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Tini a Tangaroa

Acoustic biomass estimates of southern blue whiting on the Bounty Plateau (SBW 6B) in 2023

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PLAIN LANGUAGE SUMMARY

Abundance of spawning southern blue whiting at the Bounty Platform, southeast of New Zealand, was estimated by an acoustic survey from the fishing vessel *Tomi Maru 87*. Two surveys (snapshots) were carried out overnight on 18–19 and 20–21 August 2023. The estimated biomass in 2023 was 62% higher than that from the previous acoustic survey in 2017. Data on the size distribution of the fish, collected by Fisheries New Zealand observers, and fish age data indicate that most adult size fish were from the 2012 and 2018 year classes.

EXECUTIVE SUMMARY

Wieczorek, A.M.; Escobar-Flores, P.C.; Datta, S.; O'Driscoll, R.L[1] (2024). Acoustic biomass estimates of southern blue whiting on the Bounty Plateau (SBW 6B) in 2023.

***New Zealand Fisheries Assessment Report 2024/61.* 19 p.**

FV *Tomi Maru 87* collected acoustic data from two snapshots of 14 transects each on the Bounty Plateau overnight on 18–19 and 20–21 August 2023. The snapshots covered a spawning southern blue whiting (*Micromesistius australis*) aggregation southeast of the Bounty Islands (SBW 6B). The surveyed areas in 2023 were slightly larger than those surveyed in 2017 (176 and 218 km^2 compared to 153 km^2). A spawning event was evident on 24 August, around the same time as spawning during surveys prior to 2016. The acoustic biomass estimate from the two snapshots in 2023 was 12 507 t (CV 18%), the highest recorded since 2014, and is 62% higher than the estimate from 2017, which was based on a single snapshot. Data on the size distribution of the fish, collected by Fisheries New Zealand observers, and fish age data indicate a bimodal distribution of adult size fish belonging to the 2012 and 2018 year classes.

[1] All authors with National Institute of Water and Atmospheric Research Ltd.

1. INTRODUCTION

Southern blue whiting (*Micromesistius australis*) is one of New Zealand's largest volume fisheries, with annual landings of between 10 000 t and 40 000 t since 2000 (Fisheries New Zealand 2023). Southern blue whiting (SBW) occurs in Sub-Antarctic waters, with known spawning grounds on the Bounty Platform (SBW 6B), Pukaki Rise (SBW 6R), Auckland Islands Shelf (SBW6A), and Campbell Island Rise (SBW 6I) (Hanchet 1999). Fish from the four spawning grounds are treated as separate stocks for stock assessment (Figure 1). Spawning occurs on the Bounty Platform from mid-August to early September and 3−4 weeks later in the other areas.

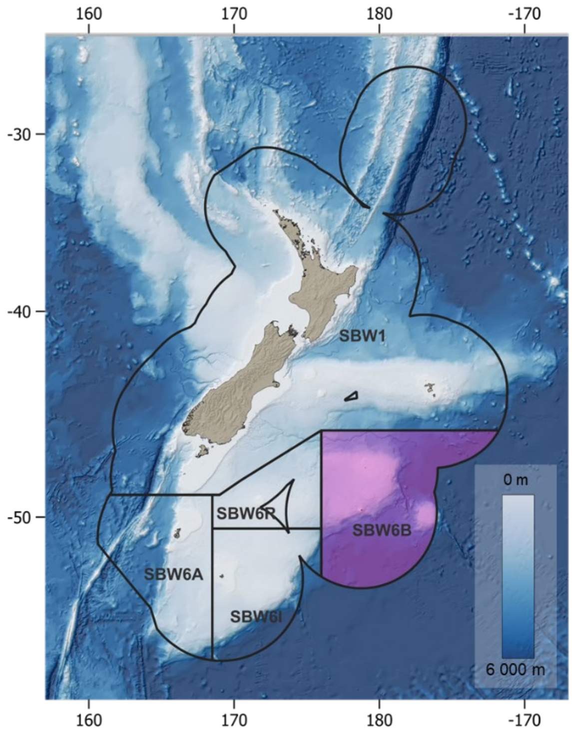

Figure 1: SBW quota management areas with SBW 6B highlighted in magenta.

A programme to estimate Southern Blue Whiting (SBW) spawning stock biomass on each fishing ground using acoustic techniques from research vessels began in 1993. The Bounty Platform, Pukaki Rise, and Campbell Island Rise were each surveyed annually between 1993 and 1995. After the first three annual surveys it was decided to survey these areas less regularly. The Bounty Platform grounds were surveyed by a research vessel in 1997, 1999, and most recently in 2001. The Pukaki area was surveyed in 1997 and 2000. The only on-going series of research surveys is on the Campbell Island Rise grounds, which have been surveyed in 1998, 2000, 2002, 2004, 2006, 2009, 2011, 2013, 2016, 2019 and 2023. All these surveys were carried out from RV *Tangaroa* using towed transducers and have been wide-area surveys intended to survey spawning SBW and pre-recruits. The results of these research surveys of spawning and pre-recruit SBW are the main input into SBW stock assessments (e.g., Fisheries New Zealand 2023).

An acoustic survey of the Campbell Island grounds was carried out from FV *Aoraki* in 2003 and showed that industry vessels with hull-mounted acoustic systems could be used to collect acoustic data on SBW in good weather (less than 25 knots of wind) (O'Driscoll & Hanchet 2004). O'Driscoll & Hanchet (2004) further demonstrated that snapshots of the main spawning aggregations could be carried out using the processing time between commercial trawls without seriously compromising fishing success. Surveys of spawning SBW using this approach were successfully carried out on the Bounty Plateau in 2004 and then annually from 2006 to 2017 (O'Driscoll 2018). Surveys from industry vessels were attempted in each year from 2018 to 2022, but no acoustic snapshots were carried out due to bad weather, poor timing or a failure to locate a stable spawning aggregation.

Industry vessel acoustic surveys provided evidence for a very strong 2002 year class when it recruited into the Bounty Platform fishery in 2007 and 2008, and the TACC for the Bounties southern blue whiting was increased from a low level of 3500 t in 2009 to 14 700 t in 2010. Estimates in surveys from 2010 to 2014 were much reduced, and the TACC decreased. The estimated biomass declined by nearly 50% in the 2015 survey estimate, and remained low in the 2016 survey. The TACC for SBW 6B was reduced to 2377 t from 1 April 2017. In 2016 and 2017 there was evidence of a new cohort (2012 cohort) entering the fishery. The TACC was increased to 3145 t for the 2018–19 and 2019–20 seasons, before a reduction to 2830 t for the 2020–21 season and a further reduction to 2264 t for 2022–23 based on a lack of information after five years of unsuccessful surveys (Fisheries New Zealand 2023).

Given the fluctuations of TACC and ongoing uncertainty about the status of the Bounty Plateau stock, it has previously been highlighted that it will be important to continue to monitor acoustic estimates of spawning SBW in that area (O'Driscoll 2018). An aggregation-based acoustic survey of the Bounty Plateau was carried out in 2023. The acoustic data were analysed to provide a biomass estimate for the stock which was then used to update the harvest control rule.

1.1 Project objectives

This report is the final reporting requirement for the Fisheries New Zealand research project SBW2021-02. The objective was to analyse acoustic data collected during the SBW6B aggregation acoustic survey to estimate stock biomass.

2. METHODS

2.1 Vessel and equipment

FV *Tomi Maru 87* is a 68 m New Zealand owned surimi trawler operated by Aurora Fisheries Ltd. The vessel is fitted with a Simrad ES80 echosounder. The Simrad ES80 was installed on *Tomi Maru 87* in May 2016 and is an updated version of the previous ES60 and ES70 echosounders. A new ES38-7 38 kHz split-beam transducer was also installed in May 2016 along with a new 70 kHz ES80 echosounder, wide-band transceiver (WBT), and ES70-7C transducer. The 38 kHz general purpose transceiver (GPT) proved incompatible with the ES80 and was replaced by a WBT in February 2017. The echosounder system used from 2017 is therefore different from those used Bounty surveys prior to 2017 and represents the start of a new calibration time series.

Calibration of the Simrad ES80 echosounder on FV *Tomi Maru 87* took place off Timaru on 19 October 2023. The root mean square (RMS) value of 0.14 dB measured from sphere echoes indicates that the 38 kHz calibration was of excellent quality (>0.4 dB is poor, 0.3–0.4 dB good, and <0.2 dB excellent, Table 1). The symmetrical nature of the pattern and the zero centre of the beam pattern indicate that the transducer and transceiver were operating correctly (Figure 2). The estimated peak gain (G_0) was 26.29 dB and the Sa correction was –0.07 dB which were comparable to previous calibration results (Table 1) and were used in the analysis of the 2023 survey results.

Table 1: Calculated echosounder calibration parameters for the 38 kHz ES80 echosounder on FV Tomi Maru 87 from 2017–2023.

Parameter	2023	2020	2019	2018	2017
Analysis software and version	ESP3 1.51.1	ESP3 1.8.4	ESP3 1.0.1	ESP3 0.9.7	ESP3 0.4.0
Angle aperture for on-axis TS estimates (°)	0.21	0.21	0.19	0.20	0.21
Mean TS within angle aperture (dB)	-40.84	-41.24	-40.96	-42.45	-42.68
Std dev of TS within angle aperture (dB)	0.26	0.13	0.23	0.09	0.27
Max TS within angle aperture (dB)	-39.80	-40.66	-39.91	-42.14	-41.71
No. of echoes within angle aperture (#)	216	936	839	388	147
On axis TS from beam-fitting (dB)	-40.75	-41.23	-40.89	-42.38	-42.63
Transducer peak gain (mean method) (dB)	26.29	26.09	26.22	26.40	26.36
Sa correction (dB)	-0.07	-0.03	-0.05	-0.02	-0.03
Beamwidth along/athwartship (º)	6.45/6.40	6.5/6.6	6.5/6.4	6.4/6.4	6.4/6.4
Beam offset along/athwartship (º)	0.03/-0.002	0.03/-0.01	0.02/0.00	0.04/-0.00	0.05/-0.02
RMS deviation (dB)	0.14	0.07	0.12	0.06	0.13
No. of echoes used to estimate beam shape (#)	20 085	15 809	18 466	7 975	10 079

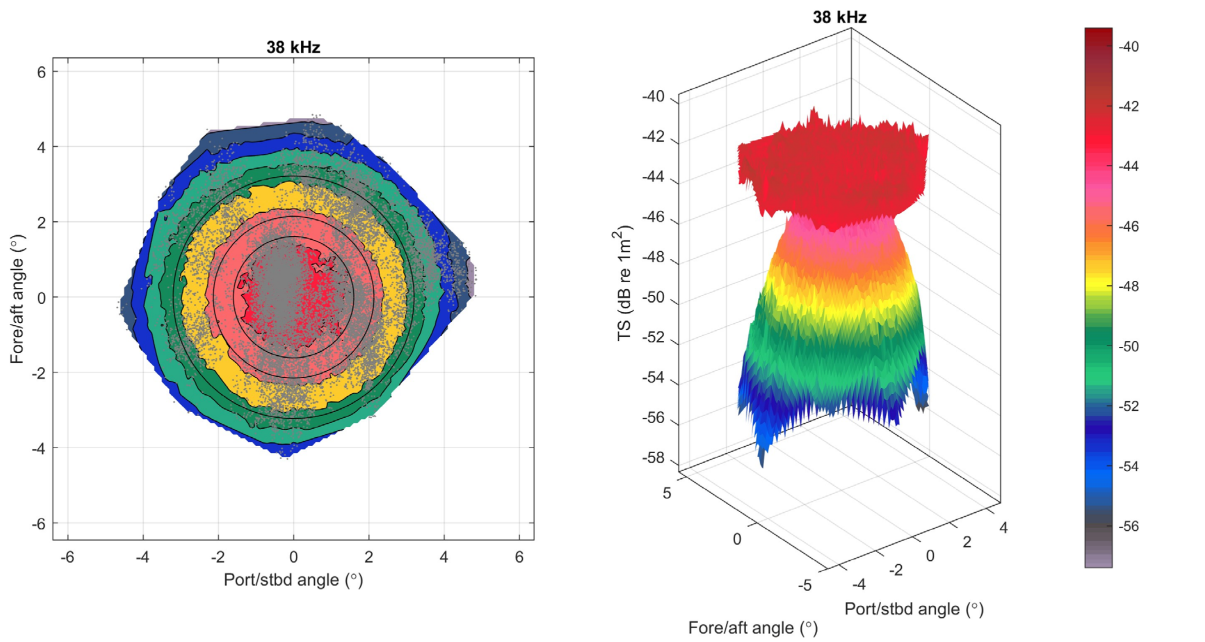

Figure 2: The estimated beam pattern from the sphere echo strength and position for the 38 kHz calibration. The dots indicate where sphere echoes were received (20 085 echoes used to estimate beam shape). The colours indicate the received/computed sphere target strength in dB re 1 m^2.

2.2 Survey design

The aim was to cover the main SBW aggregation(s) using an adaptive design. Detailed written instructions on survey design (described in O'Driscoll 2011a) were translated into Japanese and provided to the vessel officers on FV *Tomi Maru 87*.

Vessel officers were instructed to collect acoustic data continuously while trawling and searching to allow examination of the spatial distribution of fish. However, estimating SBW abundance requires a number of straight, parallel lines (transects) across an aggregation. Each of these transects was to be run at a constant speed (usually 6–10 knots), with a separate, documented, acoustic file. Transect spacing and orientation was dependent on the size and shape of the aggregation and the prevailing weather conditions, but the aim was to obtain 5–10 transects at regular intervals (e.g., 1 n. mile) across each aggregation. The importance of ensuring that transects were long enough and numerous enough to fully encompass the main aggregation(s) was emphasised. Previous acoustic surveys of the Bounty Plateau have shown that SBW are very hard to survey acoustically during the day (Hanchet et al. 2000), therefore it was requested that all transects be carried out at night.

Clear instructions were also provided on protocols for acoustic data collection, including the use of standard scientific settings on the echosounder, turning off other acoustic equipment (to avoid interference), and collecting data in suitable weather conditions.

2.3 Acoustic data analysis

Acoustic data were provided to NIWA as ES80 .raw files. Data from acoustic transects were extracted and analysed using NIWA's ESP3 software package version 1.51.1 (Ladroit et al. 2020). Echograms were visually examined, and the data groomed by a combination of automated and manual editing. Echoes from the seabed and below were removed and noise spikes and missing pings were defined as 'bad transmits' and not included in subsequent analysis. Regions corresponding to spawning SBW were then identified. Marks were classified subjectively based on their appearance on the echogram (shape, structure, depth, strength, etc.), after Hanchet et al. (2002).

Backscatter from marks identified as SBW was then integrated to produce estimates of the mean area backscattering coefficient (s_a in m^2 m^{-2}, MacLennan et al. (2002)). During integration, acoustic backscatter was corrected using an estimated sound absorption of 9.47 dB km^{-1}, which was the same value used for previous Bounty surveys (O'Driscoll 2018), and was originally based on data collected on the Campbell Island Rise in 2006 (O'Driscoll et al. 2007). No correction was applied for the speed of sound and the processing and integration was run with the transceiver default setting (see Table 3). No correction was applied for vessel motion. A Microstrain 3DM-GX1 gyro-enhanced orientation sensor was used to record vessel motion on FV *Tomi Maru 87* in 2006, but O'Driscoll et al. (2006) found that correcting for the effects of vessel motion (Dunford 2005) had very little effect (less than 1%) on biomass estimates in good weather and sea conditions because of the relatively shallow depth. Motion sensors were not fitted to FV *Tomi Maru 87* in 2023.

SBW acoustic backscatter was output in two ways: First, the mean area backscattering coefficient per transect was calculated. These values were used in biomass estimation. Second, SBW acoustic backscatter was integrated into 10-ping bins (vertical slices) to produce a set of mean area backscattering coefficients for each transect. These data had a high spatial resolution, with each value (10 pings) corresponding to about 100 m along a transect and were used to produce plots showing the spatial distribution of SBW backscattering coefficients.

2.4 Biomass estimation

The mean transect backscattering coefficients were converted to SBW biomass using a ratio, *r*, of mean weight to mean backscattering cross section (linear equivalent of target strength) for SBW. The method for calculating *r* was based on that of O'Driscoll et al. (2013), using:

1. The scaled length frequency distribution of SBW caught by FV *Tomi Maru 87* in this area in 2023, estimated from scientific observer data (methods described by Holmes et al. 2023)

2. The generic length weight relationship for spawning SBW from Hanchet (1991):

$$w = 0.00439\ FL^{3.133} \quad (1)$$

where *FL* is fork length (cm).

3. The target-strength-to-fork-length (*TS*-FL) relationship for SBW of O'Driscoll et al. (2013):

$$TS = 22.06\ \log_{10}FL - 68.54 \quad (2)$$

where *TS* is target strength (dB re 1m^2) *FL* is fork length (cm).

The *TS-FL* relationship was based on *in situ* measurements made using a net-mounted acoustic-optical system (AOS) on the Campbell Island Rise in 2011 (O'Driscoll et al. 2013) as adopted for New Zealand SBW in 2012 (O'Driscoll 2013). Mean weight and mean backscattering cross-sections were obtained by transforming the scaled length frequency distribution by equations (1) and (2) and then calculating the means of the transformed distributions.

Biomass estimates and variances were obtained from mean transect backscattering coefficient estimates using the formulae of Jolly & Hampton (1990). The surveyed areas (Table ***2***, Figure **3**) were calculated from transect start and finish positions using the formula: $a = nLW$ where *n* is the number of transects, *L* is the mean transect length (km), and *W* is the mean transect spacing (km). Biomass estimates and CVs were then estimated with and without removing "zero-transects" (i.e., the leading and trailing transects, which define the extent of the aggregation). Cordue (2008) suggested that inclusion of zero transects may overestimate CVs using the Jolly & Hampton (1990) methodology. Only whole transects with zero SBW backscatter were removed. No attempt was made to remove parts of transects with zero backscatter, as most non-zero transects had SBW over most of their length.

3. RESULTS

3.1 Acoustic data collection

Acoustic data were recorded continuously from FV *Tomi Maru 87* after departing Timaru on 8 August 2023 until arriving back in port on 31 August 2023. The vessel was on the Bounty Plateau fishing grounds from 6 to 28 August 2023. Data collected while fishing and searching were affected by acoustic noise due to sonar and other instruments and was not suitable for quantitative analysis but do provide a useful record of vessel activities and the presence of fish outside surveyed areas.

Two snapshots with 14 acoustic transects each were carried out overnight on 18–19 August 2023 and 20–21 August 2023 (Table 2). Both snapshots covered the southeastern area of the Bounty Plateau with the first snapshot being located further to the west (Figure 3).

Table 2: Summary of acoustic snapshots carried out at the Bounty Plateau in 2023 by FV Tomi Maru 87. Times are NZST.

Snapshot	Area (km^2)	Start time	End time	No. of transects
1	176.01	18 Aug 18:58	19 Aug 02:28	14
2	218.99	20 Aug 19:36	21 Aug 03:28	14

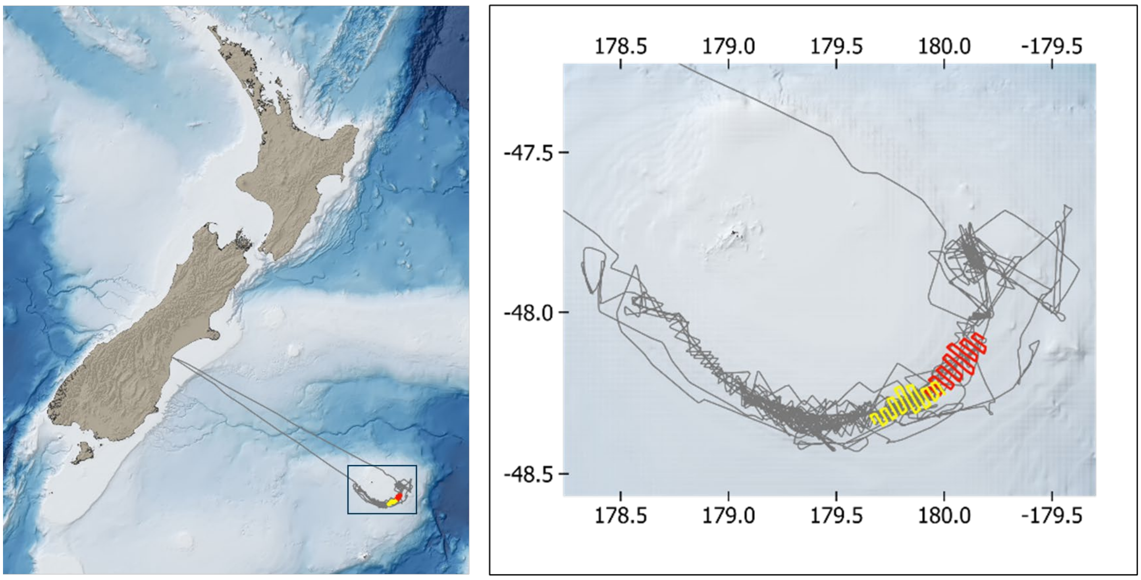

Figure 3: Map showing survey track (grey) and location of transects carried out during the first (yellow) and second (red) snapshot by FV *Tomi Maru 87* at the Bounty Plateau in 2023.

The vessel catches (which for data confidentiality reasons cannot be published within this report) indicate that catches were lower in the southwest early in the season and increased as the vessel moved counterclockwise around the plateau. This seems to be a characteristic pattern on the Bounty Plateau, where fish move in from deeper waters, get shallower, and then move counterclockwise around the Plateau.

The two survey snapshots covered areas of 176 and 218 km^2, respectively (Table 2). The areas were slightly larger than in 2017 when one snapshot covered an area of 153 km^2. The spacing between adjacent transects in 2023 was about 2 km, similar to the transect spacing in 2013–17. Transects were run from east to west (i.e., counter to the expected direction of fish movement) to reduce the risk of bias due to double counting.

The 2023 snapshots were carried out earlier than snapshots during the surveys in 2016 and 2017 (early September), but were similar to timing of snapshots in previous years in the Bounty Plateau time-series (Figure 4).

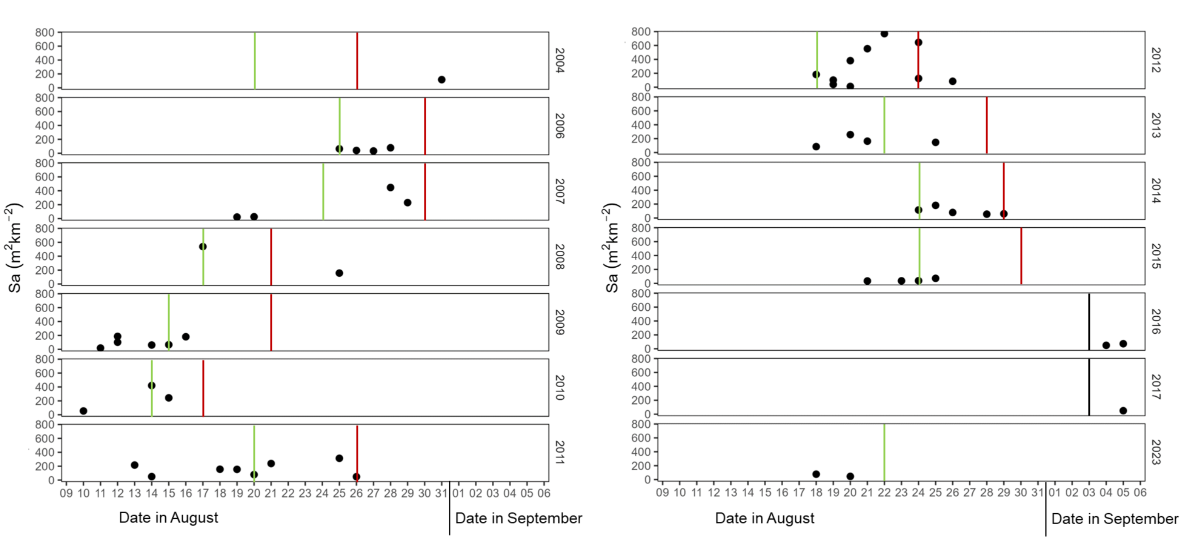

Figure 4: Mean area backscattering coefficient ($s_a \times 10^6$ expressed in $m^2\ km^{-2}$) for each snapshot (solid circles) plotted as a function of date for all snapshots carried out by industry vessels on the Bounty Plateau 2004–23. Vertical lines indicate estimated period of peak spawning based on gonad staging by observers. Green and red colours indicate first and last date with over 10% running ripe females being recorded based on gonad staging from observers. Black vertical lines are used if this was only the case for one point in time during the survey.

Timing of SBW spawning also varied between years (Figure 4). In most years spawning was over by the end of August. In 2016 and 2017 it was assumed that spawning was late, but it is also possible that most fish had already departed the grounds. During the 2023 survey, peak spawning began on 22 August when over 10% of females were classed as running ripe, and increased to 31% of running ripe females on 24 August (Figure 5). Acoustic snapshots were therefore carried out on pre-spawning aggregations.

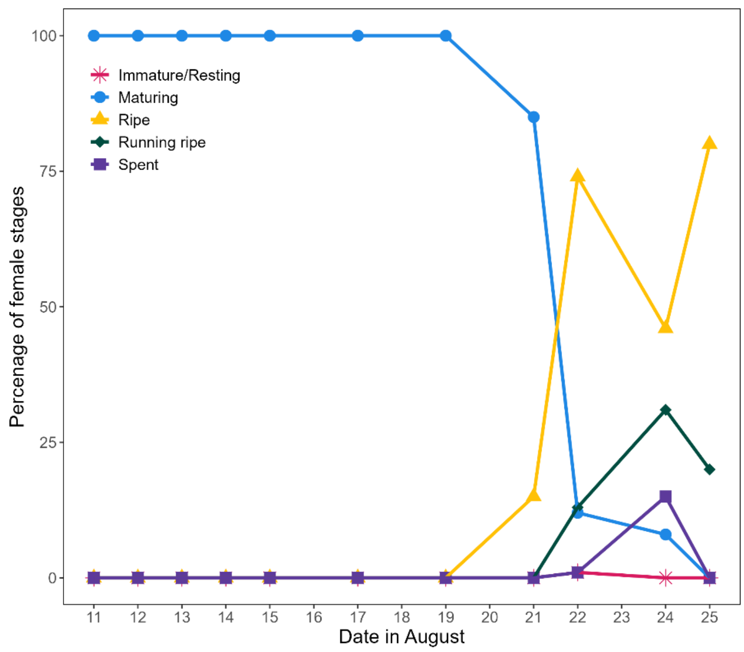

Figure 5: Percentage of female southern blue whiting gonad stages by date based on gonad staging by observers on FV Tomi Maru 87 in 2023.

3.2 Acoustic data quality

The quality of the acoustic data from the two snapshots at the Bounty Plateau in 2023 was poor to average with 35.1% and 13% of pings being flagged as bad within snapshot 1 and 2, respectively which was due to poor weather conditions (e.g., Figure 6). ES80 transceiver settings and other relevant parameters during data collection (Table 3) followed recommended protocols.

Table 3: Echosounder settings and other relevant parameters for acoustic data collection in 2023.

Parameter	38 kHz	70 kHz
Echosounder	ES80	ES80
Software version	21.11.9	21.11.9
Transducer model	ES38-7	ES70-7C
Transducer serial number	n/a	n/a
ES80 WBT serial number	714603	700875
WBT software version	2.54	2.54
Sphere type/size	tungsten carbide/38.1 mm diameter	
Operating frequency (kHz)	38	70
Transducer draft setting (m)	0.0	0.0
Transmit power (W)	2000	1000
Pulse length (ms)	1.024	1.024
Slope (%)	10.28	8.37
Transducer peak gain (dB)	25.5	27.0
Sa correction (dB)	0.0	0.0
Sample interval (ms)	0.048	0.048
Two-way beam angle (dB)	–20.70	–20.70
Absorption coefficient (dB/km)	9.77	23.86
Speed of sound (m/s)	1500	1500
Angle sensitivity (dB) alongship/athwartship	18.0/18.0	23.0/23.0
3 dB beamwidth (°) alongship/athwartship	7.0/7.0	7.0/7.0
Angle offset (°) alongship/athwartship	0.0/0.0	0.0/0.0

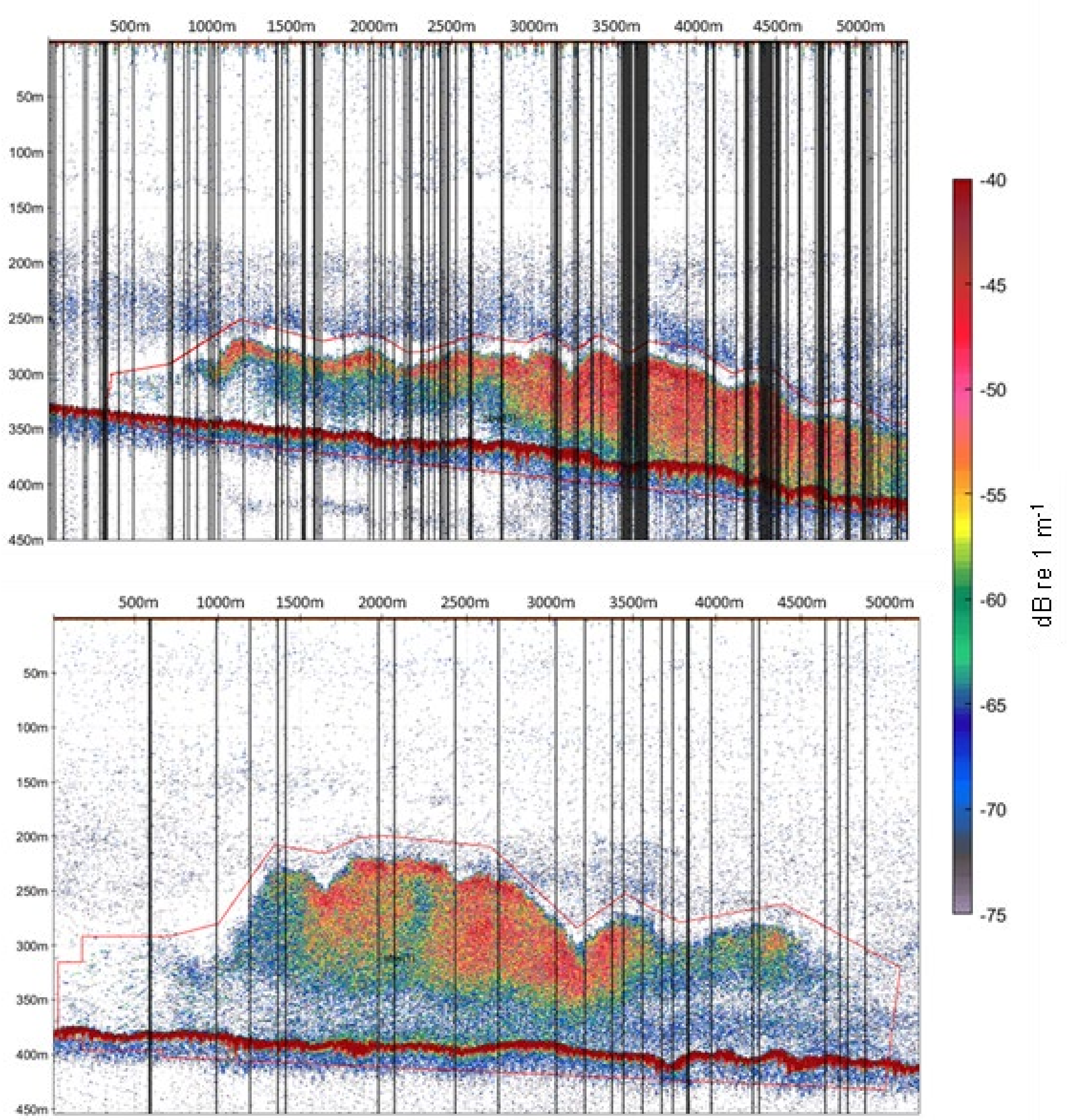

Figure 6: Examples of acoustic echograms collected at the Bounty Plateau during snapshot 1, transect 8 (upper panel) and snapshot 2, transect 4 (lower panel). Black vertical lines are where ping drop-outs due to bubble aeration in poor weather were removed. Southern blue whiting aggregations have been enclosed with red polygons.

3.3 Distribution of SBW backscatter

Mark identification of adult SBW is relatively certain at the Bounty Plateau (Hanchet et al. 2002). SBW marks were observed in water depths from 350–450 m during both snapshots (Figure 6). The spatial distribution of SBW along each transect shows that both snapshots covered the main SBW aggregation (Figure 7). There were no, or very low, densities of SBW on the outer transects and at the ends of each transect, indicating that the vessel is likely to have covered the entire extent of the aggregations.

Highest mean transect backscattering coefficients during snapshot 1 were observed along transect 8 and during snapshot 2 along transect 4 (Figure 6). In 2023, acoustic transects that crossed the high density aggregation were an average of 4.9 km long, less than in 2017 (mean length was 5.3 km), and much shorter than when SBW biomass was estimated to be highest in 2007 and 2008 (up to 15 km long).

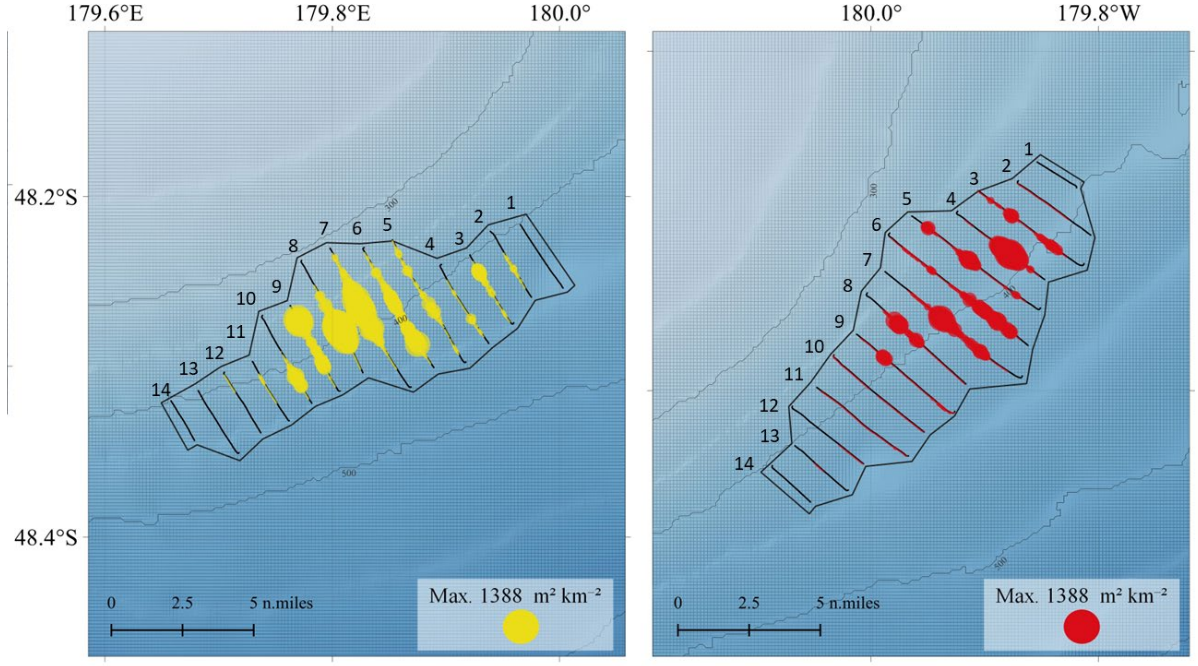

Figure 7: Spatial distribution of SBW backscatter integrated in 10-ping bins for snapshot 1 (left panel) and snapshot 2 (right panel) at the Bounty Plateau in 2023. Transects were carried out from east to west. Circle area is proportional to scaled acoustic backscattering coefficient ($s_a \times 10^6$ in $m^2\ km^{-2}$).

3.4 Biological data

FV *Tomi Maru 87* was the only vessel fishing for SBW at the Bounty Plateau during the 2023 season. The mean fork length of SBW caught by FV *Tomi Maru 87* was 43.4 cm (Figure 8). Mean weight was 613 g. Mean backscattering cross-section was 0.0005811 m^2 (equivalent to –32.4 dB), giving a ratio, *r*, of 1055 kg m^{-2}.

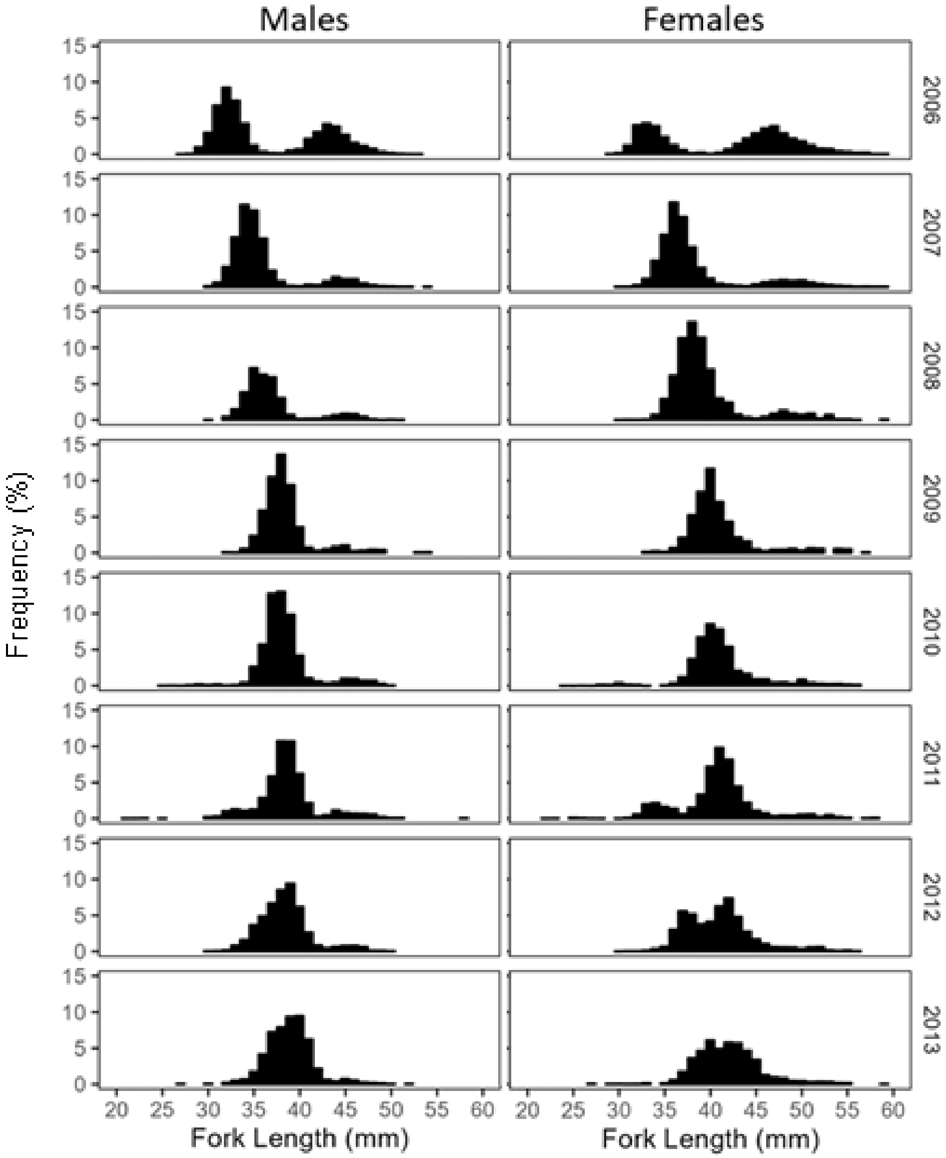

Figure 8: Scaled length frequency distributions of SBW caught on the Bounty Plateau by FV Tomi Maru 87 in 2006–23 based on scientific observer data.

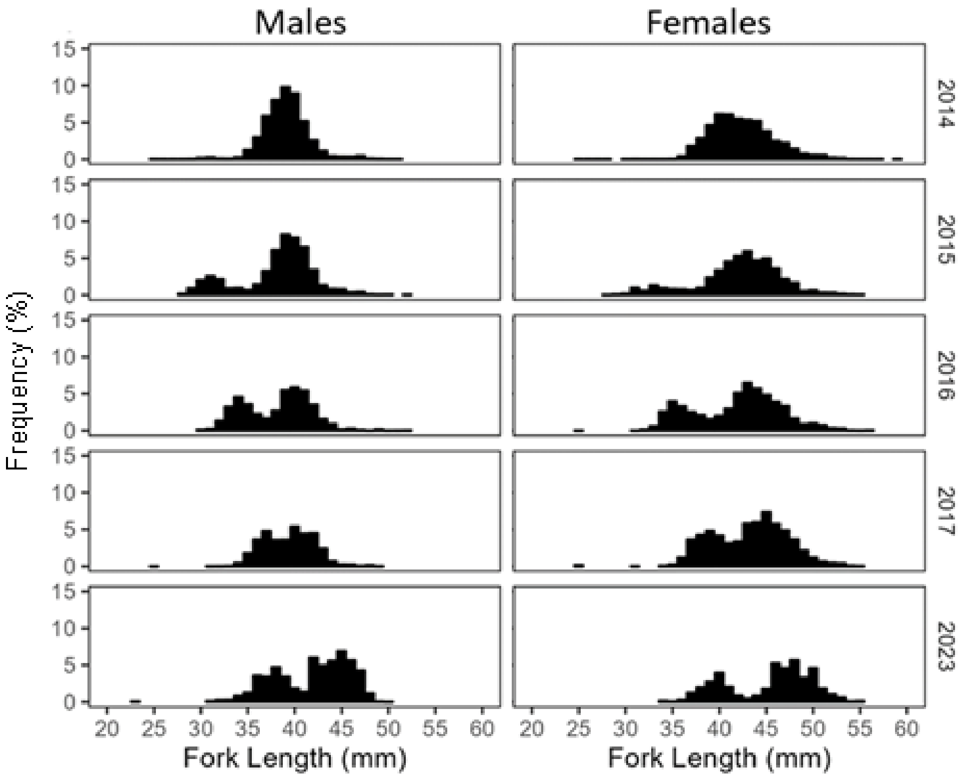

Figure 8 (cont.): Scaled length frequency distributions of SBW caught on the Bounty Plateau by FV Tomi Maru 87 in 2006–23 based on scientific observer data.

3.5 Biomass estimates

The variance of snapshot estimates is generally reduced by removing zero transects, but the differences were small. The biomass sometimes changed when zero transects were excluded as the transect spacing was not always uniform (Table 4). The acoustic biomass estimate for the snapshot in 2023, with zero transects removed, was 12 507 t (CV 17%). This was 62% higher than in 2017 and the highest biomass estimate since 2014 (Table 5).

Table 4: Stratum areas, biomass estimates, and coefficients of variation (CV) for all snapshots of spawning SBW on the Bounty Plateau carried out by industry vessels from 2004–23. All snapshots were carried out by *Tomi Maru 87* except for M1 and M2 by *Meridian* and AB1 and AB2 by *A. Buryachenko* in 2009. Snapshots in bold were averaged to produce the biomass estimates in Table 5. All estimates calculated used the TS-FL relationship given in eqn (1). Estimates from 2004 to 2013 were re-calculated in 2013 to correct for a bug in the conversion script and inconsistencies in the estimation of calibration parameters (O'Driscoll et al. 2015). * Snapshots 5 and 8 in 2012 were aborted due to fish movement or interference from other vessels.

			Calculated areas			Zero transects removed			
Year	Snapshot	No. of transects	Area (km^2)	Biomass (t)	CV (%)	No. of zero transects	Area (km^2)	Biomass (t)	CV (%)
2004	**1**	**5**	69.7	8 572	69	**0**	**69.7**	**8 572**	**69**
2006	**1**	**7**	199.4	12 600	16	**0**	**199.4**	**12 600**	**16**
	2	**5**	286.2	11 298	19	**0**	**286.2**	**11 298**	**19**
	3	4	41.3	1 327	34	0	41.3	1 327	34
	4	4	57.9	4 504	45	0	57.9	4 504	45
2007	1	7	234.5	4 100	38	1	199.0	4 081	35
	2	5	122.6	2 968	35	0	122.6	2 968	35
	3	**5**	250.2	85 700	35	**1**	**218.5**	**89 629**	**29**
	4&5	**10**	435.0	77 339	20	**1**	**417.1**	**68 942**	**20**
2008	**1**	**6**	260.4	119 017	45	**1**	**230.8**	**117 675**	**43**
	2	**5**	229.5	34 123	22	**0**	**229.5**	**34 123**	**22**
2009	M1	11	335.7	6 233	15	0	335.7	6 233	15
	M2	**8**	125.6	20 519	29	**1**	**107.4**	**19 622**	**27**
	1	**3**	232.3	14 067	42	**0**	**232.3**	**14 067**	**42**
	2	**5**	276.2	15 344	45	**1**	**249.9**	**16 230**	**44**
	AB1	7	38.8	3 858	26	0	38.8	3 858	26
	AB2	5	25.1	3 839	29	1	21.9	3 839	23
2010	1	6	52.5	2 770	51	0	52.5	2 770	51
	2	4	38.5	11 504	69	1	29.4	11 951	64
	3	**9**	85.7	17 426	37	**2**	**77.0**	**18 074**	**35**
2011	1	9	118.5	24 948	23	0	118.5	24 948	23
	2	11	136.7	6 762	17	0	136.7	6 762	17
	3	9	83.6	12 724	28	0	83.6	12 724	28
	4	7	53.9	6 614	34	2	43.9	6 614	30
	5	8	80.4	6 208	28	0	80.4	6 208	28
	6	**8**	76.8	14 090	44	**2**	**60.7**	**14 090**	**42**
	7	**8**	104.9	27 889	36	**2**	**91.4**	**27 889**	**35**
	8	9	132.2	6 304	21	0	132.2	6 304	21

Year	Snapshot	No. of transects	Calculated areas: Area (km²)	Biomass (t)	CV (%)	Zero transects removed: No. of zero transects	Area (km²)	Biomass (t)	CV (%)
2012	1	6	23.9	3 524	49	1	20.3	3 591	45
	2	6	10.2	322	84	1	8.7	336	82
	3	6	17.8	1 771	45	0	17.8	1 771	45
	4	6	16.8	6 213	39	0	16.8	6 213	39
	5*	3	4.6	46	27	0	4.6	46	27
	6	**10**	32.9	16 386	16	**1**	**30.4**	**16 288**	**14**
	7	**8**	20.2	15 093	17	**0**	**20.2**	**15 093**	**17**
	8*	3	16.7	2 029	57	0	16.7	2 029	57
	9	**8**	28.2	17 618	18	**0**	**28.2**	**17 618**	**18**
	10	5	41.2	3 383	14	0	41.2	3 383	14
2013	1	12	259.2	21 051	31	1	251.1	21 051	31
	2	**14**	175.6	44 517	46	**0**	**175.6**	**44 517**	**46**
	3	**10**	204.5	27 972	37	**2**	**170.9**	**27 491**	**34**
	4	**9**	131.7	14 364	36	**3**	**94.0**	**13 592**	**30**
2014	**1**	**8**	127.8	14 542	72	**2**	**107.2**	**14 336**	**72**
	2	**7**	102.3	18 363	70	**1**	**96.5**	**18 437**	**71**
	3	**8**	105.8	8 301	46	**2**	**84.5**	**8 209**	**43**
	4	**8**	142.3	7 732	56	**2**	**117.1**	**7 721**	**54**
	5	**12**	175.8	10 474	48	**2**	**158.6**	**10 458**	**47**
2015	1	13	165.3	5 634	21	0	165.3	5 634	21
	2	**13**	152.5	5 490	40	**0**	**152.5**	**5 490**	**40**
	3	5	74.6	2 809	78	2	54.1	2 771	80
	4	**7**	110.7	7 927	65	**1**	**98.8**	**7 961**	**65**
2016	**1**	**8**	103.5	4 766	42	**1**	**91.7**	**4 813**	**39**
	2	**9**	112.2	7 592	53	**2**	**92.7**	**7 589**	**51**
2017	**1**	**15**	152.8	7 719	25	**1**	**145.5**	**7 719**	**24**
2023	**1**	**14**	176.0	14 452	29	**3**	**150.7**	**14 452**	**25**
	2	**14**	219.0	10 561	24	**2**	**205.3**	**10 561**	**23**

Table 5: Estimates of SBW biomass (t) and CV for adult fish from research acoustic surveys of the Bounty Plateau in 1993–2001 (from Fu et al. 2013), and 'best estimates' of spawning stock biomass (SSB) from acoustic estimates from industry vessels (with zero transects removed). Estimates in 2006–09 and 2011–16 were obtained by averaging selected snapshots. All estimates calculated used the TS-FL relationship given in eqn (1).

Year	Research vessel Adult fish	Industry Vessel SSB
1993	43 338 (58%)	–
1994	17 991 (25%)	–
1995	17 945 (23%)	–
1997	27 594 (37%)	–
1999	21 956 (75%)	–
2001	11 784 (35%)	–
2004	–	8 572 (69%)
2006	–	11 949 (12%)
2007	–	79 285 (19%)
2008	–	75 899 (34%)
2009	–	16 640 (21%)
2010	–	18 074 (35%)
2011	–	20 990 (27%)
2012	–	16 333 (7%)
2013	–	28 533 (27%)
2014	–	11 832 (31%)
2015	–	6 726 (42%)
2016	–	6 201 (35%)
2017	–	7 719 (24%)
2023	–	12 507 (18%)

4. DISCUSSION

Acoustic data from the Bounty Plateau in 2023 were collected with appropriate acoustic settings and were of adequate quality to estimate biomass. Two snapshots were carried out to the southeast of the Bounty Islands within the region where the largest aggregations were observed in 2007–17. The two snapshots appeared to adequately cover the surveyed aggregations (Figure 7). Observer data indicated a spawning event from 22–25 August which is consistent with observations made prior to 2016 and 2017. In 2016 and 2017 spawning took place later in the season which may have been due to the main spawning aggregation having departed the grounds by the time the area was surveyed.

The very large decrease observed in acoustic estimates of SBW at the Bounty Plateau between 2008 and 2009 was too large to be explained by fishing and average natural mortality on the dominant 2002 year-class (Dunn & Hanchet 2015). O'Driscoll (2011a) considered three other potential explanations for the apparent decline in biomass:

1. Changes in acoustic survey methodology and equipment.
2. Changes in timing and extent of survey coverage.
3. Movement of fish from the Bounty Plateau to other areas.

Acoustic methodology, analysis, and equipment were consistent between years, and based on comparisons of the length frequency distribution of the fish, there was no evidence of movement of fish from the Bounty Plateau to other areas. Therefore O'Driscoll (2011a) concluded that the very large changes in estimated SBW abundance were probably related mainly to the timing and extent of survey coverage, and that the 2009 survey probably did not encompass the entire spawning aggregation. This conclusion was re-evaluated after the more extensive surveys in 2010–12 which supported the low biomass observed in 2009

(O'Driscoll 2011b, 2012, 2013). It is still only possible to speculate on the causes of this decline, but other suggested causes include an unusually high natural mortality (Ministry for Primary Industries, 2013).

The estimated biomass increased by 75% in 2013, but then declined in 2014–16 to below the estimates from 2009–12 (Table 5). In 2017 there was a 24% increase in estimated biomass, followed by a 62% increase in 2023. During the 2023 survey, measured adult lengths had a bimodal distribution (Figure 8), which may be from adults that entered the fishery in 2015 and 2021 originating from the 2012 and 2018 cohorts (Figure 9).

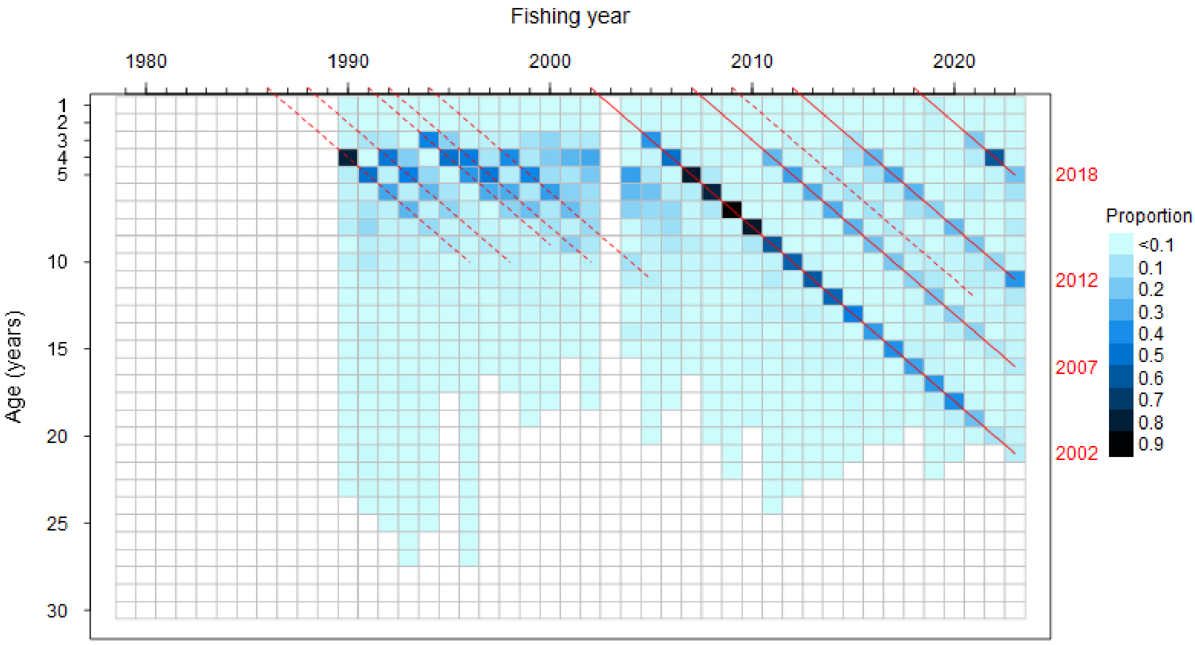

Figure 9: SBW Bounty Plateau fish age proportions by fishing year.

The inconsistent results from the aggregation-based surveys has led to a non-robust stock assessment of the Bounty stock with high uncertainty. The 2014 stock assessment was rejected by the Deepwater Fisheries Assessment Working Group (DWWG) because the assumption of a constant catchability (*q*) for the aggregation surveys was not thought to be justified (Ministry for Primary Industries, 2017). As an alternative, Doonan (2017) developed a simple harvest control rule (HCR) that uses the most recent acoustic index of abundance as an absolute measure of abundance. The HCR is given by $TACC_{t+1} = HCR_p (B_t - C_t/2)$, where B_t is acoustic abundance, C_t is catch, and HCR_{-p} is a fixed proportion in year t. This HCR was applied to the acoustic survey estimate from 2023 to provide fisheries management advice for SBW 6B.

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6. REFERENCES

Cordue, P.L. (2008). Review of estimates of Chatham Rise orange roughy biomass from plume surveys. Report for New Zealand Ministry of Fisheries, 30 August 2008. 39 p. (Unpublished report held by Fisheries New Zealand, Wellington.)

Doonan, I.J. (2017). Evaluation of a simple harvest control rule for the Bounty southern blue whiting management area (SBW6B). *New Zealand Fisheries Assessment Report 2017/52*. 14 p.

Dunford, A. (2005). Correcting echo integration data for transducer motion. *Journal of the Acoustical Society of America 118*: 2121–2123.

Dunn, A.; Hanchet, S.M. (2015). Southern blue whiting (*Micromesistius australis*) stock assessment for the Bounty Platform up to, and including, the 2011 season. *New Zealand Fisheries Assessment Report 2015/55.* 30 p.

Fisheries New Zealand (2023). Fisheries Assessment Plenary, May 2023: stock assessments and stock status. Compiled by the Fisheries Science Team, Fisheries New Zealand, Wellington, New Zealand. 1904 p.

Fu, D.; Hanchet, S.; O'Driscoll, R.L. (2013). Estimates of biomass and c.v.s of southern blue whiting from previous acoustic surveys from 1993 to 2012 using a new target strength – fish length relationship. Final Research Report for Ministry of Fisheries Research Project DEE201002SBWB. 52 p. (Unpublished report held by the Ministry for Primary Industries, Wellington.)

Hanchet, S.M. (1991). Southern blue whiting fishery assessment for the 1991–92 fishing year. New Zealand Fisheries Assessment Research Document 91/7. 48 p. (Unpublished report held in NIWA library, Wellington.)

Hanchet, S.M. (1999). Stock structure of southern blue whiting (*Micromesistius australis*) in New Zealand waters. *New Zealand Journal of Marine and Freshwater Research 33*: 599–610.

Hanchet, S.M.; Bull, B.; Bryan, C. (2000). Diel variation in fish density estimates during acoustic surveys of southern blue whiting. *New Zealand Fisheries Assessment Report 2000/16*. 22 p.

Hanchet, S.M., Grimes, P.J.; Dunford, A.; Ricnik, A. (2002). Classification of fish marks from southern blue whiting acoustic surveys. Final Research Report for Ministry of Fisheries Research Project SBW2000/02 Objective 2. 55 p. (Unpublished report held by the Ministry for Primary Industries, Wellington.)

Holmes, S.J.; Bian, R.; Doonan, I.J. (2023). Review and summary of the time series of input data available for the assessment of southern blue whiting (*Micromesistius australis*) stocks up to and including the 2022 season. *New Zealand Fisheries Assessment Report 2023/63*. 75 p.

Jolly, G.M.; Hampton, I. (1990). A stratified random transect design for acoustic surveys of fish stocks. *Canadian Journal of Fisheries and Aquatic Sciences 47*: 1282–1291.

Ladroit, Y.; Escobar-Flores, P.C.; Schimel, A.C.G.; O'Driscoll, R.L. (2020). ESP3: An open-source software for the quantitative processing of hydro-acoustic data. *SofwareX 12:* 100581.

MacLennan, D.N.; Fernandes, P.G.; Dalen, J. (2002). A consistent approach to definitions and symbols in fisheries acoustics. *ICES Journal of Marine Science 59*: 365–369.

Ministry for Primary Industries (2013). Report from the Fisheries Assessment Plenary, May 2013: stock assessments and yield estimates. Compiled by the Fisheries Science Group, Ministry for Primary Industries, Wellington, New Zealand. 1357 p.

Ministry for Primary Industries (2017). Fisheries Assessment Plenary, May 2017: stock assessments and stock status. Compiled by the Fisheries Science Group, Ministry for Primary Industries, Wellington, New Zealand. 1596 p.

O'Driscoll, R.L. (2011a). Industry acoustic surveys of spawning southern blue whiting on the Bounty Platform and Pukaki Rise 2004–09. *New Zealand Fisheries Assessment Report 2011/17*. 53 p.

O'Driscoll, R.L. (2011b). Acoustic biomass estimates of southern blue whiting on the Bounty Platform in 2010. NIWA Client Report WLG2011-01 for The Deepwater Group Ltd. 28 p.

O’Driscoll, R.L. (2012). Acoustic biomass estimates of southern blue whiting on the Bounty Platform in 2011. *New Zealand Fisheries Assessment Report 2012/16*. 26 p.

O’Driscoll, R.L. (2013). Acoustic biomass estimates of southern blue whiting on the Bounty Platform in 2012. *New Zealand Fisheries Assessment Report 2013/4*. 26 p.

O’Driscoll, R.L. (2018). Acoustic biomass estimates of southern blue whiting on the Bounty Plateau in 2017. *New Zealand Fisheries Assessment Report 2018/11*. 28 p.

O’Driscoll, R.L.; Hanchet, S.M. (2004). Acoustic survey of spawning southern blue whiting on the Campbell Island Rise from FV *Aoraki* in September 2003. *New Zealand Fisheries Assessment Report 2004/27*. 31 p.

O’Driscoll, R.L.; Hanchet, S.M.; Gauthier, S.; Grimes, P.J. (2007). Acoustic estimates of southern blue whiting from the Campbell Island Rise, August–September 2006. *New Zealand Fisheries Assessment Report 2007/20*. 34 p.

O'Driscoll; R.L.; Macaulay, G.J.; Gauthier, S. (2006). Biomass estimation of spawning southern blue whiting from industry vessels in 2006. NIWA Client Report: WLG2006-89 for the Deepwater Stakeholders Group Ltd. 43 p.

O’Driscoll, R.L.; Oeffner, J.; Dunford, A.J. (2013). In situ target strength estimates of optically verified southern blue whiting (*Micromesistius australis*). *ICES Journal of Marine Science 70*: 431–439.

O’Driscoll, R.L.; Oeffner, J.; Dunford, A.J. (2015). Acoustic biomass estimates of southern blue whiting on the Bounty Platform in 2013. *New Zealand Fisheries Assessment Report 2015/01*. 28 p.