Review of Sustainability Measures and Other Management Controls for the April 2005 - March 2006 Fishing Year

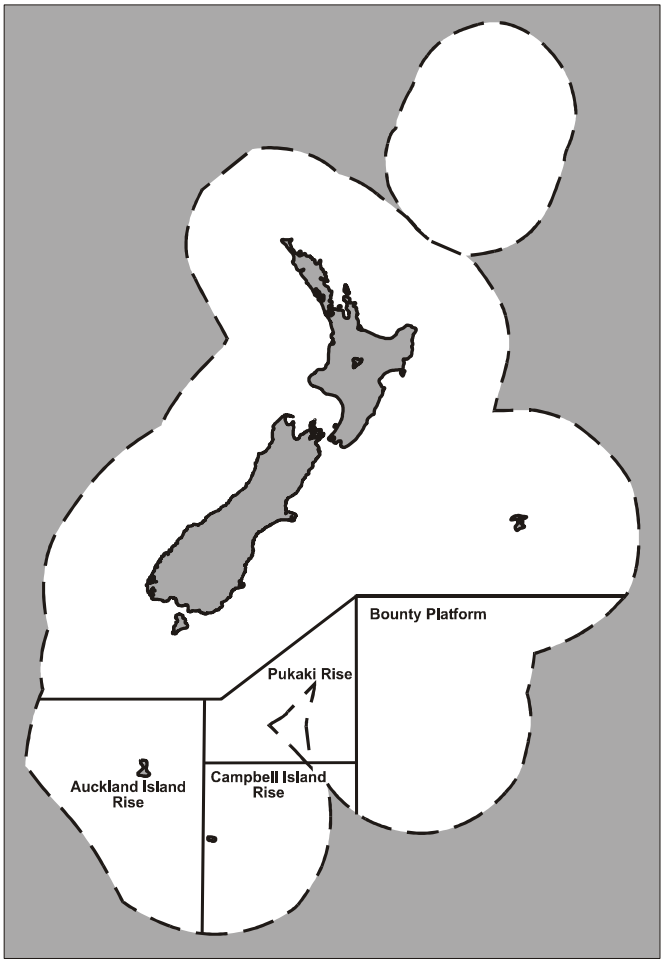
Initial Position Paper

10 February 2005

Southern Blue Whiting – Campbell Island Rise (SBW 6I)

SOUTHERN BLUE WHITING - CAMPBELL ISLAND RISE (SBW 6I)

Figure 1: **Quota Management Areas (QMAs) for Southern Blue Whiting.**



Key issues to be considered

1 The key fishery management matters to be considered for the Campbell Island Rise southern blue whiting stock (SBW 6I) are:

a) the Minister of Fisheries' decision made in April 2004 to retain the total allowable commercial catch (TACC) at 25 000 tonnes for the April 2004 to March 2005 fishing year, after taking into account the economic impacts of a TACC reduction and the relatively small increased risk to the stock (as informed by the 2003 stock assessment);

b) the Minister's view that the best available information at that time suggested a decrease in the TACC (to 20 000 tonnes or less) would be required for the April 2005 to March 2006 fishing year, unless the updated scientific information (about stock status) indicated otherwise;

c) the updated stock assessment information available for SBW 6I (based on the acoustic survey of 2004 and information from the 2004 fishery – details discussed below and provided in Appendix Two), showing that under constant catches at the current 25 000 tonne TACC level –

- stock biomass will continue to decline slowly;
- the probability that the biomass will drop below the limit reference (minimum threshold) biomass B_{1991} (the biomass in 1991 was the lowest observed, yet gave rise to good recruitment and stock recovery) increases to 13% in 2007.

Initial management proposals

2 In response to the current updated stock assessment, the Ministry of Fisheries (MFish) proposes that the Minister should consider the following two options, or an alternative option that lies within the range between them and best addresses the sustainability and utilisation obligations set out in the Fisheries Act 1996 (the Act):

Option 1

i) reduce the total allowable catch (TAC) for SBW 6I for the April 2005 – March 2006 fishing year to 20 000 tonnes;

ii) set zero allowances within the TAC for customary Mäori interests, recreational fishery interests, and other sources of fishing-related mortality;

iii) set the TACC for SBW 6I at 20 000 tonnes;

Option 2

iv) retain the TAC for SBW 6I for the April 2005 – March 2006 fishing year at 25 000 tonnes;

v) set zero allowances within the TAC for customary Mäori interests, recreational fishery interests, and other sources of fishing-related mortality;

vi) set the TACC for SBW 6I at 25 000 tonnes.

Rationale for management proposal

Updating the stock assessment

3 The proposed management actions are based on the updated stock assessment that was reported to a special stock assessment plenary in February 2005, and is summarised in Appendix Two.

4 In order to determine whether or not there was any urgent sustainability concern with the SBW 6I stock following the 2004 acoustic survey, the Middle Depths Fisheries Assessment Working Group (the working group) agreed to update the 2003 base case assessments using the updated catch-at-age data from the fishery and two different time series of acoustic biomass indices. The updated assessment represents the best available information on the SBW 6I stock status and projected performance of the

stock under a range of constant fishing-year catch levels from 10 000 tonnes up to the current TAC/TACC of 25 000 tonnes.

5 Four stock assessment model runs were considered - updates of the two base case runs used in 2003 (which differed only in the priors used for the adult 'acoustic catchability coefficient' q – one was uniform-log and the other was an informed lognormal prior), together with two alternative time series of acoustic biomass estimates. The alternative acoustic biomass series were considered to take into account the distribution of spawning fish on the 'northern' ground, which was quite different to that observed in previous years. Most of the fish caught by commercial vessels, and about 50% of the biomass from the 2004 acoustic survey, came from several aggregations to the east of the core survey area.

6 The working group considered two possible hypotheses regarding the observed distribution of fish outside the core survey area:

a) the northern aggregation had moved further east and fish were spawning outside the survey area; and

b) the fish which previously had spawned in the northern area had been caught and the fish observed outside of the core area represent a new unsurveyed part of the population.

7 Under hypothesis (i), the biomass estimate used in the assessment model should include all fish surveyed because it implies that the proportion of the surveyed population within the core area has changed. Hypothesis (ii) implies that the proportion of the total biomass within the core area has remained unchanged and that the biomass estimate used in the assessment model should include only those fish surveyed in the core survey strata.

8 The two hypotheses represent extreme ends of a continuum, so that the fish outside the survey area could include both fish that have a changed distribution as well as previously unsurveyed fish. The catch/effort and length frequency data were examined to assess which hypothesis was more likely. Since 2002, the fleet has tended to fish further east, outside the core survey area. In each year since then, the eastern aggregation outside of the core area had a similar size distribution to those fish caught in the north within the core survey area. If the northern aggregation had experienced high exploitation while the eastern aggregation had experienced little or no exploitation, the size or age structures of the two aggregations should differ. Since this was not the case, this lends more support for hypothesis (i), but does not rule out hypothesis (ii). The stock assessment was run using both sets of acoustic biomass estimates to examine the stock status under each hypothesis.

9 The working group noted that the run using an uninformed (uniform-log) q with the high acoustic biomass series sometimes led to unrealistically low estimates of q. The resulting high estimates of current biomass appeared to be inconsistent with reports from fishers that large fish were difficult to locate. The working group also noted that the runs which used the low acoustic biomass series based only on the core survey strata indicated that exploitation rates had been very high in 2004 which was considered implausible, particularly because the southern aggregation had very little catch taken from it. The working group agreed that the model run using an informed prior on q and which included the acoustic biomass indices incorporating all surveyed

strata provided the most plausible results and this was chosen as the base case. However, the working group noted that if fish had been outside the core survey area in the earlier years (hypothesis (ii)) then the assessment would underestimate the level of decline in the SBW 6I stock and would consequently overestimate the available yields. The working group agreed that hypothesis (i) would be reported as the base case and to report two sensitivity runs bracketing the base case assessment, one exploring the effect of an uninformed prior on the acoustic q and the other representing hypothesis (ii).

Stock assessment results

10 The current assessment (base case) indicates that the SBW 6I stock biomass showed a steady decline from the early 1980s until 1993, followed by a large increase to 1996, and a decline thereafter (refer to Figure 2 in Appendix Two to see the biomass trajectory). The strong 1991 year class still makes a moderate contribution to the overall catch, and the 1995, 1996, and 1998 year classes all appear to be above average. The 2001 year class is also estimated by the model to be above average, with moderate numbers caught in the fishery and seen by the acoustic survey.

11 Estimates of the expected unfished biomass B_0 over the time of the model runs (given average recruitment levels), 2004 biomass (B_{2004}), and sustainable yields have been calculated for the SBW 6I stock. The estimates of B_0 and B_{2004} are shown in Table 1.

Table 1: Bayesian median and 90% credible intervals of B_0, B_{2004} (in '000 t), B_{2004} as a percentage of B_{1991} and of B_0 , B_{1991} / B_0 for the Campbell Island stock.

Model run	B_0	B_{2004}	B_{2004} (%B_{1991})	B_{2004} (%B_0)	B_{1991} / B_0
Base case	257	82	194	32	0.16
	(227–304)	(51–122)	(128–288)	(20–44)	(0.12-0.21)
Uninformed q	264	112	230	43	0.19
	(232–321)	(66–215)	(153–340)	(25–69)	(0.13-0.25)
Low acoustic	225	36	90	16	0.18
	(202–252)	(26–60)	(66–140)	(11–26)	(0.15-0.23)

12 The base case suggests that current biomass is approximately 32% B_0, although the sensitivity runs show how sensitive the estimates are to the choice of acoustic biomass series and the prior on q.

13 The plenary noted that B_0 might not be well determined, given the high variability in recruitment levels. Recruitment in the SBW 6I stock is characterised by periods of moderate recruitment interspersed by relatively rare, extremely strong, recruitment events. Only one such event (the 1991 year class) has been observed within the (26 year) timeframe of the model, although historical data suggests that this may have happened in the past. Therefore, the plenary considered that the stock biomass in 1991 (B_{1991}) might be a better limit reference point for this stock than the more commonly used 20% B_0. Based on the assumptions of the model and the available data, B_{1991} is estimated to be about 16% of B_0 (see Table 1), and there is only a slight probability that B_{1991} exceeds 20% B_0 (see Figure 1 in Appendix Two). The biomass in 2004 is estimated (from the base case) to be approximately double B_{1991}.

14 The method used to estimate yields is explained in Appendix Two. The plenary noted that the limit biomass assumed in the yield estimation simulations is 20% B_0, which is

different from the use of B_{1991} for assessing risk in projections (as described below). No corresponding yield estimates based on the B_{1991} limit biomass reference point were available for consideration by the plenary. The estimates of the average biomass that could be expected under a current annual yield strategy (B_{MAY}), the maximum average yield under that strategy (MAY), and the current annual yield for the 2005-06 season ($CAY_{2005–06}$) are given for the SBW 6I stock in Table 2.

Table 2: Yield estimates (MAY, and CAY) and associated parameters

Stock	B_{MAY} (%B_0)	MAY (tonnes)	U_{CAY}	$CAY_{2005–06}$ (tonnes)
Campbell Island Rise SBW 6I	34	19 500	0.20	19 000

15 Projections of future biomass levels were made assuming fixed catch levels from 10,000 to 25,000 tonnes per year and recruitments drawn randomly from the distribution of year class strengths estimated by the model over the period 1977 to 2002. As an alternative to the CAY estimates, results have been presented in the form of decision tables showing the probability of biomass falling below B_{1991} for alternative catch levels from 10 000 to 25 000 tonnes (Table 3) over the next three fishing years.

16 At a constant catch level of 25 000 tonnes per year, the probability that the projected biomass will drop below B_{1991} increases from 1% to 13% over the next three years. At a constant catch level of 20 000 tonnes per year, the probability that the projected biomass will drop below B_{1991} is lower, increasing from <1% in 2005 to 5% in 2007. The median biomass estimates show that biomass is projected to decline at constant catch levels of 25 000 tonnes, but remain relatively stable at constant catch levels of 15 000 to 20 000 tonnes.

Table 3: Probability that the projected mid-season vulnerable biomass for 2005, 2006, and 2007 will be less than the mid-season vulnerable biomass in 1991 and the median projected biomass as a percentage of B_0 (with 90% credible intervals) for different constant catch levels for the Campbell Island stock base case run.

	Probability ($B_{proj}<B_{1991}$)			Median biomass as proportion B_0		
Constant catch (t)	2005	2006	2007	2005	2006	2007
10 000	<0.01	<0.01	<0.01	0.34 (0.22–0.48)	0.38 (0.25–0.57)	0.41 (0.26–0.73)
15 000	<0.01	<0.01	0.01	0.33 (0.21–0.47)	0.35 (0.22–0.53)	0.35 (0.21–0.64)
20 000	<0.01	0.02	0.05	0.32 (0.20–0.46)	0.33 (0.19–0.50)	0.31 (0.16–0.59)
25 000	0.01	0.05	0.13	0.31 (0.19–0.45)	0.30 (0.16–0.46)	0.27 (0.11–0.54)

TAC and TACC

Section 13 considerations

17 The SBW 6I stock is managed under s 13 of the Act, which prescribes that the Minister shall set the TAC in order to maintain the stock biomass at or above, or move it towards or above, the biomass level that would support the maximum sustainable yield (B_{MSY}). In considering the way in which, and rate at which, the biomass of a stock is moved towards or above a level that can produce the maximum sustainable yield (MSY), the Act, in s 13(3), requires the Minister to have regard to such social,

cultural, and economic factors as he considers to be relevant. MFish interprets that to provide the Minister with discretion when making decisions about the rate at which to move the stock biomass towards the target level, and allows for some degree of balancing of utilisation and sustainability considerations.

18 Southern blue whiting can experience marked inter-annual changes in recruitment and subsequent biomass levels. The longevity of the species (as much as 25 years) means that recruits to the fishery contribute to the stock biomass for several years, allowing it to be fished down over time. The variability inherent in the stock favours a CAY harvest strategy to enable the maximum yield to be taken over time. Accordingly, the management of the SBW 6I fishery uses a CAY approach.

19 Under a CAY strategy the annual yield is estimated as a fixed proportion (harvest rate) of the current biomass. The harvest rate used is designed to maximise the average catch (MAY) over time within an acceptable level of risk. In the case of southern blue whiting, CAY was estimated using the method of Francis (1992) where the acceptable level of risk is taken to be the probability that future biomass would fall below 20% B_0 less than 10% of the time. The average biomass under this strategy is termed B_{MAY}, which is used as a proxy for B_{MSY}.

20 The Plenary reports that under a CAY harvest strategy, the average stock size B_{MAY} is estimated to be 34% B_0 (under the assumptions and methods as described above). The updated assessment estimates the current stock size to be close to B_{MAY} (B_{2004} is estimated from the base case to be 32% B_0).

21 Under the assumptions noted above and in the plenary report, it appears that the Campbell Island Rise SBW stock is currently at or about the B_{MSY} level required by s 13. However, the stock size is projected to decline slowly (median biomass estimates) if catches continue to be taken at the level of the current TACC of 25 000 tonnes for the next three years.

22 The base case estimate of CAY is 19 000 tonnes (Table 2). The CAY is the amount estimated from the assessment that can be harvested sustainably from the stock given current biomass levels. The maximum average yield under a CAY strategy (MAY), is estimated to be 19 500 tonnes.

23 There is uncertainty associated with the estimates of yield, given that they are derived in relation to the estimates of biomass, which are uncertain (as shown by the 90% credible intervals in Table 1). Also, although the working group agreed that the assumptions under the base case provided the most plausible results, it is possible that the base case underestimates the level of decline in the stock and consequently overestimates the available yields.

Evaluation of risk

24 As noted above, the working group considered that B_0 for the SBW 6I stock might not be well determined because of the highly variable recruitment levels. The working group therefore suggested that the use of B_{1991} as a limit reference biomass level may be preferable to other reference biomass points based on B_0 (such as B_{MSY} or 20% B_0). The working group has used B_{1991} as a limit reference point since 2001.

25 As a **limit** reference point, management should aim to maintain the SBW 6I biomass above the B_{1991} level, rather than managing to that level. The likelihood that the biomass might fall below the reference limit biomass under alternative harvest levels provides the probabilistic information used for risk assessment.

26 The February 2005 plenary agreed that the probability of SBW 6I stock biomass falling below B_{1991} should be kept low for several reasons, including:

- the stock biomass has only been observed at that low level once in the time series;
- the exceptionally strong recruitment from the 1991 year class has only been observed once in the 26 years covered by the stock assessment; and
- although no stock-recruitment relationship is assumed in the model, the risks of poor recruitment might be higher at B_{1991} levels than at 20% B_0.

27 The updated base case assessment indicates that at constant catches of 25 000 tonnes per year (the current TAC/TACC), the probability that the projected biomass will drop below B_{1991} increase from 1% to 13% over the next three years (to 2007) (see Table 3). By contrast, at a constant catch level of 20 000 tonnes per year, the probability is lower, increasing from <1% to 5% over the same period. The probabilities of biomass falling below B_{1991} under constant fishing-year catches of 10 000 to 15 000 tonnes do not exceed 1% over the three years.

28 MFish has not developed a formal policy on the use of limit reference points, in particular the suitability of various levels of risk as indicated by the estimated probability of stock biomass falling below the reference limit. In previous reports, the working group has used a 10% probability level of biomass falling below the B_{1991} level as a threshold risk level. The considerations above suggest that the acceptable risk level should be lower than 10%, and that further consideration should be given to determining an agreed threshold level for management purposes.

Discussion of results

29 For the 2004-05 SBW fishing year, the Minister decided to retain the TAC and TACC at 25 000 tonnes, but he signalled to stakeholders that if no new information became available, or the new information did not support retention of the current TAC, he would be looking to reduce the TAC and TACC for the 2005-06 fishing year.

30 The 2005 updated assessment estimates current biomass to be at or near the available estimate of B_{MSY}. The results reveal similar biomass trends to the previous assessment, and show that constant catches of 25 000 tonnes over the coming three years are estimated to result in the median mid-season biomass continuing to decline, whereas catches of 20 000 tonnes maintain the biomass at or near its current level.

31 The CAY for 2005-06 is estimated as 19 000 tonnes, and the MAY at 19 500 tonnes.

32 If catches continue to be taken at the level of the current TACC, the probability of SBW 6I stock biomass dropping below B_{1991} is 1% in 2005-06, 5% the following year, and 13% in 2007-08.

33 The available information suggests that the TACC will need to be reduced to ensure the long-term sustainability of the stock. There is some question, however, regarding the timing and extent of a TAC reduction. Given that no new biomass estimate will be available until 2007, the decision for 2005-06 will probably have effect for at least two years. In that time, the projections suggest risk of biomass falling below the B_{1991} limit increasing to 5% in 2006 and 13% in 2007 if the TAC is not reduced. Given that the plenary has agreed that probability should be kept low, the assessment results support a reduction of the TAC now, rather than later.

Option 1 – reduce the TAC to 20 000 tonnes

34 The rationale for Option 1 is summarised below:

- CAY (19 000 tonnes) and MAY (19 500 tonnes) estimates are below the current TAC and TACC;
- Substantial risk (13%) of biomass falling below B_{1991} within 3 years at current TAC;
- No new biomass estimate will be available within the next two years.

35 The CAY and MAY estimates are less than the current TAC, suggesting that the current TAC is not sustainable in the longer-term. The results support the option to reduce the TAC now to 20 000 tonnes, constraining catches to levels that are in line with the expected longer-term yields.

36 Current biomass is estimated to be at or near the estimated B_{MSY} (although there is uncertainty). Catches at the current TAC are projected to result in biomass continuing to decline. The reduction to 20 000 tonnes would prevent the biomass from declining further.

37 Constant catches of 20 000 tonnes over the next three years are shown to pose a lower level of risk (reaching 5% in 2007) that biomass will decline below B_{1991} compared with the risk at the current TAC/TACC of 25 000 tonnes. The plenary agreed that the risk should be kept low (although a specific level of risk for management purposes has yet to be determined).

Option 2 – retain current TAC at 25 000 tonnes

38 The rationale for Option 2 is summarised below:

- Acknowledgement of socio-economic impacts of a TAC reduction associated;
- Current biomass is estimated to be at or near the estimated B_{MSY} level (although uncertain), but can be fished down in the short term provided that longer-term objective is to move biomass towards or above the B_{MSY} level; and
- Low probability (1%) of stock biomass falling below B_{1991} limit in 2005-06 at current TAC.

39 MFish acknowledges that reducing the TAC and TACC generally is expected to have economic effects on fishery participants. It should be noted, however, that by mid-January 2005 the reported catch from the SBW 6I stock had reached 19 671 tonnes, or approximately 20% less than the available TACC. Recent substantial reductions in the hoki TACC are likely to have implications for the SBW fishery, since the fisheries share common vessels (particularly charter vessels). Further discussion of economic factors is provided in the next section of this paper.

40 The estimates of mid-season median biomass of the stock show that it is currently at or near the estimated B_{MSY} level, and that the stock will decline if catches are taken at the level of the current TACC. The Minister can allow the biomass level of a stock to move away from B_{MSY} in the short term if his overall objective and expectation is to rebuild the stock to the required target level. In addition, the Minister can take into account social, cultural and economic factors in determining the way in which and the rate at which the biomass is moved towards or above B_{MSY}. There is uncertainty associated with these considerations also, given that the base case assessment might underestimate the decline of the stock size and overestimate yield.

41 The risk of biomass falling below B_{1991} in 2005-06 is 1% if catches are taken at the level of the current TACC in 2005-06. That level of risk does not indicate an urgent sustainability concern. However, the option of retaining the current TAC/TACC at 25 000 tonnes would carry a greater level of risk of stock size declining to an undesirable level over the three year period of the projections. The decision for 2005-06 will effectively be a two-year decision - a new assessment informed by a new acoustic biomass estimate will not be available until early in 2007, and the risk of biomass in 2006-07 falling below B_{1991} increases to 5% under the current TAC/TACC. However, a more thorough assessment of the SBW 6I stock will be completed later in 2005, and could be used to re-evaluate risks to the stock for 2006-07.

Economic and social implications

42 The SBW 6I fishery is characterised by high volumes of catch and relatively low per unit raw product values. Nearly all vessels targeting SBW in the Campbell fishery are believed to be charter vessels, many of which rely upon SBW as one of several fisheries undertaken during the year. The availability of fishing opportunities such as SBW sequenced over the year allows New Zealand fishing companies to efficiently augment harvest capacity with charter vessels where it may not be economically practical to invest in additional vessels. Coordinating charter vessels can require commitments a year in advance.

43 The predictability of SBW fishing opportunities thus becomes an important consideration in a more complex array of charter vessel arrangements in other fisheries over the course of a year. The majority of the SBW 6I fishery is conducted in a relatively short time span during September and October when spawning aggregations occur. If SBW cannot be taken in sufficiently high volumes, the economic incentive for fishers to operate in the fishery is reduced.

44 MFish recognizes that the reduction to the SBW 6I TACC proposed under Option 1 will have a direct economic effect on industry participants. The 2003-04 port price for SBW is $100 per tonne based on the 2003 Licensed Fish Receiver survey, down

from $590 per tonne reported in the 2002 survey.[1] The 2004 survey showed the port price to have increased again to $350 per tonne. The proposed reduction in catch under Option 1 could represent a 24% decline ($ 0.6 million at $100 per tonne, or $2.1 million at $350 per tonne) in gross raw product value based on the reported port price. It should be noted that revenue from landings does not provide a complete picture of economic implications, and variations in currency exchange rates, fuel prices and other operating costs will also have impacts on net returns to operators.

45 A reduction in the TACC would be expected to reduce export earnings, as well. A significant portion of SBW is processed into higher valued forms, primarily surimi and frozen fillets. The reported New Zealand FOB export value of SBW products for the 2002 calendar year totalled approximately $29.3 million, indicating relatively high value added contributions relative to the greenweight value. The SBW 6I fishery accounts for about 90 % of total SBW catch in New Zealand, and is thus an important contributor to these export earnings.

46 The economic effect would also extend to losses that might be associated with vessel lease (and other) costs if catching and processing capacity goes unused. However, the number of vessels targeting southern blue whiting in SBW 6I declined from 18 vessels during 2002-03, to 15 vessels in the 2003-04 and 2004-05 seasons, and is likely to have been influenced further by the reductions in the hoki TAC and rationalisation in the fishing industry that has resulted.

47 MFish is also aware that catch reductions can have social implications when employment opportunities for catching and processing staff are reduced. However, MFish has no estimates of the scale of effects on cultural or social factors such as employment or income that might arise from the proposed decrease in the TACC under Option 1.

48 Further discussion of economic implications is provided in Appendix One.

Recreational and Mäori customary interests

49 There is no known recreational or Mäori customary fishery for SBW 6I. MFish proposes that the Minister sets allowances of 0 tonnes for recreational and Mäori customary fishing.

Other sources of fishing-related mortality

50 Although scientific observers have reported discards of fish and accidental losses from torn or burst codends, there are no quantitative estimates of this source of mortality and no estimates of discards have been considered in the stock assessments.

51 MFish proposes that the known level of other sources of fishing-related mortality is sufficiently low that an allowance within the TAC does not to be set to account for it at this time. Further information on other sources of fishing-related mortality is provided in Appendix One.

[1] The 2003 port price is set in 2003 from data collected from the 2002 fishing year, and used in the 2003/04 levy order.

Environmental considerations

Marine Mammals

52 MFish considers that the proposed options will have no adverse implications for fur seals and other marine mammals. Further information on fur seal capture is provided in Appendix One.

Seabirds

53 MFish considers that the proposed options have no adverse implications for seabirds. Further information on seabird capture issues is provided in Appendix One.

Fish bycatch

54 The SBW 6I is mostly a midwater trawl fishery with very low bycatch of other species. The proposed options have no adverse implications for fish bycatch. Details of fish bycatch are provided in Appendix One.

Statutory considerations

55 MFish considers that the proposed management actions are consistent with the statutory considerations under the Act, as discussed below.

Section 8 – sets out the purpose of the Act as being "*to provide for the utilisation of fisheries resources while ensuring sustainability*". The initial proposal seeks to achieve that purpose by setting a TAC and TACC for the SBW 6I stock. The levels of the proposed TAC/TACC will provide for commercial utilisation while ensuring sustainability. The range of options proposed will enable commercial fishers to continue utilising the SBW 6I fishery at levels similar to the recent past, with catches constrained to levels that will ensure sustainability, based upon current information. There are no known non-commercial interests in the fishery.

Section 13 – prescribes the considerations for setting the TAC in order to obtain the maximum sustainable yield from the stock.

Section 13(2) - requires that the TAC should be set at a level that maintains the stock at or above the level that can produce the maximum sustainable yield (MSY), or moves it towards or above that level, having regard to the interdependence of stocks. The details of the current stock assessment and the implications for setting the TAC are discussed above.

While there are likely to be interactions between southern blue whiting and other species/stocks, there is no evidence of interdependence between stocks that is of significant magnitude to impact on the setting of the TAC.

MFish considers that the proposed TAC options satisfy the requirements of s 13.

***Section 13(2)(b)(ii*) –** requires that, where a stock is determined to be below the level that would produce the MSY, the TAC is set to restore the stock to or above the B_{MSY} level within a period appropriate to the stock, having regard to

the biological characteristics of the stock and any environmental conditions affecting the stock.

The *biological* characteristics of the stock mean that SBW 6I can experience marked inter-annual changes in recruitment, and subsequent biomass levels. The longevity of the species (maximum age of up to 25 years) means that there are several year classes in the fishery - recruits to the fishery contribute to the biomass for several years. Natural mortality is low after maturity, so after strong recruitment, the biomass can be fished down progressively over time. Recovery of a depleted stock will, however, be strongly dependent on the relatively unpredictable recruitment.

The Plenary report provides no indication of specific environmental conditions having been identified as affecting the stock or recruitment.

Section 13(3) – requires the Minister to have regard to the social, cultural, and economic factors he considers to be relevant, when considering the way in which, and rate at which, to move a stock towards the B_{MSY} level.

There could be social and economic consequences from the proposed options for setting the TAC/TACC for SBW 6I. The expected economic effects have been noted in the relevant part of this advice (see paragraphs 42 to 48, and Appendix One), but the precise extent of those effects has not been quantified. Economic effects can result in social effects, following on from a reduction in catching and processing capacity that would be likely to accompany a reduction in the TAC/TACC.

Section 11(1)(c) – requires that the Minister takes into account the natural variability of the stock. Southern blue whiting stocks can display large inter-annual variability in recruitment, which can give rise to substantial fluctuations in biomass. The fishery in recent years appears to have been supported by a very large recruitment in 1991, followed by recruitment levels moderately above average in 1995, 1996, 1998, and 2001. Further information is contained in the stock assessment results presented in Appendix Two.

Section 9 – requires that decision makers take into account the environmental principles set out in:

s 9(a) - specifies that associated or dependent species should be maintained above a level that ensures their long-term viability. The recorded bycatch in the SBW 6I fishery shows that the fishery takes relatively little bycatch (it is a 'clean' fishery). There are no known concerns regarding the viability of associated or dependent species.

s 9(b) – requires that the biological diversity of the aquatic environment should be maintained. SBW 6I is relatively has low bycatch as discussed above, and there is no evidence of adverse effects of the SBW 6I fishery on the maintenance of biodiversity.

s 9(c) – stipulates that habitats of particular significance to fisheries management should be protected. Midwater trawling generally is not known to

have effects on the benthos, as the gear comes into contact with the sea floor only accidentally. No habitats of particular significance for fisheries management have been identified within SBW 6I.

Section 11(1)(a) – requires that the Minister takes into account any effects of fishing on the stock and the aquatic environment before setting or varying any sustainability measure. The direct effects of target fishing on the SBW 6I stock are considered in the assessment, and can support the proposed management options. The fishery is relatively discrete, and the known effects of other target fisheries on the SBW 6I stock or its environment, and any environmental effects of the target SBW fishery, are not considered to have particular significance for setting the TAC/TACC at this time.

Section 5 – requires that decisions should be consistent with New Zealand's international obligations relating to fishing, and the provisions of the Treaty of Waitangi (Fisheries Claims) Settlement Act 1992. There is a wide range of international obligations relating to fishing (including sustainability and utilisation of fishstocks and maintaining biodiversity). MFish considers issues arising under international obligations and the provisions of the Treaty of Waitangi (Fisheries Claims) Settlement Act 1992 are adequately addressed in the management proposal for SBW 6I.

Section 11(1)(b) – requires that the Minister shall set or vary a sustainability measure only after taking into account any existing controls that apply to the stock or area concerned. A TAC and TACC (25 000 tonnes) are in place for SBW 6I. Those are the key controls under consideration for change. Other existing controls are a minimum trawl mesh size of 60 mm within the Sub-Antarctic Fishery management area (including SBW 6I). General restrictions regarding the use of trawl net mesh layers, liners, etc., also apply. Trawling in specified seamount areas is prohibited, and one specified area lies within SBW 6I (at the southern extent of the QMA). The use of net-sonde monitor cables is prohibited on all New Zealand fishing vessels or foreign-owned New Zealand fishing vessels. Those restrictions on trawling have applied for some time and MFish does not consider that they materially affect the Minister's consideration of the proposed change to the TAC/TACC. No changes to existing controls beyond the TAC/TACC are proposed.

Section 11(2A)(b) - requires that, before setting any sustainability measure, the Minister must take into account any relevant fisheries plan approved under s 11. No existing or proposed fisheries plan for SBW 6I is known to MFish.

Section 11(2A)(a) & (c) – before setting a sustainability measure, the Minister must take into account any conservation services or fisheries services, and any decisions not to require conservation or fisheries services. Any relevant conservation or fisheries services have been considered in this paper (see Appendix One – observer coverage, seabirds, fur seals, research). No decision has been made not to require a service in this fishery.

Section 11(2)(a) and (b) – stipulate that the Minister, before setting or varying any sustainability measure, must have regard to the provisions applicable to the coastal marine area known to exist in any policy statement or plan under the Resource Management Act 1991, or any relevant management strategy or plan under the

Conservation Act 1987. No such statements, strategies or plans that are relevant to the setting or varying of any sustainability measure for SBW 6I are known to MFish.

Sections 21(1)(a) and (b), (4)(i) and (ii), and (5) – prescribe the matters to be taken into account when setting or varying the TACC, including making allowances within the TAC for non-commercial Mäori customary fishing, recreational fishing, and other sources of fishing-related mortality.

The nature of the SBW 6I fishery and the interests of the respective fishing sectors have been considered in setting the TACC. There are no known Mäori customary or recreational fishing interests in the SBW 6I fishery, and no allowances are proposed. The known fishing-related mortality beyond the landed catch is small, and an allowance is not proposed.

No mätaitai exists in the SBW 6I QMA. No area has been closed or fishing method restricted under s 186A for customary fishing purposes in SBW 6I. No restrictions have been placed on fishing in any area within the QMA for recreational interests.

Section 21(2) – requires that, before setting or varying a TACC for any quota management stock, the Minister shall consult such persons and organisations as the Minister considers are representative of those classes of persons having an interest in this section, including Maori, environmental, commercial, and recreational interests.

Although there are no known customary non-commercial or recreational fishing interests in the SBW 6I fishery, key customary and recreational groups are being consulted. Environmental interests were represented at the plenary and are included in the consultation process.

Section 10 – prescribes the information principles that are to be taken into account when exercising powers and functions under the Act. Decision makers should use the best available information, consider uncertainty in that information, and be cautious when information is uncertain, unreliable, or inadequate. The absence or uncertainty of information should not be used as a reason to postpone or fail to make decisions.

MFish considers that the primary information supporting the proposed management action is provided by the current stock assessment for SBW 6I, as reported in the February 2005 plenary report. That assessment represents the best available information about the performance of the fishery under the presented range of future catch levels. MFish notes that there is uncertainty in the assessment. Having regard to the assessment and the uncertainty in it, MFish proposes that a range of management options might satisfy the sustainability and utilisation obligations under the Act.

Taking note of the uncertainties in the information and the risks to sustainability that arise, MFish considers that the assessment provides adequate indication of the need to reduce the TAC/TACC in order to satisfy the s 13 requirements, and ensure a low risk of biomass falling below the B_{1991} limit reference biomass level. However, since the updated assessment is more optimistic than the previous assessment, MFish accepts that retaining the current TAC under Option 2 provides a short-term alternative, at least for 2005-06.

Future management

Management framework

56 The TAC/TACC for SBW 6I is managed according to the requirements of s 13, with a CAY harvest strategy considered to provide the best yield from the fishery over time. MFish will be continuing work on determining the most appropriate harvest strategies for SBW stocks, and identifying the biological reference points and performance indicators needed for management. An additional sustainability 'bottom line' is provided by referencing the current biomass to the biomass in 1991, and ensuring that biomass remains above that with a high level of certainty. MFish will be working in the coming year to determine the acceptable level of certainty or risk for this reference. 1991 is established as the reference year on the recognition that biomass in that year fell to the lowest observed levels, yet subsequently gave rise to good recruitment and stock recovery. Management should aim to maintain the SBW 6I biomass above the threshold level, rather than managing to that level.

57 MFish has previously noted the difficulty in incorporating SBW stock survey information obtained in September/October with the working group fishery assessment process in time to accommodate changes in management actions prior to the beginning of the next SBW season commencing in April. Based on MFish advice and industry submissions from the 2003 review of the SBW fishery, the Minister decided in May 2003 to delay the use of stock assessment information by one fishing year, in general, with management decisions therefore applying for a period of two years.

58 MFish notes the previously expressed stakeholders' views about the planning and resourcing problems presented by the nature of the SBW fishery. MFish encourages rights holders in the SBW 6I fishery to explore solutions to the particular challenges of the SBW fishery.

Observer coverage

59 MFish will continue to monitor the catch of fur seals and seabirds in the SBW fisheries through the observer programme. A total of 240 observer days are programmed for the current business year (July 2005 to June 2006) to be applied across all SBW stocks. These observer services provide information concerning catch composition, species characteristics, conversion rates, and the bycatch of marine mammals and birds. New information gained over time will be available for consideration in future management decisions.

Research

60 A full revision of the stock assessment for the SBW 6I stock might be completed in the 2005-06 business year (SBW 2004/01), depending on priorities. Results would provide the basis for a review of management arrangements for the SBW 6I fishery applicable to the 2006-07 fishing year.

61 An acoustic survey to determine biomass is planned for the winter/spring of 2006. Results could be available for inclusion in an updated assessment that would inform management decisions for the 2007-08 year.

Conclusion

62 The current biomass is estimated to be approximately 32% B_0, which is close to the estimated average biomass that would be expected under a CAY harvest strategy. The assessment reveals that constant catches of 25 000 tonnes over the coming three years are estimated to result in the median mid-season biomass continuing to decline, whereas catches of 20 000 tonnes maintain the biomass at or near its current level.

63 The CAY estimate of 19 000 tonnes indicates the sustainable yield that can be taken from the biomass in 2005-06.

64 The assessment shows that if constant catches are taken at the level of the current 25 000 tonnes TACC over the next three years, the probability of stock size falling below the B_{1991} reference limit biomass is greater than if the TACC is reduced to 20 000 tonnes.

65 MFish considers that the available information indicates the need to reduce the TAC and TACC for sustainability reasons. The Plenary reported the view that the probability of falling below B_{1991} should be kept low because that low biomass and the exceptionally strong recruitment from it has only been observed once in the 26 years covered by the stock assessment. Although no stock recruitment relationship is assumed in the model, the risks of poor recruitment may be higher at B_{1991} levels than at higher biomass levels.

66 The option to reduce the TAC to 20 000 tonnes addresses the identified risks to the sustainability of the stock, taking into account the uncertainty of the assessment results. Further, a TAC/TACC of 20 000 tonnes is estimated to maintain stock biomass at or near its current level, is close to the estimate of CAY, and approximates the MAY that can be expected from the stock over time. Relative stability in the fishery would assist industry with its planning and coordination of catching/processing capacity, and provide for greater certainty of supply to markets.

67 While MFish acknowledges that reducing the TAC generally would have economic implications, it should be noted that, by mid-January 2005, the reported catch from the SBW 6I stock had reached 19 671 tonnes, or approximately 20% less than the available TACC. Reducing the TAC as proposed in Option 1 would thus constrain catches in 2005-06 to a similar level to that taken in the previous year.

68 The proposal under Option 1 is that the Minister should consider reducing the TAC and TACC for SBW 6I to 20 000 tonnes for the April 2005 - March 2006 fishing year.

69 However, MFish acknowledges the uncertainties in the assessment, and that reducing the TACC generally is expected to have economic effects on fishery participants.

70 Assuming that the base case results are not overly optimistic, an urgent sustainability risk to the stock does not appear to arise from fishing at the current TACC for the coming fishing year. However, the estimates of mid-season median biomass of the

stock show that the stock will continue to decline if catches are taken at the level of the current TACC. MFish considers those estimates to indicate the need to reduce the TACC to satisfy the requirements of moving the stock towards or above the biomass level that will produce the maximum sustainable yield under the agreed harvest strategy for the stock. However, the Minister can take into account social and economic considerations, and has discretion as to the way in which and rate at which a stock is moved towards or above its B_{MSY}.

71 The proposal under Option 2 is to retain the current TAC/TACC at 25 000 tonnes. Option 2 recognises short-term economic impacts on industry, but is likely to reduce biomass further below the estimated B_{MSY} and carry a greater level of risk of stock size declining to an undesirable level over the three year period of the projections. The risk arises, in part, because the decision for 2005-06 will effectively be a two-year decision, given that a new assessment informed by a new acoustic biomass estimate will not be available until early in 2007.

Preliminary recommendations

72 MFish proposes that:

EITHER

a) OPTION 1 - for the fishing year commencing on 1 April 2005, the southern blue whiting TAC for the Campbell Island Rise stock (SBW 6I) be reduced to 20 000 tonnes, and within the TAC;

   i) an allowance of 0 tonnes be made for non-commercial Mäori customary fishing interests;

   ii) an allowance of 0 tonnes be made for recreational fishing interests;

   iii) an allowance of 0 tonnes be made for other sources of fishing-related mortality; and

   iv) the TACC be set at 20 000 tonnes.

OR

b) OPTION 2 - for the fishing year commencing on 1 April 2005, the southern blue whiting TAC for the Campbell Island Rise stock (SBW 6I) be retained at 25 000 tonnes, and within the TAC;

   i) an allowance of 0 tonnes be made for non-commercial Mäori customary fishing interests;

   ii) an allowance of 0 tonnes be made for recreational fishing interests;

   iii) an allowance of 0 tonnes be made for other sources of fishing-related mortality; and

   iv) the TACC be set at 25 000 tonnes.

OR

c) an alternative option within the range presented above be chosen that best meets the sustainability and utilisation obligations set out in the Act.

APPENDIX ONE – FISHERY SUMMARY

Catch information

73 The following table illustrates the catches from the southern blue whiting fisheries by area for 1978 to 2004-05 (preliminary) from vessel logbooks and fishing returns.

Table 4: **Estimated catches (t) of southern blue whiting by area for the period 1978 to 2004–05 from vessel logbooks and QMRs. – no catch limit in place. *, before 1997-98 there was no separate catch limit for Auckland Is. Estimates for 2004–05 are preliminary.**

	Bounty Platform		Campbell Island Rise		Pukaki Rise		Auckland Is.		Total	
Fishing year	Catch	Limit	Catch	Limit	Catch	Limit	Catch	Limit*	Catch	Limit
1978*f*	0	–	6 403	–	79	–	15	–	6 497	–
1978–79+	1 211	–	25 305	–	601	–	1 019	–	28 136	–
1979–80+	16	–	12 828	–	5 602	–	187	–	18 633	–
1980–81+	8	–	5 989	–	2 380	–	89	–	8 466	–
1981–82+	8 325	–	7 915	–	1 250	–	105	–	17 595	–
1982–83+	3 864	–	12 803	–	7 388	–	184	–	24 239	–
1983–84+	348	–	10 777	–	2 150	–	99	–	13 374	–
1984–85+	0	–	7 490	–	1 724	–	121	–	9 335	–
1985–86+	0	–	15 252	–	552	–	15	–	15 819	–
1986–87+	0	–	12 804	–	845	–	61	–	13 710	–
1987–88+	18	–	17 422	–	157	–	4	–	17 601	–
1988–89+	8	–	26 611	–	1 219	–	1	–	27 839	–
1989–90+	4 430	–	16 542	–	1 393	–	2	–	22 367	–
1990–91+	10 897	–	21 314	–	4 652	–	7	–	36 870	–
1991–92+	58 928	–	14 208	–	3 046	–	73	–	76 255	–
1992–93+	11 908	15 000	9 316	11 000	5 341	6 000	1 143	–	27 708	32 000
1993–94+	3 877	15 000	11 668	11 000	2 306	6 000	709	–	18 560	32 000
1994–95+	6 386	15 000	9 492	11 000	1 158	6 000	441	–	17 477	32 000
1995–96+	6 508	8 000	14 959	21 000	772	3 000	40	–	22 279	32 000
1996–97+	1 761	20 200	15 685	30 100	1 806	7 700	895	–	20 147	58 000
1997–98+	5 647	15 400	24 273	35 460	1 245	5 500	0	1 640	31 165	58 000
1998–00†	8 741	15 400	30 386	35 460	1 049	5 500	750	1 640	40 926	58 000
2000–01#	3 997	8 000	18 049	20 000	2 864	5 500	19	1 640	24 938	35 140 ‡
2001–02#	2 261	8 000	29 999	30 000	230	5 500	10	1 640	32 501	45 140 ‡
2002–03#	7 564	8 000	33 433	30 000	508	5 500	254	1 640	41 775	45 140 ‡
2003–04#	3 812	3 500	23 718	25 000	163	5 500	116	1 640	27 812	35 640 ‡
2004–05#	1 477	3 500	19 777	25 000	180	5 500	51	1 640	21 491	35 640 ‡

f 1 April-30 September. + 1 October-30 September.
† 1 October 1998-31 March 2000 # 1 April -31 March.
‡ SBW 1 (all EEZ areas outside QMA6) had a TACC of 8 t, and reported catches of 9 t in 2000–01, 1 t in 2001–02, 16 t in 2002–03, 2.6 t in 2003–04, and 5.7 t in 2004–05.

SBW stock structure

74 For the purposes of stock assessment it is assumed that there are four stocks of SBW with fidelity within stocks: the Bounty Platform stock (SBW 6B), the Pukaki Rise stock (SBW 6R), the Auckland Islands stock (SBW 6A), and the Campbell Island stock (SBW 6I). A decision was made on introduction of this species into the QMS in 1999 to manage the four sub-Antarctic fisheries as separate stocks on the basis of the biological characteristics of the discrete fisheries.

Management strategy for SBW

75 Since 1997, management of the SBW 6I fishery has been based on a CAY strategy. A CAY strategy takes into account the biological characteristics of the stock and the current status of the stock based on a current assessment. Ageing studies have shown that SBW stocks have very high recruitment variability. This variability translates into large fluctuations in biomass. A management strategy based on CAY provides the opportunity to maximise yield from the fishery over time by taking into account fluctuations in biomass. Regular acoustic surveys (primarily focusing on the principal fishing grounds of Bounty and Campbell) and stock assessments provide estimates of

biomass and available yields that minimise risk to the fishery while maximising available yield.

Commercial fishery

76 The fishery for SBW is almost entirely concentrated on the August-September spawning aggregations, with over 90% of the catch taken within six to eight weeks, although, in recent years, fishing has extended into October. The method of catching SBW is trawling (primarily midwater).

77 A total commercial catch limit of 32,000 tonnes, with area sub-limits, was introduced for SBW in the 1992–93 fishing year. SBW 6 was introduced into the QMS by legislation on 1 November 1999 after completion of the 1999 fishing season. SBW 1 was introduced into the QMS on 1 April 2000.

78 The catch limits for the Campbell fishery have been under-caught in most years since their introduction into the QMS, although catch did increase relative to the TACCs in the 2002-03 season. The under-catch in these fisheries may reflect the relative economic value of the fish and difficulties in timing experienced by operators in this fishery rather than low stock sizes. The SBW fishery is predominantly fished by vessels following completion of the hoki fishery. A poor hoki season may result in vessels remaining longer on the hoki grounds and missing the commencement of the SBW fishing season.

79 Industry has noted that the limited duration of the season, coupled with long distances between fishing areas and significant search times to locate fish, works against the ability of the fishing industry to fish effectively in all four SBW 6 QMAs and against all four TACCs in any one season. Even in years of high fish abundance, fleet managers recognise that they lose some fishing time due to poor weather and to exploration in search of suitable fish aggregations.

Economic effects

80 The Campbell fishery is characterised by high volumes of catch and low prices. Thus, if fish cannot be taken in high volumes, the economic incentive for fishers to operate in the fishery is reduced and fishers may look to move into more lucrative fisheries.

81 An estimation of the value of the SBW6I fishery can be undertaken by an examination of port prices and TACC level. The 2003-04 port price for SBW is reported to be $100 per tonne, down significantly from the 2002-03 port price of $590 per tonne. The 2004 survey port price rose again to $350 per tonne. The landed catches for the SBW 6I fishery in 2002-03, 2003-04, and 2004-05 were about 30 000 tonnes, 25 000 tonnes, and 20 000 tonnes respectively, resulting in respective gross raw product values of $17.7, $2.5 and $7 and million (based on the relevant-year port prices).

82 A comparison of the value of catch over the five years to 2002-03 indicates that the average gross value from the SBW 6I fishery was $12.9 million (at $490 per tonne). At the 2003-04 estimated port price of $100 per tonne for the SBW 6I fishery, the 2003–04 port value declined to $2.5 million (25 000 tonnes at $100 per tonne), substantially less than the average. The 2004 port price rose again, and the catch

reported to date of about 20 000 tonnes would have represented an increase in value to approximately $7 million. The proposed reduction in catch under Option 1 (5 000 tonnes reduction for 2005-06) would represent a reduction in revenue of $ 1.75 million at the port price of $350 per tonne.

83 SeaFIC figures show that, for the 2002 Calendar year, the total free on board value (FOB, basic value of exports) of SBW was about $29 million, including surimi, frozen fillet, and frozen head and gutted product. In 2002, SBW 6I contributed roughly 90% of all SBW catch, thus accounting for the vast majority of $29 million in export earnings.

84 MFish has no estimates of the effects on cultural or social factors such as employment or income that would be associated with an increase or decrease in catch levels.

Recreational fishery

85 There is no known recreational fishery for SBW in any stock.

Mäori customary fishery

86 There is no known non-commercial Māori customary take of SBW in any stock.

Other Sources of fishing-related mortality

87 Scientific observers have reported discards of undersize fish and accidental loss from torn or burst codends.

88 NIWA estimated discards in the SBW fishery for the 1994-95 and 1995-96 fishing years. Some 39 756 tonnes of SBW were landed in those years. NIWA estimated that 616 tonnes (95% confidence intervals 295-1 145 tonnes) or 1.5% of the total SBW catch was discarded in that period.

Illegal catches

89 The level of illegal and unreported catch is thought to be low, however, the operators of one vessel have recently been convicted for area misreporting. In 2002–03, the vessel caught about 204 tonnes on the Campbell Island Rise (SBW 6I) that were reported against quota for the Pukaki Rise (SBW 6R), and another 480 tonnes caught on the Campbell Island Rise were reported against quota for the Auckland Islands Shelf (SBW 6A). Table 1 shows corrected totals by area for 2002–03.

Observer coverage

90 In the 2004-05 and 2005-06 fishing years, observer coverage is planned to cover about 330 days. This compares to the 2001-02 fishing year there where there were 408 observer days in the SBW fisheries. In 2004-05, the number of observed days achieved was 294. Note that an observer day is defined as a 12 hour shift. Normally there are two observers on board a vessel allowing 24 hour coverage to be completed.

91 Observer coverage in SBW 6 in the 2001-02 fishing year was at a level in excess of 30% so that a robust assessment can be carried out into the number of fur seals and/or

seabirds killed over the whole fishery. In the Campbell Rise (SBW 6I) fishery there were 755 tows for SBW and 403 were observed (53%), while in the Bounty Rise (SBW 6B) fishery there were 34 tows of which 25 were observed (74%).

92 MFish will continue to monitor the number of fur seals and seabirds captured in the SBW fishery through the observer programme.

Environmental Considerations

Fur Seals

93 Research reports estimate the number of New Zealand fur seals captured in the SBW fishery (from extrapolation of data from observed tows – the vast majority of fishing effort is in SBW 6I) as:

1999-00 - 14 fur seals (c.v. = 43%) (based on four confirmed deaths reported in the 27% observer coverage of the 789 tows conducted)
2000-01 - 88 seals (c.v. = 15%) (based on the seasonal mean catch rate – 62% of tows in SBW 6I were observed and 25 seals observed caught in that part of the fishery)
2001-02 – 18 seals estimated caught in SBW 6I (c.v. = 39%) (based on mean catch rate of 0.022 fur seals caught per observed tow (s.e. = 0.011)
2002-03 – 17 seals (c.v. = 24%) (based on mean catch rate in September 0.030 (s.e. = 0.010).

94 The reports reveal that fur seal bycatch rates were significantly lower in the Campbell Plateau compared to the Bounty Platform. However, the Campbell fishery generally accounts for more than 90 % of SBW target fishing effort.

95 Application of a marine mammal exclusion device has been trialed in the Auckland Islands squid fishery. Extension of use of this device for other fisheries could be considered subject to the device proving effective. Fishers in the SBW fishery currently implement a voluntary code of practice that is designed to reduce the capture of marine mammals.

Seabirds

96 Research reports estimate the following incidental captures of seabirds in the SBW fishery:

1999-00 - two seabirds were landed dead from tows off the north-eastern edge of the Campbell Plateau (Baird S J, Sept 2001). Both birds were identified as male Grey petrels. Grey petrels are considered to have a threat status of "at risk" (Seabird National Plan of Action (NPOA)).
2000-01 – one Salvin's albatross observed caught off Bounty Platform; one grey petrel and one southern cape pigeon caught north of Campbell Rise

97 Grey petrels breed at the Campbell Islands group and the Antipodes Islands with New Zealand. In 1984 the New Zealand population was estimated to be 10,000 – 50,000 pairs. The size of the total global population is not currently known. Grey petrels are

known to breed on six islands outside New Zealand. In the 1998-99 fishing year one seabird was observed caught and released alive from the Bounty Platform area.

Fish bycatch

98 The effects of fishing on any stock and the aquatic environment in general as a consequence of the SBW 6I fishery are unknown. Although there is information on incidental catch of associated or dependent species, this is insufficient information to assess the impact current levels of fishing for SBW 6I might be having on these species or the biological diversity of the aquatic environment of the SBW 6I fishery.

99 However, the latest research results confirm that the southern blue whiting fishery is characterised by relatively clean catches of the target species. Based on data collected between 1990 and 2002, results show that the three main bycatch species in the southern blue whiting fishery are hoki (0.2 % of SBW catch), ling (0.2 %) and hake (0.1 %). Given those data and the estimated target species discard proportion of 1.5 %, the southern blue whiting fishery appears to be among the least wasteful of those New Zealand trawl fisheries examined.

Research

100 An acoustic survey of the Campbell fishery was completed in winter 2004. This survey has been incorporated into an updated stock assessment, reported to a special working group plenary in February 2005 (see Appendix Two).

Compliance information

101 There are unlikely to be significant compliance concerns in the SBW 6I fishery. However, large bags taken are likely to contain damaged and undersized fish, potentially resulting in dumping and high grading of fish. Past misreporting of catches between areas has also been confirmed, and incentives exist given the large differences in the catch limits between adjacent fishery areas or stocks.

102 The operators of one vessel were recently convicted for misreporting of catch (i.e. trucking of fish). They admitted that in 2002–03 about 204 tonnes caught on the Campbell Island Rise (SBW 6I) was reported against quota for the Pukaki Rise (SBW 6R) and that another 480 tonnes from the Campbell Island Rise was reported against quota for the Auckland Islands Shelf (SBW 6A).

APPENDIX TWO – STOCK ASSESSMENT

103 Updated estimates of biomass and yield are provided for the Campbell Island Rise SBW 6I stock based on analyses using catch-at-age from the commercial fishery, acoustic survey data, and estimates of biological parameters. New information since the 2003 assessment includes the results of an acoustic survey carried out in 2004, and two years of observer proportions-at-age data.

Estimates of fishery parameters and abundance indices

104 Acoustic surveys of southern blue whiting have been carried out since 1993. Target strength work has continued each year as part of these acoustic surveys. Additional estimates from *in situ* data were reported in 2002, which indicate that the slope in the target strength – fish length relationship may be steeper than previously used (Dunford 2003). However, the Middle Depths Fisheries Assessment Working group (the WG) was unable to resolve the inconsistencies between the various data sources (swimbladder modelling, *in situ* data, and recent results from work on northern blue whiting). Therefore it was agreed to retain the original relationship between target strength and fish length from the Northern hemisphere for blue whiting (Monstad et al., 1992) as used previously in New Zealand assessments. The WG noted that if the slope in this relationship is kept the same, the value of q changes in the model but relative abundance indices are still valid, whereas if a different slope of the relationship is used the data must be reanalysed.

105 A further acoustic survey of the Campbell Island stock was completed in August/September 2004 (O'Driscoll *et al.* in prep.) Two snapshots were carried out on pre-spawning and spawning aggregations on the Campbell Island Rise. The distribution of fish on the 'northern' ground during the 2004 survey was quite different to previous years. Most of the fish caught by the commercial vessels, and about 50% of the biomass from the acoustic survey, came from several aggregations to the east of the core survey area.

106 The Plenary considered two possible hypotheses regarding the observed distribution of fish outside the core area: (1) the northern aggregation had moved further east and were spawning outside the survey area; (2) the fish which previously had spawned in the northern area had been depleted and the fish observed outside of the core area represent a new unsurveyed part of the population. Under hypothesis 1, the biomass estimate used in the assessment model should include all fish surveyed because it implies that the proportion of the surveyed population within the core area has changed. Hypothesis 2 implies that the proportion of the total biomass within the core area has remained unchanged and that the biomass estimate used in the assessment model should include only those fish surveyed in the core area. The two hypotheses represent extreme ends of a continuum, so that the fish outside the core area could include both fish that have a changed distribution as well as previously unsurveyed fish. The catch/effort and length frequency data were examined to assess which hypothesis was more likely. Since 2002, the fleet has tended to fish further east, outside the core area. In each year since then, the eastern aggregation outside of the core area had a similar size distribution to those caught in the north within the core

area. If the northern aggregation had experienced high exploitation while the eastern aggregation had experienced little or no exploitation, the size or age structures of the two aggregations should differ. Since this was not the case, this lends more support for hypothesis 1 but does not rule out hypothesis 2. The stock assessment was run using both sets of acoustic biomass estimates (Table A) to examine the stock status under each hypothesis.

107 A preliminary acoustic survey of the Campbell Island stock was carried out using an industry vessel in September 2003. Five and two acoustic snapshots were carried out on the northern and southern Campbell Island Rise respectively. The results of this survey have not been used in the stock assessment to date.

Table 5: **Estimates of biomass (000 t) for age 1, 2, 3 and 4+ fish from acoustic surveys of Bounty Platform, Pukaki Rise, and Campbell Island Rise, and CPUE indices. – no data. *Estimates include fish from outside the standard survey area.**

Year	Bounty Platform				Pukaki Rise				Campbell Island Rise				
	1	2	3	4+	1	2	3	4+	1	2	3	4+	CPUE
1986	–	–	–	–	–	–	–	–	–	–	–	–	1.00
1987	–	–	–	–	–	–	–	–	–	–	–	–	0.91
1988	–	–	–	–	–	–	–	–	–	–	–	–	0.88
1989	–	–	–	–	–	–	–	–	–	–	–	–	1.38
1990	–	–	–	–	–	–	–	–	–	–	–	–	1.06
1991	–	–	–	–	–	–	–	–	–	–	–	–	1.30
1992	–	–	–	–	–	–	–	–	–	–	–	–	0.60
1993	8.81	6.87	1.41	62.86	0.58	26.85	9.32	31.15	1.82	71.90	14.78	24.03	1.03
1994	0.09	5.87	32.07	27.67	0.01	1.19	6.36	35.97	0.33	12.26	139.55	28.84	1.19
1995	59.28	4.86	6.66	30.77	0.00	0.10	0.78	11.74	0.00	11.18	23.23	130.54	1.23
1996	–	–	–	–	–	–	–	–	–	–	–	–	2.28
1997	1.68	4.14	24.60	37.52	0.02	2.84	0.86	34.09	–	–	–	–	2.28
1998	–	–	–	–	–	–	–	–	2.28	13.14	28.02	167.67	1.74
1999	0.43	0.75	4.97	42.72	–	–	–	–	–	–	–	–	2.55
2000	–	–	–	–	0.06	3.04	2.07	29.45	0.96	10.46	8.42	135.61	1.85
2001	0.14	2.55	6.01	21.68	–	–	–	–	–	–	–	–	1.83
2002	–	–	–	–	–	–	–	–	3.06	3.73	11.55	148.19	1.94
2002*	–	–	–	–	–	–	–	–	3.06	3.83	11.84	152.18	–
2004	–	–	–	–	–	–	–	–	1.51	14.42	18.87	17.28	–
2004*	–	–	–	–	–	–	–	–	1.51	17.33	34.53	56.20	–

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

Biomass estimates for the Campbell Island stock

109 The stock assessment model partitions the Campbell Island stock into two sexes and age groups 2–11, with a plus group at age 11. There are two time steps in the model (Table B). In the first time step 90% of natural mortality takes place. In the second

time step, fish ages are incremented; the 2-year-olds are recruited to the population, which is then subjected to fishing mortality; and the remaining 10% of natural mortality.

Table 6: **Annual cycle of the stock model, showing the processes taking place at each step, and the available observations. Fishing mortality (F) and natural mortality (M) that occur within a time step occur after all other processes. M, proportion of M occurring in that time step.**

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

110 The model assumes that the fishing selectivity after age 4 is 1.0, and estimates selectivity for each sex for ages 2 to 4. Selectivities were assumed constant over all years in the fishery, and hence there was no allowance for annual changes in selectivity. In line with previous assessments no stock-recruitment relationship is assumed in the model. The proportion of males at recruitment (age 2) was assumed to be 0.5 of all recruits. As it is a spawning fishery, the maturity ogive was assumed to be the same as the selectivity ogive estimated in the model. Note that the maturity ogive is only used to report spawning stock biomass. The maximum exploitation rate (U_{max}) was set at a value of 0.7. The choice of the maximum exploitation rate has the effect of determining the minimum possible virgin biomass allowed by the model. Because of the large inter-annual differences in growth, caused by the occurrence of the strong and weak year classes, length-at-age vectors were calculated for each year, and used in the modelling. Lengths-at-age were converted to weights-at-age in the model using the length-weight relationship given below:

Estimates of biological parameters for the Campbell Island Rise southern blue whiting stock.

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

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

111 The model was fitted to the two series of acoustic biomass estimates of ages 2, 3, and 4+ fish given in Table C and the proportions-at-age data from the commercial fishery. The acoustic survey estimates were used as relative estimates of mid-season biomass (i.e. after half the catch has been removed), with associated c.v.s estimated from the survey analysis. Catch-at-age observations were available from the commercial fishery for the period 1979 to 2004. Catch-at-age data were fitted to the model as proportions-at-age, where estimates of the proportions-at-age and associated c.v.s by age were estimated using the NIWA catch-at-age software by bootstrap (Bull & Dunn 2002). Zero values were replaced with the value 0.0002 with an associated c.v. of 1.5. Ageing error was assumed to be zero.

112 Lognormal errors, with known c.v.s were assumed for the relative biomass and proportions-at-age data. The c.v.s available for these data allow for sampling error

only. However, additional variance assumed to arise from differences between model simplifications and real world variation, was added to the sampling variance. The additional variance, termed process error, was estimated in an initial run of the model using all the available data. A process error of 0.4 was estimated for the proportions-at-age data and was added to each observation for all subsequent model runs. The process error estimated for the acoustic indices was zero.

Table 7: **Decomposed biomass estimates (t) and c.v.s by survey and age group used for the Campbell Island Rise stock assessment. *Estimates include fish from outside the standard survey area.**

	Age 2		Age 3		Age 4+	
Year	Biomass	c.v.	Biomass	c.v.	Biomass	c.v.
1993	71 902	23	14 781	22	24 033	21
1994	12 259	38	139 552	37	28 841	36
1995	11 176	25	23 228	28	130 535	30
1998	13 142	20	28 022	19	167 668	18
2000	10 460	23	8 421	20	135 612	17
2002	3 732	76	11 549	72	148 189	68
*2002	3 829	76	11 842	72	152 184	68
2004	14 412	16	18 873	24	17 283	32
*2004	17 327	16	34 527	27	56 197	38

Estimation

113 Model parameters were estimated using Bayesian methods implemented using the NIWA stock assessment program CASAL v2.06 (Bull et al. 2004). For initial runs only the mode of the joint posterior distribution was sampled. For the final runs presented here, the full posterior distribution was sampled using Markov Chain Monte Carlo (MCMC) methods, based on the Metropolis-Hastings algorithm.

114 MCMC chains were estimated using a burn-in length of 0.5 million iterations, with every 2 000th sample taken from the next 2 million iterations (i.e., a final sample of length 1000 was taken from the Bayesian posterior).

115 Equilibrium "virgin" biomass is equal to the population that there would have been if all the YCS were equal to one and there was no fishing. However, there was a period of unknown (and possibly large) catches from the Campbell Island stock before 1979, and there is high recruitment variability in the stock, so the initial 1979 biomass was allowed to differ from the equilibrium virgin biomass. The initial population in 1979 (ages 3 to 11+) was estimated for each sex. Year class strengths were estimated for all years from 1977 to 2002, under the assumption that the estimates from the model should average one.

Prior distributions and penalty functions

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

Table 8: **The distributions, priors, and bounds assumed for the various parameters being estimated in the Campbell Island Rise stock assessment. The parameters are mean and c.v. for lognormal; and mean and s.d. for normal. *The prior for the adult (4+) acoustic *q* used for a sensitivity run. The process errors were fixed at their MPD values when carrying out the MCMCs.**

Parameter	N	Distribution	Values		Bounds	
	i)		Mean	c.v. / s.d.	Lower	Upper
B_0	1	Uniform-log	–	–	30 000	800 000
Acoustic qs age 2, 3	2	Uniform-log	–	–	0.1	2.8
YCS	26	Lognormal	1.00	1.30	0.001	100
Initial population	18	Uniform-log	–	–	2e5	2e12
Selectivity ages 2-4 (by sex)	6	Uniform	–	–	0.0001	1
M (average)	1	Lognormal	0.20	0.20	0.075	0.325
M (difference)	1	Normal	0.00	0.05	-0.05	0.05
Process errors	4	Uniform-log			0.0001	1
Acoustic age 4+ q	1	Lognormal	1.40	0.20	0.1	2.8
*Acoustic age 4+ q	1	Uniform-log	–	–	0.1	2.8

117 The informed prior for the adult (4+) acoustic *q* was obtained using the approach of Cordue (1996). Uncertainty over various factors including mean target strength, acoustic system calibration, target identification, shadow or dead zone correction, and areal availability were all taken into account. In addition to obtaining the bounds, a mean for each factor was also assumed. The factors were then multiplied together. This independent evaluation of the bounds on the acoustic *q* suggested a range of 0.65–2.8, with a mean of 1.4 and a c.v. of 0.2. As the 90% confidence bounds of *q* from preliminary MCMC runs extended lower than 0.65, the WG agreed to extend the lower bound to 0.1. The informed prior for the adult acoustic *q* will need to be revised in future to take account of the new estimates of the absorption coefficient, towbody motion (pitch and roll), and the target strength-fish length relationship.

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

Basecase runs and sensitivity tests

119 The WG initially considered four runs. These runs were essentially updates of the two base case assessments used in 2003, together with the two alternative time series of acoustic estimates. The two base case assessments in 2003 differed only in the priors used for the adult acoustic *q* (one was uniform-log and the other was an informed lognormal prior). The run using an uninformed (uniform-log) *q* with the high acoustic biomass series sometimes led to unrealistically low estimates of *q*. The resulting high estimates of current biomass appeared to be inconsistent with reports from fishers that large fish were difficult to locate. The runs which used the low acoustic biomass series based only on the core survey strata indicated that exploitation rates had been very high in 2004 which was considered implausible, particularly because the southern aggregation had very little catch taken from it. The WG agreed that the model run using an informed prior on *q*, and which included the acoustic biomass

indices incorporating all surveyed strata, provided the most plausible results and this was chosen as the base case. However, the WG noted that if fish had been outside the core survey area in the earlier years (Hypothesis 2) then the assessment would underestimate the level of decline in the Campbell Island stock and would consequently overestimate the available yields. The Plenary agreed that Hypothesis 1 would be reported as the base case and to report two sensitivity runs bracketing the base case assessment, one exploring the effect of an uninformed prior on the acoustic q and the other representing Hypothesis 2 (Table E).

Table 9: Model run labels and descriptions for the base case and sensitivity runs.

Model label	Description
Base case	Lognormal prior on adult acoustic q, and high acoustic biomass series
Uninformed q	Uniform-log prior on adult acoustic q, and high acoustic biomass series
Low acoustic	Lognormal prior on adult acoustic q, and low acoustic biomass series

120 Since 2001, the Plenary has used B_{1991} as a limit reference biomass level for the Campbell Island Rise stock. Recruitment in the Campbell Island Rise stock is characterised by periods of moderate recruitment interspersed by relatively rare, extremely strong, recruitment events. Only one such event (1991 year class) has been observed within the timeframe of the model, although historical data suggests that this may have happened in the past. Given the high variability in recruitment levels, B_0 is probably not well determined. Therefore, the Plenary considered that B_{1991} may be a better limit reference point than the more commonly used 20% B_0. Based on the assumptions of the model and the available data, B_{1991} is estimated to be about 16% of B_0 and there is only a slight probability that B_{1991} exceeds 20% B_0 (Figure 1).

121 The Plenary agreed that the probability of falling below B_{1991} should be kept low for several reasons including: the stock biomass has only been observed at that low level once in the time series; the exceptionally strong recruitment from the 1991 year class has only been observed once in the 26 years covered by the stock assessment; and although no stock recruitment relationship is assumed in the model, the risks of poor recruitment may be higher at B_{1991} levels than at 20%B_0.

122 The Plenary does not have an agreed target reference biomass level or associated risk level for the Campbell Island Rise stock. The development of an appropriate target reference biomass level will be the focus of future discussions, and will require some direction from fisheries managers on the acceptable levels of risk and the harvest strategy to be applied.

Results

123 For each model run, MPD fits were obtained and qualitatively evaluated. MCMC estimates of the median of the posterior and 90% credible intervals are reported for virgin biomass, B_{2004}, B_{2004} (as %B_0), and B_{2004} (as %B_{1991}).

124 The estimated MCMC marginal posterior distributions for spawning stock biomass by year are shown for the base case in Figure 2, and the results summarised in Table F. The run suggests that the stock biomass showed a steady decline from the early 1980s until 1993 followed by a large increase to 1996, and a decline thereafter. Exploitation rates are shown in Figure 3. The strong 1991 year class still makes a moderate

contribution to the overall catch, and the 1995, 1996, and 1998 year classes all appear above average (Figure 4). The 2001 year class is also estimated to be above average by the model, with moderate numbers caught in the fishery and seen by the acoustic survey. Estimates of the adult acoustic q, the 2004 exploitation rate and M are given in Table F.

125 The sensitivity runs show that the estimates of B_{2004} and stock status are very sensitive to the choice of acoustic biomass series and the prior used for the acoustic q (Table F).

Table 10: **Bayesian median and 90% credible intervals of B_0, B_{2004} (in '000 t), B_{2004} as a percentage of B_{1991} and of B_0 , B_{1991} / B_0, adult 4+ acoustic *q*, the 2004 exploitation rate, and M for each of the three runs for the Campbell Island stock.**

	B_0	B_{2004}	B_{2004} ($\%B_{1991}$)	B_{2004} ($\%B_0$)	B1991 / B0	q	U_{2004}	M
Base case	257	82	194	32	0.16	1.13	0.27	0.17
	(227–304)	(51–122)	(128–288)	(20–44)	(0.12-0.21)	(0.96–1.33)	(0.19–0.40)	(0.13–0.20)
Uninformed q	264	112	230	43	0.19	0.88	0.20	0.19
	(232–321)	(66–215)	(153–340)	(25–69)	(0.13-0.25)	(0.54–1.21)	(0.11–0.33)	(0.14–0.25)
Low acoustic	225	36	90	16	0.18	1.23	0.53	0.17
	(202–252)	(26–60)	(66–140)	(11–26)	(0.15-0.23)	(1.03–1.38)	(0.35–0.67)	(0.14–0.213)

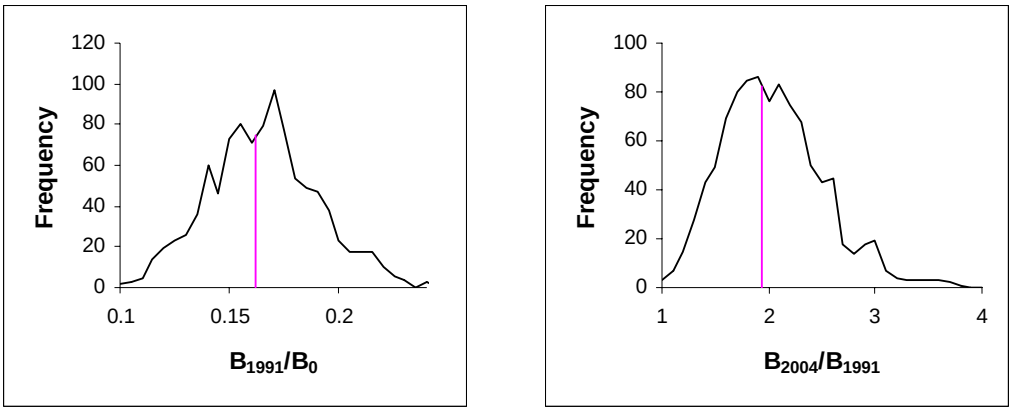


Figure 1: Posterior distributions for B_{1991}/B_0 (median 0.162) and B_{2004}/B_{1991} (median 1.94) for the Campbell Island stock for the base case.

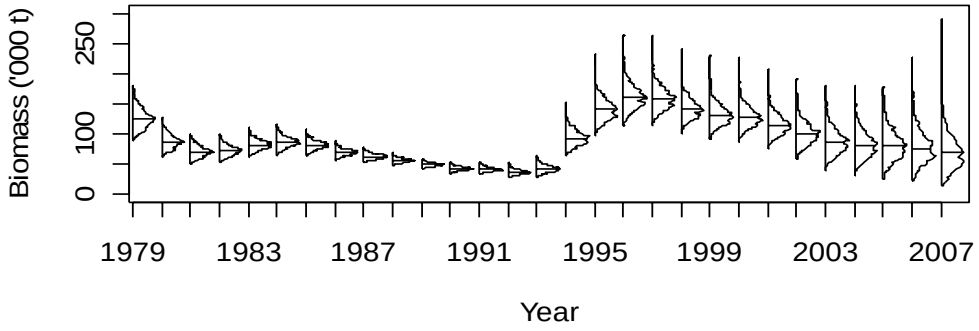


Figure 2: Estimated posterior distributions of biomass trajectories for the Campbell Island stock for the base case, with 3 year projections assuming 25 000 t catch.

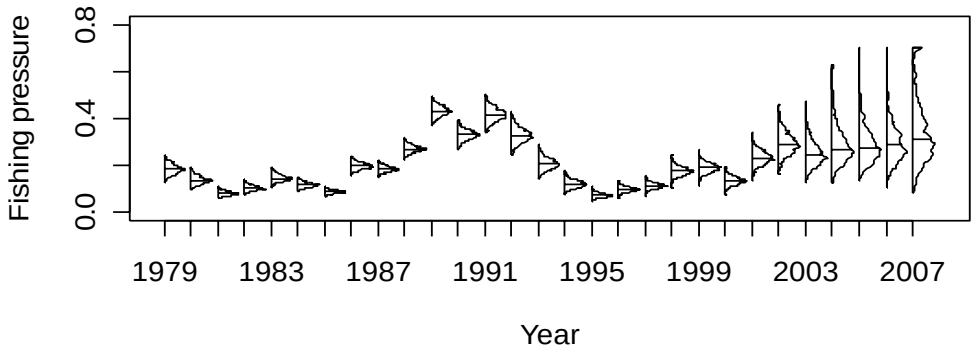


Figure 3: Estimated posterior distributions of exploitation rates for the Campbell Island stock for the base case, with 3 year projections assuming 25 000 t catch.

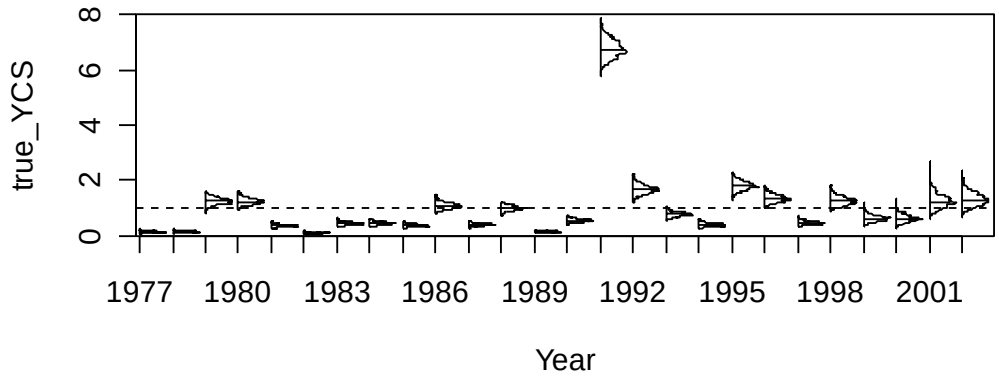


Figure 4: Estimated posterior distributions of year class strengths for the Campbell Island stock for the base case.

Yield estimates

126 Estimates of sustainable yields have been calculated for the Campbell Island Rise for each of the runs. Yield estimates were based on the 1000 samples from the Bayesian posterior, with yield estimates based on stochastic simulations run over 100 years (Bull et al. 2003). The simulation method of Francis (1992) was used to estimate MAY and CAY subject to the constraint that spawning stock biomass should not fall below 20% of B_0 more than 10% of the time. The estimates of B_{MAY}, MAY, and $CAY_{2005–06}$ are given for the Campbell Island stock in Table G. MCY and BMCY estimates have not been presented for the current assessment update due to the fact that the methods for calculating these reference points are currently under revision.

Table 11: Yield estimates (MAY and CAY) and associated parameters.

Model run	B_{MAY} (%B_0)	MAY (t)	U_{CAY}	$CAY_{2005–06}$ (t)
Campbell Island Rise	34	19 500	0.20	19 000
Bounty Platform	36	6 461	0.20	4 034

127 For the Campbell Island Rise stock the Plenary noted that the limit biomass assumed in the yield estimation simulations is 20%B_0, which is different from the use of B_{1991} for assessing risk in projections. No corresponding yield estimates based on the B_{1991} limit biomass reference point were available for consideration by the Plenary.

Other yield estimates and stock assessment results

128 Projections were made assuming fixed catch levels from 10,000 to 25,000 t per year using the MCMC samples. Recruitments were drawn randomly from the distribution of year class strengths estimated by the model over the period 1977 to 2002.

129 As an alternative to the yield estimates, the results have been presented in the form of decision tables. In the Campbell assessment the probability that mid-season biomass for the specified year will be less than the limit reference biomass is reported in Table H for alternative catch levels from 10 000 to 25 000 tonnes.

Table 12: **Probability that the projected mid-season vulnerable biomass for 2005, 2006, and 2007 will be less than the mid-season vulnerable biomass in 1991 and the median projected biomass as a percentage of B_0 (with 90% credible intervals) for different constant catch levels for the Campbell Island stock base case run.**

	Probability ($B_{proj}<B_{1991}$)			Median biomass as proportion B_0		
Constant catch (t)	2005	2006	2007	2005	2006	2007
10 000	<0.01	<0.01	<0.01	0.34 (0.22–0.48)	0.38 (0.25–0.57)	0.41 (0.26–0.73)
15 000	<0.01	<0.01	0.01	0.33 (0.21–0.47)	0.35 (0.22–0.53)	0.35 (0.21–0.64)
20 000	<0.01	0.02	0.05	0.32 (0.20–0.46)	0.33 (0.19–0.50)	0.31 (0.16–0.59)
25 000	0.01	0.05	0.13	0.31 (0.19–0.45)	0.30 (0.16–0.46)	0.27 (0.11–0.54)

Status of the Campbell Island stock

130 The 2003 Campbell Island stock assessment was updated by including the results of the 2004 acoustic survey and two additional years of proportion-at-age data. For the base case, B_{2004} was estimated to be 82 000 tonnes (90% credible interval 59 000–122 000 tonnes), corresponding to 32%B_0 (90% credible interval 20–44%). Estimates of B_{2004} were sensitive to the choice of series of acoustic survey estimates and to the prior used for the adult acoustic *q*.

131 The very strong 1991 year class persisted in the fishery in 2004. The TACC was reduced to 25 000 tonnes in 1 April 2003, and at this level of catch, the biomass is projected to decline slowly. At the current TACC level, the probability that the biomass will drop below B_{1991} is projected to increase from 1% to 13% over the next three years (Table H).

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