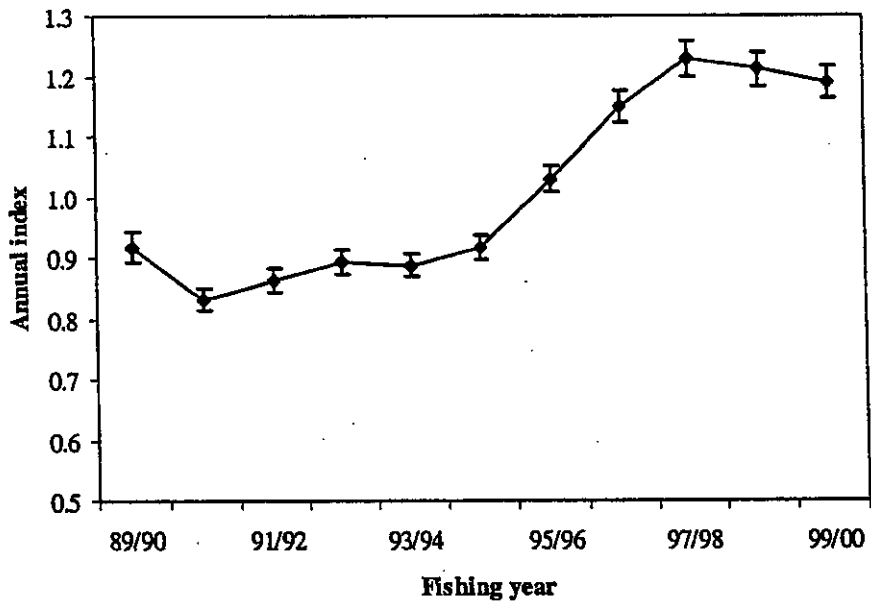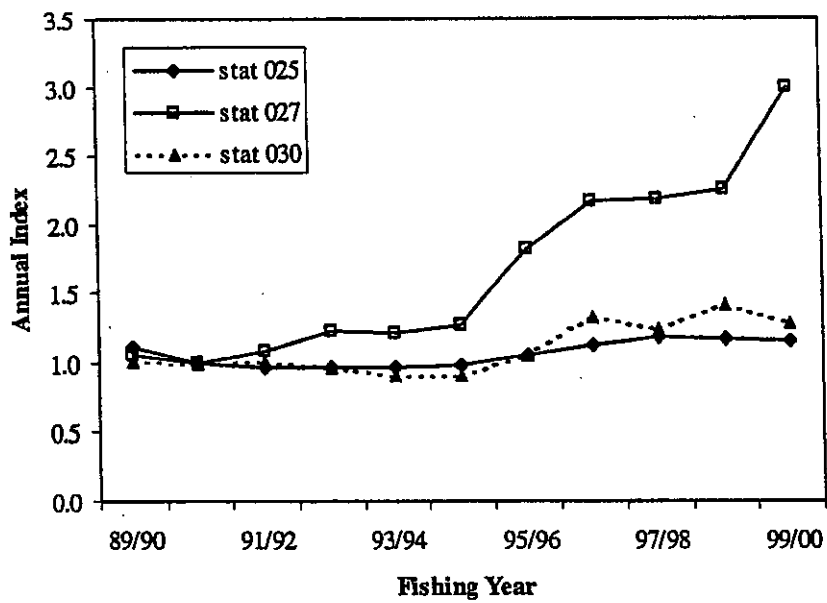
Figure 6: Annual indices from the BCO 5 standardised CPUE model.

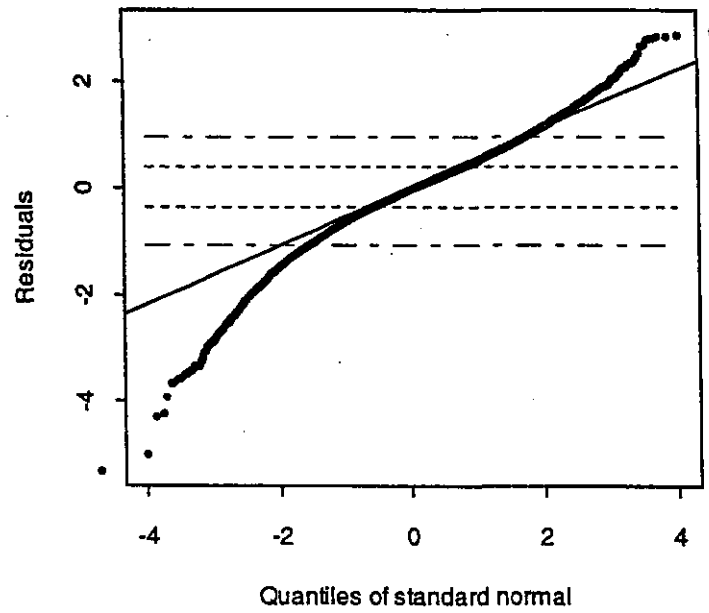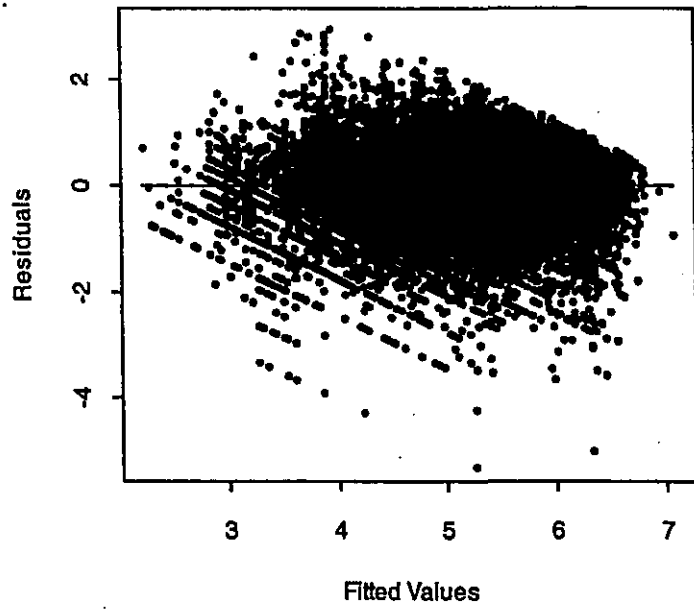Figure 7: Annual indices for main Statistical Areas of BCO 5 from individual CPUE models.
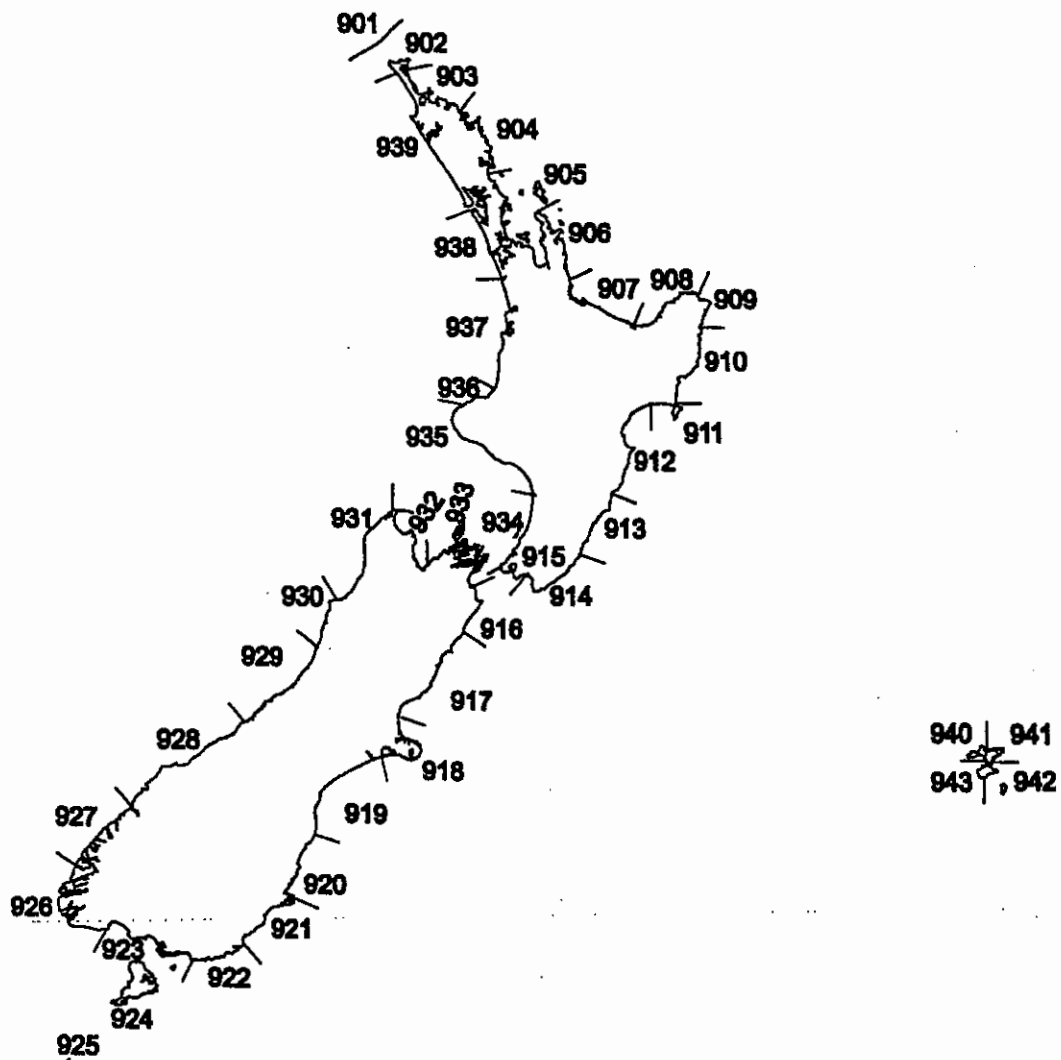
Figure 8: Residual plot (top) and quantile-quantile plot (bottom) for the BCO 5 CPUE model. The dashed lines on the quantile-quantile plot represent the 5%, 25%, 75%, and 95% quantiles of the fitted data.

Appendix 1. Map of Rock Lobster Statistical Areas

MFish Boundaries
General Stat Areas and FMAs

MINISTRY OF FISHERIES
Te Tautiaki i nga tini a Tangaroa

Auckland Harbour Inset