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EXECUTIVE SUMMARY

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The current report stems from objective 7 carried out under contract to MFish: "To estimate pre-recruit and recruited southern blue whiting (SBW) biomass from the earlier acoustic surveys using decomposition (SBW9801)." The aims of this work were twofold. Firstly, to re-examine the echo traces from previous surveys to ensure target identification had been carried out in a consistent manner both within and between surveys. Secondly, when mixed schools of pre-recruit and recruited fish occurred to decompose them into age classes.

All echotraces from previous acoustic surveys of southern blue whiting were re-examined by area. For each area, echotraces of marks which had been identified by trawling as belonging to a particular SBW category were set aside. These were then compared both within and between surveys for consistency. Characteristics of these marks including size, shape, density, length, distance above bottom, bottom depth, etc, were then used qualitatively to distinguish between the SBW categories. These characteristics were then used to categorise marks which had not originally been identified by trawling. For consistency with previous years the categories were broadly defined as adult (mainly fish which were going to spawn that year), immature (mainly 2 year olds) and juvenile (mainly 1 year olds).

The biomass from each SBW category was then decomposed into the following age groups: 4+ and over, 3+, 2+, and 1+, where each category may contain a percentage of fish from each of these age groups. Each adult category was usually decomposed using the scaled adult commercial length frequency distribution for that ground and year. For the Campbell Island grounds, marks in the northern and southern grounds were decomposed using scaled length frequencies corresponding to each ground. Each pre-recruit category was usually decomposed using the length frequency distribution for that pre-recruit category obtained from research trawling on *Tangaroa* for that ground and year.

As a result of the re-analysis a number of recommendations are made. Objective techniques need to be developed for mark identification. More trawls need to be carried out improve the target identification and age decomposition and to allow estimation of the precision of the biomass estimates. The extent to which other species may be contributing to the backscatter needs to be explored – particularly for the pre-spawning adult and pre-recruit marks. Lastly, the build up of the pre-spawning and spawning aggregations, particularly on the Bounty Platform, needs to be better understood.

1. INTRODUCTION

The four known spawning grounds for southern blue whiting (SBW) are on the Bounty Platform, Pukaki Rise, Campbell Island Rise, and Auckland Islands Shelf. A programme to estimate SBW spawning stock biomass on the first three grounds using acoustic techniques began in 1993 (Hanchet *et al.* 1994). The three grounds were surveyed again in 1994 (Hanchet & Ingerson 1996), and the Auckland Islands Shelf ground was added in 1995 (Ingerson & Hanchet 1996). After the first three surveys it was decided to survey these areas biannually: the Bounty and Pukaki spawning grounds were surveyed in 1997 (Grimes & Hanchet 1999), the Campbell grounds in 1998 (Hanchet *et al.* 2000b), and the Bounty grounds in August 1999 (Hanchet & Grimes 2000).

The current report stems from objective 7 carried out under contract to MFish: "To estimate pre-recruit and recruited SBW biomass from the earlier acoustic surveys using decomposition (SBW9801)."

The aims of this work were twofold. Firstly, to re-examine the echo traces from previous surveys to ensure target identification had been carried out in a consistent manner both within and between surveys. Secondly, when mixed schools of pre-recruit and recruited fish occurred to decompose them into age classes.

The main aim of the acoustic surveys has been to develop a time series of abundance indices of recruited fish (i.e., fish which have recruited into the commercial fishery) for modelling. Because the commercial fishery targets mainly the dense spawning aggregations, the recruited fish are mainly sexually mature. In addition to the spawning fish, pre-recruit fish (immature 1, 2, and 3 year olds) are also found in the survey area. Attempts to quantify pre-recruit biomass in previous surveys by separation into "immature" (mainly 2 year old fish) and "juvenile" (1 year old fish) categories was problematic due to the occurrence in some years of 1, 2, and 3 year old fish in mixed schools (Hanchet *et al.* 1994, Hanchet & Ingerson 1996).

Decomposition of mixed schools was first attempted for surveys of the Bounty Platform by Grimes & Hanchet (1999). However, this was not done in a rigorous manner, and they recommended that this be repeated for the Bounty Platform, and also carried out for the Pukaki Rise. Decomposition of immature (mainly 2 and 3 year old) fish was also attempted for the Campbell Island Rise (Hanchet *et al.* 2000b), but again was not done in a rigorous manner. The current project was therefore aimed at improving the estimates of pre-recruit and recruited biomass by carrying out this decomposition, using the length frequency and age data collected during the surveys and by the commercial fishery, on a transect by transect basis.

2. METHODS

The general methods used to re-examine, decompose, and treat the acoustic data are summarised below. The details and results of the re-analysis are then given for each survey and area in turn.

2.1 Re-examination of echotraces

All echotraces from previous acoustic surveys of southern blue whiting were re-examined by area. For each area, echotraces of marks which had been identified by trawling as belonging to a particular SBW category were set aside. These were then compared both within and between surveys for consistency. Characteristics of these marks including size, shape, density, length, distance above bottom, bottom depth, etc, were then used qualitatively to distinguish between the SBW categories.

These characteristics were then used to categorise marks which had not originally been identified by trawling. For consistency with previous years the categories were broadly defined as adults (mainly fish which were going to spawn that year), immature (mainly 2 year olds) and juveniles (mainly 1 year olds). The actual age composition of that category was then calculated by applying an age frequency distribution in the decomposition step (*see* below).

The 1993 acoustic echotraces from each of the areas were re-examined, and the results re-analysed in 1994 (*see also* Hanchet & Ingerson 1996). The revised biomass estimates were used in stock assessment, but the new stratum biomass estimates were never documented. Therefore, some of the differences in results presented in this report stem from differences in interpretation in the 1994 re-analysis rather than from this current review.

2.2 Decomposition

In the original analysis the echotraces were divided into categories or 'mark' types – adult, immature, juvenile (*see* above). The purpose of the decomposition was to decompose these mark types into the following age groups: ≥ 4+, 3+, 2+, and 1+, where each mark type may contain a percentage of fish from these groups.

For a stratum, i, the biomass of southern blue whiting in age group, g, in mark-type, m, is given by

$$B_{i,m}^{g} = \frac{\text{abscf}_{i,m} \times p_{g,m} \times A_i \times \overline{w}_g}{\overline{<\sigma_{bs,m}>}}$$

where A_i is the area of the stratum (in km^2), $\text{abscf}_{i,m}$ is the mean back scattering in units of (fish per m^2), $\overline{<\sigma_{bs,b}>}$ is the mean tilt-averaged acoustic cross-section (in m^2) for the mark, $p_{g,m}$ is the proportion of group g in mark m by numbers, and $\overline{w}_g$ is the mean weight (in kg) of group g in the stratum. The mean tilt-averaged acoustic cross-section $\overline{<\sigma_{bs,b}>}$ is given by

$$\overline{<\sigma_{bs,m}>} = \sum_{g} p_{g,m} \overline{<\sigma_{bs,g,m}>}$$

where $\overline{<\sigma_{bs,g,m}>}$ is the mean tilt-averaged cross-section for group g and is given by

$$\overline{<\sigma_{bs,m,g}>} = \sum_{l} f_{g,m,l} 10^{\frac{\langle TS \rangle(l)}{10}}$$

where $f_{g,m,l}$ is the fraction of group g in mark-type m with length l (in m), $\langle TS \rangle(l) = a + b \times \log_{10} l$ is the tilt-averaged target strength-to-length function. Target strength is measured in dB re 1μPa at 1 m.

The tilt-averaged acoustic cross-section is given by

$$<\sigma_{bs}> = \int \sigma_{bs}(\theta) g(\theta) d\theta$$

where θ is the tilt angle (in the pitch plane only), $\sigma_{bs}(\theta)$ is the acoustic cross-section as a function of θ and $g(\theta)$ is the probability of a fish being at an angle θ. Tilt-averaged target strength, $\langle TS \rangle$, is given by $10 \log_{10} <\sigma_{bs}>$.

Target strength–fish length and fish weight–fish length relationships (male, female, and average) were used together with the length frequencies to estimate the mean weight and mean backscattering cross section in each area.

The analyses in previous surveys have used the target strength–fish length relationship used for blue whiting in the Northern Hemisphere (Monstad *et al.* 1992). Recent studies on gadoids in the Northern Hemisphere (Rose 1998) have suggested a higher target strength (similar slope but higher intercept). *In situ* target strength data collected during the 1998 southern blue whiting acoustic survey agree with the recent Northern Hemisphere relationship (Macaulay 1999). However, *in situ* data from the 1994 survey agree with the old Northern Hemisphere relationship (McClatchie *et al.* 1998). The *in situ* data collected from both New Zealand surveys, and results of swimbladder modelling studies (McClatchie *et al.* 1998), suggest a steeper slope than the Northern Hemisphere studies. The target strength–fish length relationship used in previous years was retained in the current analysis because it is not yet known which alternative relationship is most likely.

The target strength–fish length relationship is:

$$TS = 21.8 \log_{10} FL - 72.8$$

where TS is target strength in decibels and FL is fork length in centimetres (*see* Grimes & Hanchet 1999 for further details).

The weight–length relationships, which apply to spawning fish, were taken from Hanchet (1991).

Decomposition of the SBW categories or mark types was carried out using a length frequency distribution and age length key which characterised that particular category. Each adult category was usually decomposed using the scaled adult commercial length frequency distribution for that ground and year. For the Campbell Island grounds, marks in the northern and southern grounds were decomposed using scaled length frequencies corresponding to each ground. Each pre-recruit category was usually decomposed using the length frequency distribution for that pre-recruit category obtained from research trawling on *Tangaroa* for that ground and year. In some areas or years where no research trawls were carried out the commercial trawl data had to be used instead. Because of the larger mesh size (60 mm) used in the commercial trawls the proportion of smaller fish (under 30 cm) may have been underestimated in these cases. The length frequency file used to decompose a category in each year, area, and stratum is shown in Appendix 1, and the actual length frequency data are given in Appendix 2. A single age length key was available for each area and year to convert the proportion at length to proportion at age.

Calculation of *c.v.*s for the biomass estimates of the various age groups is desirable and was considered. Although *c.v.*s could be calculated for each of the age groups, the variance reflects only the between transect sampling variation, and does not include variation from the length frequency and ageing data. A better estimate of variance would be obtained by also bootstrapping the length frequency data (Bull *et al.*, 2000). However, often only one trawl was available to do the decomposition. We have therefore not attempted to calculate *c.v.*s for the decomposed biomass estimates.

2.3 Treatment of results

In most acoustic surveys two snapshots were carried out on each ground, and in the surveys between 1993 and 1995 adaptive strata were also used. There are therefore a number of possible ways in which a "best estimate" could be derived. There has been much discussion in the past within the

Middle Depth Working Group over which snapshots, and which adaptive strata, are most appropriate in deriving the "best estimates" for use in modelling. For the current analysis we have adopted the same approach as has been agreed to in the past by the Working Group.

In general:

- for 1+ and 2+ fish the average of the snapshots was used;
- for 3+ and ≥ 4+ fish where possible the two snapshot estimates were usually averaged to provide the best estimate (unless there was evidence that the fish were not on the ground in one snapshot);
- for 3+ and ≥ 4+ fish adaptive strata were usually included;
- if a stratum was surveyed in one snapshot but not the other then the biomass estimate was assumed to be the same for both snapshots (unless there was strong evidence for movement).

3. RESULTS

3.1 Bounty Platform

There appears to be a strong diel effect in adult southern blue whiting acoustic density estimates on the Bounty Platform, with night time transect densities being significantly higher than day time estimates (Hanchet *et al.* 2000a). Therefore, where sufficient night time data were available, transects which had been carried out during the day were removed from the analysis. This applied to stratum 1 in 1993 and to strata 1 and 2 in 1994. During surveys in 1995, 1997, and 1999 all transects used for estimation of adult biomass were carried out at night. Also, only adaptive strata carried out at night were used in the analyses.

Adult (recruited) fish marks were reasonably easy to identify. Marks from pre-spawning adult fish were reasonably dense, and typically occurred in the bottom 50–100 m of the water column, and had bottom contact. In the early part of the season they were typically in 400–550 m bottom depth, but in some years, as the season progressed, they moved inshore as shallow as 200 m. Spawning fish marks were extremely dense, and although the densest parts were 50–100 m off the bottom, there was usually some bottom contact with at least part of the mark. Pre-recruit fish marks (including both 1 and 2 year old fish) were more typically less dense, and were usually 50–100 m up off the bottom with little or no bottom contact. They were found at a range of bottom depths from 200 m to 550 m. Most pre-recruit fish were found either to the west or east of the Platform in strata 1, 4, and 6i.

3.1.1 1993

When the 1993 survey data were examined it was evident that marks in stratum 1 which had originally been classified as adults actually comprised a mixture of bottom marks (adults) and mid-water marks (pre-recruits). Furthermore, research trawls 2 and 12 carried out in stratum 1 at the time both had a mixture of adults and pre-recruit fish (Appendix 2a, lfimm1). The marks were therefore re-categorised on the basis of distance off the bottom as either adults or pre-recruits. The adult marks were assumed to be in the bottom 50 m and were decomposed using the commercial length frequency data. The pre-recruit marks were assumed to be 50–200 m above the bottom and were decomposed using the length frequency distribution of the two research trawls. The categories assigned to marks in the other strata remained largely unchanged and were decomposed using the appropriate length frequency distributions (Appendix 2a).

During the 1993 survey there was strong evidence for movement of adult fish around the Bounty Platform as snapshot 1 was in progress (Hanchet *et al.* 1994). Because of this, it was believed that

adult fish were not adequately surveyed in snapshot 1. In snapshot 2 there was some concern that fish may have been double counted, once as they moved through stratum 1 into the spawning area, and again on the spawning ground in stratum 2. However, there is no strong evidence to support this. Much of the biomass originally thought to be adults in stratum 1 in snapshot 2 was in fact pre-recruit fish. The best estimate of 3+ and ≥ 4+ biomass is therefore believed to be the estimate from snapshot 2 (Table 1).

3.1.2 1994

Data from the first three snapshots only were considered for analysis. Several changes were made to the original mark classification for adults in strata 1 and 2. As with the 1993 analysis, some of the marks in strata 1 and 2 which were originally classified as adults were in fact 50–100 m off the bottom with little or no bottom contact, and were more likely to be pre-recruit fish. They were similar to marks seen in strata 3 and 4 and were reclassified as immature and treated in the same way as those fish (*see* below). Other marks in stratum 1 with more consistent bottom contact were assumed to comprise mainly 3 year old fish on the basis of three commercial trawls and one *Tangaroa* trawl (Appendix 2a, lfadu1). Although a small proportion (about 5%) of age 2 fish (25–28 cm long) were caught in each tow, it is unknown how well these smaller fish were sampled by the commercial tows. The densest adult marks were seen in stratum 2 and these were decomposed using the scaled commercial length frequency data.

Several reasonably dense marks categorised as immature fish were seen in strata 3 and 4 in each of the snapshots (Hanchet & Ingerson 1996). Three commercial trawls were made in these strata, one reported "very small fish", a second reported a size range of 23–36 cm), whilst the third trawl was measured and ranged from 25 to 35 cm with a 40:60 ratio of age 2:3 fish (MFish, unpublished data). In the absence of other data (no successful *Tangaroa* trawls were carried out) this trawl was used to decompose these immature marks, but it is again unknown how well the smaller 2 year old fish were sampled by the commercial net. The juvenile biomass was decomposed assuming that all the juvenile marks represented 1 year old fish (Appendix 2a, lfjuv).

As in the past, snapshot 3 including the adaptive stratum was considered to be the best estimate of 3+ and ≥ 4+ biomass (Table 2).

3.1.3 1995

All transects were included because all transects in the key strata 1 and 2 were carried out at night. Some slight changes were made to the original mark classification. New marks in stratum 1 and marks originally classed as adults in stratum 3 were different from the main adult pre-spawning and spawning marks seen in stratum 2. They appeared to be more similar in character (moderately dense, similar bottom depth and height above the bottom) to marks representing 3 year old fish seen in the 1994 and 1997 surveys. No length data were available for these marks from either research or commercial trawls, so they have been decomposed using the length frequency of 3 year olds from a trawl from TAN9710 (Appendix 2a, lfjuv1). Adult marks were decomposed using the scaled commercial length frequency data. An extensive area of marks in strata 3 and 4 were originally classified as juvenile (1 year old) fish on the basis of a single *Tangaroa* trawl. Examination of the echotraces for those transects suggests that the original interpretation was probably correct; the densest part of the marks were 50–150 m off the bottom during the night, and were 20–50 m off the bottom during the day. The juvenile category was therefore decomposed using *Tangaroa* trawl 1 (Appendix 2a, lfjuv2).

As in the past, the results of the two snapshots (including the adaptive strata) were averaged to produce a best estimate (Table 3).

3.1.4 1997

Only three very slight changes were made to the original mark classification, with immature marks on three transects being reclassified as adults. Length frequency data were available from eight commercial trawls and six *Tangaroa* trawls. The main adult pre-spawning marks in stratum 2 were sampled both by the commercial fleet and by *Tangaroa* (tows 3 and 7) and both gave very similar results. These marks were therefore decomposed using the scaled commercial length frequency data. A second set of adult marks in stratum 4 was decomposed using *Tangaroa* (tow 4), because it had a different size and age structure (Appendix 2a, lfadu4). The pre-recruit marks were decomposed using appropriate *Tangaroa* tows from the survey (Appendix 2a).

As in the past, the results of the two snapshots were averaged to produce a best estimate (Table 4).

3.1.5 1999

No changes were made to the original mark classification for the survey. Mark identification was given in detail by Hanchet & Grimes (2000) and is not repeated here. Adult marks were decomposed using the scaled commercial length frequency data. Pre-recruit marks were decomposed using appropriate *Tangaroa* tows from the survey (Appendix 2a).

As in the past, the two snapshots were averaged to provide estimates of 1 and 2 year olds, whilst snapshot 2 was assumed to provide the best estimate of 3+ and ≥ 4+ biomass (Table 5).

3.1.6 All years

The best estimates for all years are summarised in Table 6.

3.2 Campbell Island Rise

There is no evidence for a strong diel effect in adult southern blue whiting acoustic density estimates on the Campbell Island Rise (Hanchet *et al.* 2000a), so both day and night transects were used.

On the Campbell Island Rise the marks from pre-spawning adult fish had a wide range of different characteristics. During the day adult marks were sometimes hard down carpeting the bottom 10–20 m or sometimes forming plumes up to 50–100 m (and on one occasion 200 m) above the bottom. Most, but not all, plumes had bottom contact. At night the adult marks extended 150–200 m off the bottom and were sometimes bottom referenced with bottom contact throughout, or in more steeply shelving areas (e.g., stratum 7) were surface referenced, and clearly separated from the bottom at the deeper end. During the early part of the season the adult schools were typically in a bottom depth of 450–600 m. As the spawning season approached the schools became denser and the fish migrated higher up in the water column, and were occasionally found at night within 200 m of the surface. In addition to the vertical change in distribution, adult fish on the northern ground also moved in the horizontal plane. In most years the pre-spawning fish formed loose aggregations over a wide area. These then aggregated up into several smaller denser schools for spawning. After spawning the fish dispersed moving west and/or south into slightly shallower water.

Immature marks (mainly 2 year old and some immature 3 year old fish) showed a similar wide range of mark characteristics to pre-spawning adults, although they tended to be less dense than the adult marks. The best way to separate them from the pre-spawning adults was through depth. All *Tangaroa* trawls carried out in less than 400 m caught only young fish (under 4 years old). All trawls deeper than about 420 m were dominated by adults, although in some years they included a small proportion of immature 1, 2, or 3 year old fish. Immature fish marks were usually found in a bottom depth of 350–420 m throughout most of the survey area. In the 1998 survey 1 year old fish were found in shallower water by themselves, and also with the immature 2 and 3 year olds.

3.2.1 1993

Several changes were made to the original mark classification after the echo traces were re-examined. Marks on four transects in deeper water at the southern end of stratum 7 were redefined as adult (they were originally classed as possible adults). Similar types of marks in the same location were identified as adult southern blue whiting in the 1995 and 1998 surveys. Additionally, one mark in stratum 5 was changed from immature to adult.

In the original analysis the proportion of adult and immature biomass in the northern aggregation (strata 2 and 4) changed substantially between snapshots (although the total biomass remained the same). In snapshot 1 adult biomass was 22 000 t and immature biomass was 18 000 t, whereas in snapshot 2 they were 9000 t and 29 000 t respectively (Hanchet *et al.* 1994, Table 5). When the echotraces were compared between snapshots it became evident that there had been a slight shift in the depth distribution of the adult marks. In snapshot 1 there was a clear separation of immature and adult marks at a bottom depth of about 430 m. However, in snapshot 2 the deeper adult marks were largely absent, and there were denser marks at about 400–440 m. It appeared then that the adult fish had moved into shallower water in snapshot 2, and were found together with the immature fish. This was confirmed by examining data from the commercial fleet. In snapshot 1 the fleet were mainly fishing in bottom depths of 450–475 m (inter-quartile range), whereas in snapshot 2 they were mainly fishing in 420–445 m. Furthermore, the proportion of smaller fish in the commercial length frequency data increased from 4% in snapshot 1 to 11% in snapshot 2 (n = 3551 fish measured). We tried to correct for this by applying the commercial length frequency from snapshot 2 to the adult and immature marks in snapshot 2 (Appendix 2b, lfadu2). However, this resulted in most of the biomass in snapshot 2 becoming 3+ and 4+ and over fish, which, we considered, also did not reflect the true situation. Because a representative length frequency for these mixed marks in snapshot 2 was not available, it was decided to ignore the snapshot 2 biomass, and to use instead the estimates from snapshot 1.

All adult marks in the other strata were decomposed using the scaled commercial length frequency distribution (Appendix 2b). Immature marks in stratum 2 were decomposed using a commercial trawl made in shallow water in that stratum, whilst immature fish in the other strata were decomposed using *Tangaroa* trawl 36, and another commercial trawl (Appendix 2b). It is not known how representatively the smaller 1 and 2 year old fish were sampled by the commercial tows.

The two snapshots including the adaptive strata were averaged to provide the best estimate for all age groups (Table 7).

3.2.2 1994

Several changes were made to the original mark classification after the echo traces were re-examined. As for the 1993 survey, marks on two transects in deeper water at the southern end of stratum 7 were redefined as adult. Additionally, one mark in stratum 4 was changed from immature to adult.

Adult marks were decomposed by applying the appropriate scaled commercial length frequency data, and immature marks in the northern strata (1–4, and 8) were decomposed using *Tangaroa* trawl 25, and those in the southern strata (5–7) using *Tangaroa* trawl 28 (Appendix 2b).

The two snapshots including the adaptive strata were averaged to provide the best estimate for all age groups (Table 8).

3.2.3 1995

No changes were made to the original mark classification. Adult marks were decomposed by applying the appropriate scaled commercial length frequency data, and immature marks in all strata were decomposed using *Tangaroa* trawl 8 (Appendix 2b). The two snapshots including the adaptive strata were averaged to provide the best estimate (Table 9).

3.2.4 1998

No changes were made to the original mark classification. Adult marks were decomposed by applying the appropriate scaled commercial length frequency data, immature marks in all strata were decomposed using *Tangaroa* trawls 2, 3, and 11, which comprised a mixture of 1, 2, and 3 year old fish (Appendix 2b, lfimm), and juvenile marks were decomposed using *Tangaroa* trawl 12 (Appendix 2b, lfjuv).

Hanchet *et al.* (2000) considered that the biomass of adults in snapshot 2 was overestimated because it included a proportion of biomass due to a range of other species including silverside, hoki, and ling. An estimate of the biomass of this "other" category was obtained from snapshot 1 when the adult SBW were in deeper water (Table 10). The "other" marks were therefore decomposed by applying the scaled adult SBW commercial length frequency data for the northern ground. These decomposed values were then subtracted from the total biomass estimated from the mixed SBW/other marks in snapshot 2 (Table 11).

As in the past the results of the two snapshots and experimental strata were averaged to provide best estimates (Table 11).

3.2.5 All years

The best estimates for all years are summarised in Table 12.

3.3 Pukaki Rise

There is no evidence for a strong diel effect in adult southern blue whiting acoustic density estimates on the Pukaki Rise (Hanchet *et al.* 2000a), so both day and night transects were used.

There is more uncertainty over mark identification on the Pukaki Rise than in either of the other two areas. Dense pre-spawning or spawning adult marks are infrequent, and tend to be much smaller than in the other areas. Immature fish are located in all the strata around the Pukaki Rise, and unlike the Campbell area there is no clear depth cut off between adult and immature fish. Both *Tangaroa* and commercial trawls commonly catch a mixture of immature and adult fish from all but the densest marks. Also, the mark characteristics themselves may change considerably between years. For example, in the 1993 survey large plumes of 2 year old SBW with a high vertical extent (extending up to 250 m above the seabed) were seen during the day on several transects. In other years 2 year olds have been found only in the bottom 10–30 m during the day.

Despite the uncertainty, some generalisations can be made. In most years, pre-spawning and spawning adult fish were most commonly found from 350 to 400 m. The marks extended up to 200 m off the bottom at night but were relatively hard down (in the bottom 10–20 m) during the day. They were usually found in stratum 2 and the southern ends of strata 1 and 3. Immature 2 and 3 year old fish were most commonly found between 300 and 400 m, and so overlapped with adults at the deeper end of their range. They were found throughout the survey area in all strata. No specific schools of 1 year old fish were located, and it is suspected that they inhabit water shallower than 250 m on the Pukaki Rise (Grimes & Hanchet 1999).

3.3.1 1993

Categorisation of marks from the 1993 survey was difficult because of the wide variety of types of marks and the mixed results of the *Tangaroa* and commercial trawls. The trawling showed that there was clearly an overlap between the distribution of immature 2 year old fish and adults. At times clean catches of adults were made by *Tangaroa* and the commercial fleet, but at other times there was a mixture of the two (Appendix 2c). The first objective of the re-analysis was to try and separate out marks containing the two categories wherever possible. When this was not possible a composite LF was applied which was thought to be representative of that particular depth and area.

One dominant feature of the survey was the occurrence of large plumes with a high vertical extent (extending up to 250 m above the seabed) seen during the day on several transects in strata 2 and 3. Midwater trawling suggested these comprised only 2 year old (21–27 cm long) SBW (Appendix 2c, lfimm1). However, a trawl targeted at the base of the plume caught a mixture of adults and 2 year old fish (tow 27). Commercial trawls made on dense marks in the vicinity of the plumes on the stratum 1/2 boundary caught a high proportion of 2 year old fish (Appendix 2c, lfadu2), whereas commercial trawls made near the stratum 2/3 boundary caught a smaller proportion of 2 year old fish (Appendix 2c, lfadu3). This necessitated the division of the adult marks into three separate groups, and each was decomposed using its own specific length frequency distribution (Appendix 2c). Immature marks were also split up into two on the basis of location and mark type.

A number of other marks (small bobbles) which were originally classified as SBW had no bottom contact during the day, and as a result of more recent target identification work were assumed not to be SBW.

The two snapshots were averaged to produce a best estimate (Table 13).

3.3.2 1994

As with the 1993 survey, categorisation of marks from the 1994 survey was difficult because of the variety of marks and the mixed results of the *Tangaroa* and commercial trawls. The trawling showed

that there was clearly an overlap between the distribution of immature 3 year old fish (25–32 cm long) and adults. At times clean catches of adults were made by *Tangaroa* and the commercial fleet, but at other times there was a mixture of the two (Appendix 2c). The first objective of the re-analysis was to try and separate out marks containing the two categories wherever possible. When this was not possible a composite LF was applied which was thought to be representative of that particular depth and area.

Some dense adult marks fished by the commercial fleet in stratum 1 were almost all adults (Appendix 2c, lfadu1). Commercial trawls made on dense marks in the west of stratum 2 caught a mixture of 3 year olds and adults (Appendix 2c, lfmix), whereas commercial trawls in the east of stratum 2 caught a much higher proportion of adults (Appendix 2c, lfadu2). Lastly, trawls in strata 3–5 caught mainly immature 3 year olds (Appendix 2c, lf3plus). This necessitated the division of the adult marks into four separate groups, and each was decomposed using its own specific length frequency distribution (Appendix 2c). Typical immature marks were only seen in stratum 1, and these were decomposed using a trawl from 1993.

The two snapshots were averaged to produce a best estimate (Table 14).

3.3.3 1995

No changes were made to the original mark classification for the 1995 survey. Most of the adult biomass came from light marks seen in 350–400 m around the southern part of the Rise. Two trawl carried out by *Tangaroa* (not shown) caught similar sized fish to the commercial fleet (Appendix 2c), so the scaled commercial length frequency data were used to decompose the adults in all areas. No obvious immature marks were evident when the echotraces were re-examined.

The results of the two snapshots were averaged to produce a best estimate (Table 15).

3.3.4 1997

No changes were made to the original mark classification. Most of the adult biomass came from a dense daytime bottom mark in snapshot 1 and three dense midwater spawning marks in snapshot 2 which were being fished by the commercial fleet. Adult marks were therefore decomposed by applying the appropriate scaled commercial length frequency data (Appendix 2c). Other less dense marks were found in both snapshots in stratum 4 to the southeast of the Rise. Although no trawls were carried out on these marks by *Tangaroa*, a number of trawls were carried out in the area by a commercial vessel at the end of September. They caught a mixture of immature and adult fish (Appendix 2c, trip 1039), and so this was used to decompose the marks in stratum 4 and other strata originally classed as immature. It is unknown how well the smaller 2 year old fish were sampled by the commercial tows.

The results of the two snapshots were averaged to produce a best estimate (Table 16).

3.3.5 All years

The best estimates for all years are summarised in Table 17.

4. DISCUSSION

4.1 Re-examination of echotraces

As expected, the original target identification was reasonably consistent between years and areas. A number of changes were made to the original mark classification for the 1993 and 1994 surveys of the Bounty Platform, but apart from that few other changes were made. This is not too surprising as the adult spawning aggregations are quite distinctive, and much denser than anything else seen in the area (Grimes & Hanchet 1999, Hanchet & Grimes 2000). The main problems lie in distinguishing pre-recruit fish from pre-spawning adult fish when they occur in the same depth range, and in separating out the 1, 2, and 3 year olds from each other (Hanchet *et al.* 2000b).

Techniques for discriminating between targets have been developed for other species (e.g., Rose & Leggett 1988, Rose 1992). In the recent review of southern blue whiting acoustic surveys it was recommended that a library of known acoustic signals and their supporting data be developed (Rose 1998). An objective is currently underway in SBW1999/01 to further improve the acoustic technique for southern blue whiting. A study has been initiated into determining whether southern blue whiting acoustic marks can be objectively separated into different size categories and separated from other species using electronic techniques. Once this study has been completed it should be possible to identify the marks more objectively.

4.2 Decomposition

The decomposition of the SBW categories biomass into biomass at age has resulted in an improvement to the previous analyses. However, it should be recognised that the length frequency data used for the decomposition, in particular for the pre-recruit and "mixed" marks, were often less than ideal. Often the mark was identified using only one trawl, and sometimes the size distribution from a trawl from another year had to be used. There are also problems with the size selectivity of the trawls, particularly for the commercial trawls using a 60 mm cod end mesh.

There is a clear need for more targeted research trawling to better estimate size and age structure for decomposition. More trawls will also enable the estimation of precision (*c.v.*s) using bootstrapping (*see also* Bull *et al.* 2000)

In the current analysis we have considered only decomposition of SBW categories into the various SBW age classes. No allowance has been made for the contribution of other species to the backscattering assigned to the SBW categories. In the dense adult southern blue whiting marks fished by the commercial fishery there is very little bycatch (Hanchet *et al.* 1994), and the contribution to the biomass would be minimal. However, in the pre-spawning or post-spawning adult marks and the pre-recruit marks there is often a significant bycatch of other species in the bottom trawl such as rattails, ghost shark, ling, hoki, and silverside (Hanchet *et al.* 2000b, Hanchet & Grimes 2000). There are probably also large quantities of small mesopelagic species such as lanternfish and pearlside which are not retained by the mesh. In the analysis of the 1999 survey of the Bounty Platform, Hanchet & Grimes (2000) concluded that the contribution of other species to the backscattering would have only a slight effect on the biomass estimates of the more dispersed schools of juvenile and immature fish, and have little effect on the estimates of adults. A correction was applied to the post-spawning adult marks in the Campbell Island 1998 survey, but apart from that the problem has not been addressed in the southern blue whiting surveys. Future work needs to be carried out to determine the scale of the problem.

4.3 Treatment of results

The decision as to which snapshots to use for the best estimate has also been somewhat subjective. In the present analysis we used the same snapshots that have been agreed to by the Middle Depths Working Group in the past. The timing and biomass estimates of the snapshots are compared to the timing of the spawning season in Table 18. For the Campbell surveys the biomass increased slightly each year from snapshot 1 to snapshot 2, which coincided with the onset of spawning. However, on the Pukaki Rise there appeared to be a slight decrease in biomass from snapshot 1 to snapshot 2, which again coincided with the onset of spawning. In most years there is not a large difference between the two snapshots in these areas, and the differences probably just reflect sampling precision. For the Campbell and Pukaki surveys we always took the average of the two snapshots, and there appears to be no clear reason to change this. There has been concern in the Working Group that the low adult estimate on the Pukaki Rise in 1995 was due to an early acoustic survey and a late spawning season that year. Although the 1995 survey was completed about a week before spawning began, there is no reason why the estimate should be low. In both 1993 and 1994, snapshot 1 was completed about a week before spawning began, yet the estimate was as high as that from snapshot 2. Although it is possible that the fish arrived on the grounds late in 1995, there is no evidence for this from the reproductive data.

There have been much larger differences in biomass between snapshots on the Bounty Platform (Table 18). In 1993, 1994, and 1999 the biomass was considerably higher in the later snapshot than in the earlier ones. In 1993 the fish were clearly on the grounds in snapshot 1, as evidenced by high commercial catch rates (Hanchet *et al.* 1994), but they appeared to be migrating around the Platform ahead of the research vessel and were not sampled by the survey. In 1994 and 1999, considerable searching was carried out by several commercial fishing vessels during snapshot 1, but they were unable to find concentrations of fish. It is believed that in those two years some of the fish had not arrived on the ground when the first snapshot was carried out, and so the best estimate was taken to be snapshot 2.

5. RECOMMENDATIONS

As a result of the re-analysis, the following recommendations are made.

- Objective techniques need to be developed for mark identification.
- More trawls need to be carried out to improve the target identification and age decomposition, and to allow estimation of the precision of the biomass estimates.
- The extent to which other species may be contributing to the backscatter needs to be explored, particularly for the pre-spawning adult and pre-recruit marks.
- The build up of the pre-spawning and spawning aggregations, particularly on the Bounty Platform, needs to be better understood.

6. ACKNOWLEDGMENTS

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Table 1: Stratum area (km²) and biomass (t) by stratum and snapshot of age 1, 2, 3, and 4+ SBW for the 1993 Bounty Platform survey. Best estimate is the mean of snapshots 1 and 2 for 1yo and 2yo, and snapshot 2 for 3yo and 4yo+. Strata with an H refer to the adaptive survey. Italicised entries were obtained from the subsequent snapshot

			Biomass (t)			
Snapshot	Stratum	Stratum area	1yo	2yo	3yo	4yo+
1	1	1 466	2 052	1 022	210	5 610
	2	2 754	84	20	34	11 799
	3	2 479	2 966	79	0	0
	4	1 953	888	3 996	0	0
	5	1 306	204	75	3	11
	7	*536*	*446*	*221*	*43*	*296*
Total			6 640	5 413	290	17 716
2	1	1 433	6 020	2 995	615	15 835
	2	2 511	262	21	33	11 555
	2H	2 205	0	0	1	421
	3	1 967	2 694	848	0	0
	4	1 953	1 782	4 109	0	0
	5	817	46	78	3	8
	7	536	446	221	43	296
	8H	306	0	75	133	46 297
Total (excl H)			11 250	8 272	1 309	27 694
Total (incl H)			10 988	8 326	1 410	62 857
Best estimate			**8 814**	**6 870**	**1 410**	**62 857**

Table 2: Stratum area (km²) and biomass by stratum and snapshot of age 1, 2, 3, and 4+ SBW for the 1994 Bounty Platform survey. Strata with an H refer to the adaptive survey. Best estimate is mean of snapshots 1, 2, and 3 for 1yo and 2yo, and snapshot 3 for 3yo and 4yo+. Italicised entries were obtained from snapshot 1

			Biomass (t)			
Snapshot	Stratum	Stratum area	1yo	2yo	3yo	4yo +
1	1	1 466	0	1 007	7 108	2 294
	2	2 754	60	627	3 738	4 553
	3	2 479	0	1 858	4 401	62
	4	1 953	0	1 225	2 885	10
	5	1 306	0	55	131	0
	7	691	0	0	0	0
Total			60	4 772	18 263	6 919
2	1	1 466	0	580	11 269	4 784
	2	2 754	222	917	2 291	285
	3	2 479	0	87	206	0
	4	1 706	0	3 510	8 270	28
	5	*1 306*	*0*	*55*	*131*	*0*
	7	*691*	*0*	*0*	*0*	*0*
Total			222	5 149	22 167	5 097
3	1	1 466	0	3 128	7 647	158
	2	1 823	0	795	10 441	17 236
	2H	1 774	0	551	2 769	2 962
	3	1 692	0	19	44	0
	4	1 800	0	3 544	8 349	28
	5	*1 306*	*0*	*55*	*131*	*0*
	7	*691*	*0*	*0*	*0*	*0*
	8H	49	0	395	13 126	24 524
Total (excl. H)			0	7 541	18 940	17 422
Total (incl. H)			0	7 692	32 066	27 672
Best estimate			**94**	**5 871**	**32 066**	**27 672**

Table 3: Stratum area (km²) and biomass by stratum and snapshot of age 1, 2, 3, and 4+ SBW for the 1995 Bounty Platform survey. Strata with an H refer to the adaptive survey. Best estimate is mean of snapshots 1 and 2 for each age group. Italicised entries were obtained from the previous snapshot

			Biomass (t)			
Snapshot	Stratum	Stratum area	1yo	2yo	3yo	4yo+
1	1	1 466	0	27	394	2 059
	2	2 750	0	88	2 774	18 732
	2H	2 275	0	34	1 064	7 188
	3	2 500	12 594	1 307	2 087	493
	4	1 953	46 690	3 390	0	0
	5	1 306	0	0	0	0
	8H	475	0	89	2 806	18 954
Total (excl. H)			59 284	4 812	5 255	21 284
Total (incl. H)			59 284	4 847	6 351	28 694
2	*1*	*1 466*	*0*	*27*	*394*	*2 059*
	2	2 300	0	123	3 874	26 166
	2H	1 580	0	3	95	642
	3	*2 500*	*12 594*	*1 307*	*2 087*	*493*
	4	*1 953*	*46 690*	*3 390*	*0*	*0*
	5	*1 306*	*0*	*0*	*0*	*0*
	8H	950	0	138	4 389	29 651
Total (excl. H)			59 284	4 847	6 355	28 718
Total (incl. H)			59 284	4 865	6 965	32 845
Best estimate			**59 284**	**4 856**	**6 658**	**30 770**

Table 4: Stratum area (km²) and biomass by stratum and snapshot of age 1, 2, 3, and 4+ SBW for the 1997 Bounty Platform survey. Best estimate is mean of snapshots 1 and 2 for each age group.

			Biomass (t)			
Snapshot	Stratum	Stratum area	1yo	2yo	3yo	4yo+
1	1	1 319	108	20	402	2 115
	2	1 308	28	24	1 557	23 963
	3	1 857	0	0	5	70
	4	2 643	1 754	4 793	34 203	20 545
	6i	2 761	786	1 846	2 244	51
Total			2 676	6 683	38 411	46 744
2	1	1 319	104	80	1 181	176
	2	1 308	0	23	1 526	23 487
	3	1 163	80	187	233	101
	4	1 956	140	475	6 823	4 505
	6i	2 169	358	840	1 022	23
Total			682	1 605	10 785	28 292
Best estimate			**1 679**	**4 144**	**24 598**	**37 518**

Table 5: Stratum area (km^2) and biomass by stratum and snapshot of age 1, 2, 3, and 4+ SBW for the 1999 Bounty Platform survey. Best estimate is the mean of snapshots 1 and 2 for 1yo and 2yo, and snapshot 2 for 3yo and 4yo+. Italicised entries were obtained from the previous snapshot

Stratum	Area (km^2)	Biomass (t)			
		1yo	2yo	3yo	4yo+
Snapshot 1					
1	1 319	20	139	971	3 336
2	1 308	46	64	184	1 729
3	1 857	34	41	8	27
4	2 643	22	65	757	7 674
5	4 776	–	–	121	1 236
5i	2 191	0	3	–	–
6i	2 585	134	158	–	–
Total		256	470	2 041	14 002
Snapshot 2					
1	926	0	21	157	366
2	1 342	0	2	48	487
3	1 431	403	750	4 475	39 670
4	2 178	64	89	168	963
5	*4 776*	–	–	*121*	*1 236*
5i	*2 191*	*0*	*3*	–	–
6i	*2 585*	*134*	*158*	–	–
Total		601	1 020	4 969	42 722
Best estimate		**429**	**745**	**4 969**	**42 722**

Table 6: Comparison of biomass estimates (t) by survey and age group for the Bounty Platform from the new and the original analyses

New analysis

Year	1yo	2yo	3yo	4yo+
1993	8 814	6 870	1 410	62 857
1994	94	5 871	32 066	27 672
1995	59 284	4 856	6 658	30 770
1997	1 679	4 144	24 598	37 518
1999	429	745	4 969	42 722

Original analysis

Year	1yo	2yo	3yo+
1993	7 200	5 900	94 600
1994	200		64 000
1995	93 300	0	35 200
1997	620	2 000	64 600

Table 7: Stratum area (km²) and biomass (t) by stratum and snapshot of age 1, 2, 3, and 4+ SBW, for the 1993 Campbell Island Rise. Strata with an H refer to the adaptive survey, and were used to calculate the totals. The best estimate is the average of snapshots 1 and 2, including the average of the adaptive strata 8Hn and 8Hd, for all age groups. Italicised entries were obtained from the previous snapshot

			Biomass (t)			
Snapshot	Stratum	Stratum area	1yo	2yo	3yo	4yo +
1	1	4 500	0	0	0	0
	2	3 437	1 698	785	4 929	7 017
	2H	3 173	1 174	524	819	1 431
	4	2 839	18	11 001	2 966	4 786
	4H	1 966	0	6 256	134	0
	5	4 247	0	60 200	1 294	0
	6	2 618	0	0	0	0
	7	3 580	16	8 193	2 623	4 456
	8He	544	32	2 463	5 102	9 194
	8Hn	774	622	440	3 024	5 468
	8Hd	774	548	22	3 637	6 588
Total (excl. H)			1 732	80 179	11 812	16 259
Total (incl. H)			1 807	77 867	13 303	21 109
2	*1*	*4 500*	*0*	*0*	*0*	*0*
	2	*3 437*	*1 698*	*785*	*4 929*	*7 017*
	2H	*3 173*	*1 174*	*524*	*819*	*1 431*
	4	*2 839*	*18*	*11 001*	*2 966*	*4 786*
	4H	*1 966*	*0*	*6 256*	*134*	*0*
	5	4 247	28	44 290	5 363	8 033
	6	2 618	0	0	0	0
	7	3 580	8	12 174	1 509	2 271
	8He	*544*	*32*	*2 463*	*5 102*	*9 194*
	8Hn	*774*	*622*	*440*	*3 024*	*5 468*
	8Hd	*774*	*548*	*22*	*3 637*	*6 588*
Total (excl. H)			1 752	68 250	14 767	22 107
Total (incl. H)			1 827	65 938	16 259	26 957
Best estimate			**1 817**	**71 902**	**14 781**	**24 033**

Table 8: Stratum area (km²) and biomass(t) by stratum and snapshot of age 1, 2, 3, and 4+ SBW, for the 1994 Campbell Island Rise survey. Strata with an H or F refer to the adaptive survey. Best estimate is the average of snapshots 1 and 2, including the average of the adaptive strata 8Fn and 8Fd, for all age groups. Italicised entries were obtained from the previous snapshot

Snapshot	Stratum	Stratum area	Biomass (t) 1yo	2yo	3yo	4yo +
1	1	4 500	0	0	0	0
	2	3 474	12	205	1 167	792
	3	2 824	0	0	0	0
	4	2 692	144	2 575	13 904	9 303
	4H	2 633	0	195	7 570	6 302
	5	4 228	0	1 303	26 884	4 162
	7	3 349	2	5 283	77 803	11 354
	8H	59	0	112	4 360	3 630
Totals	(excl. H)		158	9 366	119 758	25 611
	(incl. H)		14	7 098	117 784	26 240
2	1	2 408	0	0	0	0
	1F	2 250	0	0	0	0
	2	3 474	448	7 251	11 997	2 872
	3	*2 824*	*0*	*0*	*0*	*0*
	4	2 692	192	3 070	4 265	517
	5	4 228	0	879	3 096	146
	7	3 349	4	6 003	133 529	20 888
	8Fn	158	0	371	14 407	11 993
	8Fd	158	0	63	2 458	2 046
Totals	(excl. F)		644	17 203	152 887	24 423
	(incl. F)		644	17 420	161 320	31 443
Best estimate			**329**	**12 259**	**139 552**	**28 841**

Table 9: Stratum area (km^2) and biomass (t) by stratum and snapshot age 1, 2, 3, and 4+ SBW, for the 1995 Campbell Island Rise survey. Strata with an H refer to the adaptive survey. Best estimate is the average of snapshots 1 and 2 including the adaptive strata for all age groups. Italicised entries were obtained from the previous snapshot

			Biomass (t)			
Snapshot	Stratum	Stratum area	1yo	2yo	3yo	4yo +
1	1	2 250	0	0	0	0
	2	3 437	0	2 829	3 018	5 974
	3	2 824	0	164	4 691	48 140
	3H	2 284	0	5	167	1 717
	4	2 700	0	2 151	2 461	6 307
	5	4 247	0	6 626	6 984	14 161
	7	3 500	0	890	3 430	22 075
	8H	580	0	231	6 639	68 117
Totals	(excl. H)		0	12 660	20 584	96 657
	(incl. H)		0	12 732	22 699	118 351
2	2	3 400	0	1 289	1 375	2 722
	3	2 153	0	171	4 901	50 291
	$3H_2$	2 284	0	0	15	159
	4	2 700	0	644	3 605	32 226
	$4H_2$	2 565	0	612	3 425	30 615
	5	*4 247*	*0*	*6 626*	*6 984*	*14 161*
	7	3 500	0	1 016	9 770	72 616
	$8dH_2$	48	0	20	555	5 695
	$8nH_2$	270	0	57	1 632	16 750
Totals	(excl. H)		0	9 746	26 635	172 016
	(incl. H)		0	9 620	23 756	142 718
Best estimate			**0**	**11 176**	**23 228**	**130 535**

Table 10: Stratum area (km²) and biomass (t) by stratum and snapshot of age 1, 2, 3, and 4+ SBW, and "other" species (including silverside, hoki, ling) for the 1998 Campbell Island Rise survey.

Snapshot	Stratum	Stratum area	Biomass (t) 1yo	2yo	3yo	4yo+
1	2	2 912	329	1 730	514	312
	3N	2 342	0	0	0	0
	3S	1 013	1	254	2 244	13 300
	4D	1 341	1	273	2 409	14 278
	4S	1 200	870	2 336	627	14
	5	2 893	303	957	257	6
	6	4 711	0	0	0	0
	7	3 879	810	5 704	7 538	157 025
	Total		**2 314**	**11 254**	**13 589**	**184 935**
2	2	1 912	134	1 155	3 742	20 983
	3N	2 342	0	0	0	0
	3S	1 013	0	16	138	817
	4D	1 341	0	94	827	4 903
	4S	1 350	130	960	3 885	22 176
	5	3 029	973	7 446	9 056	43 180
	6N	1 570	1	338	2 989	17 716
	7	3 769	924	3 620	971	27
	7F	186	8	2 430	21475	127 274
	Total		**2 170**	**16 059**	**43 083**	**237 076**
2	7DN1	61	3	1 117	9 869	58 487
	7DN2	69	6	2 041	18 034	106 883
	7DN3	65	7	2 164	19 124	113 341
	7DN4	69	5	1 832	16 192	95 961
	7DN5	95	4	1 222	10 803	64 027
"Others"						
1	4D	1 341	0	52	458	2 713
	4S	1 200	0	83	738	4 372
	5	2 893	0	33	292	1 728
	6	4 711	0	29	261	154
	Total		0	197	1 749	8 967

Table 11: Adult biomass estimates of age 1, 2, 3, and 4+ SBW for the northern and southern aggregations for the 1998 Campbell Island Rise survey. Best estimate is the average of the snapshots for each aggregation

Snapshot	Biomass (t)			
	1+	2+	3+	4+
Northern aggregation				
1	1 504	5 550	6 051	27 910
2	1 238	10 009	20 637	109 775
Others	0	197	1 749	8 967
Snap 2 – others	*1 238*	*9 812*	*18 888*	*100 808*
Mean	1 371	7 681	12 470	64 359
Southern aggregation				
1	810	5 704	7 538	157 025
2	932	6 050	22 446	127 301
7DN1	927	4 737	10 840	58 514
7DN2	930	5 661	19 005	106 910
7DN3	931	5 784	20 095	113 368
7DN4	929	5 452	17 163	95 988
7DN5	928	4 842	11 774	64 054
Mean	912	5 461	15 552	103 309
Sum of aggregations	**2 283**	**13 142**	**28 022**	**167 668**

Table 12: Comparison of biomass estimates (t) by survey and age group for the Campbell Island Rise from the new and the original analyses using adaptive strata

New analysis

	1yo	2yo	3yo	4yo+
1993	1 817	71 902	14 781	24 033
1994	329	12 259	139 552	28 841
1995	0	11 176	23 228	130 535
1998	2 283	13 142	28 022	167 668

Original analysis

Year	1yo	2yo	Adult (SSB)
1993	–	*89 600*	*18 500*
1994	–	22 400	161 400
1995	–	19 800	121 100
1998	1 300	13 000	171 500

Table 13: Stratum area (km²) and biomass (t) by stratum and snapshot of age 1, 2, 3, and 4+ SBW for the 1993 Pukaki Rise survey. Best estimate is mean of two snapshots for all age groups. The italicised entries were obtained from the subsequent snapshot

			Biomass (t)			
Snapshot	Stratum	Stratum area	1yo	2yo	3yo	4yo +
1	1	703	42	4 247	5 712	17 473
	2	1 949	592	25 351	3 639	13 688
	3	837	32	1 325	161	566
	4	*326*	*22*	*1 005*	*20*	*263*
Totals			688	31 828	9 532	31 990
2	1	703	78	3 132	140	210
	2	1 949	360	17 305	8 453	27 723
	3	837	8	425	485	2 117
	4	326	22	1 005	20	263
Totals			468	21 867	9 098	30 313
Best estimate			**578**	**26 848**	**9 315**	**31 152**

Table 14: Stratum area (km²) and biomass (t) by stratum and snapshot of age 1, 2, 3, and 4+ SBW for the 1994 Pukaki Rise survey. Best estimate is mean of two snapshots for all age groups. The italicised entries were obtained from the previous snapshot

			Biomass (t)			
Snapshot	Stratum	Stratum area	1yo	2yo	3yo	4yo +
1	1	703	0	17	86	1 882
	2	1 949	2	518	4 235	33 379
	3	837	0	31	275	2 768
	4	326	0	24	211	2 134
	5	220	0	2	19	188
Totals			2	592	4 826	40 351
2	1	703	10	761	69	798
	2	1 949	4	919	6 784	20 236
	3	837	0	95	866	8 718
	4	326	0	18	164	1 646
	5	*220*	*0*	*2*	*19*	*188*
Totals			14	1 795	7 902	31 586
Best estimate			**8**	**1 193**	**6 364**	**35 969**

Table 15: Stratum area (km²) and biomass (t) by stratum and snapshot of age 1, 2, 3, and 4+ SBW for the 1995 Pukaki Rise survey. Best estimate is mean of snapshots 1 and 2 for 1yo and 2yo and snapshot 2 for 3yo and 4yo+. The italicised entries were obtained from the previous snapshot

			Biomass (t)			
Snapshot	Stratum	Stratum area	1yo	2yo	3yo	4yo +
1	1	703	0	7	53	822
	2	1 949	0	43	321	4 963
	3	837	0	35	264	4 084
	4	326	0	0	0	0
Totals			0	85	638	9 869
2	1	703	0	1	13	202
	2	1 949	0	58	432	6 669
	3	837	0	59	436	6 746
	4	*326*	*0*	*0*	*0*	*0*
Totals			0	118	911	13 617
Best estimate			**0**	**102**	**775**	**11 743**

Table 16: Stratum area (km²) and biomass (t) by stratum and snapshot of age 1, 2, 3, and 4+ SBW for the 1997 Pukaki Rise survey. Best estimate is mean of two snapshots for all age groups

			Biomass (t)			
Snapshot	Stratum	Stratum area	1yo	2yo	3yo	4yo +
1	1	676	2	261	17	250
	2	1 247	2	293	85	3 235
	3	813	2	255	92	3 641
	4	1 147	18	2 085	177	3 775
	5	1 765	6	848	594	25 212
Totals			30	3 742	965	36 113
1	1	676	0	15	1	15
	2	1 247	4	534	371	15 722
	3	813	2	498	364	15 477
	4	1 147	8	887	58	846
	5	1 765	0	0	0	0
Totals			14	1 934	794	32 060
Best estimate			**22**	**2 838**	**864**	**34 086**

Table 17: Comparison of biomass estimates (t) by survey and age group for the Pukaki Rise from the new and the original analyses. SSB, spawning stock biomass

New analysis

Year	1yo	2yo	3yo	4yo+
1993	578	26 848	9 315	31 152
1994	8	1 193	6 364	35 969
1995	0	102	775	11 743
1997	22	2 838	864	34 086

Original analysis

Year	1yo	2yo	Adults (SSB)
1993	0	26 300	*49 800
1994	0	200	*39 000
1995	0	30	12 800
1997	0	3 100	31 000

* Includes some immature 2 or 3 yr old fish.

Table 18: Timing of snapshots and adult (≥3+ fish) biomass estimates (x 10^3 t) from acoustic survey snapshots in relation to the spawning season (>10% running ripe) for each area and year. Bio, biomass; *, dates are estimates only. Biomass estimates in italics not used for best estimate

	Snap 1		Snap 2		Snap 3		Spawning season
	Date	Bio	Date	Bio	Date	Bio	
Bounty							
1993	21–25 Aug	*18.0*	25–29 Aug	64.2			21–29 Aug
1994	15–18 Aug	*25.1*	18–21 Aug	*27.3*	21–25 Aug	59.7	22–27 Aug
1995	16–22 Aug	35.1	27–29 Aug	39.8			24–28 Aug
1997	17–23 Aug	85.1	23–27 Aug	39.0			30–31 Aug
1999	14–19 Aug	*16.0*	20–28 Aug	47.7			1–6 Sep
Campbell							
1993	6–12 Sep	34.4	13–19 Sep	43.2			21–26 Sep
1994	11–16 Sep	144.1	16–21 Sep	203.7			17–28 Sep
1995	7–13 Sep	141.1	14–19 Sep	166.5			14–20 Sep
1998	7–14 Sep	198.5	16–22 Sep	192.7			16–27 Sep
Pukaki							
1993	31Aug–1 Sep	41.5	3–5 Sep	39.4			7–9 Sep
1994	31Aug–4 Sep	45.2	4–6 Sep	39.6			*10–12 Sep
1995	30Aug–1 Sep	10.5	1–2 Sep	14.5			*9–10 Sep
1997	29–31 Aug	37.1	2–5 Sep	32.9			2–6 Sep
Auckland							
1995	5–7 Sep	4.4	19–21 Sep	7.8			*11–15 Sep

Appendix 1a: Length frequency files used for decomposition of the SBW categories on the Bounty Platform. –, not surveyed

		Snapshot 1			Snapshot 2		
	Stratum	Adult	Immature	Juvenile	Adult	Immature	Juvenile
1993	1	lfadu	lfimm1	lfimm1	lfadu	lfimm1	lfimm1
	2	lfadu	–	lfjuv	lfadu	–	lfjuv
	3	lfadu	lfimm3	lfjuv	lfadu	lfimm3	lfjuv
	4	lfadu	lfimm3	lfjuv	lfadu	lfimm3	lfjuv
	5	lfadu	lfimm5	lfjuv	lfadu	lfimm5	lfjuv
	7	lfadu	lfimm1	lfimm1	lfadu	lfimm1	lfimm1
	2H	lfadu	–	lfjuv	lfadu	–	lfjuv
	8H	lfadu	–	lfjuv	lfadu	–	lfjuv
1994	1	lfadu1	lfimm	lfjuv	lfadu1	lfimm	lfjuv
	2	lfadu	lfimm	lfjuv	lfadu	lfimm	lfjuv
	3	lfadu	lfimm	lfjuv	lfadu	lfimm	lfjuv
	4	lfadu	lfimm	lfjuv	lfadu	lfimm	lfjuv
	5	lfadu	lfimm	lfjuv	lfadu	lfimm	lfjuv
	7	lfadu	lfimm	lfjuv	lfadu	lfimm	lfjuv
	2H	lfadu	–	–	lfadu	–	–
	8H	lfadu	–	–	lfadu	–	–
1995	1	lfadu	–	lfjuv1	–	–	–
	2	lfadu	–	lfjuv2	lfadu	–	lfjuv2
	3	lfjuv1	–	lfjuv2	–	–	–
	4	lfadu	–	lfjuv2	–	–	–
	2H	lfadu	–	lfjuv2	lfadu	–	lfjuv2
	8Hn	lfadu	–	lfjuv2	–	–	–
	8H	–	–	–	lfadu	–	lfjuv2
1997	1	lfadu	lfimm1	lfjuv	lfadu	lfimm1	lfjuv
	2	lfadu	lfimm3	lfjuv	lfadu	lfimm3	lfjuv
	3	lfadu	lfimm3	lfjuv	lfadu	lfimm3	lfjuv
	4	lfadu4	lfimm3	lfjuv	lfadu4	lfimm3	lfjuv
	6i	lfadu	lfimm3	lfjuv	lfadu	lfimm3	lfjuv
1999	1	lfadu	lfimm3	lfjuv12	lfadu	lfimm3	lfjuv12
	2	lfadu	lfimm3	lfjuv12	lfadu	lfimm3	lfjuv12
	3	lfadu	lfimm3	lfjuv12	lfadu	lfimm3	lfjuv12
	4	lfadu	lfimm3	lfjuv12	lfadu	lfimm3	lfjuv12
	6i	lfadu	lfimm3	lfjuv12	lfadu	lfimm3	lfjuv12

Appendix 1b: Length frequency files used for decomposition of the SBW categories on the Campbell Island Rise from 1993 to 1998. –, not surveyed

		Snapshot 1		Snapshot 2	
	Stratum	Adult	Immature	Adult	Immature
1993	2	lfadu	lfjuv2	lfadu2	lfadu2
	2H	lfadu	lfjuv2	lfadu2	lfadu2
	4	lfadu	lfjuv4	lfadu2	lfadu2
	4H	lfadu	lfjuv4	lfadu2	lfadu2
	5	lfadu	lfjuv4	lfadu	lfjuv4
	7	lfadu	lfjuv4	lfadu	lfjuv4
	8Hn	lfadu	lfjuv2	–	–
	8He	lfadu	lfjuv4	–	–
	8H	–	–	lfadu2	lfadu2
1994	2	lfaduN	lfimm1	lfaduN	lfimm1
	4	lfaduN	lfimm1	lfaduN	lfimm1
	4H	lfaduN	lfimm1	–	–
	5	lfaduS	lfimm2	lfaduS	lfimm2
	7	lfaduS	lfimm2	lfaduS	lfimm2
	8H	lfaduN	lfimm1	–	–
	8F	–	–	lfaduN	lfimm1
1995	2	lfaduN	lfimm	lfaduN	lfimm
	3	lfaduN	lfimm	lfaduN	lfimm
	3H	lfaduN	lfimm	–	–
	$3H_2$	–	–	lfaduN	lfimm
	4	lfaduN	lfimm	lfaduN	lfimm
	$4H_2$	–	–	lfaduN	lfimm
	5	lfaduS	lfimm	lfaduS	lfimm
	7	lfaduS	lfimm	lfaduS	lfimm
	8H	lfaduN	lfimm	–	–
	$8dH_2$	–	–	lfaduN	lfimm
	$8nH_2$	–	–	lfaduN	lfimm

		Snapshot 1			Snapshot 2			
	Stratum	Adult	Immature	Juvenile	Adult	Immature	Juvenile	Other
1998	2	lfaduN	lfimm	lfjuv	lfaduN	lfimm	lfjuv	lfaduN
	3N	lfaduN	lfimm	lfjuv	lfaduN	lfimm	lfjuv	lfaduN
	3S	lfaduN	lfimm	lfjuv	lfaduN	lfimm	lfjuv	lfaduN
	4D	lfaduN	lfimm	lfjuv	lfaduN	lfimm	lfjuv	lfaduN
	4S	lfaduN	lfimm	lfjuv	lfaduN	lfimm	lfjuv	lfaduN
	5	lfaduN	lfimm	lfjuv	lfaduN	lfimm	lfjuv	lfaduN
	6	lfaduN	lfimm	lfjuv	–	–	–	–
	6N	–	–	–	lfaduN	lfimm	lfjuv	lfaduN
	7	lfaduS	lfimm	lfjuv	lfaduS	lfimm	lfjuv	–
	7F	–	–	–	lfaduS	lfimm	lfjuv	–
	7DN1-5	–	–	–	lfaduS	lfimm	lfjuv	–

Appendix 1c: Length frequency files used in both snapshots for decomposition of the SBW categories on the Pukaki Rise from 1993 to 1997. –, not surveyed

	Stratum	Adult1	Adult2	Adult3	Immature1	Immature 2
1993	1	lfadu	lfadu2	–	lfimm1	lfimm2
	2	lfadu	lfadu2	lfadu3	lfimm1	lfimm2
	3	lfadu	–	lfadu3	lfimm1	lfimm2
	4				lfimm1	lfimm2
	5				lfimm1	lfimm2

		Adult	Mix	3plus	Immature
1994	1	lfadu1	lfmix	lf3plus	lfimm
	2	lfadu2	lfmix	lf3plus	lfimm
	3	lfadu2	lfmix	lf3plus	lfimm
	4	lfadu2	lfmix	lf3plus	lfimm
	5	lfadu2	lfmix	lf3plus	lfimm

		Adult
1995	All strata	lfadu

		Adult	Immature
1997	All strata	lfadu	lfimm

Appendix 2a: Length frequency files used to decompose the acoustic marks on the Bounty Platform. Source: Obs, scaled observer length frequency data (x10^3); T93/2, year of *Tangaroa* acoustic survey and tow number(s); 788/30, observer trip and tow number

					1993				1994				1995				1997				1999
Leng	lfadu Obs	lfimm1 T93/2,12	lfimm3 T93/7	lfimm5 T93/8	lfjuv T93/5	lfadu Obs	lfadu1 *T94/8	lfimm 788/30	lfjuv T93/5	lfadu Obs	lfjuv1 T97/1	lfjuv2 T95/1	lfadu Obs	lfadu4 T97/4	lfimm1 T97/1	lfimm3 T97/6	lfjuv #T97/6	lfadu Obs	lfimm3 T99/8,9	lfjuv12 T99/4,15,16
13	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	13	0	6	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
15	0	57	0	7	31	0	0	0	31	0	0	0	0	0	0	2	2	0	0	0
16	1	118	2	7	109	0	0	0	109	0	0	2	0	0	0	4	4	0	0	0
17	0	89	5	2	73	0	0	0	73	0	0	17	0	2	0	18	18	0	0	0
18	0	37	5	1	17	0	0	0	17	0	0	23	0	4	0	27	27	0	0	7
19	0	4	6	0	1	0	0	0	1	0	0	27	0	3	0	23	23	0	0	76
20	0	0	0	0	0	0	0	0	0	0	0	29	0	0	0	12	12	0	0	276
21	0	1	0	0	0	0	0	0	0	0	0	19	0	0	0	1	1	0	0	301
22	1	1	1	0	0	0	0	0	0	0	0	3	0	0	0	1	0	0	0	111
23	3	0	12	2	0	0	0	0	0	0	0	1	0	0	0	2	0	0	0	7
24	8	6	30	6	0	1	0	1	0	0	0	0	0	1	0	10	0	6	0	3
25	18	8	50	4	0	8	2	6	0	0	1	0	0	2	1	27	0	18	1	28
26	11	16	28	2	1	30	8	12	1	5	6	0	0	3	6	41	0	7	3	94
27	9	22	20	0	0	32	8	17	0	27	10	0	6	11	10	33	0	11	8	147
28	7	6	9	1	0	39	7	13	0	67	24	0	6	33	24	27	0	24	19	105
29	7	7	0	0	0	88	10	6	0	209	38	0	5	42	38	26	0	75	19	23
30	2	2	0	1	0	260	25	9	0	427	46	0	12	40	46	14	0	201	41	17
31	6	0	0	0	0	531	57	24	0	708	34	0	17	34	34	6	0	397	79	7
32	24	0	0	0	0	716	78	14	0	683	28	0	38	23	28	2	0	760	105	10
33	72	2	0	0	0	690	86	21	0	706	9	0	51	7	9	1	0	1 238	83	19
34	441	2	0	1	0	452	59	12	0	883	11	0	93	14	11	0	0	1 575	46	15
35	939	5	0	0	0	264	33	4	0	1 013	4	0	131	11	4	0	0	2 335	20	22
36	1 315	6	0	0	0	178	11	0	0	1 151	1	0	175	19	1	1	0	2 364	4	17
37	1 704	8	0	0	0	199	12	0	0	1 294	0	0	217	11	0	0	0	2 559	3	20
38	1 979	9	0	0	0	255	10	0	0	1 165	1	0	202	17	1	0	0	2 137	1	17
39	2 218	5	0	0	0	324	10	0	0	876	1	0	152	12	1	0	0	2 096	0	16
40	2 343	4	0	0	0	391	14	0	0	719	1	0	123	3	1	0	0	1 574	0	12
41	2 222	6	0	0	0	537	12	0	0	553	0	0	101	3	0	0	0	1 294	0	6
42	1 984	2	0	0	0	503	13	0	0	550	0	0	115	1	0	0	0	1 277	0	12
43	1 447	2	0	0	0	502	8	0	0	547	1	0	68	1	1	0	0	1 180	0	9

44	1 183	0	0	0	0	386	11	0	0	564	0	0	53	2	0	0	0	845	0	5
45	1 004	0	0	0	0	280	4	0	0	453	0	0	35	1	0	0	0	696	0	3
46	922	1	0	0	0	236	7	0	0	357	0	0	27	1	0	0	0	518	0	4
47	770	0	0	0	0	171	6	0	0	289	0	0	22	1	0	0	0	486	0	3
48	584	1	0	0	0	208	2	0	0	292	1	0	15	0	1	0	0	417	0	3
49	379	0	0	0	0	151	2	0	0	235	0	0	23	0	0	0	0	260	0	1
50	250	0	0	0	0	110	2	0	0	199	0	0	14	0	0	0	0	257	0	3
51	250	0	0	0	0	81	1	0	0	154	0	0	15	0	0	0	0	251	0	0
52	207	0	0	0	0	70	0	0	0	94	0	0	18	0	0	0	0	155	0	0
53	180	0	0	0	0	38	1	0	0	57	0	0	12	0	0	0	0	103	0	0
54	101	0	0	0	0	38	0	0	0	38	0	0	10	0	0	0	0	61	0	1
55	79	0	0	0	0	27	2	0	0	37	0	0	5	0	0	0	0	42	0	0
56	22	0	0	0	0	16	0	0	0	20	0	0	3	0	0	0	0	23	0	0
57	18	0	0	0	0	9	0	0	0	10	0	0	3	0	0	0	0	17	0	0
58	5	0	0	0	0	3	0	0	0	6	0	0	0	0	0	0	0	5	0	0
59	7	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	8	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Total	22 724	441	168	40	233	7 825	501	139	233	14 392	217	121	1 769	302	217	278	87	25 275	432	1 400

T94/8, 791/14, 788/38
* T97/6 only fish < 22 cm

Appendix 2b: Length frequency files used to decompose the acoustic marks on the Campbell Island Rise. Source: Obs, scaled observer length frequency data (x10^3); T93/36, year of *Tangaroa* acoustic survey and tow number(s); 638/177, observer trip and tow number

				1993				1994			1995				1998
Length	lfadu	lfadu2	lfjuv2	lfjuv4	lfaduN	lfaduS	lfimm1	lfimm2	lfaduN	lfaduS	lfimm	lfaduN	lfaduS	lfimm	lfjuv
	Obs	#Obs2	638/177	T93/36 & 636/146	Obs	Obs	T94/25	T94/28	Obs	Obs	T95/8	Obs	Obs	T98/2,3,11	T98/12
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
17	10	14	14	0	0	0	0	0	0	0	0	2	0	2	17
18	25	26	26	0	0	0	0	0	0	0	0	1	0	6	49
19	31	31	31	0	0	0	3	0	0	0	0	0	0	28	68
20	13	11	11	0	0	0	3	0	0	0	0	3	0	49	23
21	5	4	4	0	0	2	0	0	0	0	0	2	0	30	6
22	1	1	1	2	0	0	0	0	0	0	0	6	0	39	0
23	1	0	0	9	0	0	0	0	0	0	0	23	0	52	0
24	4	1	1	51	0	2	1	1	0	0	0	54	1	73	0
25	17	7	2	84	6	11	3	3	0	0	0	123	4	85	0
26	70	14	2	91	10	165	19	11	0	4	4	241	9	83	0
27	94	32	7	63	70	650	30	30	9	0	24	467	31	55	0
28	182	41	5	49	310	1 539	28	55	18	12	30	1 057	38	26	0
29	100	22	0	22	672	3 254	26	48	169	69	46	1 892	85	20	0
30	73	15	0	6	1 043	5 377	7	23	424	132	57	2 196	106	16	0
31	25	11	0	3	1 329	5 558	1	18	920	382	22	1 978	93	14	0
32	22	5	0	0	1 318	4 920	2	7	1 888	578	14	1 465	104	7	0
33	103	9	0	1	980	3 184	0	4	2 914	851	2	747	98	5	0
34	251	16	0	1	597	2 162	0	2	3 581	738	2	589	143	1	0
35	439	48	3	2	300	1 133	0	0	3 489	661	1	726	275	0	0
36	815	80	2	2	268	461	0	0	2 846	469	2	1 500	564	0	0
37	1 037	97	4	0	114	206	0	0	2 193	283	0	2 871	1 091	0	0
38	1 343	146	6	1	81	114	0	0	1 400	165	0	4 685	1 792	0	0
39	1 522	165	3	0	117	43	0	0	761	71	0	6 424	2 013	0	0
40	1 635	162	4	0	217	127	0	0	409	55	0	6 460	2 077	0	0
41	1 456	163	6	0	265	195	0	0	218	47	0	5 969	1 996	0	0
42	1 317	160	3	0	360	317	0	0	244	30	0	5 149	1 768	0	0
43	1 317	166	1	0	421	261	0	0	228	42	0	3 995	1 447	0	0
44	1 207	167	2	0	376	194	0	0	219	88	0	2 489	1 015	0	0

45	1 090	151	5	0	362	158	0	0	251	86	0	1 490	679	0	0
46	946	120	2	0	258	108	0	0	191	65	0	923	319	0	0
47	700	105	3	0	215	73	0	0	199	29	0	576	208	0	0
48	604	83	3	0	139	63	0	0	130	42	0	449	138	0	0
49	465	76	3	0	100	63	0	0	79	39	0	351	84	0	0
50	282	50	1	0	100	84	0	0	65	41	0	295	117	0	0
51	131	23	1	0	39	44	0	0	65	27	0	140	65	0	0
52	120	18	0	0	18	29	0	0	39	20	0	95	44	0	0
53	82	14	0	0	5	23	0	0	25	10	0	74	43	0	0
54	21	5	0	0	12	35	0	0	7	13	0	27	18	0	0
55	37	3	0	0	4	9	0	0	10	6	0	28	10	0	0
56	0	2	0	0	2	0	0	0	3	1	0	2	3	0	0
57	0	0	0	0	0	0	0	0	0	1	0	2	0	0	0
58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
59	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	17 592	2 264	156	387	10 110	30 562	123	202	22 994	5 055	204	55 567	16 479	591	165

Obs2, Unscaled observer LF data for 18–20 September 1993

Appendix 2c: Length frequency files used to decompose the acoustic marks on the Pukaki Rise. Source: Obs, scaled observer length frequency data (x10^3); T93/28, year of *Tangaroa* acoustic survey and tow number(s); 788/63, observer trip and tow number

					1993					1994	1995		1997
Length	lfadu Obs	lfadu2 *Obs2	lfadu3 *Obs3	lfimm1 T93/28	lfimm2 T93/27	lfadu1 788/63 & 792/2,3	lfmix 788/61 & 789/67,68	lfadu2 *Obs4	lf3plus *T94/11, 18,19	lfimm T93/28	lfadu Obs	lfadu Obs	lfimm 1039/18-51
15	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	1	0	0	0	0	0	0	0	0
19	0	0	0	1	1	0	0	0	0	1	0	0	1
20	0	0	0	0	1	0	0	0	2	0	0	0	2
21	5	8	2	3	3	0	0	0	6	3	0	0	3
22	28	27	9	14	21	0	0	0	2	14	0	1	7
23	50	57	11	43	53	0	0	0	1	43	0	4	30
24	87	104	14	32	57	0	0	2	3	32	0	11	65
25	68	103	11	17	41	0	4	2	29	17	0	19	160
26	27	61	1	4	12	0	8	5	73	4	0	13	119
27	20	34	0	1	2	1	23	23	119	1	2	8	62
28	9	20	2	0	1	0	37	47	206	0	4	3	28
29	9	9	1	0	2	0	63	65	252	0	5	2	24
30	2	1	1	0	0	1	62	60	198	0	18	1	9
31	4	4	3	0	0	0	40	26	71	0	21	1	3
32	51	14	9	0	0	1	18	17	36	0	60	1	3
33	151	41	27	0	0	1	4	7	7	0	123	3	1
34	372	84	55	1	1	4	7	17	9	1	112	10	4
35	529	114	87	0	1	7	2	20	0	0	94	18	5
36	509	88	76	1	1	7	16	44	1	1	75	29	15
37	286	68	49	0	0	17	24	85	1	0	54	48	21
38	179	40	21	0	0	25	13	120	0	0	57	60	37
39	129	24	18	0	1	23	27	117	0	0	64	76	35
40	91	10	11	0	1	14	18	129	0	0	99	72	26
41	134	14	12	0	1	21	12	89	0	0	136	70	22
42	141	28	22	0	1	15	10	67	2	0	153	88	22
43	245	30	34	0	0	5	10	40	1	0	201	101	21
44	342	56	60	0	2	5	9	66	0	0	155	98	22

45	531	81	76	0	1	4	11	81	0	0	130	106	18
46	681	92	91	0	3	5	7	129	0	0	54	105	11
47	660	90	81	0	1	13	7	169	0	0	66	106	13
48	715	108	87	0	5	10	10	144	0	0	93	93	13
49	705	142	86	0	3	9	9	158	0	0	93	73	4
50	487	106	54	0	2	3	14	127	0	0	67	44	3
51	457	65	59	0	2	3	9	96	0	0	84	21	3
52	226	53	24	0	2	3	9	61	0	0	60	20	4
53	139	30	19	0	2	1	2	48	0	0	35	17	4
54	124	16	9	0	1	0	2	15	0	0	24	11	2
55	31	12	2	0	0	1	1	16	0	0	9	4	0
56	11	4	0	0	0	0	0	3	0	0	8	3	0
57	9	0	2	0	0	0	0	6	0	0	2	1	0
58	1	1	0	0	0	0	0	0	0	0	0	0	0
59	0	0	0	0	0	0	0	0	0	0	0	0	0
60	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	8 245	1 839	1 126	117	226	199	488	2 101	1 019	117	2 162	1 340	822

*Obs2, Unscaled observer data for stratum 1 and west of stratum 2 for 2–4 September 1993; trips 638, 645, 649, 669
*Obs3, Unscaled observer data for east of stratum 2 and stratum 3 for 2–5 September 1993; trips 637, 645, 649
*Obs4, Unscaled observer data for east of stratum 2 for 2–8 September 1994; trips 788, 789, 792
*T94, TAN9408/11,18,19; observer trips 788/64, 792/4, 9.