Science Policy

NIWA

Taihoro Nukurangi

Determination of movement of blue cod in Southland

Glen Carbines

Final Research Report for
Ministry of Fisheries Research Project BCO9702

National Institute of Water and Atmospheric Research

October 1998

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Report Title Determination of movement of blue cod in Southland

Author Glen Carbines

1. **Date** 30 September 1998

2. **Contractor** National Institute of Water and Atmospheric Research Limited

3. **Project Title** Determination of movement of blue cod in Southland

4. **Project Code** BCO9702

5. **Project Leader** Glen Carbines

6. **Duration of Project**

   Start date: 1 October 1997
   Completion date: 30 September 1999

7. **Executive Summary**

Movement patterns of blue cod are currently unclear, and it has not been established if blue cod can be regarded as a single stock within some of the present fish stock areas. The current study sought to determine movement of blue cods in Southland (BCO5), which accounts for 57% of all New Zealand blue cod quota.

Determining the final design of the tagging programme began in October 1997. A balanced stratified series of replicated sites within strata spread throughout domestic return area 025 was chosen and is presented. Based on the results of a previous tagging feasibility study, ten thousand 1.5 cm yellow T-bar tags from Hallprint PTY. Ltd (Australia) were used. All tags carry an individual identification number and the words "REWARD – NIWA, P.O. Box 6414 DUNEDIN".

Two commercial fishing boats were chartered from Bluff (FV Rex and FV Roseanne) and accompanied by NIWA staff to tag fish. Tagging commenced earlier than planned because of concerns over the El Nino event, but was completed within budget over a total of 15 fishing days per vessel (n=2). By the end of March 1998, 9368 blue cod had been tagged over nine discreet sites within domestic fishing return area 025.

In addition to the spatial stratification in the design of the programme, another variable soon became apparent during fishing and three distinctly different bottom types were identified throughout sites. Tagged fish ranged in size from 140–510 mm total length with a mean of 324.58 ± 0.52. Length frequency distributions are given for the three strata and bottom types are presented.

To encourage the return of fish, and the integrity of their catch data, a reward system of T-shirts and a prize lottery was used. A popular article outlining the tagging program, rewards, and return procedures was published in the commercial magazine *Seafood New Zealand* and reported in the *Southland Times* news paper.

Currently, after five months at liberty, 212 of the 9368 tagged blue cod have been returned (2.26%). Blue cod have been returned from all sites and most bottom types within those sites. Numbers of returns varied greatly between sites and between strata. Most returns have come from the Stewart Island strata (n=96), then the New Zealand strata (n=82) and least from the Foveaux Straight strata (n=34).

To date the maximum distance travailed was 64 km, but most fish travelled a mean of approximately 2 km and a median of 640 meters. Fish tagged in the Stewart Island strata seem to be moving slightly further than others, and the smallest distances moved were of fish tagged around rock.

The next phase of the programme will involve the continued returning of tagged fish over another one-year period before the production of a final report in September 1999.

8. Objectives

1. To design a tagging programme to determine movements of blue cod in domestic fishing return areas 025 and 030 in Southland.

2. To complete the tagging phase of the programme.

3. To begin the recovery phase of the programme.

Introduction

Blue cod (*Parapercis colias*) are endemic to New Zealand. They are not a true cod but a member of the weaver family (Pinguipedidae), of which 43 species are described throughout the Indo-Pacific region. Overseas studies of species of the genus *Parapercis* have shown them to hold long term stable territories, and to be short ranging (Stroud, 1984; Kobayashi *et al*, 1993a & b). However, movement patterns of blue cod are unclear (Rapson, 1956; Mace & Johnson, 1983; Mutch, 1983) and it has not been established if blue cod can be regarded as a single stock within some of the present fish stock areas (Warren, *et al*, 1997).

The current study sought to determine movement of blue cod in Southland (BCO5), which accounts for 57% of New Zealand blue cod quota.

Blue cod distribution and movement

Blue cod are distributed from the shore to the shelf edge around New Zealand's entire coastline, but they are most abundant around Southland and the Chatham Islands. Found on reef edges, on shingle/gravel or sandy bottoms, often close to rocky outcrops, they are bottom dwelling carnivores. Although they are most commonly found shallower than 150 m, deep-water trawlers have reported catches of blue cod from depths over 350 m (Carbines, 1996b). However, like most reef fish (Jones, 1988) blue cod are not evenly distributed throughout these habitats and several biological and physical factors appear to influence their distribution. To further complicate matters, the proportional effects of these factors varies with the age of the fish (Mutch, 1983).

From anecdotal information (Rapson, 1956), and observations of the distribution of pelagic blue cod eggs (Robertson, 1973), it is believed that most spawning and settlement occurs in relatively deep offshore areas. Newly recruited blue cod are then thought to remain in up to 100 m depth until they reach a size of 18–20 cm when they move inshore (Rapson, 1956). It has also been shown that densities of localised adult blue cod are temporally stable on a long term scale and their distribution is inversely related with macro-algae abundance (Mutch, 1983).

As with other members of the family Pinguipedidae (Stroud, 1984; Kobayashi *et al*, 1993a & b), large male blue cod have been shown to be territorial, holding large and rather loose territories (Mutch, 1983). In Northland, Mutch (1983) found that home ranges increase with the size of the individual holding the territories and that small social groups exist with the home range of large dominant males encompassing the home ranges of 3–5 females. Younger blue cod appear to have a more transient existence and may form spawning aggregations, though this would be an unusual event for a reef fish (Warren *et al*, 1997).

Blue cod management

As for all quota management species, separate fishstocks of blue cod have been designated (10 in the case of blue cod) to allow for more effective management. Each fishstock is defined by its own quota management area (e.g. BCO5) within which are a number of domestic fishing return areas (e.g. seven for BCO5, Fig 1).

For the purposes of management, it is assumed that fish in each fishstock intermingle and breed. In reality, there may be more, smaller blue cod "stocks" which may necessitate modifications to the management arrangements currently in place. Further information on the movements of blue cod should therefore be aimed at determining the most appropriate scale for management of this species.

The Ministry of Fisheries tender BCO9702 therefore called for a comprehensive tagging programme to determine movement information for Southland blue cod (BCO5).

Previous Attempts to Tag Blue Cod

The first major blue cod tagging programmed involved button-tagging of 5050 fish in the inner and outer Marlborough Sounds during 1940 and 1941 (Rapson, 1956). However, only 194 (3.8%) of these fish were recaptured, 83 within 3 months, 62 between 3 and 6 months and 49 after 6 months. This recapture rate was too small to enable any firm conclusions to be made.

During the early 1970s, another 2430 blue cod were dorsally anchor tagged at 110 stations in the Marlborough Sounds (Mace & Johnson, 1983). Tag shedding rates, as indicated by double tagging, were high and only 84 fish (3.5%) were recovered. Again, no conclusive results about blue cod movement were able to be obtained.

While the distance moved and the proportion of the population that does move has not been determined from past tagging studies, it appears that the distance individuals move is size related. Mace and Johnson (1983) found that blue cod under 30 cm moved greater distances than larger fish. Rapson (1956) also identified size-related movements from both tagging data and anecdotal information.

Results of NIWA Tagging Trials

Previous attempts to tag and track the movements of blue cod used external tags inserted into dorsal muscle tissue of blue cod in the Marlborough Sounds (Rapson, 1956; Mace & Johnson, 1983). Both of these studies had limited recoveries, which were primarily attributed to poor tag retention. Double tagging indicated that tag loss was high (Mace & Johnson, 1983) and divers observed that other blue cod frequently "bit off" the dorsally located floy tags.

Carbines (1995a, 1995b, 1998b) evaluated the feasibility of tagging blue cod with a variety of new and old tags (1995–96 & 1996–97 contract with the Ministry of Fisheries, SOBCO4). Five tags were tested in an aquarium for site selection and 700 blue cod were released near Stewart Island to examine tag retention as part of a tetracycline age validation study.

From the blue cod tagging feasibility experiment, Carbines (1998b & c) recommend the use of a T-tag in a ventral position inserted through the base of the pelvic fin. This had several advantages, listed below:

- T-tags are relatively cheap and easy to insert, with no anaesthetising of fish necessary.
- There is low mortality as drugging fish is not required.
- They are visibly the most obvious of the tags tested, and had the highest recognition rate among commercial fishers.
- Their retention rate was estimated to be 69.8% for over two years (See Carbine, 1998b).
- The estimated return rate for this tag had been increased to 5.23% over two years (See Carbine, 1998c).
- Each tag has an individual number.
- They are not cryptic and are stand alone tag responsible for their own recognition.
- They don't suffer the problems of other tags (See Carbine, 1998c).

- They already have a high profile among Southland fishers (Carbines, 1994, 1995a).
- They are the only tags able to provide enough information for returning by fishers.

9. OBJECTIVE 1:

To design a tagging programme to determine movements of blue cod in domestic fishing return area 025 in Southland.

9.1 Methods

Work to finalise design of the tagging programme began in October 1997. As the design was proposed by NIWA in the tender document, three replicate sites (approximately 5 km^2) needed to be identified in each of three strata; i.e.: near-shore mainland New Zealand, mid Foveaux Straight, and near-shore Stewart Island. The three replicate sites needed to be evenly spaced within each of these three strata at areas of relatively high blue cod abundance, so that a total of 9 sites could be identified.

In late October 1997, a meeting was held with several experienced commercial blue cod fishers in Bluff to identify the final locations of the nine sites.

Given an expected return rate of 5.2%, it was necessary to tag at least 1000 blue cod per site to ensure that the number of fish returned in each domestic return area is comparable to the sample sizes of successful movement studies in other species (Francis, 1988; Beentjes & Francis, In Press).

Consequently, an order for 10 000 T-bar tags was placed with Hallprint PTY. Ltd (Australia) in December 1997. To secure vessel time an advertisement was place in the Southland Times newspaper calling for tender of vessel charter for the tagging programme.

9.2 Results

The final design of the tagging programme was presented in Carbines (1997b). It is a balanced stratified series of replicated sites within strata spread throughout domestic return area 025 (Fig 2).

Based on the known distribution of this species determined from discussions with the commercial Southland blue cod fishing industry, three replicate sites (approximately 5 km^2) were chosen in each of three strata; i.e.: near-shore mainland New Zealand (NZ 1–3), mid Foveaux Straight (FV 1–3), and near-shore Stewart Island (SI 1–3) (See Fig 2). The three replicate sites were relatively evenly spaced longitudinally within each stratum at areas of relatively high blue cod abundance.

Ten thousand 1.5 cm yellow T-bar tags were received from Hallprint PTY. Ltd (Australia) in January 1998. All tags carry an individual identification number and the words "REWARD – NIWA, P.O. Box 6414 DUNEDIN".

Tagging commenced earlier than originally planned (See Tender document BCO9702) because of concerns that the then El Nino event may reduce the number of fishable days in Foveaux Strait.

Three tenders were received from the newspaper advertisement, of these two vessels were chosen, based primarily on the price and the level of the skippers blue cod commercial fishing experience. Charter agreements were completed for tagging to commence on the 19th of January 1998.

9.3 Conclusion

This design (Fig 2) will allow the movements of blue cod to be determined in areas spanning most of domestic return area 025. As sites were placed at least 7 km apart in longitude, and at least 10 km apart in latitude, movements in different parts of the domestic return area can be assessed independently for different tagging sites, as well as between strata. This will determine if, and at what spatial scale, movement is occurring (for more details see NIWA tender document BCO802).

10. OBJECTIVE 2:

To complete the tagging phase of the programme.

10.1 Methods

To minimise costs, NIWA used the commercial blue cod fleet to undertake tagging. Two commercial fishing boats were chartered from Bluff (FV Rex and FV Rosane) and accompanied by NIWA staff to tag fish. Skippers of each vessel were instructed on areas to fish, the days of fishing required, and provided with all necessary tagging equipment – measuring boards, holding tanks, and customised recording forms. All tags had an individual identification number and the words "REWARD – NIWA, P.O. Box 6414 DUNEDIN".

Pots were set in a systematic manner at several discrete fishing spots (approximately 300 m^2) throughout each site until a target number of blue cod were tagged and released at that site. While sites were carefully balanced, fishing spots and the numbers of fish tagged within sites were chosen opportunistically, based on the availability of fish. All sizes of blue cod were caught using commercial cod pots covered in a 1 cm soft mesh. This technique has been shown to cause no mortality of returned fish, even if they are handled poorly (Carbines, 1996a, 1997a, In Press).

As blue cod are thought to hold large and relatively stable territories (Mutch, 1983) all efforts were made to return fish to the specific area caught, this is why discrete fishing spots within sites were used. After each pot was lifted, fish were quickly removed from pots and placed in onboard holding tanks with constant running sea water. They were then measured to the nearest centimetre below, individually tagged at the base of the pelvic fin using a 1.5 cm yellow T-tag and released at the centre of the fishing site (release station).

Within each fishing spot the location of the release station (the centre of the fishing spot) was recorded using a Global Positioning System (GPS), depth and bottom type was also be recorded. These small scale positions may enable *a posteriori* analysis of movements within sites.

10.2 Results

Tagging commenced earlier than planned because of concerns that the then El Nino event may reduce the number of fishable days in Foveaux Strait. All tagging took a total of 15 fishing days for each of the two vessels over three distinct periods of fine weather. Consequently, by the end of March 1998, 9368 blue cod had been tagged at the nine sites within domestic fishing return area 025 (Table 1 & Fig 3).

The target of 1000 fish tagged per site was surpassed in most cases except at site Foveaux Straight One (FV1, n=993) and Stewart Island Three (SI3, n=904) where catch rates were notably lower than other sites (Table 1).

In addition to the spatial stratification in the design of the programme, another variable soon became apparent during fishing. Three distinctly different bottom types were able to be identified, and one of the was used to describe each release station. Using commercial fishing sonar, experienced blue cod fishers were able to determine if the bottom type was either sand (Sand), bryozoan beds (Bryo), or rocky reef fringe (Rock). A small dredge was used to confirm the sonar observations.

While this new variable was not balanced in the design of the programme, it has been incorporated opportunistically.

Table 1: Number of blue cod tagged by bottom type within Site

Site	Sand	Bryo	Rock	Total
FV1	0	263	730	**993**
FV2	514	533	0	**1047**
FV3	199	835	0	**1034**
NZ1	102	102	889	**1093**
NZ2	276	706	48	**1030**
NZ3	119	262	664	**1045**
SI1	0	641	557	**1198**
SI2	404	620	0	**1024**
SI3	350	74	480	**904**
Total	**1964**	**4036**	**3368**	**9368**

A total of 139 release stations were used throughout the nine sites, an average of 15 stations per site and 67 fish per station (Table 2). Interestingly, there was a major difference in the average number of fish per release station between the three habitat types (i.e., sand 41, bryozoan 70, rock 99) indicating that blue cod are fished best around rocks.

Table 2: Number of release stations used by bottom type within Site

Site	Sand	Bryo	Rock	Total
FV1	0	2	4	**6**
FV2	13	7	0	**20**
FV3	4	9	0	**13**
NZ1	4	5	7	**16**
NZ2	14	15	7	**36**
NZ3	4	1	6	**11**
SI1	0	8	4	**12**
SI2	5	7	0	**12**
SI3	4	3	6	**13**
Total	**48**	**57**	**34**	**139**

Mean bottom depth of release stations is presented in table 3 and it appears that there is a slight trend of shallower sites in the New Zealand stratum. Release station depths ranged from 13 to 54.3 meters, but were on average 33.5 meters.

Table 3: Mean (±se) depth (m) of release stations by bottom type per Site

Site	Sand	Bryo	Rock	Total
FV1	–	51.2±0.00	31.9±0.09	**37.0±0.28**
FV2	33.9±0.04	34.0±0.07	–	**34.0±0.04**
FV3	33.4±0.11	35.1±0.14	–	**34.8±0.11**
NZ1	40.7±0.00	41.5±0.00	34.0±0.21	**35.3±0.19**
NZ2	26.2±0.39	32.4±0.06	13.0±0.00	**29.8±0.18**
NZ3	29.6±0.00	32.9±0.00	25.7±0.10	**27.9±0.11**
SI1	–	28.6±0.26	45.7±0.26	**36.6±0.31**
SI2	35.0±0.14	29.4±0.15	–	**31.6±0.14**
SI3	42.1±0.00	30.0±0.00	29.1±0.08	**34.2±0.21**
Total	**34.5±0.13**	**33.6±0.10**	**32.8±0.14**	**33.5±0.07**

The length frequency of all tagged blue cod is given in figure 3, and the mean total lengths by sites and bottom types are given in table 4. The mean total length of all blue cod tagged was 325 ± 0.51 mm, just below the minimum legal size (33 cm). However, there were notable size differences between sites, both between and within strata (Table 4).

Blue cod tagged in mid Foveaux Straight were largest (Table 4 & Fig 4), followed by those tagged on the South Island coast (Table 4 & Fig 5). Blue cod tagged on Stewart Island were smallest (Table 4 & Fig 6). There was also a recognized size gradient between bottom types with blue cod tagged on sand being the largest (Table 4 & Fig 7).

Table 4: Mean size (mm) of tagged blue cod by bottom type per Site

Site	Sand	Bryo	Rock	Total
FV1		314±3.01	327±1.74	**323±1.52**
FV2	332±2.87	345±2.39		**339±1.85**
FV3	362±2.75	324±1.51		**331±1.41**
NZ1	315±3.62	311±3.39	311±1.21	**312±1.09**
NZ2	327±3.09	324±1.94	294±11.79	**324±1.67**
NZ3	350±2.86	339±2.34	335±1.41	**338±1.13**
SI1		305±1.95	313±1.69	**309±1.31**
SI2	321±3.16	308±2.28		**313±1.87**
SI3	321±2.05	347±4.82	346±2.16	**336±1.51**
Total	**330±1.24**	**322±0.80**	**324±0.76**	**325±0.51**

10.3 Conclusion

The tagging phase of this project was completed to agreed specifications and design, within the time frame specified in the tender document BCO9702. A total of 9368 blue cod were T-tagged at 9 sites throughout domestic return area 025.

The identification of three distinct bottom types may enable additional evaluations of blue cod movement. The size distribution of tagged blue cod varied within, and between strata and between bottom types. Further analysis will be presented in the projects' final report in September 1999.

11. OBJECTIVE 3

To begin the recovery phase of the programme.

11.1 Methods

The return of tagged blue cod is the most crucial phase of the tagging program and begins as soon as the first fish were released. All tagging was completed by March 1998 and the recovery phase will run until August 1999 (16 months).

The blue cod fishery is mainly seasonal as many fishers are involved in the rock lobster fishery over the early summer period (Warren *et al*, 1997). However, the timing of the tagging phase has allowed returns to be collected over two seasons of the blue cod fishery (Warren *et al*, 1997).

From the blue cod tagging feasibility trials, the T-tag return rate was 5.2% for over two years, but 4.3% for the same period as the current programme. Therefore an estimated 387 fish can be expected to be returned by August 1999. To encourage the returns of these fish, and the integrity of their catch data, a reward system is proposed.

Several rewards have been used in past studies but fishers have been particularly encouraged to participate by offering T-shirts and prize lotteries (Francis, 1988; Beentjes & Francis, In Press). For the current tagging program a "Blue Cod – Tagging Program" T-shirt is given to all participants who return a tag and its relevant catch information. However, as most returns are anticipated to come from the commercial

sector, it is likely that individual operators will each catch and return several fish. To encourage their continued participation, each returned tag also entitles the bearer to enter a September 1999 prize draw for a New Zealand mystery weekend for two.

To encourage participation and education, a popular article outlining the tagging program, rewards, and return procedures was published in the commercial magazine Seafood New Zealand (Carbines, 1998a), and reported in the *Southland Times* news paper. To further reach recreational fishers, NIWA gave a T-shirt for all tagged blue cod and sponsored the largest blue cod prize at the 1998 Stabi-craft southern marine open water-fishing tournament in Bluff. Fishers were asked to record catch location as accurately as they could (GPS if possible), fish length, and date of capture.

Tags and their catch information are received by a post box address marked on the tags. At the end of each month the information is entered onto an Excel© data base which then generates a form letter and chart to the participants informing each of them where and when their fish was tagged and caught, growth and distance travelled. The letter and a "Blue Cod – Tagging Program" T-shirt is then be sent to participants and their name entered into the lottery prize draw at the end of the program.

This phase of the programme will involve the continued returning of tagged fish over another one-year period before production of a final report. At the conclusion of the 15-month return phase of the program, the database will need to be analysed in August 1999. In order to determine the spatial and temporal scale of blue cod movements, tag data will be analysed in conjunction with estimates of fishing effort (Francis, 1987).

A final report of the two-year program will then be submitted at the end of the 1998/99 fishing year to coincide with the draw of the lottery prize.

11.1 Results

After five months at liberty, 212 of the 9368 tagged blue cod have been returned (2.26%). Blue cod have been returned from all sites and most bottom types within those sites (Table 5). However, numbers of returns have varied greatly between sites and between strata (Table 5). Most returns have come from the Stewart Island strata (n=96), then the New Zealand strata (n=82), and least from the Foveaux Straight strata (n=34).

Table 5: Number of blue cod returned by tagging bottom type by Site

Site	Sand	Bryo	Rock	Total
FV1	–	0	6	**6**
FV2	7	16	–	**23**
FV3	2	3	–	**5**
NZ1	1	2	9	**12**
NZ2	3	8	2	**13**
NZ3	6	12	39	**57**
SI1	–	6	24	**30**
SI2	2	8	–	**10**
SI3	27	11	18	**56**
Total	**48**	**66**	**98**	**212**

Numbers of blue cod tagged by bottom type was not balanced, so comparison of returns by this variable must use the percentages of returned fish (Table 6). These showed a large difference between returns by release station bottom type, most coming from rocky areas (2.91%), then sand (2.44%) and least from bryozoans (1.64%).

Table 6: Percentage return of tagged blue cod by bottom type within Site

Site	Sand	Bryo	Reef	Total
FV1	–	0.00%	0.82%	**0.60%**
FV2	1.36%	3.00%	–	**2.20%**
FV3	1.01%	0.36%	–	**0.48%**
NZ1	0.98%	1.96%	1.01%	**1.10%**
NZ2	1.09%	1.13%	4.17%	**1.26%**
NZ3	5.04%	4.58%	5.87%	**5.45%**
SI1	–	0.94%	4.31%	**2.50%**
SI2	0.50%	1.29%	–	**0.98%**
SI3	7.71%	14.86%	3.75%	**6.19%**
Total	**2.44%**	**1.64%**	**2.91%**	**2.26%**

Collection of length data from returned fish cannot be controlled and unfortunately may not be reliable as some fish have apparently shrunk, indicating a possible inconsistency in fishers' length measurements.

Table 7: Mean size (mm) of returned blue cod by tagged bottom type per Site.

Site	Sand	Bryo	Rock	Total
FV1	–	–	373±21.75	**373±21.75**
FV2	346±19.5	370±6.37	–	**363±7.75**
FV3	355±3.54	370±6.24	–	**364±5.18**
NZ1	335	348±8.84	359±10.65	**355±8.40**
NZ2	292±28.1	350±6.12	345±3.54	**336±10.1**
NZ3	334±5.19	351±5.79	359±5.18	**355±3.93**
SI1	–	363±8.31	338±4.68	**344±4.55**
SI2	368±1.77	366±9.30	–	**367±7.45**
SI3	346±5.30	349±5.89	343±4.94	**345±3.24**
Total	**342±4.99**	**359±2.88**	**352±3.25**	**352±2.12**

However, most fishers gave very specific details of recapture location, so there is a high level of confidence regarding movement data. Mean distance travelled by release site by bottom types is given in table 8, the over all mean being 2.09±2.12 km.

Table 8: Mean (± se) distance (km) moved by returned blue cod by tagging bottom type within Site

Site	Sand	Bryo	Rock	Total
FV1	–	–	0.78±21.8	0.78±21.8
FV2	1.99±19.5	0.88±6.37	–	**1.21±7.45**
FV3	0.59±3.54	0.61±6.24	–	**0.60±5.18**
NZ1	4.99	3.46±8.84	3.34±10.7	**3.50±8.40**
NZ2	0.31±28.1	4.83±6.12	0.45±3.53	**3.11±10.1**
NZ3	0.30±5.19	0.54±5.77	0.34±5.18	**0.38±3.93**
SI1	–	1.07±8.31	1.18±4.68	**1.16±4.55**
SI2	2.49±1.77	4.10±9.30	–	**3.78±7.45**
SI3	3.09±5.30	5.69±5.88	4.57±4.94	**4.07±3.24**
Total	**2.31±4.99**	**2.57±2.88**	**1.64±3.25**	**2.09±2.12**

However, means of distances travelled have very large relative standard errors (Table 8) because movement data is asymmetrical with a large range (Table 9).

Table 9: Range of distance moved tagging bottom type within Site

Site	Sand	Bryo	Rock	Total
FV1	–	–	0.29–1.31	**0.29–1.31**
FV2	0.36–9.95	0.25–1.78	–	**0.25–9.95**
FV3	0.41–0.77	0.17–0.827	–	**0.17–0.83**
NZ1	4.99	3.46	2.80–3.87	**2.80–4.99**
NZ2	0.30–0.32	0.51–12.70	0.19–0.71	**0.19–12.71**
NZ3	0.10–0.62	0.13–1.05	0.02–0.90	**0.02–1.05**
SI1	–	0.16–1.52	0.42–3.413	**0.16–3.41**
SI2	2.49	1.26–15.22	–	**1.26–15.22**
SI3	0.62–64.34	0.55–27.55	0.03–15.37	**0.03–64.34**
Total	**0.10–64.34**	**0.13–27.55**	**0.02–15.37**	**0.02–64.34**

A median distance travelled might therefore be a better description of population movement data and given in table 10. The overall median distance moved was only 640 meters, compared to the equivalent mean of 2.09 km. Median distance moved was greatest for the Stewart Island stratum (0.93 km) followed by Foveaux Straight (0.74 km) and least for mainland New Zealand (0.46 km).

Table 10: Median distance (km) move by returned blue cod by tagging bottom type within Site

Site	Sand	Bryo	Rock	Total
FV1	–	–	0.75	**0.75**
FV2	0.71	0.74	–	**0.74**
FV3	0.59	0.83	–	**0.77**
NZ1	4.99	3.46	3.4	**3.43**
NZ2	0.32	0.86	0.45	**0.71**
NZ3	0.17	0.61	0.33	**0.36**
SI1	–	1.49	1.02	**1.02**
SI2	2.49	1.26	–	**1.87**
SI3	0.62	0.62	1.26	**0.63**
Total	**0.62**	**0.78**	**0.55**	**0.64**

11.1 Conclusions

To date this tagging programme has returned more blue cod (n=212) than either previous programme (Rapson, 1956 (n=194); Mace & Johnson, 1983 (n=84). Returns have come from all sites and are currently ahead of target. While most blue cod appear to be highly localised with a median distanced travelled of only 640 meters, at least one has moved as far as 64.34 km.

The return phase of this project is due to conclude in August 1999. The final report is due in September 1999. Based on a return rate of 5.2% (Carbines, 1998c), it is expected that another 275 blue cod will be returned by then.

At the conclusion of the return phase, a full analysis of movement data will be done to determine distance travelled between strata, sites, and bottom types. Length by distance moved and fishing effort comparisons with returns will also be made.

12. Publications

Carbines, G.D. (1998). How far to blue cod move? *Paper presentation to the New Zealand Marine Sciences Society Annual Conference.* July 1998, Christchurch.

Carbines, G.D. (1998). How far do blue cod move. *Seafood New Zealand. August 1998. Vol. 6, No. 7:* 44–47.

Carbines, G.D, (1998). Blue cod age validation, tagging feasibility and sex-inversion. Research Report for Ministry of Fisheries Project SOBC04. 77 pp.

13. Data Storage

The data collected in this project is stored on the MFish recreational database housed at Greta Point.

Acknowledgement

All those who have returned tags are thanked. Thanks also go Milton Roderique and Alan Whiting (FV Rex), Sid Bull (FV Rosane), Mery Leask (Bluff fishermen's radio), Malcolm Francis, Jill Parkyn, Andrew Willsman.

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Carbines, G.D. (1996a). The mortality of hooked and returned blue cod (*Parapercis colias*) in the Marlborough Sounds of New Zealand. *Paper presentation to the New Zealand Marine Sciences Society Annual Conference.* April 1996, Christchurch.

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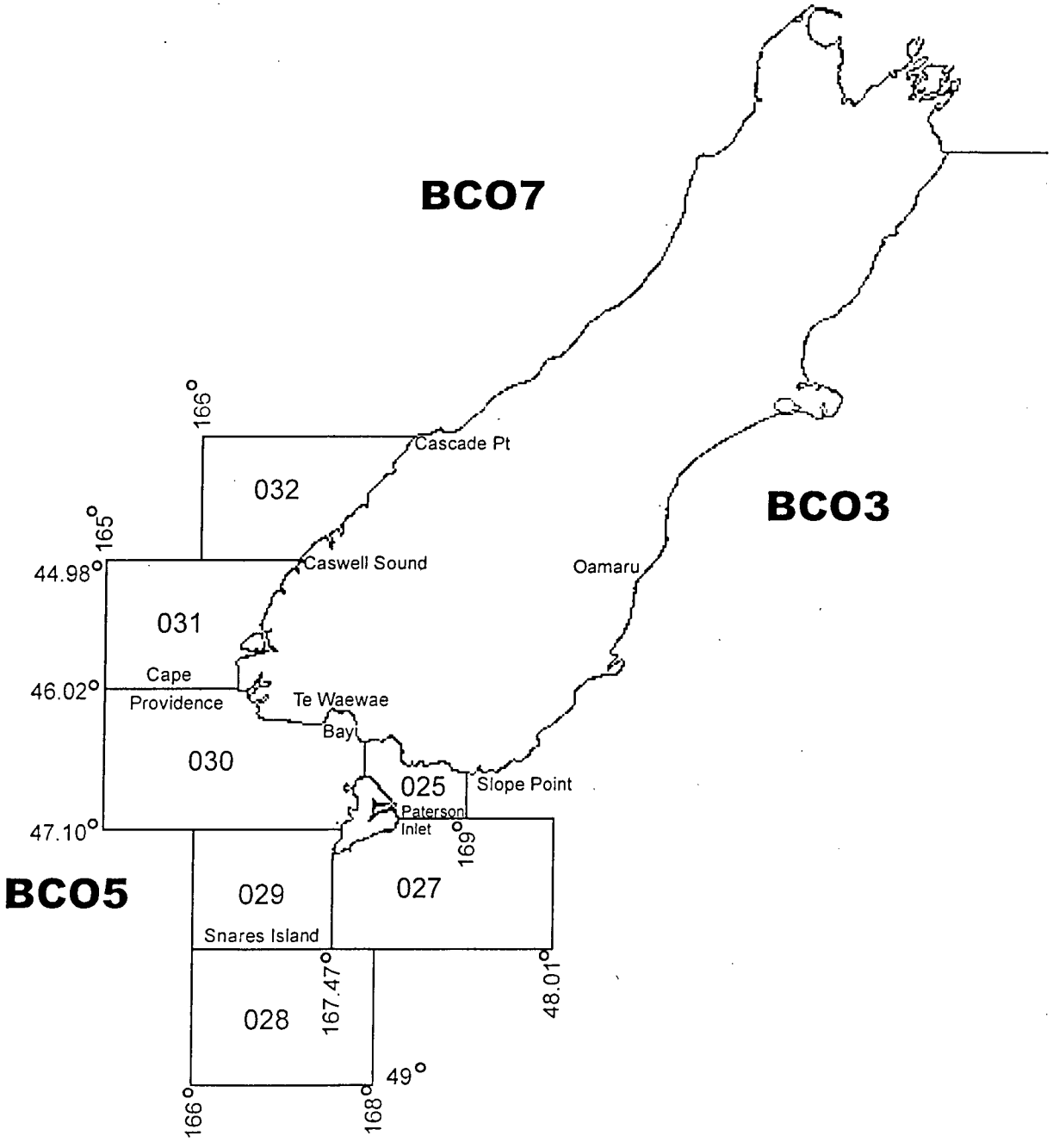


Figure 1: The three blue cod Quota Management Areas (QMA) in the South Island (BCO3, BCO5, BCO7). The seven domestic fishing return areas within BCO5 are shown.

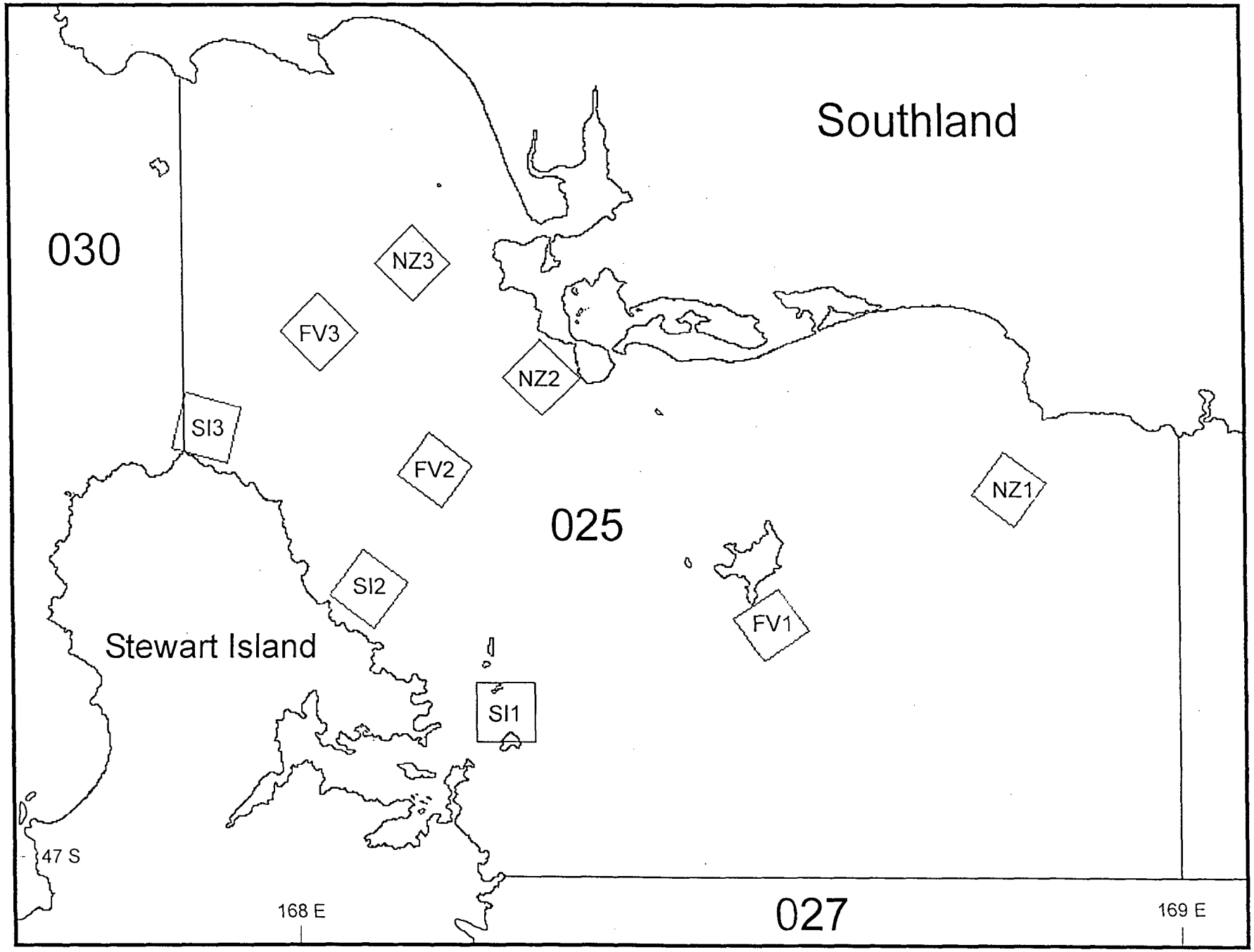


Figure 2: The final design of the tagging programme im domestic return area 025. Consisting of three strata (NZ, FV, SI) each with three replicate tagging sites (5km^2) spread evenly throughout.

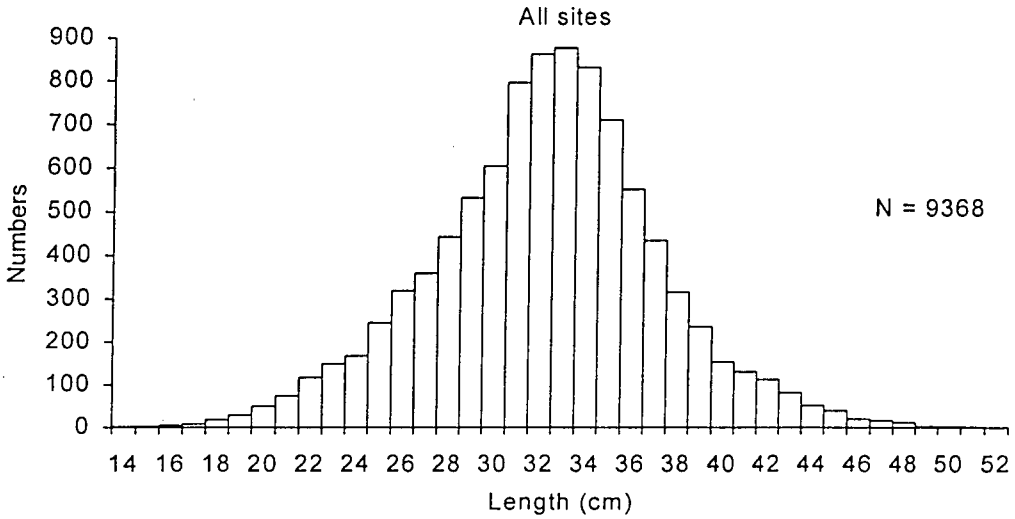
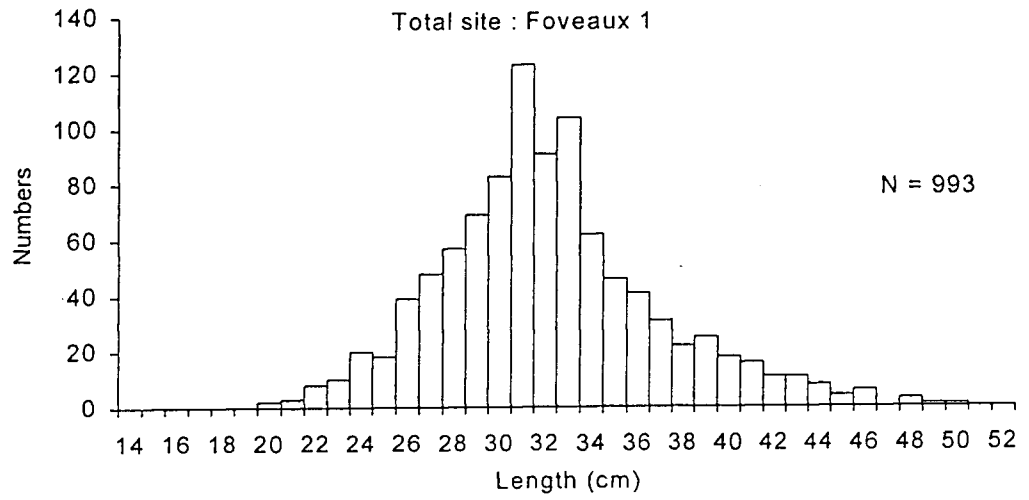
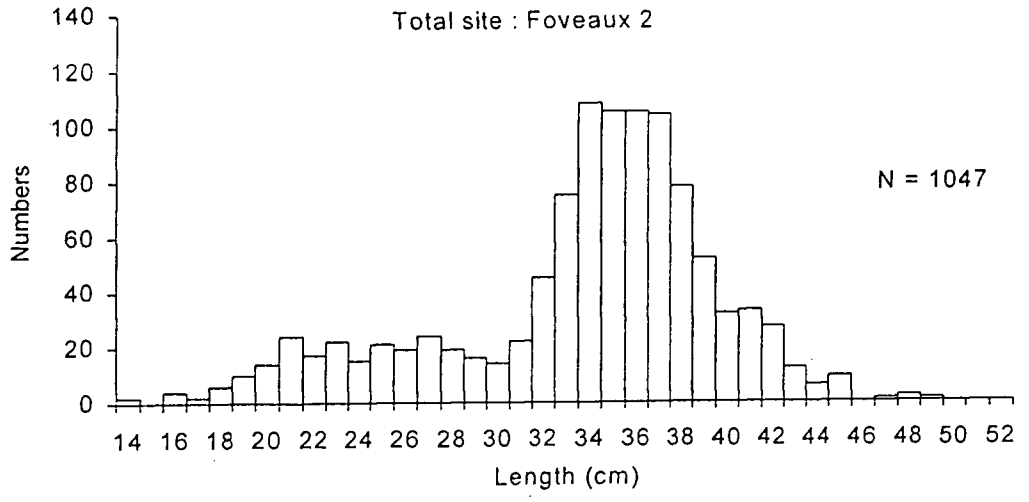


Figure 3: Length frequencies of blue cod from all sites.





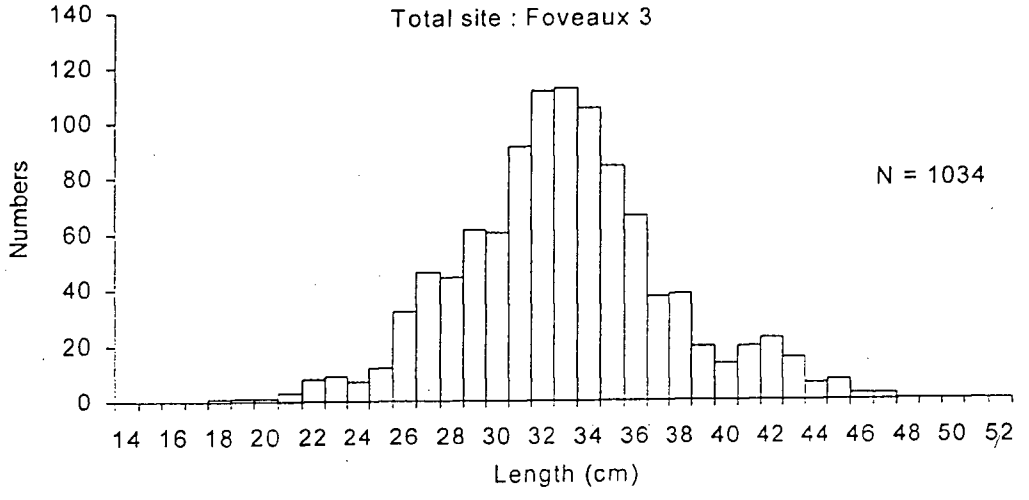
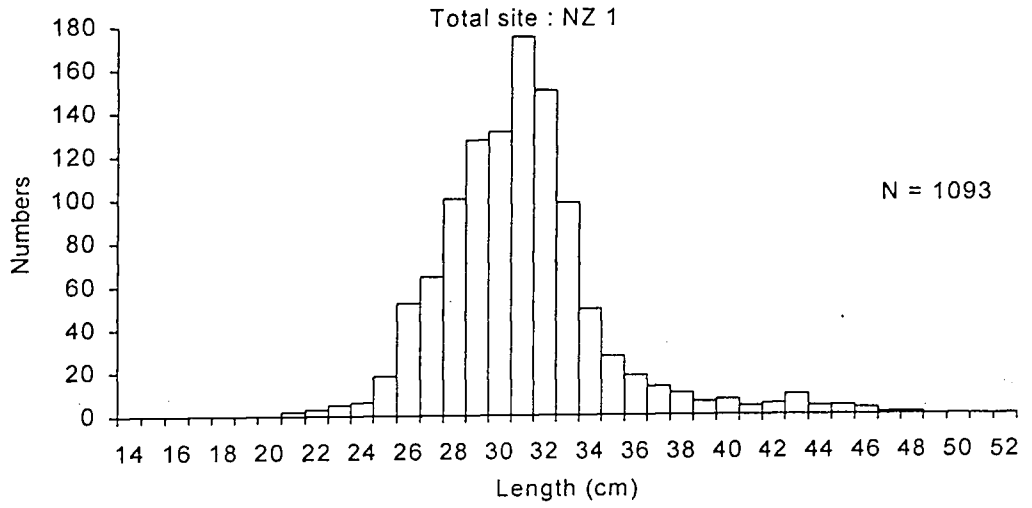
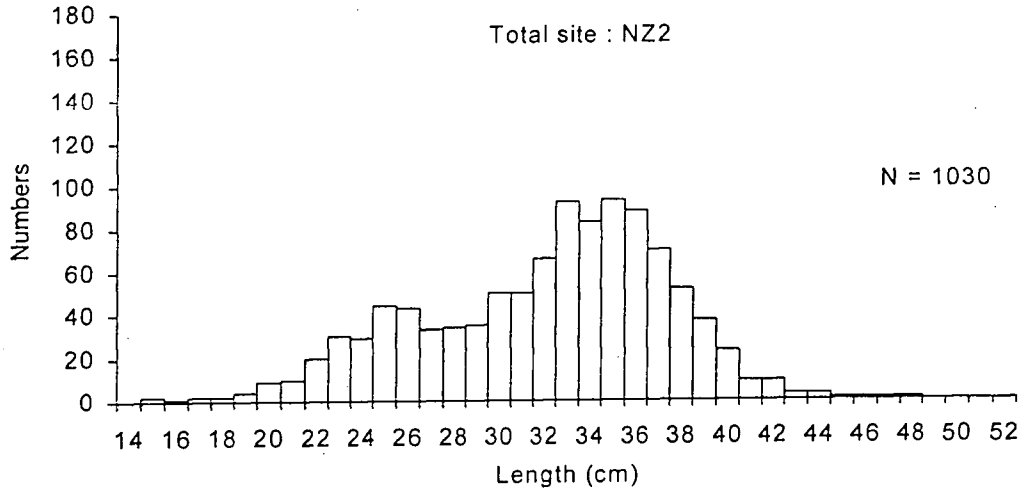


Figure 4: Length frequencies of blue cod from stratum Foveaux Straight.





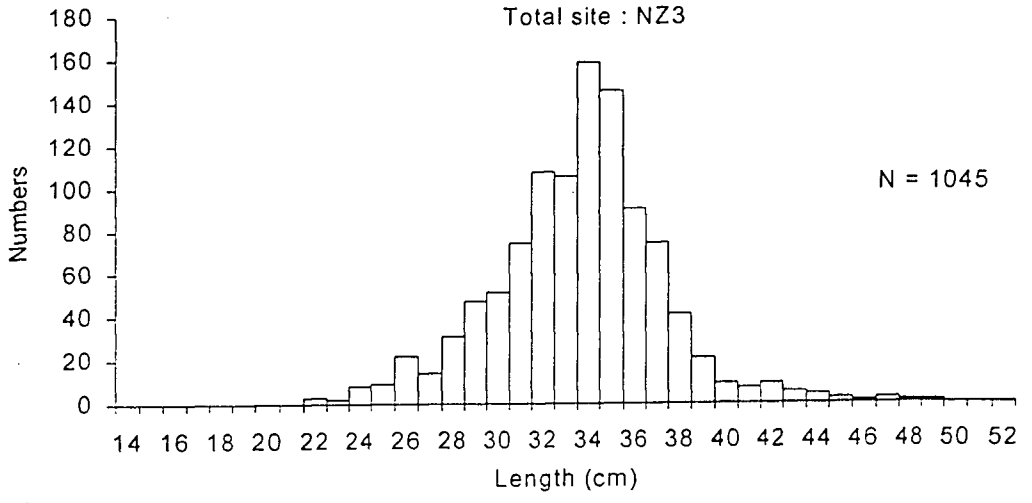
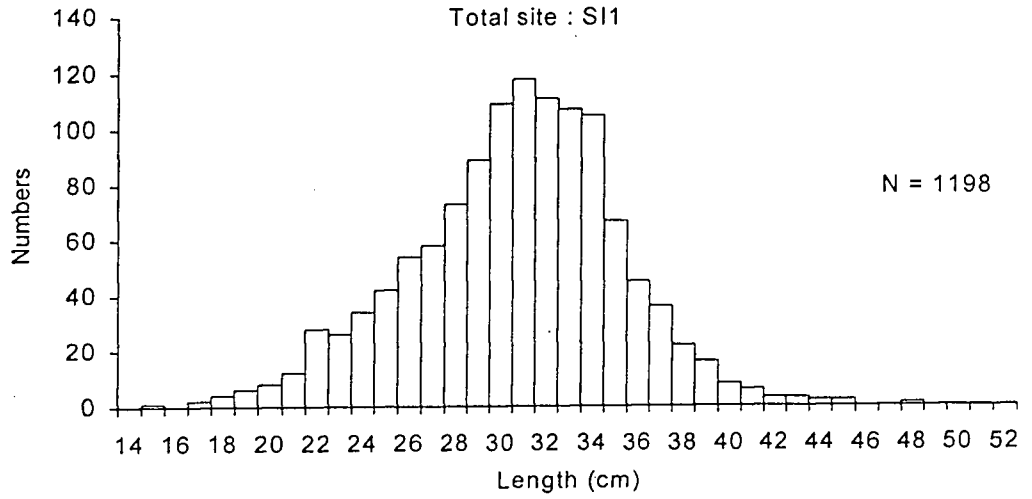
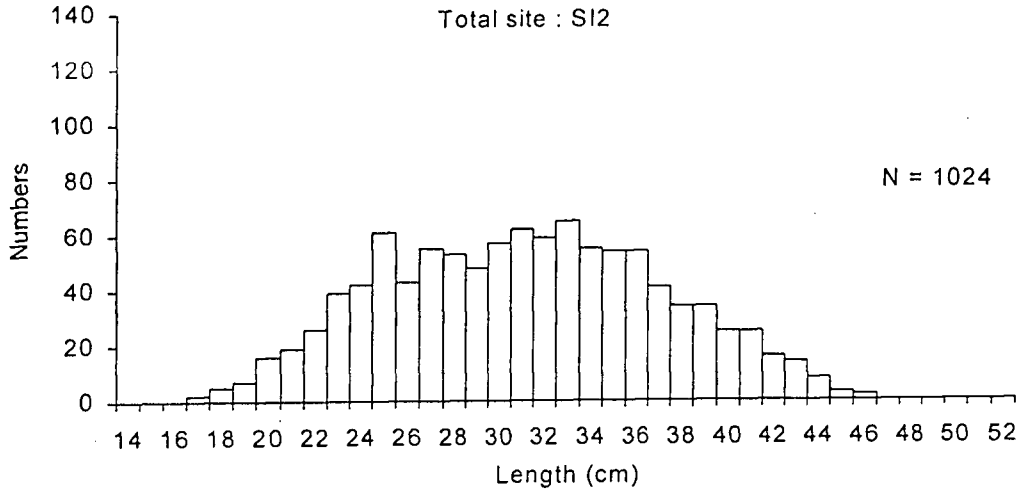


Figure 5: Length frequencies of blue cod from stratum mainland New Zealand.





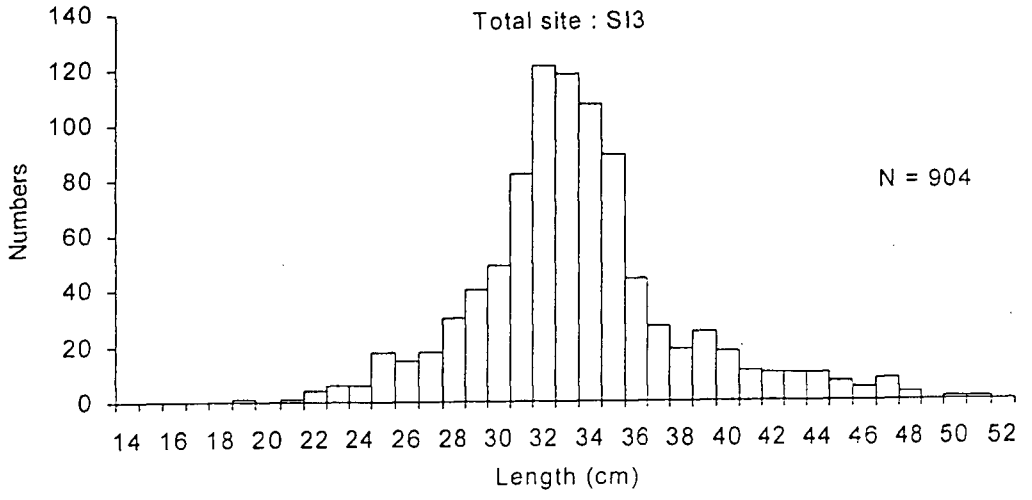
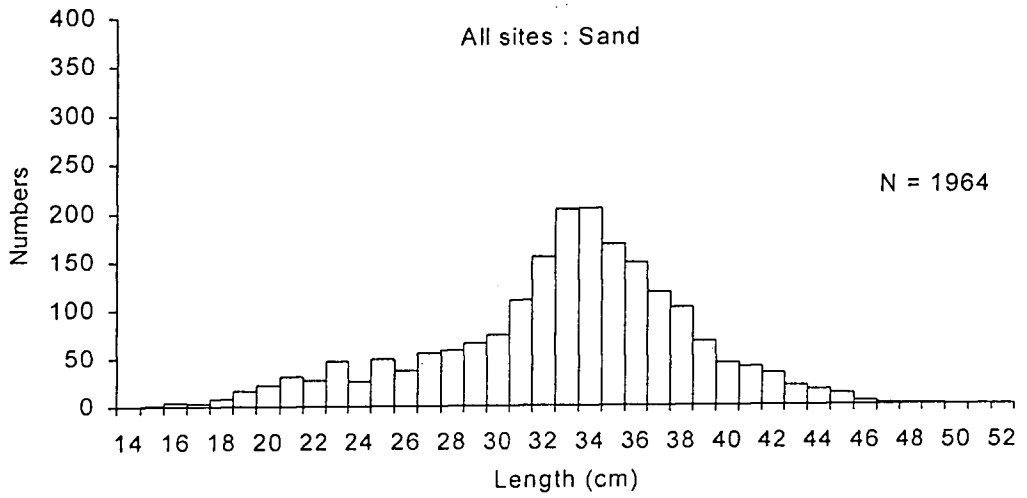
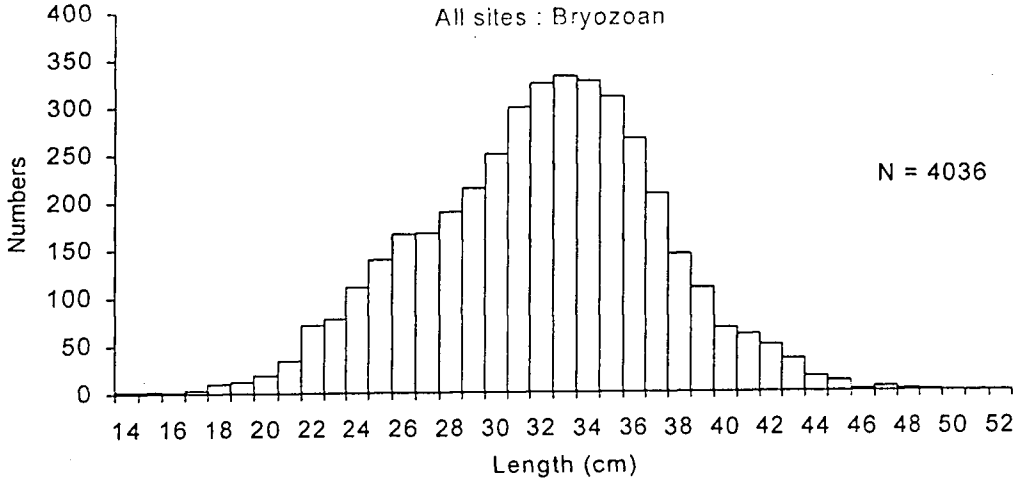


Figure 6: Length frequencies of blue cod from stratum Stewart Island.





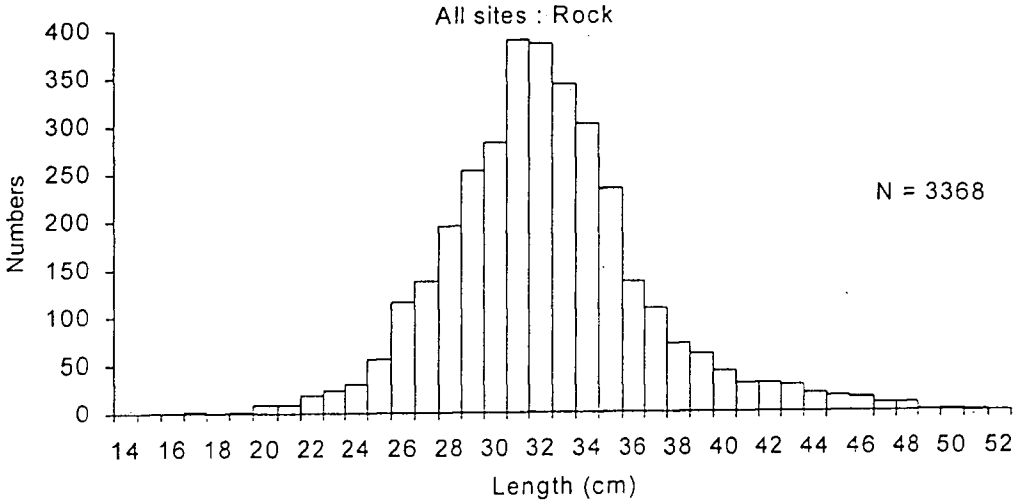


Figure 7: Length frequencies of blue cod from different bottom types throughout all the sites.