ACOUSTIC SURVEY OF CHOKKA SQUID ON INSHORE SPAWNING GROUNDS BETWEEN SEAL POINT AND MAITLANDS IN THE NOVEMBER 2020 CLOSED SEASON FROM RESEARCH INFLATABLE *ABYSS*

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This is a report on an acoustic survey of adult chokka squid *Loligo reynaudii* in water shallower than 50 m between Cape Seal and Maitlands between 3 and 21 November 2020, shortly before the opening of the season. The survey was carried out from research inflatable *Abyss* (Fig.1) which was equipped with two scientific echo sounders firing synchronously into 38 and 200 kHz split-beam transducers. They were mounted in close proximity to maximise beam overlap, and thereby comparison of acoustic backscatter at these two frequencies as a means of target identification.

Fig. 1: Research Inflatable *Abyss*

The major objective of the survey was to make an acoustic estimate of squid biomass in the survey area, building on progress in previous years, using well-established echo-integration techniques and software together with estimates of *Loligo reynaudii* target strength (TS) made from previous studies by Soule *et al.* (2010).

The study was a follow-up to a survey of *Loligo reynaudii* over a far greater area (Aasvogels Pt. to Cape Recife, to a maximum depth of 120 m) from *R.V. Ellen Khuzwayo* in November 2019 (Soule and Hampton, 2020). That survey generated what was considered to be a low estimate of squid biomass, possibly due to, *inter alia*, the survey being too early in relation to the spawning peak. Because *Ellen Khuzwayo* was not available for a repeat survey in 2020, and the very limited range and duration of the inflatable, the current survey was aimed at estimating acoustically the spawning biomass over a much smaller, albeit important, part of the inshore spawning grounds, within water shallower than 50 m.

The sounders were successfully calibrated by standard sphere in Port St. Francis on 3 November (see results in Appendix A). Thereafter, between 4 and 7 November, small-scale surveys and drifts to collect information on target strength and compare the backscattering strength of squid at 38 and 200 kHz were carried out on marks off Jeffreys Bay and the Krom. After a period of bad weather when no surveying was possible, the first wide-area survey was carried out between Maitlands and the Gamtoos River mouth on two grids of parallel lines on average 0.75 nmiles apart (Surveys 01a and 01b) on 10 November. This was followed by a break of four days due to a combination of bad weather, a faulty auto-pilot on *Abyss* (which necessitated abandoning Survey 02) and the need for staff changes.

The wide-area survey was resumed on 15 November with a survey between Jeffreys Bay and Seal Point on parallel lines 1.2 nmiles apart (S03). This area was re-surveyed on 17 November on parallel lines interleaved with those of Survey 03. The survey was designated as Survey 04. Between these two surveys, the area between Maitlands and the Gamtoos River mouth was re-surveyed on parallel lines 1.2 nmiles apart on 16 November (designated Survey 05).

The wide-area survey ended with a re-survey of this area on parallel lines interleaved with those of Survey 05 (Survey 06). Whenever feasible during the wide-area surveys, small-scale intensive surveys of individual squid aggregations, usually followed by drifts over the mark to collect further target strength information, were carried out opportunistically. The study ended on 21 November with a small-scale intensive survey of a mark off Seal Point (designated survey SP-S01), followed by the final drift experiment (SP-D02). The survey grids for all five large-scale surveys are shown in Fig. 2 overleaf. Further details of both the wide-area and the small-scale surveys, and of the drifts, are shown in Appendix B.

Up until 7 November, information on the locations of commercially viable squid aggregations and biological information was provided by F.V. *Sparadon*, and thereafter by F.V. *Michele*. The former caught 9.1 tonnes of the research quota of 10 tonnes, and the latter 9.9 tonnes. The greatest proportion of the catch made by *Sparadon* in the survey area was from a mark off Jeffreys Bay in 3 sessions resulting in a total of 3.1 tonnes, most of which (63%) was taken on the afternoon of 4 November i.e after Survey JB-S01 had been carried out on the same mark by *Abyss* that morning. (It is interesting to note that a follow-up replicate survey, Survey JB-S02, conducted on the following day produced an estimate of 3.3 tonnes; i.e. 2.1 tonnes less than the estimate obtained the previous day, prior to *Sparadon* fishing on the mark).

Michele took a total of 5.4 tonnes in the research area. Of this, 2.5 tonnes was caught at the Krom and 1.5 tonnes from a second mark south-east of the Gamtoos River mouth, in a depth of approximately 37 m. Biological information, derived mainly from the *Michele* catches in the latter part of the survey, is shown in Table 3.

All wide-area surveys except Survey 02 (which was abandoned) were used for estimating squid biomass in the area. An estimate and CV for the area between Maitlands and Jeffreys Bay was made by averaging the estimates from Surveys 01, 05 and 06, which covered similar ground, and an estimate for the coast between Jeffreys and Seal Point by averaging the estimates from Surveys 03 and 04, which were two days apart, and whose grids were interleaved. These two estimates were combined to give an estimate of squid biomass and accompanying CV between Seal Point and Maitlands (ie. for most of St Francis Bay).

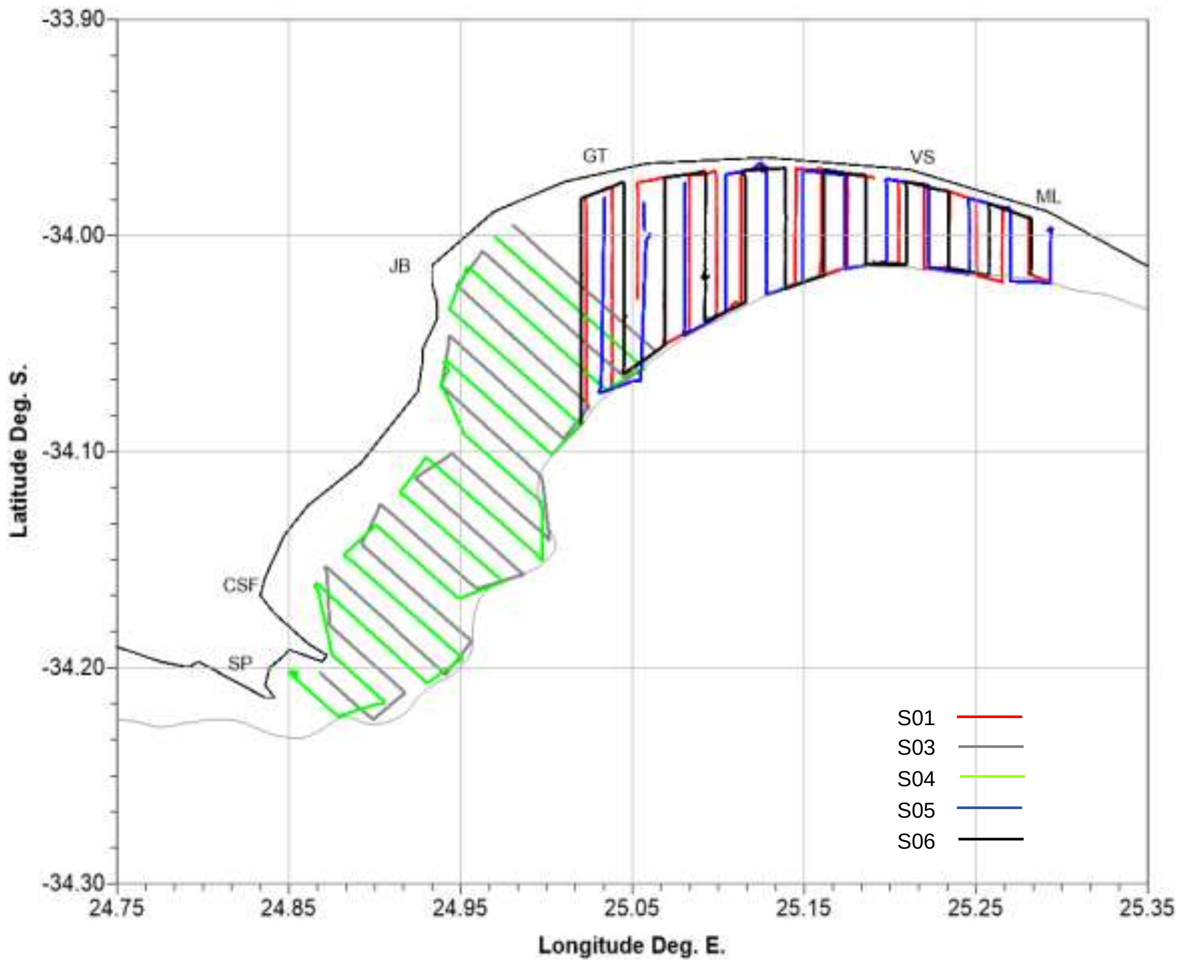

Fig. 2: Map showing wide area surveys (S01, S03, S04, S05 and S06) carried out by *Abyss* between Maitlands and Cape Seal between 10 and 19 November.

In estimating biomass, the Soule *et. al.* (2010) relationship between *L. reynaudii* target strength at 38 kHz and length was used throughout. In all, eight small-scale, intensive surveys were conducted on known squid aggregations: four in Jeffreys Bay, three off the Krom and one off Seal Point.

Drift experiments to collect target strength data for future analysis were also carried out in these positions as well as further east, between Gamtoos Mouth and Maitlands, to confirm the presence of squid marks detected during Surveys 05 and 06. The positions of these surveys and drifts are shown in Fig. 3.

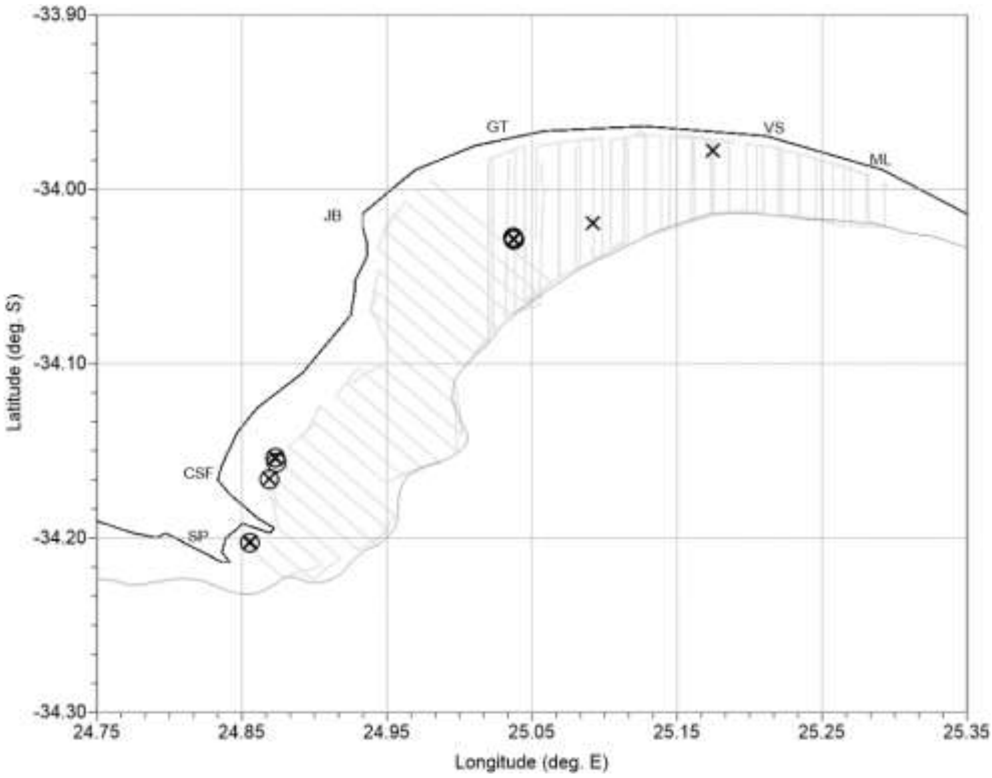

Fig. 3: The location of intensive small-scale surveys (◯) and drifts (X) carried out from *Abyss* between 04 and 20 November 2020.

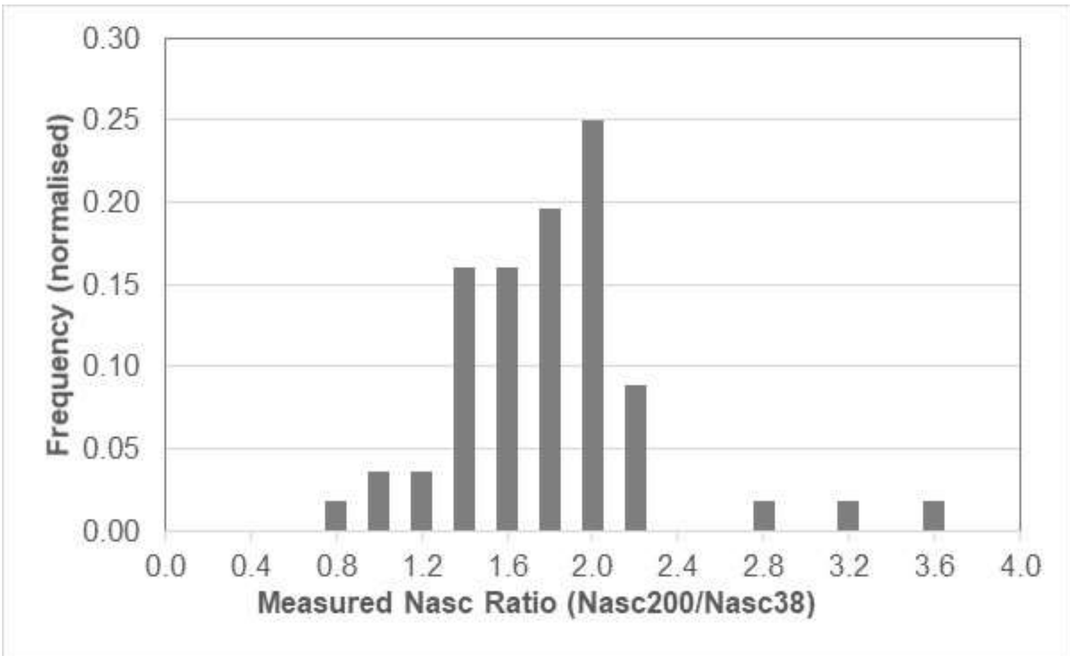

Fig. 4: Measured ratios in the back-scattering strength at 200 kHz to 38 kHz (“Nasc 200 /Nasc 38”) obtained from 56 passes over known squid marks during the small-scale surveys.

The greatest challenge in the analysis was the identification and extraction of echoes from squid in the presence of other scatterers such as pelagic fish and fish targets close to the bottom. A new, empirical, identification method based on differences in the measured back-scatter at 38 and 200 kHz, was tested on scattering from aggregations known to be of squid. It was found that the scattering at 200 kHz ran fairly consistently at around twice that at 38 kHz (Fig. 4). This can be seen in Fig. 4, where 90% of the ratios from 56 passes over known squid marks lie between about 1.4 and 2.2, with a peak at 2.0..

Since differences such as this are not consistently observed in the scattering from fish schools, we concluded that the method has promise for squid identification. However, as can be seen in Fig. 4, there were inconsistencies which need to be better understood if the frequency-dependence of the back-scatter is to be used as a robust identification tool. At this stage therefore, we used the method sparingly, together with other identifiers; principally mark configuration, target strength distributions (where obtainable), size, and the mean and maximum back-scattering strength of the aggregation. To allow to some extent for identification uncertainty, we classified targets as A (well identified); B (less well identified, but probably squid), or C (not identified; probably not squid). We calculated estimates for the A - Category and B - Category targets separately. Assuming the A estimate to be the lower limit and the sum of the A and B estimates the upper limit, we took the midpoint of these two estimates as the best estimate obtainable from the data, and report here accordingly.

The A and B estimates from the individual wide area surveys, and the A + B/2 estimates and CVs from the combined surveys, are shown in Table 1. Table 2 shows biomass and CV estimates for the eight individual aggregations which were surveyed intensively.

Wide Area Survey	Mark Category	Biomass (T)	Biomass Cat A+ ½Cat B (T)	CV	Average Biomass (T)	CV
S01	A	75.39	103.80	0.485	136.41	0.279
	B	56.82				
S05	A	133.43	162.03	0.423		
	B	57.19				
S06	A	85.73	143.41	0.530		
	B	115.36				
S03	A	150.31	186.87	0.395	155.42	0.306
	B	73.12				
S04	A	96.28	123.96	0.484		
	B	55.36				
Total Wide Area Biomass					291.83	0.209

Table 1: Estimated biomass and CVs derived from wide-area Surveys S01, S05 and S06 in the east (Maitlands to Jeffreys Bay) and Surveys S03 and S04, between Jeffreys Bay and Cape Seal, to the west.

Given the limitations imposed by the small size of the vessel, much of value was achieved in this study due to the intensive effort and partly, the fortuitously good weather.

The biomass estimate for the whole area (292 tonnes) is nearly six times greater than the estimate for this area from the *Ellen Khuzwayo* survey in 2019 (Soule and Hampton 2020), with a much lower CV (21 % vs 39%). In addition, the use of target strength and differences in the back-scatter at two different frequencies as identification tools was advanced. Whether the estimate of overall biomass could be used as an index of biomass over the whole inshore fishing ground would depend on whether the proportion of the spawning population east of Cape St Francis in November (estimated at approximately 6% from the large-scale *Ellen Khuzwayo* survey) is reasonably constant from year to year, which is currently unknown.

Wide Area Survey	Mark Category	Biomass (T)	Biomass Cat A+ ½Cat B (T)	CV	Average Biomass (T)	CV
JB-S01	A	5.25	5.44	0.328	6.48	0.192
	B	0.37				
JB-S02	A	3.10	3.30	0.366		
	B	0.40				
JB-S03A	A	8.45	8.92	0.341		
	B	0.94				
JB-S03B	A	7.85	8.24	0.347		
	B	0.78				
KM1-S01	A	5.05	5.70	0.281	4.50	0.290
	B	1.30				
KM1-S02	A	2.98	3.30	0.626		
	B	0.63				
KM2-S01	A	25.61	27.12	0.382	27.12	CV1
	B	3.02				
SP-S01	A	3.18	3.48	0.298	3.48	CV1
	B	0.59				
Aggregated Biomass (J-Bay, Krom and Seal Point)					41.58	0.254

Table 2: Estimated biomass and CVs derived from surveys conducted on known squid aggregations at Jeffreys Bay (4), the Krom (3) and Cape Seal (1). Surveys were combined and the estimates averaged where applicable.

We recommend that to overcome this problem, R.V. *Ellen Khuzwayo* (or another suitably-equipped large research vessel) be used in future surveys to cover the entire fishing ground, employing (and in all likelihood improving), the target identification methods developed in the current survey. An advantage of *Ellen Khuzwayo* apart from her far greater range and sea-kindliness, is that her transducers have similar beamwidths and are closely spaced which will improve the ability to "match" regions of backscatter at different frequencies. On *Abyss* - due to size constraints - we were limited to deploying a wide beam (12°) transducer at 38kHz which resulted in the back-scatter volume being significantly greater than at 200 kHz, which fired into a narrower (7°) transducer. Although the transducer spacing provided ample beam overlap, the different beamwidths most probably contributed to the variability in the results, particulary in cases where the aggregation was patchy or not substantially greater than the beamwidths at that range. (Maximum possible beam overlap is particularly desirable when comparing back-scatter at different frequencies for target identification purposes).

We recommend further that R.V. *Abyss* complement the *Ellen Khuzwayo* survey by investigating and confirming the identity of significant marks detected during the survey, and adding further information on target strength and the frequency-dependence of the back-scatter from squid. She could also assist by conducting structured small-surveys in water too shallow to be surveyed by the larger vessel.

Vessel	Date/2020 (Session)	Position (Latitude Longitude)	Sample Weight [g]	N_M / N_F	N_{TOT}	$\overline{W}$ [g]	$\overline{ML}$ [cm]
F/V Sparadon	31/10 (2)	34° 01.76' 25° 02.23'	*(47500)*[1]	92 / 17	109	239 [2]	24.0 [2]
	31/10 (3)	33° 59.74' 25° 11.20'	*(71000)*[1]	105 / 43	148	N/A	N/A
	04/11 (11)	34° 01.75' 25° 02.24'	*(54000)*[1]	85 / 10	95	N/A	N/A
	05/11 (12)	34° 01.78' 25° 02.24'	*(55000)*[1]	84 / 8	92	N/A	N/A
F/V Michele	07/11 (1)	34° 09.25' 24° 52.35'	25500	84 / 10	94	218	24.3
	08/11 (2)	34 09.24' 24 52.34'	25300	69 / 2	71	256	25.0
	10/11 (7)	34° 00.75' 25° 18.98'	19000	61 / 13	74	216	24.4
	10/11 (8)	34° 00.23' 25° 17.37'	13000	46 / 12	58	203	23.5
	10/11 (9)	34° 01.21' 25° 05.48'	38500	106 / 10	116	250	24.5
	11/11 (10)	34° 12.17' 24° 51.26'	11000	37 / 5	42	235	24.1
	13/11 (13)	33° 58.77' 25° 10.78'	10000	17 / 23	40	271	23.8
	13/11 (14)	33° 59.43' 25° 11.66'	4500	18 / 3	21	194	22.8
	15/11 (16)	34° 01.78' 25° 02.27'	41500	106 / 36	142	242	25.1
	15/11 (17)	34° 10.00' 24° 52.09'	13000	39 / 0	39	333	30.7

1: The biological information obtained from Sparadon for catches in the survey area was considered unreliable.
2. Data obtained from post-cruise biological analysis performed by G. Kant, sessions 3, 11 and 12, still outstanding.

Table 3: Sex ratios, mean weight and mean length of squid sampled from *Sparadon* and *Michele* catches during the closed season. Due to inconsistencies in the biological data obtained from *Sparadon* the sample weights and squid mean weights have been omitted from the table.

We conclude that sufficient progress towards the ultimate goal of obtaining an acoustic estimate of *L. reynaudii* biomass on the entire inshore spawning ground was made through the current survey to warrant vigorous continuation of the project, especially if R.V. *Khuzwayo* can be secured for future large-scale surveys in the November closed season. Furthermore, we believe that the achievements to date warrant publication in a peer-reviewed marine science journal. We are willing to prepare and submit a manuscript, as we were requested to do by the SASMIA Scientific Review Panel in 2020.

References

Soule, M. A., Hampton, I., and Lipinski, M. R. 2010- Estimating the target strength of live, free-swimming chokka squid *Loligo reynaudii* at 38 and 120 kHz. ICES Journal of Marine Science, 67: 1381–1391.

Soule, M.A. and I. Hampton 2020. Acoustic survey of chokka squid (*Loligo reynaudii)* from *R.V. Ellen Khuzwayo*, 30 October to 9 November 2019. Report, to South African Squid Scientific Working Group by Fisheries Resource Surveys cc. Cape Town. 36 pp.

Appendix A

Calibration summary

FREQUENCY: 38 kHz	Cape St. Francis (Mooring)		Gamtoos River Mouth (S05)		Oudekraal Cape Town	
DATE	03 November 2020		16 November 2020		16 April 2021	
38.1mm WC Sphere Range	2.8 m		11.6 m		14.8 m	
RESULTS	ER60 Lobe	EchoView	ER60 Lobe	EchoView	ER60 Lobe	EchoView
G_0 (dB)	20.86	20.67	20.60	20.47	20.63	20.62
S_{Acorr} (dB)	-0.8	-0.73	-0.78	-0.77	-0.65	-0.75
S_{VGain} (dB)	20.06	19.95	19.82	19.70	19.98	19.86
Along. Beam/ Offset (deg.)	12.07 (-0.06)	12.67 (+0.09)	12.05 (-0.20)	12.36 (-0.32)	12.13 (-0.13)	*
Athwart. Beam/Offset (deg.)	12.11 (+0.08)	12.60 (-0.05)	11.91 (+0.07)	12.15 (+0.06)	12.07 (-0.02)	12.41 (+0.03)
Deviation: Beam Model (dB)	0.18	—	0.35	—	0.26	—
Deviation: Poly. Model (dB)	0.14	—	0.34	—	0.23	—

* No estimate due to insufficient data

Table A.1: Calibration Results obtained at 38 kHz for the ES38-12 pod-mounted split beam transducer

FREQUENCY: 200 kHz	Cape St. Francis (Mooring)		Gamtoos River Mouth (S05)		Oudekraal Cape Town	
DATE	03 November 2020		16 November 2020		16 April 2021	
38.1mm WC Sphere Range	2.8 m		11.6 m		14.8 m	
RESULTS	ER60 Lobe	EchoView	ER60 Lobe	EchoView	ER60 Lobe	EchoView
G_0 (dB)	26.59	26.38	26.90	26.58	26.83	26.69
S_{Acorr} (dB)	-0.78	-0.86	-0.80	-0.77	-0.78	-0.73
S_{VGain} (dB)	25.81	25.52	26.10	25.80	26.05	25.96
Along. Beam/Offset (deg.)	6.40 (-0.18)	*	6.51 (-0.24)	6.68 (-0.37)	6.69 (-0.03)	6.59 (-0.08)
Athwart. Beam/Offset (deg.)	6.40 (-0.01)	6.59 (+0.04)	6.59 (-0.01	6.56 (-0.03)	6.62 (+0.02)	6.82 (+0.00)
Deviation: Beam Model (dB)	0.18	—	0.33	—	0.18	—
Deviation: Poly. Model (dB)	0.15	—	0.31	—	0.16	—

* No estimate due to insufficient data

Table A.2: Calibration Results obtained at 200 kHz for the ES200-7C pod-mounted split beam transducer.

APPENDIX B

Closed Season Squid Research – Acoustic Surveys – November 2020

Date (2020)	Location	Type	Reference	Local Time (hh:mm)		Position		Ave. Speed (kts)	Lines (n)	Ave. Line Spacing (nm)	Ave. Line Length (nm)	Survey Length (nm)	Survey Area (nm^2)
				Start	End	Lat. (S)	Long. (E)						
03 Nov.	Port St Francis	Cal.	PSF-Cal-01	17:38	18:44	34° 11.066	24° 51.130	—	—	—	—	—	—
04 Nov.	Jeffreys Bay (J-Bay)	Surv.	JB-S01 (38)	08:52	10:06	34° 01.768	25° 02.230	5.00	16	0.025	0.34	6.13	0.133
		Surv.	JB-S01 (200)	10:12	10:51	34° 01.768	25° 02.230	4.94	9	0.021	0.28	3.18	0.053
		Drift	JB-D01 (38)	08:56	09:33	34° 01.743	25° 02.203	0.05	—	—	—	—	—
		Drift	JB-D01(200)	11:30	11:42	34° 01.764	25° 02.211	0.46	—	—	—	—	—
05 Nov.	Jeffreys Bay (J-Bay)	Surv.	JB-S02	16:51	17:52	34° 01.758	25° 02.224	4.53	13	0.016	0.30	4.57	0.068
		Drift	JB-D02	17:58	18:50	34° 01.758	25° 02.229	0.91	—	—	—	—	—
07 Nov.	Krom	Surv.	KM1-S01	05:44	07:13	34° 09.266	24° 52.352	4.69	16	0.020	0.38	6.93	0.129
		Drift	KM1-D01	07:18	08:20	34° 09.264	24° 52.339	0.58	—	—	—		—
	Jeffreys Bay (J-Bay)	Surv.	JB-S03a	12:45	14:24	34° 01.694	25° 02.193	4.72	17	0.023	0.39	7.70	0.157
		Surv.	JB-S03b	14:24	15:02	34° 01.772	25° 02.215	4.81	8	0.024	0.35	3.04	0.067
	Krom	Drift	KM1-D02	20:36	21:38	34° 09.273	24° 52.376	0.45	—	—	—	—	—
		Cal.	KM-Cal-02	20:50	20:59	34° 09.284	24° 52.356	—	—	—	—	—	—
10 Nov.	Mtlnds - Gmts	Surv.	S01A (wide)	07:46	10:12	—	—	7.52	7	0.742	1.90	18.13	9.84
			S01B (wide)	10:41	16:49	—	—	8.93	11	0.752	3.84	54.05	32.06
15 Nov.	J-Bay - Seal Pt.	Surv.	S03 (wide)	05:46	14:40	—	—	7.28	12	1.19	4.12	64.03	59.33
	Seal Pt.	Drift	SP-D01	14:48	15:00	34° 12.161	24° 51.317	0.70	—	—	—	—	—
	Krom	Drift	KM1-D03	15:25	16:35	34° 09.274	24° 52.344	0.41	—	—	—	—	—
16 Nov.	Mtlnds - Gmts	Surv.	S05 (wide)	06:15	14:31	—	—	7.92	12	1.18	3.09	51.70	44.09
	Van Stadens	Drift	VS-D01	08:52	09:36	33° 58.712	25° 10.453	1.07	—	—	—	—	—
	Gamtoos	Cal.	GTS-Cal-03	12:13	12:38	33° 58.657	25° 04.234	—	—	—	—	—	—
17 Nov.	J-Bay - Seal Pt.	Surv.	S04 (wide)	06:45	14:40	—	—	8.17	12	1.19	3.90	63.28	56.95
19 Nov.	Mtlnds - Gmts	Surv.	S06 (wide)	07:44	15:55	—	—	7.60	12	1.18	3.29	55.11	46.84
	Gamtoos	Drift	GTS-D01	12:01	12:49	34° 01.205	25° 05.489	0.70	—	—	—	—	—
20 Nov.	Krom	Surv.	KM1-S02	06:46	08:05	34° 09.433	24° 52.393	6.81	14	0.033	0.58	8.87	0.264
		Surv.	KM2-S01	08:17	10:06	34° 10.009	24° 52.102	6.09	19	0.033	0.48	11.02	0.309
		Drift	KM2-D01	10:09	11:19	34° 09.987	24° 52.099	1.03	—	—	—	—	—
21 Nov.	Seal Pt.	Surv.	SP-S01	10:20	12:13	34° 12.188	24° 51.289	5.56	20	0.015	0.45	10.33	0.133
		Drift	SP-D02	12:44	13:14	34° 12.179	24° 51.286	0.66	—	—	—	—	—
	Krom	Cal.	KM-Cal-04	15:14	15:48	34° 10.745	24° 51.058	—	—	—	—	—	—