TARGET STRENGTHS OF ANTARCTIC KRILL (*EUPHAUSIA SUPERBA*)

I. Everson, D.G. Bone, J.L. Watkins and K.G. Foote

Abstract

The Mean Volume Backscattering Strength of encaged aggregations of swimming krill have been measured at 38 and 120 kHz in a sheltered bay at South Georgia. The results indicate that the Target Strength values are approximately 10dB lower than previously assumed.

Résumé

Des concentrations encloses de krill mobile ont été mesurées à 38 et 120 kHz. Les résultats indiquent que les valeurs de la réponse acoustique sont nettement moins élevées que l'on supposait jusqu'à présent.

Резюме

Средняя сила обратного рассеивающего объема помещенных в садки агрегаций плавающего криля составляла 38 и 120 кГц в спокойном заливе Южной Георгии. Результаты показывают, что величины силы цели были приблизительно на 10 децибел ниже, чем ранее предполагаемые.

Resumen

Se ha medido la Fuerza de Retrodispersión del Volumen Medio de las agregaciones enjauladas de krill que nada a 38 y 120 kHz en una bahía protegida en Georgia del Sur. Los resultados indican que los valores de la Fuerza de Blanco son aproximadamente 10dB más bajos de lo que previamente se había supuesto.

1. INTRODUCTION

Euphausia superba is recognised to occupy a key position in the Antarctic ecosystem (Everson 1987, Laws 1985). The attempt to quantify its abundance in 1981 over part of its area of occurrence in the Southern Ocean occassioned the "largest acoustic survey of a marine species ever undertaken" (Anon. 1986). Insofar as it was desired to derive absolute measures of stock strength by the traditional echo integration method (Forbes and Nakken 1972, Johannesson and Mitson 1983), knowledge of the target strength is essential.

The problem of the target strength of krill has long been troublesome (Everson 1987). Firstly, only a few measurements on *E. superba* have been reported, and fewer applied, e.g., those by Protaschuk and Lukashova (1982) at 120 kHz and those by Nakayama et al. (1986) at 200 kHz. To supplement such measurements, recourse has been made to measurements on other krill species and fresh water shrimp, on tethered live, defrosted or otherwise preserved specimens, in fresh water as well as sea water. In addition the state of equipment calibration has generally not been reported, notwithstanding use of hydrophones, which method is fraught with errors and whose accuracy "is probably no better than ±1.4 dB" (Blue 1984). This figure is much inferior to that readily obtainable with standard spheres (Foote and MacLennan 1984, Robinson 1984, Foote et al. 1987), which is now the accepted method of calibrating fisheries acoustics instruments.

Recourse has also been made to model calculations, e.g., the scattering model of Greenlaw (1977) or radiation model of Kristensen (1983), to establish the frequency dependence of target strength. The latest calculations (Stanton 1988a, b), however, must cast doubt on the predictability of krill target strength by such models.

It is the aim of this work to describe a new series of measurements of the target strength of *E. superba*, made in January and February 1988. These were performed on encaged, otherwise free-swimming aggregations of krill at 38 and 120 kHz. In anticipation of submitting a detailed account of the experimental method and analysis to a journal, these parts, to the extent that they are complete, are only summarized, the primary objective here being to orient. Likewise, the measurement results are presented without the broader analysis that is evidently required for their explanation.

2. EXPERIMENTAL DESIGN

Earlier studies on the target strength of euphausiids and other small crustaceans convinced the authors of the need to perform all measurements on the animal of interest, *E. superba*. The work of Køgeler et al. (1987) was noted for its finding of systematic variations in density of euphausiids and the copepods *Calanus finmarchicus* and *C. hyperboreus* with size and season. The nominal density of these species, and that of *E. superba* too, is so close to the density of sea water that quite small changes can be very significant in the context of echo formation (Greenlaw et al. 1980). This is why it was necessary to travel south of the Antarctic Convergence, to where *E. superba* is found.

Given the general weakness of acoustic scattering by euphausiids, with physical properties similar to those of sea water, it was widely desired to perform the measurements on known targets. This was the motivation for measuring encaged aggregations of krill.

Several additional wishes contributed to the experimental design. Firstly, the recognised directionality of scattering by euphausiids (Greenlaw 1977) persuaded the authors to attempt concurrent photographic measurements of behaviour during the acoustic observations. Secondly, the desire to characterise the physical properties of the object animal by laboratory measurements of density and longitudinal sound speed, among others, made a shore base highly desirable. Thus it was that the measurement venue became a raft moored in the harbour of the abandoned, and sadly vandalized, whaling station at Stromness on the island of South Georgia.

The decision to measure encaged aggregations of krill allowed a wealth of experience on encaged fish to be tapped, as represented in the bibliography in Foote (1986). In addition, an experiment in fisheries acoustics (Foote 1983) could serve as a model for the present experiment. This was mostly followed, the major exception being acoustic measurements on single animals. Although planned, these were precluded by the lowness of the krill target strengths, which was already obvious from the very first encaged-aggregation measurements.

3. MATERIALS

3.2 Experimental Site

The primary measurements were made from a raft anchored securely 200 m from shore in 50-m-deep water in the harbour at Stromness on South Georgia. The site was protected from the open sea by an island blocking most of the harbour mouth. Swell with amplitude up to 0.5 m did pass through, however. The site was subject to violent catabatic winds rushing down the large and open valley behind Stromness. These reached severe gale force on roughly one out of two days, and hurricane force about once a fortnight. Depending on the wind direction and temperature, the immediate surface layer in the harbour could become quite brackish owing to glacial runoff. However, this light-water layer was seldom thicker than about 1 m, and did not affect the conduct of the measurements, which were performed far below it.

3.3 Krill Supply and Maintenance

Although krill frequently occur around South Georgia, their presence in bays, such as Stromness, is unpredictable. Fresh supplies of good-condition, live krill were obtained by RRS *John Biscoe* at approximately fortnightly intervals throughout the experiment. Krill captured by trawling were immediately put into sea water-filled tanks on the trawling deck. Dead or damaged krill were removed from the tanks while the ship was at sea. Live, good-condition krill were transferred to the holding pens when the ship returned to Stromness.

This supply was augmented by fortuitous swarms of krill in the harbour. On each such occasion it was possible to attract the krill at night by surface lighting to the very edge of the holding pens, where they could be caught and transferred in the freshest condition by dip net. It was estimated that 500 000 krill were secured after about one hour on each occasion.

The krill were kept in a cluster of four holding pens. Each was cylindrical in form, with 2 m diameter and 3 m depth. An air pump, driven by generator ashore, lifted water from 5 m depth to above the surface, where its fall into the pen entrained additional air. The rapid growth of algae on the sidewalls of the pens provided a source of food for the krill, which were frequently observed to be grazing on this.

An enclosure net was hung around the holding pens, this and a fine-mesh covering of the surface openings protected the krill from predators, such as penguins and seals.

3.3 Cage

Useful acoustic measurements were obtained with each of two identical cages. These were right octagonal cylinders of 0.5 m height and 0.5 m diameter measured across the flat sides of the octagon, measured between opposite sides. The volume was thus 0.104 m^3.

The material used in the construction was plastic netting of rectangular grid 3.2 x 3.6 mm. This was procured from Internet Incorporated, Minneapolis, Minnesota, USA. The netting, product number ON-8360, is normally used in reinforcing paper, as for towelling.

The cages were constructed by sewing, with monofilament nylon, pre-cut octagonal end panels of the mesh to the long edges of a pre-cut rectangular panel, which formed the sidewall. The sidewall was closed by sewing with the same monofilament nylon.

3.4 Measurement Configuration

The cage was suspended approximately 6 m below the transducers, which were mounted on a weighty frame from which other gear was suspended. The cage itself was suspended between two lightweight square frames, 3 m on a side. Lines of monofilament nylon were attached to each of sixteen corners. The upper eight were attached to a superior frame, the lower eight to the inferior frame. An underwater television camera was suspended from the inferior frame, pointing upwards towards the cage. The entire rig was suspended by a single rope attached to the transducer frame and allowing raising and lowering by a winch attached to a gantry positioned over one of two identical 4 x 4 m square moon-pools on the raft. The normal operating depth of the transducers was 9 m.

3.5 Acoustic Equipment

It was desired to use the same kind of equipment for the measurements as is typically used during surveys. This was done with the SIMRAD EK-400 echosounder (Brede 1984a) normally used on board RRS *John Biscoe*. The echosounder was used in its dual 38 and 120 kHz modes together with UNIVERSAL SONAR transducers, each with nominal 10 deg beamwidth. Integration of the squared echo signals was performed with the SIMRAD QD digital echo integrator (Brede 1984b). Both echosounder and integrator were housed ashore, in the laboratory, together with other equipment. This included a BAS system for display and logging of data. The cable link was entirely satisfactory. Additional acoustic equipment consisted of three calibration spheres; 60 and 23 mm diameter copper spheres and a 38.1 mm diameter tungsten carbide sphere (Foote and MacLennan 1984).

3.6 Photographic Equipment

The principal photographic equipment that worked consisted of an underwater television camera and programmable videotape units for the display, recording and replay of the television images.

A stereoscopic camera system was also suspended with the television camera. However, for a variety of reasons and in spite of arduous if Sisyphean labours, the system provided few data and none on the particular acoustically measured krill.

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4. METHODS

Measurements were made of encaged krill, empty cages, calibration spheres, and volume reverberation. Each series of measurements on a given object is referred to as an event.

4.1 Echosounder Operation

The acoustic measurements were generally made in the same way. Standard settings were used on the EK-400 echosounder. The time-varied-gain (TVG) function was the "20 log r" type. The pulse repetition frequency was a constant 50 pulses/min, with alternating transmissions at 38 and 120 kHz. The nominal pulse duration in the measurements considered here was 1.00 ms. Attenuator and gain settings were adjusted depending on the measurement object.

4.2 Echo Integration

Integration of the squared received voltage was performed over the full range interval corresponding to echoes from the cage. This was [6.0, 8.0] m for nearly all measurements. The exceptional cases with krill involved Event numbers 54 and 55, when the cage was lowered 1 m, for which the integration interval was [7.0, 9.0] m.

Results of echo integration were summed over intervals corresponding to either 0.2 or 1.0 nautical miles at a simulated vessel speed of 10 knots, hence for 1.2 or 6 min, respectively. The cumulative numbers were divided by the interval duration and presented as "mean volume backscattering strength" in decibels (Brede 1984b). These values, together with those from other integration intervals, were displayed on a screen and stored on a BAS data logger at the end of each interval.

4.3 Calibration

On-axis calibration with standard spheres was performed throughout the experiment as often as circumstances permitted. In the absence of the cage, the sphere was lowered to a position intended to be at the centre of the cage. The echosounder and integrator were then operated as during the cage measurement. Adjustments of the attenuator and gain settings during several calibrations established the relative accuracy of these.

To supplement the on-axis calibrations at cage depth, the spare tungsten carbide sphere was suspended at a fixed position below the transducers, but outside of the cage integration interval. This provided a ready means of monitoring the equipment performance.

4.4 Empty Cage and Volume Reverberation Measurements

Empty-cage measurements were also performed as circumstances allowed, but again covering the entire period of the krill measurements. Measurement of the water volume without cage, but with rig in place, established the general lowness of the volume reverberation. Continual monitoring with the underwater television camera confirmed the general absence of visible extraneous scatterers near the cage. The exceptions were provided by several occurrences of krill swarms in Stromness harbour, occasional occurrences of acoustically inevident ctenophores, and rare, brief visits by the odd Gentoo penguin or blue-eyed shag.

4.5 Beam-Pattern Mapping

The tungsten carbide sphere was also used to map the transducer beam patterns. The adopted procedure was that due to Simmonds (1984), although with a deliberately lesser degree of automation.

4.6 Krill Measurement

Measurement of krill began with their capture in a holding pen, by a small dip net, with c. 100 cm^2 opening, and transfer to a 100 litre tub half-filled with surface sea water. After reaching the predetermined number, more or less, the tub was ferried to the measurement raft. Here the krill were introduced into the cage, this having been raised to the surface the krill were syphoned in through a slit in the top panel. Handling of the krill was thus minimal, and their apparently vigorous condition was continually confirmed by television. Emptying of the cage proceeded through a slit in the bottom panel. Both slits were secured by threading monofilament nylon through reinforced meshes on the sides of the opening.

Upon completing an encaged-krill measurement series, the krill were transferred to the laboratory in a tub with sea water. On average, about half of the krill continued swimming vigorously, and nearly all showed signs of life, although the overall condition did vary considerably from event to event. Some of the krill were used in measurements of sound speed, as in Køgeler et al. (1987), but with recognition of the error in their equation, evidently copied from Equation (3.3) in Kristensen (1983). The salinity of the sea water was measured, and the temperature was monitored continually during the sound speed measurements. Measurements of total length of krill and wet weight were performed on the samples used for sound speed measurement and sometimes also on samples taken directly from the tub.

The total number of krill removed from the cage was also determined. This was generally less than the starting number by a few percent, presumably owing to cannibalism. In the worst case, Event number 36, the initial number was reduced by 7%, but over a 42-hour period. In another case, Event number 20, the number increased by two specimens, believed entrapped by the cage during intense swarming observed in the harbour.

A Plessey CTD-sonde was suspended at the nominal 15-m depth of the cage, but from the second moon-pool reserved for such measurements. When working, both salinity and temperature were recorded at 15-second intervals throughout the day. In addition, the light intensity at the same depth was recorded at 2-minute intervals.

5. DATA ANALYSIS

The first step in the analysis was to decide which data were usable. Whole events with encaged krill had to be purged for the following reasons: (1) early use of wrong integration limits, (2) distortion of the cage, with displacement from the usual position in the beam, due to entangling of the cage suspension lines, and (3) damage of the cage, with mass escape of krill, owing to a presumed collision or attack by a seal. Half the data from another event, number 28, had to be purged because of severing of the lifting rope to the underwater rig in heavy-swell conditions.

Data in the remaining events were purged very cautiously owing to these causes: (1) event start-up effects, always of short duration, (2) observed or presumed interference by extraneous scatterers such as fish, penguins, or krill swarms in the harbour attracted deliberately to the measurement raft by using underwater lights at night, (3) radio interference with the receivers during arrival of a yacht under motor power, and (4) trial use of different echosounder settings or transducer beamwidths. For some events no data were purged, and for no event was as much as 15% of the data purged, except for the fourth cause.

In order to extract target strengths or backscattering cross sections from the QD echo integrator data, the "mean volume backscattering strengths" had to be reduced. This entailed a number of analyses.

(1) Conversion factors. To express the echo integrator data as absolute quantities, the calibration data were reduced. Upon combining, the following factors were derived for adding to the logarithmic QD units: - 42.3 and -31.1 dB for the data at 38 and 120 kHz, respectively. The total range of variation of these factors was ±0.4 dB each.

(2) Time-varied-gain (TVG) corrections factors. Several errors were incurred by the use of TVG in the receiver. One is due to the rather short target range, 6-7 m, for which the pulse length, 1.47 m, is not negligibly small. The other error is due to the distributed nature of the cage and krill aggregation, which is to be compared to the compactness of the calibration sphere. The extent of the cage, and krill aggregation too if so dispersed, was 0.5 m vertically and slightly more aslant as viewed from the transducer. For the particular "20 log r" TVG used throughout the measurements, the resulting correction factors are -0.4 dB for the cage at nominal 6 m range and 1.0 dB for the cage at nominal 7 m range. These figures apply at both frequencies. The estimated uncertainties of the correction factors, due to uncertainty in the precise target ranges, are ±0.2 and ±0.1 dB at the respective 6- and 7-m ranges.

(3) Beam pattern compensation factors. The transducer beams were nonuniform across the cage and unaligned with the cage axis. Each beam center was inferred from the respective beam-pattern-mapping data by a least-squares procedure based on comparison with the theoretical beam patterns. Integration of the squared beam pattern over the cage cross section and normalizing this to the solid angle formed by the cage results in the following compensation factors: 0.9 and 0.7 dB at 38 and 120 kHz, respectively, for the cage at nominal 6-m depth, and 0.7 and 0.6 dB for the cage at nominal 7-m depth. Estimated uncertainties due to uncertainty in both measured and computed beam patterns are ±0.1 dB.

Application of the three factors to the echo integrator data produces a series of numbers for the equivalent target strength of the krill and cage together. This is alternatively expressed through the backscattering cross section σ by the standard relation, TS=10 log $\sigma/4$ (Urick 1975), but with use of SI units.

The cage contribution can be removed in two different ways. (1) Because of the availability of empty-cage measurements, these can be summarized, and the mean contribution can be subtracted in the appropriate intensity domain (Foote 1983). The effective cage target strengths in uncompensated QD units are -20.3 and -19.3 dB at 38 and 120 kHz, respectively, with respective uncertainties of ±1.2 and ±1.4 dB. Following subtraction, averaging yields the mean backscattering cross section per krill. (2) The effective cage contribution can also be inferred by regressing the equivalent backscattering cross section of cage and krill on the number of encaged krill. The intercept is then the cage contribution, and the slope or regression coefficient is the mean backscattering cross section of a single krill. Both methods of compensating for the cage contribution are used.

6. RESULTS

Some summary results of events with apparently usable krill data are presented in Table 1. The mean target strengths, denoted TS, are determined in the usual fashion. First, the mean backscattering cross section σ is computed; then the mean target strength is derived from the definition TS=10 log $\sigma/4$.

The mean krill target strength, denoted $TS_{1\ krill}$ in Table 1, is determined by the first method of removing the cage contribution, viz. by subtracting the mean empty-cage contribution in the intensity domain. The missing datum, for Event number 54 at 120 kHz, reveals a flaw in the method if not in the data. Here the actual cage contribution must be less than the number assumed for it. Indeed, the echo strength of cage and krill together is less than the mean cage contribution.

Curiously, or not, the equivalent target strength at 38 kHz of cage and krill together for Event number 54 is greater than that for Event number 55, although the second has twice the number of krill of the first. Given the proximity of the events, their data are not used in the analyses reported in Table 2.

The results of averaging the corresponding single-krill backscattering cross sections in Table 1 is shown in the 'subtraction' row of Table 2. The coefficient of variation of σ is included together with the mean target strength. The additional quantities are defined thus: $TS_{1,2}$=10 log $(\sigma \pm \Delta\sigma)/4$.

The equivalent mean target strength of cage and krill together is denoted $TS_{cage+N\ krill}$ in Table 1. Regression of the corresponding backscattering cross section on N allows derivation of σ for one krill through the regression coefficient. This is shown in the 'regression' row in Table 2. The coefficient of variation in this case is formed by expressing the standard error of the regression coefficient as a percentage of the regression coefficient, namely σ.

The analyses reported in Table 2 have been repeated for another subset of the data in Table 1. This excludes the data with rms lengths greater than 34.0 mm. The results are not significantly different from their antecedents. Specifically, TS decreases by 0.2 dB at each frequency for the 'subtraction' method, while remaining unchanged for the 'regression' method. The rms length for the two subsets are 33.2 and 31.6 mm, respectively.

7. DISCUSSION

If the reader is looking for a simpler answer to the problem of krill target strength than is contained in Table 2, then so are the authors. The discrepancy between the respective results is uncomfortably, if not discomfitingly, large.

It is to be admitted at once that the present analysis is incomplete for other data from the experiment have not yet been analysed. These include videotape recordings of the krill distribution across the cage, other notes on the behaviour and condition of the encaged krill, data on the light intensity at the cage depth, and measurements of longitudinal sound speed and density of krill removed from the cage.

The importance of behavioural data derives from the recognition of krill as a directional scatterer (Greenlaw 1977). As is the case with another directional scatterer, commercially important fish at ultrasonic frequencies (Nakken and Olsen 1977), systematic changes in tilt angle distribution can have dramatic effect of target strength (Foote 1980, 1987).

At the outset of the experiment it was the authors, firm intention to collect data on the tilt angle distribution of the encaged krill. However, the stereoscopic camera system failed utterly to provide any data bearing on the measured krill.

Clues to possible behavioural effects may be found in the video tape record. A quantitative image analysis by one of the authors (JLW) is underway.

The record of light intensity at cage depth may also elucidate a major determinant of behaviour, if applicable to encaged krill. This is pure speculation at the moment, but correlation with the quantified videotape data or, better, acoustic data themselves, may prove this.

Condition could also be a critical factor affecting or determining target strength. While the quality of encaged krill was often excellent, those krill caught at sea by trawling had a distinctly higher mortality than those caught beside the holding pen by dip net. Only active swimmers were introduced into the cage, but the change in condition over the duration of an event was often considerable.

This change in condition might be expected to affect the measurements in two ways. Firstly, the change in condition may have a behavioural consequence, as in changing the tilt angle distribution. Secondly, a changing condition may affect the physical properties of the animal, as is the case for fish (Gytre 1987). Since these are only slightly different from the respective properties of sea water under any circumstances, a small change in physical properties may have a very big effect of target strength (Greenlaw et al. 1980).

A direct approach to the problem of the influence of krill condition on target strength is to analyse the acoustic record for time variations both within events and from event to event. In the case of intra-event comparisons, this could proceed by averaging the acoustic data over intervals of, say, several hours. The problem would be to distinguish variations due to changing condition from those due to diurnal or other strong effects. This problem might be circumvented through the search for inter-event differences, as, for example, among different events that used krill with the same origin.

Some collateral, still unanalyzed data from the experiment that might shed light on the role of condition are those collected on density and sound speed. These data were planned for use in modelling work, but may serve a more immediate, interpretive function.

The same is true with respect to extinction. A regression analysis of the single-krill target strengths on cage density has been performed. The results are marginally significant at the 0.10-0.05 level, but not at 0.02. Thus the phenomenon of extinction may be noticeable in the data, but determination of the extinction cross section must be rather uncertain. One thing that is certain about extinction is that if it was present to a significant degree, then it will require raising the computed means shown in Table 2.

The mentioned analysis of extinction has been interesting for yielding quite large values for the extinction cross sections, compared to the mean backscattering cross sections, at both frequencies. This is not inconsistent with scattering theory. It may even be as revealing in its way as resonances are in other applications. Again, a fuller analysis should prove the point.

Some other outstanding work of concern to the authors involves describing the various dependences of krill target strength. This is allied with the modelling effort, but also requires more data on acoustic, behavioural, and physical properties. An especially regrettable shortcoming of the experiment is the absence of gravid krill. Controlled acoustic measurement of these in a future experiment is unavoidable for addressing the general survey situation.

8. CONCLUSION

Notwithstanding the noted discrepancies in Table 2 and also the large uncertainties in estimated mean target strengths, the general finding of this study is clear. The target strengths of krill at 38 and 120 kHz are quite low compared to earlier assumed values. Justification for this may be found in basic scattering theory: small euphausiids, even *E. superba*, with physical properties only slightly different from those of sea water, cannot possess target strengths even remotely comparable to those of swimbladder-bearing fish of similar size, which has been the implicit assumption until now.

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Table 1: Summary of krill target strengths by event. The respective sample size is denoted N_s. Each acoustic sample is the result of averaging over a 6-min interval at the effective PRF of 25 pulses/min.

			Krill lengths (mm)				TS (dB) at 38 kHz			TS (dB) at 120 kHz		
Event no.	Duration	Mean no. krill N	$l^{2\,1/2}$	$\overline{l}$	Δl	n_s	$TS_{1\ krill}$	$TS_{cage+Nkrill}$	n_s	$TS_{1\ krill}$	$TS_{cage+Nkrill}$	n_s
17	16h46m	496	39.2	38.9	4.4	458	-84.1	-55.9	159	-75.9	-46.5	159
19	15h22m	246	31.5	31.3	3.4	100	-82.6	-57.1	132	-74.5	-47.3	132
20	23h16m	351	33.7	33.3	4.8	100	-82.8	-56.1	206	-76.2	-47.4	206
26	23h 1m	752	30.5	30.4	2.4	300	-87.8	-57.3	202	-77.3	-46.2	202
28	38h38m	390	29.7	29.6	2.2	100	-83.6	-56.4	189	-74.6	-46.3	189
30	40h13m	458	34.9	34.8	3.2	200	-85.1	-56.9	376	-74.8	-46.0	376
36	42h31m	1368	31.6	31.5	3.0	500	-85.5	-53.5	424	-75.6	-43.2	424
37	18h13m	787	30.8	30.7	3.2	200	-88.0	-57.3	180	-76.5	-45.7	180
43	37h 3m	398	33.0	32.9	2.8	200	-87.6	-58.8	164	-77.0	-47.5	358
47	64h41m	1593	32.5	32.3	2.9	397	-89.1	-55.9	318	-79.7	-45.7	298
50	42h36m	850	31.1	31.0	2.7	200	-86.6	-56.1	232	-78.0	-46.3	411
52	65h 5m	816	38.1	37.9	3.8	200	-84.2	-54.3	632	-75.4	-44.8	632
54	62h44m	394	31.2	31.0	3.7	200	-86.9	-58.4	619	-	-50.2	619
55	46h 7m	794	31.0	30.8	3.3	200	-88.3	-58.7	459	-80.7	-48.6	461

Table 2: Summary results for each of two methods of removing the empty-cage contribution based on the data in Table 1 exclusive of those for Event numbers 54 and 55.

	38 kHz					120 kHz				
Method	$\overline{\sigma}$(mm²)	cv(%)	$\overline{TS}$	TS_1	TS^2	$\overline{\sigma}$(mm²)	cv(%)	$\overline{TS}$	TS_1	TS^2
Subtraction	0.039	47	-85.1	-87.9	-83.4	0.311	31	-76.1	-77.7	-74.9
Regression	0.015	46	-89.4	-92.1	-87.7	0.173	33	-78.6	-80.3	-77.4

Légendes des tableaux

Tableau 1 Résumé des réponses acoustiques du krill par cas. La taille de l'échantillon respectif est dénotée N_s. Chaque échantillon acoustique est le résultat d'une prise de moyenne pour un intervalle de 6 minutes à une fréquence effective de répétition de 25 pulsations/minute.

Tableau 2 Résultats résumés de chacune des deux méthodes pour ôter la contribution de la cage vide, basés sur les données figurant au Tableau 1, à l'exclusion de celles sur les cas numérotés 54 et 55.

Заголовки к таблицам

Таблица 1 Сводка данных отдельных замеров акустической силы цели криля. Соответственный объем пробы отмечен N_s. Каждая акустическая проба является результатом усреднения по 6-минтервалу при действующей частоте повторения импульсов (PRF), которая составляет 25 импульсов/мин.

Таблица 2 Сводка результатов для каждого из двух методов внесения поправки на пустой садок, основанных на данных таблицы 1, за исключением замеров 54 и 55.

Encabezamientos de las Tablas

Tabla 1 Resumen de las fuerzas de blanco del krill en cada caso. El tamaño de la muestra respectiva está indicada N_s. Cada muestra acústica es el resultado de promediar sobre un intervalo de 6 minutos al efectuivo PRF de 25 pulsos/min.

Tabla 2 Resumen de los resultados para cada uno de los dos m´todos de retirar la contribución de la jaula-vacia basada en los datos de la Tabla 1, excepto los datos para el Caso, números 54 y 55.