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Report of the Workshop on the Determination of Acoustic Target Strength of Redfish (WKTAR)

1-3 June 2010

Tromsø, Norway

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Executive summary

The Workshop on the Determination of Acoustic Target Strength of Redfish (WKTAR) met in Tromsø, Norway on 1–3 June 2010. The workshop was chaired by Mike Jech and Benjamin Planque and was attended by eight participants from five countries. The objective of the workshop was to propose a target strength equation for redfish (*Sebastes mentella*) in the North Atlantic based on the best available scientific knowledge. This was achieved through an extensive review of published and ongoing studies. Data from these studies were evaluated, ranked, and served as input to a meta-analysis. The meta-analysis results indicated that the best candidate for a general model of *S. mentella* TS-length equation at 38 kHz is the free slope model: $TS = 10.6 \log(L) - 55.4$. However, the meta-analysis revealed important departures from this equation in individual studies and the reasons for such discrepancies are generally undetermined or at best very poorly documented. To address this problem the following three actions were recommended: 1) ensure that high quality acoustic/biological data for TS determination are collected during redfish surveys, 2) perform simultaneous comparative measurements between EK500 & EK60 echosounders for Target Strength determination and 3) pursue TS analysis during a new workshop WKTAR-II.

1 Opening of the meeting

The meeting opened at 9:00 on 1 June 2010 at the Skansen house in Tromsø. After in-house information provided by B. Planque, the chairs (M. Jech and B. Planque) introduced the ToRs and the rational for the meeting. Participants (see Annex 1) introduced themselves.

2 Adoption of the agenda

The draft agenda was adopted, and it was agreed that some flexibility should be preserved to adapt the schedule to varying time needs for the presentations and discussions.

3 General approach

Prior to the workshop, the group conducted a literature review and assembled the references pertaining to acoustic measurement of redfish in the North Atlantic Ocean. This review highlighted the variety of data spanning nearly 30 years of acquisition. Over this period the technology has improved from single beam to split-beam systems with more stable electronics, and post-processing methods and techniques have improved the capacity to extract information. In-situ surveys and experiments and ex-situ measurements comprise the overall dataset. The group discussed how to incorporate the data from these disparate sources. M. Jech presented an overview of the data from the literature review, and summarized the data with a figure of length vs. target strength (TS) where the mean length and mean TS, as well as an estimate of the spread, from each reference was presented. This figure showed no extreme points and that all the data could be incorporated into an analysis. The group discussed and agreed upon a meta-analysis of these data.

Meta-analysis is a general method to incorporate data when the “raw” data are not available. In this case, many target strength (hundreds to thousands) and length (tens to hundreds) measurements are combined into a mean TS and length, often with some measure of the variability. It is usually inconvenient to return to these individual points, so meta-analysis was developed to utilize the existing information. This requires some level of aggregation of the data, and needs criteria to accept or reject data in the meta-analysis. Then when data are accepted, criteria are needed to determine how they should be weighted.

The overall procedure was to go chronologically through the papers and evaluate each based on the criteria. The criteria with the greatest priority were: the species needed to be *Sebastes mentella*, the acoustic data were collected with a split-beam system, and the data were collected in situ. In addition to these criteria, the acoustic and biological methodology, geographic location, species composition, depth and/or range to the targets, and post-processing methods for each individual study were evaluated. After each paper was discussed, it was ranked on a scale of zero to five. A rank of zero indicated that the data could still be presented but would have no influence on the statistical analysis. A rank of five indicated full influence, and ranks of one to four had less influence. These ranks were used in the weighting of the data in the statistical analysis.

A spreadsheet was generated with the variables and ranking. The variables were: mean length, number of length observations, standard deviation of length, minimum length, maximum length, mean weight, standard deviation of weight, minimum weight, maximum weight, mean target strength, number of target strength observations, standard deviation of target strength, minimum target strength, maximum target strength, mean depth of the targets, minimum depth of the targets, maximum depth of the targets, in situ or ex situ, geographic location, month and year of the data collection, species identification, time of day (day or night), echosounder type, maturity stage (juvenile or adult), and the rank.

After the data were entered and audited by each investigator (or by a proxy when the investigator was not present), they were analysed using the meta-analysis construct (see Section 5).

4 Review of individual studies

Mamylov and Sergeeva (1982): This paper is one of the earliest references for target strength of redfish, but it gives only cursory information for redfish, where most of the paper describes backscatter from cod and haddock. As such, no information on the raw data are provided. The target strength is derived from the maximum length and target strength and only ranges of length and target strength are available (i.e. no mean length or TS). The echosounder is one of the first generation Simrad EK model and is not a split-beam system. The pulse length is suspected to be 0.6 ms. Target strength registrations are from depths of approximately 500m, which suggests that only big fish are retained (i.e. the signal to noise ratio (SNR) possibly masks low target strength targets). It is unlikely that the original data can be retrieved. We recommend that this should not be used in a quantitative meta-analysis but should be displayed for comparison with the results of the meta-analysis. **Ranking: 0.**

Foote (Foote *et al.*, 1986; Foote 1987): The 1987 paper gives the same data as in the 1986 paper, so all reference is given to the 1986 paper. The species identification is probably *S. marinus*, rather than *S. mentella*, given the location (Lofoten, Norway) and depth of investigation (165-225m). The mean length and mean target strength are derived from a single trawl haul (i.e. one observation with 7584 individual targets). The full length distribution and TS distribution are presented. Standard deviation in TS is not presented but could be calculated from Figure 3 and the number of targets used to construct this figure. Because the species is believed to be *S. marinus*, the reference is given a ranking of 1. **Ranking 1.**

Orlowski (1990): These data are from the Irminger Sea and Reykjanes Ridge area. The results are derived from three trawl hauls and acoustic data from 220m and shallower. The species identification is *S. mentella,* which is realistic given the location and depths. The data are aggregated so it is not possible to separate results from individual hauls. Because the echosounder was not a split–beam system and there are concerns over the accuracy of the calibration (a 0.5 dB difference between the “factory” calibration and an at-survey verification), the reference is given a ranking of 1. **Ranking: 1.**

Reynisson (1992): In 1991 and 1992 acoustic surveys on oceanic redfish in the Irminger Sea (between Iceland and Greenland) were carried out (Magnusson et. al. 1992a, 1992b). TS data were collected from 0–300 m on and off during these surveys, using an EK500 split-beam echosounder. Sixteen separate TS measurements were carried out at different locations, at cruising speed, during trawling and at different times of the day. Ten trawl stations, all using a Gloria midwater trawl, were used as the basis for biological information. Mean length and weight, standard deviation and distribution are reported as well as number of accepted single-targets. Length and weight range for the collective trawl stations are given. During night, bimodal TS-distributions were observed, with one mode below -55 dB. This mode is believed to originate from myctophids. In that case a -53 dB cut-off was used. Particularly in the uppermost 150 m, a notable decrease in TS was observed with depth. At depths greater than 250 m problems with multiple targets were thought to affect the split-beam measurements. In view of the short range in mean length and the dynamic nature of target strength, it was thought appropriate to express the result as a single mean target strength within 100–200 m depth; TS= -40 dB, for mean fish length 36.9 cm. This results in an intercept of -71.3 dB in a 20logL TS-equation. **Ranking: 5**

Reynisson and Sigurdsson (1996): In 1995 a dedicated survey to monitor variations in target strength and integrated values between day and night was undertaken. Continuous acoustic monitoring along a 10nmi transect for consecutive 3 days in two areas was carried out using an EK500 split-beam echosounder. The intention was to use a Gloria midwater trawl. The winch broke down after two hauls, so an inefficient small pelagic trawl had to be used for the remainder of the survey. This explains the small trawl samples (212 and 56 individuals in the respective areas), but the length range and mean length are similar to those obtained in the area in earlier years.

Software was used to track individual targets (Ona and Hansen 1991). This did not change the results from the study although the number of accepted targets was greatly reduced. As observed in 1991 and 1992, multiple targets deeper than 200–250m seem to be problematic. Similarly, TS decreased with depth in the uppermost 150 m.

The shape of the TS-distributions, and mean TS, changed progressively through the day and a strong correlation between mean TS and integrated values was observed. Potential problems were with deep scattering layer species moving up during night-time. For the integrated 24 hour period the mean TS is -40 dB, but from 0600 to 2200 (daytime) it is -39.7 dB. Lower night-time values may be explained by changes in behaviour of redfish or some other day-night cycle rather than intrusion of small DSL species. **Ranking: 5.**

Reynisson (presentation during this meeting): A re-analysis of the 1995 data (Reynisson and Sigurdsson, 1996) with a focus on the problem of multiple echoes was presented at the workshop. Following the recommendation from Gauthier and Rose (2001), the number of fish per sampling volume according to integration (N_v) and the number of single targets detected (T_v) by the split-beam sounder (EK500) were compared within the 120 – 200 m depth interval. An average of 500 pings in 10 m depth bins was used for the comparison. Under ideal conditions the expected ratio should be 1:1, given that the target strength used in converting integrated values to the number of fish is the correct one, that the single-target detection efficiency is 100 per cent, and that no multiple targets are present. In order to get a stable linear relationship T_v between and N_v the night-time and daytime data had to be separated. By adjusting TS to -39.8 dB at night and -36.2 dB during the day, a T_v / N_v-ratio of 1 could be realized in both cases. The ratio was only slightly dependent on depth within the depth range considered, but below 250 m the depth effect was confirmed. TS values as measured by the split-beam system are -42 dB at night and -39 dB during the day. In general one cannot expect, even under favourable conditions, that N_v and T_v are equal. The single-target recognition efficiency of the split-beam system is hardly 100%, some multiple echoes will be rejected and others accepted. The split-beam efficiency might well be as low as 50%. This is not known, and surely varies with conditions and equipment settings.

It is important to note that N_v levels for the case considered are in an overwhelming majority below 0.04. This is the threshold density determined by Sawada *et al.* (1993). In this analysis no tracking software was used and a 5.1 degree detection angle was used. **No ranking**

Discussion: multiple echoes are expected to reduce the ratio for high densities of targets. Changes in fish behaviour between day and night may explain changes in ratios between day and night. Target detection efficiency less than 100% would lead to ratio <1:1. The available data show that the average density seems low enough to get reliable TS. Another potential explanation for diurnal variability is redfish physiology where Gauthier and Rose (2002b) show that TS can be modified following a day-night cycle, because of gas resorption and secretion in the gas bladder.

Gauthier and Rose (2002a): This paper reports on in-situ measurements from mixed aggregations of *Sebastes mentella* (numerically dominant) and *S. fasciatus*, although hybridization is common in the study area. Thirty one TS/length estimates are provided, derived from 21 trawls, and includes eight sets of simultaneous TS data collection using a towed echosounder as well as a hull-mounted echosounder. The majority of TS data were obtained during the night as the fish were aggregated during the day. Biological sampling was mainly from demersal trawls, with a few midwater trawls as necessary. Mean fish length and mean TS are presented, along with TS and length histograms for eight pairs of towed/hull-mounted TS data. No TS or fish length range or standard deviation are given but would be available from the authors.

Because the species was not 100% *S. mentella*, there was less than one trawl per TS experiment, and the majority of the trawls were demersal and presumably carried out during the day when TS data were not obtained, the ranking was slightly reduced from the highest level. **Ranking: 4**.

Gauthier and Rose (2001): This paper reports on ex-situ experiments conducted on 16 *Sebastes* specimens (stated as being either *S. mentella* or *fasciatus*) caught by line/hooks and kept in monofilament cages for subsequent TS measurements at a depth of 10 m. At least 2 hours of data were collected from each fish, and mean TS was plotted against mean fish length. TS histograms are also provided for each set of measurements. Some information is provided on fish tilt angle, obtained from simultaneous video recordings.

Because these experiments were ex-situ (potentially altering the fish behaviour and hence the tilt angle from their natural behaviour), there was difference in depth between sampling and measurement, and that the species was not confidently known to be *S. mentella*, the rank for these results was low **Ranking: 2**.

Gauthier and Rose (2002b): This paper reports on ex-situ measurements from a single, encaged, immobilized Atlantic beaked redfish (*Sebastes,* actual species not given) conducted over a 12 hour period. A marked change of about 3 dB in target strength was observed during the night period, which was hypothesized to be due to an endogenous hydrostasis mechanism in the swimbladder.

For the same reasons as the Gauthier and Rose (2001) ex-situ experiments, the rank for this result is low. Despite the low ranking, this is potentially a very important observation and does corroborate in situ measurements of Reynisson and Sigurdsson (1996). **Ranking: 2**.

Ermolchev (2009; 2010): These papers present the methods and results of *in situ* target-strength measurements of the Atlantic deep-water redfish (*Sebastes mentella*) in the Norwegian and Irminger Seas. A. Astakhov presented these at the workshop. The data are from combined acoustics and trawling measurements. Registrations are taken along the trawl path, where the depth and distance behind the vessel of the net were compensated for. The echograms were scrutinized in FAMAS (post-processing software) for redfish echoes, and aggregations were eliminated from the analysis. In this method, the 'correct' mean length is obtained by adjusting the coefficients of the TS-L equation. The final results from this method was K=-69.6 (the intercept of $TS=20\log_{10}(L)+K$) for the Irminger Sea and K=-69.4 for the Norwegian Sea. The group noted that the distribution of TS is different (higher) than what was observed by Reynisson in the 1990s (Reynisson 1992; Reynisson and Sigurdsson 1996). This may be a problem linked to TS detection of the EK60vs.EK500, but the group cannot conclude this at this time. **Ranking: 5.**

Kang and Hwang (2003): This paper presents ex-situ measurements on a Pacific species of redfish (aka 'rockfish'), *S. schlegeli* at three frequencies (38, 120, and 200 kHz). Because these fish are from the Pacific, and the measurements are ex situ, the rank was set to 0. **Rank 0**.

Bethke 1 (presentation during this meeting). A direct method to measure TS values by comparing measured and expected TS patterns from trawl hauls was developed. The basic idea was to convert the length distribution into a TS distribution using an unknown, initial intercept *K*. However, a single length does not convert to single TS because of variability in TS measurements. So, each individual length was translated into a Gaussian distribution of TS and, therefore, the expected TS distribution is obtained from the distribution of lengths by convoluting each with the Gaussian distribution. The directly measured TS distribution can be compared while changing the intercept of the TS equation. The best fit between observed TS and expected TS is found when correlation between the two is a maximum. In essence this method is similar to standard techniques. The method is based on the assumption that most direct measurements of the echosounder are correct and the maxima of both distributions – the computed distribution from the trawl haul and that directly measured – can be found at the same place if the intercept is chosen correctly. The main advantage of this method is that it is not necessary to selected TSmax and TSmin threshold values to estimate K (as was the case for Ermolchev 2009 and 2010). For unimodal distributions (typically for redfish) it is only possible to estimate the intercept K, however, for multimodal distributions it should be possible to estimate both parameters of the standard TS equation. Only one trawl from a Norwegian Sea survey has been analysed, but it was planned to apply the method on other data (Iceland, Russia, Norway). **No Ranking.**

Savina and Planque (presentation during this meeting). The method presented was investigated by Esther Savina during her master project in 2009. Data were collected using an EK60 echosounder, during the pelagic redfish survey conducted in the Norwegian Sea in summer 2008 (ICES, 2008). There is no doubt about species identification and all collected redfish specimen were *S. mentella*. The methodology is based on visual counting of targets on the echogram and measurement of s_A at different Sv-threshold levels. For each registration and Sv-threshold level, the coefficient of the 20logL equation is estimated from the following equation: $K=20\log(L)+10\log(4\pi N/A)$-

10log(sA) where *L* is the mean length of fish, *N* the number of counted targets, *A* the area sampled and sA the area backscattering coefficient. Data from 16 samples with 7 Sv thresholds were analysed. The results showed a strong effect of thresholding and the group suggested that this possibly resulted from sA integration of targets that are not redfish at low threshold values. This could be corrected by reanalysing the data by taking target sA only (instead of the sA for the whole registration). Alternatively it might be possible to use the threshold/K plots and only select K estimates for high threshold levels, if the K has flattened out (i.e. no significant effect of thresholding). The group also recommended that the same data should be analysed by looking directly at the TS distribution. Because of these methodological issues, the results from this analysis were not included in the meta-analysis. **No Ranking.**

Bethke 2 (presentation during this meeting). This method is an extension of the Savina and Planque presentation and is based on the same idea; however, correcting errors introduced by thresholding the volume backscatter (Sv) data. The problem is described in Bethke (2004). A larger Sv threshold results in a smaller effective two-way beam angle and therefore in a smaller sample area. Therefore, a smaller number of redfish may be counted from the sample area (see Savina and Planque, this report). The effect of thresholding is different for each fish length having different TS values. In extreme cases a threshold that is too large may exclude small fish from counting. This is the intention for non-target fish but introduces errors if the excluded fish is from the target species. A smaller sample area corresponds to a lower sA measured from this area. However, thresholding may change the sample area and the loss of signal energy during the measurements in a different way so that one error doesn't compensate the other. The presented method deals in more detail with the errors and delivers probably more accurate estimations than the method of Savina and Planque. **No Ranking.**

Pedersen *et al.* (unpublished data and manuscript). Measurements described in this manuscript were performed during June and July 2001 in the Irminger Sea. The majority of the measurements were performed during the day. Redfish (*S. mentella*) TS data were collected with a towed body, deployed from the RV "G. O. Sars", equipped with Simrad EK 60 echosounders operating at two frequencies (38 and 120 kHz). The system included two pressure stabilized transducers (ES38-DD and ES120–7D) and was calibrated according to standard practices using Simrad calibration software. A depth "calibration" was also performed by measuring the TS of a calibration sphere with the towed body lowered to different depths. The measured sphere TS at 38 kHz increased with depth, likely due to pressure effects on the transducer, but this observed increase in TS with depth is unusual for this type of transducer (ES38DD). These measurements were used to compensate redfish TS data (~-1.7 dB at 500 m). Biological data were gathered from four commercial trawl hauls, taken in nearby areas at similar time and depths as the TS measurements were performed. Two trawl hauls using RV "G. O. Sars" small pelagic trawl was also used. Eight TS measurements were performed, all but one of redfish beneath the deep scattering layer (~600 m). The range from the transducer to the redfish was in general greater than 200 m because of the deep scattering layer, but the redfish beneath this layer were highly dispersed. TS data were target tracked and analysed in Matlab, and filtered with respect to off-axis beam angle and fish density ("Sawada index" Sawada *et al.,* 1993). The number of accepted single targets in each measurement ranged between 500–1800. **Ranking 5.**

5 Meta-analysis

Dr Alf Harbitz was invited to discuss the principles, advantages and limitations of a meta-analysis of the data presented at the workshop. The group discussed the weighting of different studies and observations within them. There was a consensus that it might be reasonable to use a weight of *r*/*n* for individual observations of a study where *r* is the rank of the study and *n* the number of observation in the study. Another weighting strategy might consist of affecting weights of (*r*/*N*) where *N* is the total number of observations over all studies. Alf Harbitz also mentioned the possibility of weighting individual observations by their respective variances (in TS conditional on L).

It was advised to start the meta-analysis with the standard 20log(L) function (i.e. fixed rather than free slope) and use diagnostic tools (e.g. plot of residuals) after the model is fitted, before possibly moving to free slope models. The additional possibility exists, to test if the slope (in a free slope model) is significantly different from 20. This may be achieved by bootstrapping individual observations (i.e. {L, TS}) from the different studies and thus constructing the empirical distribution of slope and intercept. The group discussed the implication of finding slope estimates far from 20. This turned out to be a question of biological/hydroacoustics concern rather than statistical one. Similarly it was agreed that differences between TS-L functions may arise from a variety of sources such as small (immature) vs. large (mature) fish, type of echosounder used, in-situ vs. ex-situ studies, day vs. night, geographical area. These should be considered in the analysis.

On the basis of the above recommendations, and considering the time available at the workshop to conduct the meta-analysis, the following approach was followed:

1. Assemble data from the selected studies, down to the individual sample level. For each data point the following information is reported (if available): Data source, geographical location, month, year, species, day/night, echosounder type, juvenile/adult, min/max/mean depth of measurement, min/max/mean/sd length of fish, min/max/mean/sd weight of fish, number of fish sampled, min/max/mean target strength and number of individual targets (Annex 5).
2. Generate a scatterplot of the TS vs. Length data with indication of the following attributes
    a. Study id., number, and data weights
    b. Geographical area
    c. Depth
    d. Day/night
    e. Echosounder
3. Fit the following models: fixed slope (20log(L)) function using two different weighting schemes, *r*/*n* and *r*/*N* (see above); free slope function with weighting scheme *r*/*n*; and piecewise fixed slope function with separate slopes for small and large fish.
4. Estimate the slope and intercept distributions from bootstrapping.

The results of the meta-analysis are presented in Figures 1-4. The entire dataset spans a relatively large length range (14.8 to 41.4cm) as well as TS range (-44.3 to -36.5dB), but individual studies span much smaller ranges, both in fish length and TS (Figure 1). There is clear geographical structure in the range of length and TS observed (Figure 2, top-left): records in the Irminger Sea are mostly for large fish, records in the Newfoundland area for small fish, and records in the Norwegian-Barents Sea span a large fraction of the length range. Similarly, there is a structuring in the depth of sampling with largest fish only sampled in deeper waters and 25-30cm fish almost exclusively sampled in shallow waters (Figure 2, top-right). The same applies for the time of sampling (Figure 2, bottom-left) with smallest fish sampled at night, 25-30cm fish mostly sampled during the day and larger fish sampled in both periods. Several types of echosounders have been used but most studies have used Simrad EK60 or EK500 (Figure 2 bottom-right). Studies with the EK500 span most of the length range (except for very large sizes) whilst studies conducted with the EK60 only measured large fish. Because the distribution of methodological settings is unbalanced and confounded (i.e. the settings are not independent), it is difficult to identify the sources of possible differences in TS-length equations. This might be achieved through coordinated sampling design over the range of fish length; depth, area, and time as through comparative measurements with EK60 and EK500 (see section 6, recommendations).

Fitting the TS-length equation to the entire weighted dataset, provides a way to derive a first estimate of a general equation which accounts for all uncertainties associated with the methodological aspects mentioned above. The choice of the weighting scheme had very minor effect on the estimate of K for the fixed-slope equation (Table 1 and Figure 3), and only the first weighting scheme was therefore kept for further analysis. Visual inspection of the residuals (not shown, but can be derived from Figure 3) indicate that the fixed-slope models (Model 1 and 2) are biased towards underestimation of TS for small fish and overestimation of TS for large ones. The free slope model (Model 3) clearly outperforms the two previous ones (standardized residuals in Table 1) and the residuals are evenly distributed. The alternative fixed-slope piecewise model (Model 4) has similar fitting performance, but is difficult to interpret why the two models have different intercepts. Is it because of physiological differences between mature (large) and immature (small fish)? Is it due to geographical heterogeneity in redfish acoustic properties? Is it an effect of depth or is it related to the time of sampling? It is not possible to conclude on these questions due to the unbalanced and confounded distribution of methodological settings.

Because of the rather large scatter of TS and length data, there is a relative uncertainty in the absolute estimates of K and a from the free slope model (Figure 4). The 95% intervals derived from bootstrapping are [50.9,59.6] for K and [7.6,13.2] for a. However, as commonly observed for linear regression models, the slope and intercept are strongly correlated (Figure 4, bottom-left), so for any value of K, a can only belong to a narrow range of values, and vice-versa. It is noticeable that the value 20 is clearly excluded from the bootstrapped distribution of a. For that reason, the fixed slope models (20Log(L)) should not be recommended.

The free slope model appears as the best candidate for a general model of *S. mentella* TS-length equation, given the data available at the time of this workshop. The recommended TS-length equation at 38kHz for *S. mentella* is:

$$\mathbf{TS = 10.6\ log(L) - 55.4}$$

6 Recommendations for future research

One major result from the work conducted during WKTAR is the provision of a general equation which can be used as a standard generic for TS-length of *S. mentella* in the North Atlantic. However, the meta-analysis revealed that there are important departures from this equation in individual studies and the reasons for such discrepancies are generally unknown and at best very poorly documented. Inter-study variations in TS/length relationship may arise from a number of sources which include: physiological differences between mature (large) and immature (small fish), physiological variations associated with fish depth, daily physiological variations, geographical variations is TS, technological issues related to depth of hydroacoustic observation or technological differences between echosounder types.

To address this problem the following three actions are recommended:

1. **Ensure that high quality acoustic/biological data for TS determination are collected during redfish surveys.** At present, collection and processing of hydroacoustic and biological data for the purpose of Target Strength determination is only performed on an ad hoc basis. We recommend that such data collection should be included in the survey planning of the international redfish surveys coordinated under ICES auspices, by the Working Group on Redfish Surveys (WGRS).
2. **Perform simultaneous comparative measurements between EK500 and EK60 for Target Strength determination.** The predominance of target-strength measurements have been collected with the Simrad EK500, whereas the EK60 has now become the de-facto instrument for collecting acoustic data. There are differences in acquisition and processing of acoustic data between the two systems and these may contribute to differences in target-strength measurements (e.g. Jech *et al*., 2005). We recommend that in- and ex-situ experiments be designed and executed to compare EK500 and EK60 target-strength measurements and this issue be brought to the attention of the ICES Working Group Fisheries Acoustics Science and Technology (WG-FAST) for evaluation.
3. **Recommendation on continuing TS analysis during a new workshop WKTAR-II**. In order to address the questions raised above (understanding the reasons for inter study variations in TS estimates) and eventually revise the general TS equation proposed here, a second workshop on the target determination of redfish should be held when sufficient additional data has been collected and processed. The date for this workshop is left open.

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8 Figures and Table

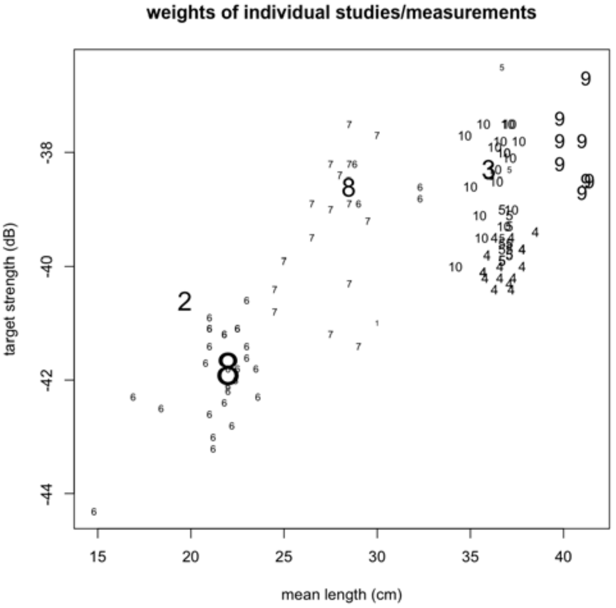

Figure 1. Target Strength and body length data used in the meta analysis. The font size is related to the weight given to individual observations (following the r/n weighting scheme). Each number refer to a specific study: 1: Mamylov and Sergeeva (1982), 2: Foote *et al.* (1986), 3: Orlowski (1990), 4: Reynisson (1992), 5: Reynisson and Sigurdsson (1996), 6: Gauthier and Rose (2002a), 7: Gauthier and Rose (2001), 8: Gauthier and Rose (2002b), 9: Pedersen (this report), 10: Ermolchev (2010).

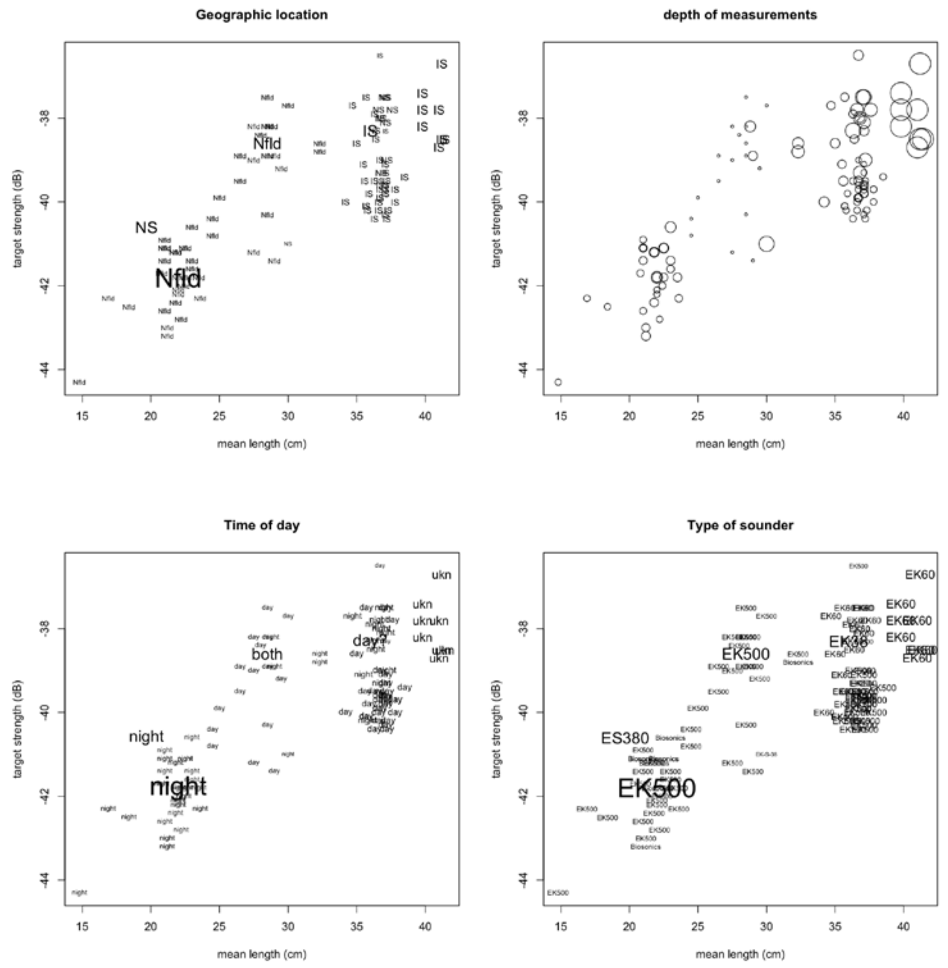

Figure 2. Meta-information on individual data. Top-left: geographical location, IS=Irminger Sea, NS=Norwegian-Barents Sea, Nfld=Newfoundland. Top-right: depth. The circle size is proportional to the mean depth of observation with depths ranging from 10 to 724. Bottom-left: time of sampling (day, night, both or unknown). Bottom-right: type of echosounder used (EK60, EK500, Biosonics, EK-S-38, EK-38, ES380). The font size is related to the weight given to individual observations, as in Figure 1.

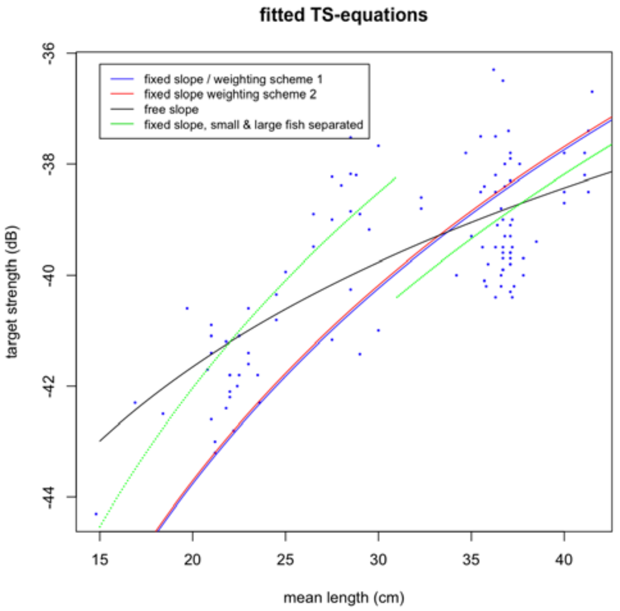

Figure 3. Fit of TS-length equations. Blue dots: individual data points. Red line: fit of the fixed-slope model (20log(L)) with weighting scheme r/n. Blue line: fit of the fixed-slope model (20log(L)) with weighting scheme r/N. Black line: fit of the free slope model with weighting scheme r/n. Green line: fit of a piecewise model with fixed slope and different intercepts for small (<31cm) and large (>=31cm) fish, with weighting scheme r/n.

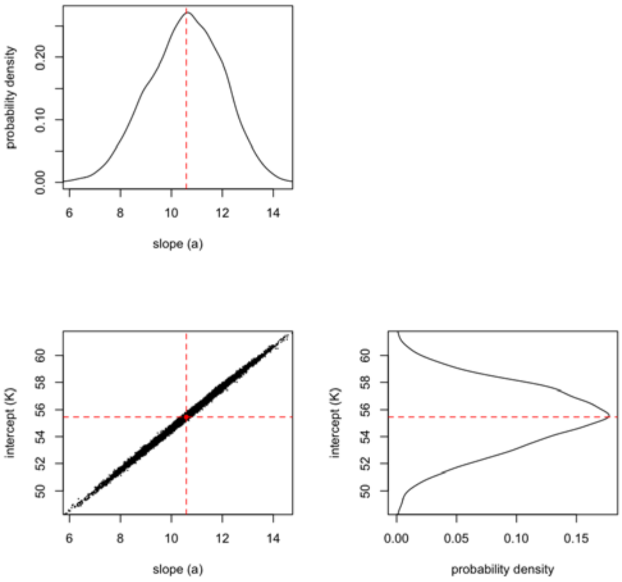

Figure 4. Bootstrap distributions of the slope and intercept for the free slope model. Top left: probability density of the slope estimate. Bottom right: probability density of the intercept estimate. Bottom left: scatterplot of slope vs. intercept for 10,000 bootstraps showing the high correlation between the two. The dotted lines indicate the values of K and a for the free slope model (Model 3 in Table 1).

Table 1. Summary of outputs for the four TS-length models. Model 1: fixed slope with weighting scheme r/n, Model 2: fixed slope with weighting scheme r/N, Model 3: free slope with weighting scheme r/n, Model 4: piecewise fixed slope with weighting scheme r/n. Model fits are presented in Figure 3.

	K	K STD. ERR.	SLOPE	SLOPE STD. ERR.	DF	RES. STAND ERR.
Model 1	69.6	0.13	20 (fixed)	N/A	108	1.40
Model 2	69.7	0.13	20 (fixed)	N/A	109	1.35
Model 3	55.4	1.35	10.6	0.89	107	0.98
Model 4	68.1/70.4	0.15/0.10	20 (fixed)	N/A	107	0.92

Annex 1: List of participants

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Annex 2: Agenda

Tuesday, 1 June

0900 Introduction and Logistics, B. Planque and M. Jech

0930 Presentations on ToRs (a) and (b): Review published research and ongoing work relevant to the determination of acoustic target strength of beaked redfish (*Sebastes mentella*)

1200 Lunch

1300 Discussion of TORs (a) and (b)

1600 End

Wednesday, 2 June

0900 Logistics, B. Planque and M. Jech

0915 Discussion of TOR (b): Propose a target strength equation for *S. mentella* based on the best available scientific knowledge

1200 Lunch

1300 Discussion of TOR (c): Describe and recommend additional research which may be required to improve the target strength equation

1700 End

Thursday, 3 June

0900 Logistics, B. Planque and M. Jech

0915 Continue discussions and begin generating report.

1200 Lunch

1300 Discussion and report writing.

1700 End

Annex 4: Recommendations

The following recommendations are proposed, following WKTAR:

RECOMMENDATION	FOR FOLLOW UP BY:
1. Ensure that high quality acoustic/biological data for TS determination are collected during redfish surveys	WGRS
2. Simultaneous comparative measurments between EK500 and EK60 for Target Strength determination	WGFAST
3. Recommendation on continuing TS analysis during a new workshop WKTAR-II	WGRS/WGFAST

Details on these recommendations are given in section 6 of the report.

Annex 5: Study/Data Table

Data Table: Data compiled and used in the meta-analysis of TS-length

num	*Source*	*In-Ex_Situ*	*Geo_Location*	*Month*	*Year*	*Species*	*Day-Night-Both*
1	Mamylov	insitu	NS	Feb	1981	spp	night
2	Foote_etal	insitu	NS	Mar	1984	spp	night
3	Orlowski	insitu	IS	May-Jun	1986	mentella	day?
4	Reynisson	insitu	IS	June	1991-1992	mentella	day
5	Reynisson	insitu	IS	June	1991-1992	mentella	day
6	Reynisson	insitu	IS	June	1991-1992	mentella	day
7	Reynisson	insitu	IS	June	1991-1992	mentella	day
8	Reynisson	insitu	IS	June	1991-1992	mentella	day
9	Reynisson	insitu	IS	June	1991-1992	mentella	day
10	Reynisson	insitu	IS	June	1991-1992	mentella	day
11	Reynisson	insitu	IS	June	1991-1992	mentella	day
12	Reynisson	insitu	IS	June	1991-1992	mentella	night
13	Reynisson	insitu	IS	June	1991-1992	mentella	day
14	Reynisson	insitu	IS	June	1991-1992	mentella	day
15	Reynisson	insitu	IS	June	1991-1992	mentella	day
16	Reynisson	insitu	IS	June	1991-1992	mentella	day
17	Reynisson	insitu	IS	June	1991-1992	mentella	day
18	Reynisson	insitu	IS	June	1991-1992	mentella	day
19	Reynisson	insitu	IS	June	1991-1992	mentella	day
20	Reynisson-Sigurdsson	insitu	IS	Jun-Jul	1995	mentella	day
21	Reynisson-Sigurdsson	insitu	IS	Jun-Jul	1995	mentella	day
22	Reynisson-Sigurdsson	insitu	IS	Jun-Jul	1995	mentella	day
23	Reynisson-Sigurdsson	insitu	IS	Jun-Jul	1995	mentella	day
24	Reynisson-Sigurdsson	insitu	IS	Jun-Jul	1995	mentella	day
25	Reynisson-Sigurdsson	insitu	IS	Jun-Jul	1995	mentella	day
26	Reynisson-Sigurdsson	insitu	IS	Jun-Jul	1995	mentella	day
27	Reynisson-Sigurdsson	insitu	IS	Jun-Jul	1995	mentella	day
28	Reynisson-Sigurdsson	insitu	IS	Jul	1995	mentella	day
29	Reynisson-Sigurdsson	insitu	IS	Jul	1995	mentella	day
30	Reynisson-Sigurdsson	insitu	IS	Jul	1995	mentella	day
31	Reynisson-Sigurdsson	insitu	IS	Jul	1995	mentella	day
32	Reynisson-Sigurdsson	insitu	IS	Jul	1995	mentella	day
33	Reynisson-Sigurdsson	insitu	IS	Jul	1995	mentella	day
34	Reynisson-Sigurdsson	insitu	IS	Jul	1995	mentella	day
35	Reynisson-Sigurdsson	insitu	IS	Jul	1995	mentella	day

num	*Source*	*In-Ex_Situ*	*Geo_Location*	*Month*	*Year*	*Species*	*Day-Night-Both*
36	Gauthier-Rose_2002a	insitu	Nfld	Jul	1996	mentel-la&fasciatus	night
37	Gauthier-Rose_2002a	insitu	Nfld	Jul	1996	mentel-la&fasciatus	night
38	Gauthier-Rose_2002a	insitu	Nfld	Jul	1996	mentel-la&fasciatus	night
39	Gauthier-Rose_2002a	insitu	Nfld	Jul	1996	mentel-la&fasciatus	night
40	Gauthier-Rose_2002a	insitu	Nfld	Jul	1996	mentel-la&fasciatus	night
41	Gauthier-Rose_2002a	insitu	Nfld	Jul	1996	mentel-la&fasciatus	night
42	Gauthier-Rose_2002a	insitu	Nfld	Jul	1996	mentel-la&fasciatus	night
43	Gauthier-Rose_2002a	insitu	Nfld	Jul	1996	mentel-la&fasciatus	night
44	Gauthier-Rose_2002a	insitu	Nfld	Jul	1996	mentel-la&fasciatus	night
45	Gauthier-Rose_2002a	insitu	Nfld	Jul	1996	mentel-la&fasciatus	night
46	Gauthier-Rose_2002a	insitu	Nfld	Jan	1997	mentel-la&fasciatus	night
47	Gauthier-Rose_2002a	insitu	Nfld	Jan	1997	mentel-la&fasciatus	night
48	Gauthier-Rose_2002a	insitu	Nfld	Jan	1997	mentel-la&fasciatus	night
49	Gauthier-Rose_2002a	insitu	Nfld	Jan	1997	mentel-la&fasciatus	night
50	Gauthier-Rose_2002a	insitu	Nfld	Jan	1997	mentel-la&fasciatus	night
51	Gauthier-Rose_2002a	insitu	Nfld	Jan	1997	mentel-la&fasciatus	night
52	Gauthier-Rose_2002a	insitu	Nfld	Jan	1997	mentel-la&fasciatus	night
53	Gauthier-Rose_2002a	insitu	Nfld	Jan	1997	mentel-la&fasciatus	night
54	Gauthier-Rose_2002a	insitu	Nfld	Jan	1997	mentel-la&fasciatus	night
55	Gauthier-Rose_2002a	insitu	Nfld	Jan	1997	mentel-la&fasciatus	night
56	Gauthier-Rose_2002a	insitu	Nfld	Jan	1997	mentel-la&fasciatus	night
57	Gauthier-Rose_2002a	insitu	Nfld	Mar	1998	mentel-la&fasciatus	night
58	Gauthier-Rose_2002a	insitu	Nfld	Mar	1998	mentel-la&fasciatus	night
59	Gauthier-Rose_2002a	insitu	Nfld	Mar	1998	mentel-la&fasciatus	night
60	Gauthier-Rose_2002a	insitu	Nfld	Mar	1998	mentel-la&fasciatus	night
61	Gauthier-Rose_2002a	insitu	Nfld	Mar	1998	mentel-la&fasciatus	night
62	Gauthier-Rose_2002a	insitu	Nfld	Mar	1998	mentel-la&fasciatus	night
63	Gauthier-Rose_2002a	insitu	Nfld	Mar	1998	mentel-la&fasciatus	night
64	Gauthier-Rose_2002a	insitu	Nfld	Mar	1998	mentel-la&fasciatus	night
65	Gauthier-Rose_2002a	insitu	Nfld	Jun	1998	mentel-la&fasciatus	night

num	*Source*	*In-Ex_Situ*	*Geo_Location*	*Month*	*Year*	*Species*	*Day-Night-Both*
66	Gauthier-Rose_2002a	insitu	Nfld	Jun	1998	mentella&fasciatus	night
67	Gauthier-Rose_2001	exsitu	Nfld	Aug	1999	mentella&fasciatus	day
68	Gauthier-Rose_2001	exsitu	Nfld	Aug	1999	mentella&fasciatus	day
69	Gauthier-Rose_2001	exsitu	Nfld	Aug	1999	mentella&fasciatus	day
70	Gauthier-Rose_2001	exsitu	Nfld	Aug	1999	mentella&fasciatus	day
71	Gauthier-Rose_2001	exsitu	Nfld	Aug	1999	mentella&fasciatus	day
72	Gauthier-Rose_2001	exsitu	Nfld	Aug	1999	mentella&fasciatus	day
73	Gauthier-Rose_2001	exsitu	Nfld	Aug	1999	mentella&fasciatus	day
74	Gauthier-Rose_2001	exsitu	Nfld	Aug	1999	mentella&fasciatus	day
75	Gauthier-Rose_2001	exsitu	Nfld	Aug	1999	mentella&fasciatus	day
76	Gauthier-Rose_2001	exsitu	Nfld	Aug	1999	mentella&fasciatus	day
77	Gauthier-Rose_2001	exsitu	Nfld	Aug	1999	mentella&fasciatus	day
78	Gauthier-Rose_2001	exsitu	Nfld	Aug	1999	mentella&fasciatus	day
79	Gauthier-Rose_2001	exsitu	Nfld	Aug	1999	mentella&fasciatus	day
80	Gauthier-Rose_2001	exsitu	Nfld	Aug	1999	mentella&fasciatus	day
81	Gauthier-Rose_2001	exsitu	Nfld	Aug	1999	mentella&fasciatus	day
82	Gauthier-Rose_2001	exsitu	Nfld	Aug	1999	mentella&fasciatus	day
83	Gauthier-Rose_2002b	insitu	Nfld	Jan	1997	mentella&fasciatus	night
84	Gauthier-Rose_2002b	exsitu	Nfld	Jan	1997	mentella&fasciatus	both
85	Pedersen_20XX	insitu	IS	Jun	2001	mentella	ukn
86	Pedersen_20XX	insitu	IS	Jun	2001	mentella	ukn
87	Pedersen_20XX	insitu	IS	Jun	2001	mentella	ukn
88	Pedersen_20XX	insitu	IS	Jul	2001	mentella	ukn
89	Pedersen_20XX	insitu	IS	Jul	2001	mentella	ukn
90	Pedersen_20XX	insitu	IS	Jul	2001	mentella	ukn
91	Pedersen_20XX	insitu	IS	Jul	2001	mentella	ukn
92	Pedersen_20XX	insitu	IS	Jul	2001	mentella	ukn
93	Ermolchev_2010	insitu	NS	Aug	2008	mentella	day
94	Ermolchev_2010	insitu	NS	Aug	2008	mentella	night
95	Ermolchev_2010	insitu	NS	Aug	2008	mentella	night
96	Ermolchev_2010	insitu	NS	Aug	2008	mentella	night
97	Ermolchev_2010	insitu	NS	Aug	2008	mentella	night
98	Ermolchev_2010	insitu	NS	Aug	2008	mentella	day
99	Ermolchev_2010	insitu	NS	Aug	2008	mentella	night
100	Ermolchev_2010	insitu	NS	Aug	2008	mentella	night
101	Ermolchev_2010	insitu	NS	Aug	2008	mentella	night
102	Ermolchev_2010	insitu	IS	Jun	2007	mentella	day
103	Ermolchev_2010	insitu	IS	Jul	2007	mentella	day

num	*Source*	*In-Ex_Situ*	*Geo_Location*	*Month*	*Year*	*Species*	*Day-Night-Both*
104	Ermolchev_2010	insitu	IS	Jul	2007	mentella	day
105	Ermolchev_2010	insitu	IS	Jul	2007	mentella	day
106	Ermolchev_2010	insitu	IS	Jul	2007	mentella	night
107	Ermolchev_2010	insitu	IS	Jul	2007	mentella	night
108	Ermolchev_2010	insitu	IS	Jul	2007	mentella	night
109	Ermolchev_2010	insitu	IS	Jul	2007	mentella	night
110	Ermolchev_2010	insitu	IS	Jul	2007	mentella	night

Data Table continues...

num	*Sounder_Type*	*Juvenile-Adult*	*Comments*	*Length_Mean*	*Length_N*	*Length_SD*	*Length_Min*	*Length_Max*
1	EK-S-38	NA	NA	30.0	NA	NA	26.0	34.0
2	ES380	NA	NA	19.7	92	8.7	9.0	43.0
3	EK38	NA	NA	36.0	NA	NA	NA	NA
4	EK500	adult	NA	37.2	NA	NA	NA	NA
5	EK500	adult	NA	38.5	NA	NA	NA	NA
6	EK500	adult	NA	37.2	NA	NA	NA	NA
7	EK500	adult	NA	35.9	NA	NA	NA	NA
8	EK500	adult	NA	37.8	NA	NA	NA	NA
9	EK500	adult	NA	37.3	NA	NA	NA	NA
10	EK500	adult	NA	36.6	NA	NA	NA	NA
11	EK500	adult	NA	36.6	NA	NA	NA	NA
12	EK500	adult	NA	35.8	NA	NA	NA	NA
13	EK500	adult	NA	35.7	NA	NA	NA	NA
14	EK500	adult	NA	35.7	NA	NA	NA	NA
15	EK500	adult	NA	37.1	NA	NA	NA	NA
16	EK500	adult	NA	36.3	NA	NA	NA	NA
17	EK500	adult	NA	36.3	NA	NA	NA	NA
18	EK500	adult	NA	37.8	NA	NA	NA	NA
19	EK500	adult	NA	37.8	NA	NA	NA	NA
20	EK500	adult	Area_1	37.1	212	NA	26.0	43.0
21	EK500	adult	Area_1	37.1	212	NA	26.0	43.0
22	EK500	adult	Area_1	37.1	212	NA	26.0	43.0
23	EK500	adult	Area_1	37.1	212	NA	26.0	43.0
24	EK500	adult	Area_1	37.1	212	NA	26.0	43.0
25	EK500	adult	Area_1	37.1	212	NA	26.0	43.0
26	EK500	adult	Area_1	37.1	212	NA	26.0	43.0
27	EK500	adult	Area_1	37.1	212	NA	26.0	43.0
28	EK500	adult	Area_2	36.7	56	NA	30.0	45.0
29	EK500	adult	Area_2	36.7	56	NA	30.0	45.0
30	EK500	adult	Area_2	36.7	56	NA	30.0	45.0
31	EK500	adult	Area_2	36.7	56	NA	30.0	45.0
32	EK500	adult	Area_2	36.7	56	NA	30.0	45.0
33	EK500	adult	Area_2	36.7	56	NA	30.0	45.0
34	EK500	adult	Area_2	36.7	56	NA	30.0	45.0
35	EK500	adult	Area_2	36.7	56	NA	30.0	45.0
36	EK500	NA	NA	21.0	NA	NA	NA	NA
37	EK500	NA	NA	23.0	NA	NA	NA	NA
38	EK500	NA	NA	22.0	NA	NA	NA	NA

num	*Sounder_Type*	*Juvenile-Adult*	*Comments*	*Length _Mean*	*Length _N*	*Length_ SD*	*Length_ Min*	*Length_ Max*
39	Biosonics	NA	NA	22.0	NA	NA	NA	NA
40	EK500	NA	NA	23.0	NA	NA	NA	NA
41	Biosonics	NA	NA	23.0	NA	NA	NA	NA
42	EK500	NA	NA	21.2	NA	NA	NA	NA
43	Biosonics	NA	NA	21.2	NA	NA	NA	NA
44	EK500	NA	NA	21.8	NA	NA	NA	NA
45	Biosonics	NA	NA	21.8	NA	NA	NA	NA
46	EK500	NA	NA	21.8	NA	NA	NA	NA
47	EK500	NA	NA	22.5	NA	NA	NA	NA
48	Biosonics	NA	NA	22.5	NA	NA	NA	NA
49	Biosonics	NA	NA	22.5	NA	NA	NA	NA
50	EK500	NA	NA	21.0	NA	NA	NA	NA
51	Biosonics	NA	NA	21.0	NA	NA	NA	NA
52	EK500	NA	NA	21.0	NA	NA	NA	NA
53	Biosonics	NA	NA	21.0	NA	NA	NA	NA
54	EK500	NA	NA	32.3	NA	NA	NA	NA
55	Biosonics	NA	NA	32.3	NA	NA	NA	NA
56	EK500	NA	NA	28.8	NA	NA	NA	NA
57	EK500	NA	NA	22.2	NA	NA	NA	NA
58	EK500	NA	NA	16.9	NA	NA	NA	NA
59	EK500	NA	NA	20.8	NA	NA	NA	NA
60	EK500	NA	NA	23.6	NA	NA	NA	NA
61	EK500	NA	NA	23.5	NA	NA	NA	NA
62	EK500	NA	NA	14.8	NA	NA	NA	NA
63	EK500	NA	NA	18.4	NA	NA	NA	NA
64	EK500	NA	NA	22.4	NA	NA	NA	NA
65	EK500	NA	NA	22.0	NA	NA	NA	NA
66	EK500	NA	NA	29.0	NA	NA	NA	NA
67	EK500	NA	NA	24.5	NA	NA	24.5	30.0
68	EK500	NA	NA	24.5	NA	NA	24.5	30.0
69	EK500	NA	NA	25.0	NA	NA	24.5	30.0
70	EK500	NA	NA	26.5	NA	NA	24.5	30.0
71	EK500	NA	NA	26.5	NA	NA	24.5	30.0
72	EK500	NA	NA	27.5	NA	NA	24.5	30.0
73	EK500	NA	NA	27.5	NA	NA	24.5	30.0
74	EK500	NA	NA	27.5	NA	NA	24.5	30.0
75	EK500	NA	NA	28.0	NA	NA	24.5	30.0
76	EK500	NA	NA	28.5	NA	NA	24.5	30.0
77	EK500	NA	NA	28.5	NA	NA	24.5	30.0
78	EK500	NA	NA	28.5	NA	NA	24.5	30.0
79	EK500	NA	NA	28.5	NA	NA	24.5	30.0
80	EK500	NA	NA	29.0	NA	NA	24.5	30.0
81	EK500	NA	NA	29.5	NA	NA	24.5	30.0
82	EK500	NA	NA	30.0	NA	NA	24.5	30.0
83	EK500	NA	NA	22.0	NA	NA	NA	NA
84	EK500	NA	NA	28.5	1	0.0	28.5	28.5
85	EK60	NA	NA	39.8	21	3.9	25.0	49.0
86	EK60	NA	NA	39.8	21	3.9	25.0	49.0
87	EK60	NA	NA	39.8	21	3.9	25.0	49.0
88	EK60	NA	NA	41	186	2.7	25.0	49.0
89	EK60	NA	NA	41	186	2.7	25.0	49.0

num	*Sounder_Type*	*Juvenile-Adult*	*Comments*	*Length_Mean*	*Length_N*	*Length_SD*	*Length_Min*	*Length_Max*
90	EK60	NA	NA	41.2	46	3.7	25.0	49.0
91	EK60	NA	NA	41.2	151	2.8	25.0	49.0
92	EK60	NA	NA	41.4	136	2.8	25.0	49.0
93	EK60	NA	NA	37.1	420	NA	32.0	43.0
94	EK60	NA	NA	37.0	347	NA	32.0	44.0
95	EK60	NA	NA	36.6	607	NA	33.0	44.0
96	EK60	NA	NA	36.8	380	NA	32.0	43.0
97	EK60	NA	NA	37.2	338	NA	31.0	43.0
98	EK60	NA	NA	37.6	660	NA	32.0	43.0
99	EK60	NA	NA	37.1	1222	NA	33.0	43.0
100	EK60	NA	NA	36.8	374	NA	32.0	44.0
101	EK60	NA	NA	36.3	407	NA	32.0	44.0
102	EK60	NA	NA	34.2	55	NA	30.0	48.0
103	EK60	NA	NA	35.6	67	NA	31.0	41.0
104	EK60	NA	NA	35.0	181	NA	29.0	40.0
105	EK60	NA	NA	35.7	89	NA	30.0	40.0
106	EK60	NA	NA	36.8	55	NA	29.0	42.0
107	EK60	NA	NA	36.3	84	NA	30.0	40.0
108	EK60	NA	NA	35.5	65	NA	27.0	40.0
109	EK60	NA	NA	36.4	120	NA	29.0	41.0
110	EK60	NA	NA	34.7	149	NA	26.0	40.0

Data Table continues...

num	*Weight_Mean*	*Weight_SD*	*Weight_Min*	*Weight_Max*	*TS_Mean*	*TS_N*	*TS_SD*	*TS_Min*	*TS_max*
1	350	NA	NA	NA	-41.0	85	NA	-43	-39
2	NA	NA	NA	NA	-40.6	7584	NA	NA	NA
3	659	NA	NA	NA	-38.3	NA	NA	NA	NA
4	643	NA	NA	NA	-40.4	1370	NA	NA	NA
5	752	NA	NA	NA	-39.4	2582	NA	NA	NA
6	642	NA	NA	NA	-39.5	1180	NA	NA	NA
7	559	NA	NA	NA	-39.8	4039	NA	NA	NA
8	702	NA	NA	NA	-40.0	499	NA	NA	NA
9	617	NA	NA	NA	-40.2	3388	NA	NA	NA
10	645	NA	NA	NA	-40.0	596	NA	NA	NA
11	645	NA	NA	NA	-40.2	838	NA	NA	NA
12	612	NA	NA	NA	-40.2	1006	NA	NA	NA
13	635	NA	NA	NA	-40.1	2897	NA	NA	NA
14	635	NA	NA	NA	-40.1	2015	NA	NA	NA
15	655	NA	NA	NA	-40.3	1210	NA	NA	NA
16	588	NA	NA	NA	-39.5	726	NA	NA	NA
17	588	NA	NA	NA	-40.4	3463	NA	NA	NA
18	732	NA	NA	NA	-39.7	1988	NA	NA	NA
19	732	NA	NA	NA	-39.7	802	NA	NA	NA
20	652	NA	NA	NA	-39.1	873	NA	NA	NA
21	652	NA	NA	NA	-39.3	4224	NA	NA	NA
22	652	NA	NA	NA	-39.6	7193	NA	NA	NA
23	652	NA	NA	NA	-39.7	9373	NA	NA	NA
24	652	NA	NA	NA	-39.8	9669	NA	NA	NA
25	652	NA	NA	NA	-39.8	7881	NA	NA	NA

num	*Weight _Mean*	*Weight _SD*	*Weight _Min*	*Weight _Max*	*TS_Me an*	*TS_N*	*TS_S D*	*TS_Min*	*TS_max*
26	652	NA	NA	NA	-39.6	4260	NA	NA	NA
27	652	NA	NA	NA	-38.3	764	NA	NA	NA
28	629	NA	NA	NA	-39.0	213	NA	NA	NA
29	629	NA	NA	NA	-39.6	1514	NA	NA	NA
30	629	NA	NA	NA	-39.7	3937	NA	NA	NA
31	629	NA	NA	NA	-39.9	5718	NA	NA	NA
32	629	NA	NA	NA	-39.9	7813	NA	NA	NA
33	629	NA	NA	NA	-39.9	8019	NA	NA	NA
34	629	NA	NA	NA	-39.5	4190	NA	NA	NA
35	629	NA	NA	NA	-36.5	577	NA	NA	NA
36	139	NA	NA	NA	-42.6	525	NA	NA	NA
37	155	NA	NA	NA	-41.6	327	NA	NA	NA
38	143	NA	NA	NA	-42.2	1106	NA	NA	NA
39	143	NA	NA	NA	-41.8	1023	NA	NA	NA
40	160	NA	NA	NA	-41.4	602	NA	NA	NA
41	160	NA	NA	NA	-40.6	1508	NA	NA	NA
42	216	NA	NA	NA	-43.0	1949	NA	NA	NA
43	139	NA	NA	NA	-43.2	3697	NA	NA	NA
44	142	NA	NA	NA	-42.4	1015	NA	NA	NA
45	142	NA	NA	NA	-41.2	1432	NA	NA	NA
46	141	NA	NA	NA	-41.2	1051	NA	NA	NA
47	157	NA	NA	NA	-41.8	2057	NA	NA	NA
48	157	NA	NA	NA	-41.1	3318	NA	NA	NA
49	157	NA	NA	NA	-41.1	2200	NA	NA	NA
50	127	NA	NA	NA	-40.9	516	NA	NA	NA
51	127	NA	NA	NA	-41.1	1043	NA	NA	NA
52	127	NA	NA	NA	-41.4	686	NA	NA	NA
53	127	NA	NA	NA	-41.1	1460	NA	NA	NA
54	463	NA	NA	NA	-38.6	131	NA	NA	NA
55	463	NA	NA	NA	-38.8	833	NA	NA	NA
56	362	NA	NA	NA	-38.2	556	NA	NA	NA
57	153	NA	NA	NA	-42.8	648	NA	NA	NA
58	73	NA	NA	NA	-42.3	128	NA	NA	NA
59	125	NA	NA	NA	-41.7	132	NA	NA	NA
60	168	NA	NA	NA	-42.3	330	NA	NA	NA
61	175	NA	NA	NA	-41.8	151	NA	NA	NA
62	74	NA	NA	NA	-44.3	170	NA	NA	NA
63	94	NA	NA	NA	-42.5	357	NA	NA	NA
64	153	NA	NA	NA	-42.0	339	NA	NA	NA
65	NA	NA	NA	NA	-42.1	393	NA	NA	NA
66	NA	NA	NA	NA	-38.9	404	NA	NA	NA
67	NA	NA	239	431	-40.4	1477	NA	-50	-34
68	NA	NA	239	431	-40.8	1334	NA	-46	-36
69	NA	NA	239	431	-39.9	5559	NA	-44	-36
70	NA	NA	239	431	-39.5	1922	NA	-47	-34
71	NA	NA	239	431	-38.9	708	NA	-44	-34
72	NA	NA	239	431	-41.2	1362	NA	-50	-34
73	NA	NA	239	431	-39.0	1950	NA	-49	-33
74	NA	NA	239	431	-38.2	171	NA	-47	-33
75	NA	NA	239	431	-38.4	486	NA	-42	-36
76	NA	NA	239	431	-37.5	272	NA	-47	-34
77	NA	NA	239	431	-40.3	670	NA	-45	-36

num	*Weight_Mean*	*Weight_SD*	*Weight_Min*	*Weight_Max*	*TS_Mean*	*TS_N*	*TS_SD*	*TS_Min*	*TS_max*
78	NA	NA	239	431	-38.2	18533	NA	-45	-34
79	NA	NA	239	431	-38.9	262	NA	-45	-33
80	NA	NA	239	431	-41.4	17140	NA	-52	-33
81	NA	NA	239	431	-39.2	2993	NA	-50	-34
82	NA	NA	239	431	-37.7	2429	NA	-46	-32
83	NA	NA	NA	NA	-41.8	NA	NA	NA	NA
84	NA	NA	NA	NA	-38.6	NA	NA	-42	-36
85	1227.9	234	200	1650	-37.8	1873	NA	-60	-27
86	1227.9	234	200	1650	-38.2	1156	NA	-60	-27
87	1227.9	234	200	1650	-37.4	1771	NA	-60	-27
88	859.8	178	200	1650	-38.7	662	NA	-60	-27
89	859.8	178	200	1650	-37.8	819	NA	-60	-27
90	878.3	228	200	1650	-38.5	814	NA	-60	-27
91	871.7	188	200	1650	-36.7	579	NA	-60	-27
92	884.4	183	200	1650	-38.5	1054	NA	-60	-27
93	614	NA	NA	NA	-37.5	2610	NA	NA	NA
94	611	NA	NA	NA	-37.5	2046	NA	NA	NA
95	587	NA	NA	NA	-37.8	11094	NA	NA	NA
96	599	NA	NA	NA	-38.0	11131	NA	NA	NA
97	617	NA	NA	NA	-39.0	442	NA	NA	NA
98	642	NA	NA	NA	-37.8	335	NA	NA	NA
99	612	NA	NA	NA	-38.1	699	NA	NA	NA
100	597	NA	NA	NA	-39.3	150	NA	NA	NA
101	574	NA	NA	NA	-38.3	381	NA	NA	NA
102	490	NA	NA	NA	-40.0	2397	NA	NA	NA
103	542	NA	NA	NA	-39.5	770	NA	NA	NA
104	514	NA	NA	NA	-38.6	7435	NA	NA	NA
105	543	NA	NA	NA	-37.5	2763	NA	NA	NA
106	599	NA	NA	NA	-38.0	2385	NA	NA	NA
107	574	NA	NA	NA	-37.9	2734	NA	NA	NA
108	538	NA	NA	NA	-39.1	3800	NA	NA	NA
109	582	NA	NA	NA	-38.5	9159	NA	NA	NA
110	503	NA	NA	NA	-37.7	5625	NA	NA	NA

Data Table continues...

num	*Depth_Mean*	*Depth_Min*	*Depth_Max*	*Rank*	*Weight_1*	*Weight_2*
1	490.0	480	500	0	0	0
2	NA	165	225	1	1	0.009091
3	NA	80	220	1	1	0.009091
4	157.0	100	200	5	0.3125	0.045455
5	154.0	100	200	5	0.3125	0.045455
6	159.0	100	200	5	0.3125	0.045455
7	152.0	100	200	5	0.3125	0.045455
8	151.0	100	200	5	0.3125	0.045455
9	162.0	100	200	5	0.3125	0.045455
10	161.0	100	200	5	0.3125	0.045455
11	153.0	100	200	5	0.3125	0.045455
12	156.0	100	200	5	0.3125	0.045455
13	164.0	100	200	5	0.3125	0.045455
14	165.0	100	200	5	0.3125	0.045455

num	*Depth_Mean*	*Depth_Min*	*Depth_Max*	*Rank*	*Weight_1*	*Weight_2*
15	151.0	100	200	5	0.3125	0.045455
16	167.0	100	200	5	0.3125	0.045455
17	161.0	100	200	5	0.3125	0.045455
18	166.0	100	200	5	0.3125	0.045455
19	160.0	100	200	5	0.3125	0.045455
20	112.5	100	125	5	0.3125	0.045455
21	137.5	125	150	5	0.3125	0.045455
22	162.5	150	175	5	0.3125	0.045455
23	187.5	175	200	5	0.3125	0.045455
24	212.5	200	225	5	0.3125	0.045455
25	237.5	225	250	5	0.3125	0.045455
26	262.5	250	275	3	0.1875	0.027273
27	287.5	275	300	1	0.0625	0.009091
28	112.5	100	125	5	0.3125	0.045455
29	137.5	125	150	5	0.3125	0.045455
30	162.5	150	175	5	0.3125	0.045455
31	187.5	175	200	5	0.3125	0.045455
32	212.5	200	225	5	0.3125	0.045455
33	237.5	225	250	5	0.3125	0.045455
34	262.5	250	275	3	0.1875	0.027273
35	287.5	275	300	1	0.0625	0.009091
36	169.0	100	800	4	0.129032	0.036364
37	198.0	100	800	4	0.129032	0.036364
38	143.0	100	800	4	0.129032	0.036364
39	267.0	100	800	4	0.129032	0.036364
40	239.0	100	800	4	0.129032	0.036364
41	319.0	100	800	4	0.129032	0.036364
42	216.0	100	800	4	0.129032	0.036364
43	246.0	100	800	4	0.129032	0.036364
44	239.0	100	800	4	0.129032	0.036364
45	288.0	100	800	4	0.129032	0.036364
46	241.0	100	800	4	0.129032	0.036364
47	224.0	100	800	4	0.129032	0.036364
48	253.0	100	800	4	0.129032	0.036364
49	284.0	100	800	4	0.129032	0.036364
50	165.0	100	800	4	0.129032	0.036364
51	167.0	100	800	4	0.129032	0.036364
52	209.0	100	800	4	0.129032	0.036364
53	210.0	100	800	4	0.129032	0.036364
54	338.0	100	800	4	0.129032	0.036364
55	387.0	100	800	4	0.129032	0.036364
56	320.0	100	800	4	0.129032	0.036364
57	146.0	100	800	4	0.129032	0.036364
58	152.0	100	800	4	0.129032	0.036364
59	179.0	100	800	4	0.129032	0.036364
60	196.0	100	800	4	0.129032	0.036364
61	234.0	100	800	4	0.129032	0.036364
62	143.0	100	800	4	0.129032	0.036364
63	151.0	100	800	4	0.129032	0.036364
64	169.0	100	800	4	0.129032	0.036364
65	134.0	100	800	4	0.129032	0.036364
66	256.0	100	800	4	0.129032	0.036364
67	10.0	10	10	2	0.125	0.018182

num	*Depth_Mean*	*Depth_Min*	*Depth_Max*	*Rank*	*Weight_1*	*Weight_2*
68	10.0	10	10	2	0.125	0.018182
69	10.0	10	10	2	0.125	0.018182
70	10.0	10	10	2	0.125	0.018182
71	10.0	10	10	2	0.125	0.018182
72	10.0	10	10	2	0.125	0.018182
73	10.0	10	10	2	0.125	0.018182
74	10.0	10	10	2	0.125	0.018182
75	10.0	10	10	2	0.125	0.018182
76	10.0	10	10	2	0.125	0.018182
77	10.0	10	10	2	0.125	0.018182
78	10.0	10	10	2	0.125	0.018182
79	10.0	10	10	2	0.125	0.018182
80	10.0	10	10	2	0.125	0.018182
81	10.0	10	10	2	0.125	0.018182
82	10.0	10	10	2	0.125	0.018182
83	350.0	NA	NA	4	2	0.036364
84	10.0	10	10	2	1	0.018182
85	724.0	500	NA	5	0.625	0.045455
86	724.0	500	NA	5	0.625	0.045455
87	724.0	500	NA	5	0.625	0.045455
88	724.0	500	NA	5	0.625	0.045455
89	724.0	500	NA	5	0.625	0.045455
90	724.0	500	NA	5	0.625	0.045455
91	724.0	500	NA	5	0.625	0.045455
92	724.0	500	NA	5	0.625	0.045455
93	470.0	310	490	5	0.277778	0.045455
94	470.0	310	490	5	0.277778	0.045455
95	400.0	310	490	5	0.277778	0.045455
96	400.0	310	490	5	0.277778	0.045455
97	410.0	310	490	5	0.277778	0.045455
98	400.0	310	490	5	0.277778	0.045455
99	400.0	310	490	5	0.277778	0.045455
100	400.0	310	490	5	0.277778	0.045455
101	490.0	310	490	5	0.277778	0.045455
102	290.0	213	290	5	0.277778	0.045455
103	270.0	213	290	5	0.277778	0.045455
104	270.0	213	290	5	0.277778	0.045455
105	225.0	213	290	5	0.277778	0.045455
106	260.0	213	290	5	0.277778	0.045455
107	213.0	213	290	5	0.277778	0.045455
108	230.0	213	290	5	0.277778	0.045455
109	230.0	213	290	5	0.277778	0.045455
110	230.0	213	290	5	0.277778	0.045455