NIWA
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Orange roughy target strength and target identification

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Objective 2

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Final Research Report

Report Title	Orange roughy target strength and target identification
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7. EXECUTIVE SUMMARY

Target strength and target identification formed part of the overall work associated with the acoustic survey of the Mid-East Coast orange roughy in June and July 2001, but it was given a lower priority than biomass data collection. In the event, no target strength-target identification data were gathered from roughy aggregations. However, drops to roughy depths were made in 5 locations on ground that was difficult to trawl in an attempt to get some information on what targets were present by using target strength and rate-of-change of phase. For this, standard short, single-frequency (38 kHz) sound pulses were used. For many of the drops, these were alternated with long, frequency-swept (chirp) pulses (34.5-59.5 kHz). The drops were on two sorts of marks: thin background layers and denser marks showing characteristic 'red flecks' in echograms from hull-mounted systems. Drops on the latter were in the Rock Garden and near Ritchie Hill (at 'Paul's Spot'). The 'red flecks' appeared to be mostly from large swimbladdered fish such as Johnson's cod.

Although the data aided target identification during the survey, because none were collected on marks who's composition was unequivocally known, they are of limited value in updating target strength estimates for orange roughy and other species. However, they do represent a new collection of both target strength and chirp data from an area with a different species mix from previous work (which has all been on the Chatham Rise.)

8. OBJECTIVES

This report describes the outcome of Objective 2 of Project ORH2000/01: "to improve estimates of target strength and refine target identification of orange roughy and associated species."

9. INTRODUCTION

With exception of some data from the most recent survey (ORH2001/01), biomass has been estimated using echo-integration and for this approach, estimates of the target strengths of orange roughy and associated species are necessary to convert acoustic backscatter into biomass. The method also requires a means of classifying targets.

9.1 Target strength

Target strength is best estimated *in situ*, using a split or dual beam transducer (Ehrenberg 1979). However, there are substantial difficulties in applying this to orange roughy because of the depths at which they live, the high density of the spawning aggregations, their avoidance behaviour, their low target strength and the mix of other species when they are dispersed. Nevertheless, substantial progress has been made in estimating roughy target strength in recent years both from *in situ* measurements and by modelling. For *in situ* data NIWA has developed a new method for selecting targets based on rate of change of phase (RCP) (Barr et al. 2000) which has resulted in revised estimates for roughy. A sophisticated modelling approach for orange roughy is currently under development under project ORH2001/01 (Macaulay 2002).

There remains some uncertainty about orange roughy target strength and there was even more uncertainty when we developed our bid for this project (April 2001). In particular, we have no *in situ* target strength data for the Mid-East Coast fishery.

9.2 Target identification

There are two broad approaches to classifying targets, using respectively:

- bulk scattering properties of fish aggregations and assemblages,
- scattering properties of individual fish.

The first is the by far the dominant approach and the biomass estimates for the survey forming Objective 1 of this project were derived in this way (Hart et al. 2003; Doonan et al. 2003).

The work described here focused on the second approach and is based on both the RCP method used for target strength as above (Barr et al. 2000) and on broadband, chirp transmissions which generate signatures derived from fish morphology and anatomy (Barr 2001; Barr & Coombs 2002; Barr et al. 2002).

In the overall project, the survey work took highest priority and target strength and target identification data collection were carried out as circumstances permitted.

10. METHODS

Data for this work were collected during the Mid-East Coast orange roughy survey carried out in June and July 2002 with *Tangaroa* (voyage TAN0109) and *Tasman Viking* (TVI0101).

10.1 Equipment

All of the survey data were gathered using NIWA's Computerised Research Echosounder technology (*CREST*) (Coombs 1994). Target strength data were collected with both the main survey deep-tow system and with the special-purpose 'frame'. Chirp data were collected only with the frame.

The survey system consisted of our standard 3 m flat-nosed, torpedo-shaped towed body with underwater electronics and a Simrad ES38DD split-beam transducer ('TB2') as described in McClatchie & Coombs (2000).

The frame system consisted of an open, stainless steel structure with underwater electronics and both Simrad ES38DD and Sonar Research and Development (SRD) PE4-40LQ-NZOT split-beam transducers as described in Barr et al. (2002). The frame was also fitted with a battery powered, underwater camera and video recorder. A bank of high intensity, green, light emitting diodes provided illumination. The SRD transducer was a wide beam-angle type intended for close range use with the camera.

For target strength and RCP measurements, the system transmitted a short single frequency pulse (0.32 ms at 38 kHz) and the received data were filtered, complex demodulated, corrected for spherical spreading and sound absorption with a $40\log_{10}R$ time varied gain and stored. For chirps, a long, linearly increasing, swept-frequency pulse (8 ms with a range of 34.5 to 59.5 kHz) was transmitted and received data were stored without any processing (i.e., raw analog-to-digital converter values were saved.) Most of the frame data were collected in a configuration in which these two modes were alternated. The data handling capacity of the system imposes a range limit which for the target strength mode was about 100 m but for the chirp 50 m. The system was set so that the 50 m covered the range 20-70 m. The vessel was always drifting during frame deployments but underway (albeit at only 1-2 knots) with the standard towed body.

The standard system was calibrated in the large tank at Greta Point before and after the survey and a deep-drop calibration (see Doonan et al. 2001) was carried out during an oreo survey in November 2001 (TAN0117). The calibrations followed the approach of Foote et al. (1987). A 38.1 mm ± 2.5 μm diameter tungsten carbide sphere with nominal target strength of –42.4 dB was used as a calibration standard. The frame was always deployed with a tungsten carbide sphere suspended about 10 m beneath it (in a similar fashion to Kloser et al. 2000). The sphere was visible in most transects allowing both direct comparison of fish and sphere target strengths and system calibration. Calibrations and other system parameters are listed in Table 1. The sphere was not visible in the chirps and these were calibrated using data from the TAN0117.

10.2 Data processing

Target strength data were analysed as described in Barr et al. (2000). Selection criteria were less stringent than in our earlier *in situ* target strength work (e.g., McClatchie & Coombs 2000) and targets were screened only for echo-length, angle in the beam and variability in angle of arrival. RCP (degrees/m) was estimated for each accepted echo by fitting a quadratic function to the centre 3 points and taking the gradient at the middle of these.

Chirp data were processed as described in Barr et al. (2002). The raw data were cross-correlated with the transmitted chirp transform to produce a 'pulse-compressed' output (Chu & Stanton 1998) which was displayed as an echogram and examined manually for pulse signatures.

11. RESULTS

The spawning period of roughy is quite short and the population in the survey area scattered with few distinctive aggregations. The highest priority activity was the abundance survey and when time was available explicitly for target strength and target identification work, the aggregations had all dispersed. Some data were collected in what were historically roughy spawning locations in the vicinity of Ritchie Hill, primarily to see if the characteristic 'roughy arc' (Barr et al. 2000) was present and these are discussed below. However, no data were collected in clear-cut roughy marks and we have no independent verification of individual targets.

11.1 Areas and catches

Drops to roughy depths were made in 5 locations as shown in Figure 1. There were trawls in the vicinity of all of these, most of which caught some roughy but there was only one large catch (11 t) which was taken in the Rock Garden (TVI0101 station 20). Only one trawl intersected with any of the target strength-identification acoustic tracks.

One drop was in the Rock Garden (mark-type GREY LAYER RED FLECKS in Hart et al. 2003), one on the side of Ritchie Hill at 'Paul's Spot' (on RED FLECKS mark-type) and three drops were in deep-water (1000-1200 m) on the background layer (BACKGROUND mark-type) in the valley between the Rock Garden and the main coastal shelf.

11.2 Rate-of-change-of-phase

Figure 2 shows target strength versus RCP for 2 files (D31 and D35) recorded in the Rock Garden in a GREY LAYER RED FLECKS mark. Both show characteristic 'roughy' signatures and both show the presence of large swimbladdered scatterers such as Johnson's cod. It should be noted that the 'roughy' signature can also be produced by other non-swimbladdered fish and by scatterers with small air bubbles (~1 mm) such as siphonophores (Barr & Coombs submitted). We also point out that the 'arc' shown in the figures was fitted by eye to data collected over a roughy aggregation in Barr et al. (2000) rather than by any formal statistical procedure.

Figure 3 shows target strength versus RCP for 4 files (D39, D42, D43 and D45) recorded in Paul's Spot in a RED FLECKS mark. All except D39 show significant presence of large swimbladdered fish whilst D39 shows the strongest non-swimbladdered signature. The large scatterers mostly came from distinct aggregations such as the plume-like structures in the echogram in Figure 6. One trawl crossed transect D42 (TVI0101 station 26) and the catch in this was 59 % Johnson's cod. Other swimbladdered species in this catch were hoki (7 %), spikey oreo (5 %) and ribaldo (5 %). A small sample of cod was measured (34) and the mean length was 45 cm. From Macaulay et al. (2001) the target strength of a 45 cm Johnson's cod is –33.2 dB. This is consistent with the target strength distribution of D42, which is shown, together with the Johnson's cod length frequency from trawl 26, in Figure 4.

Figure 5 shows target strength versus RCP for 4 files (D63, D64, D107 and D112) recorded in a BACKGROUND mark. D112 was the only file presented here that was collected with the standard towed body and it contained considerably more data than the others. D112 shows a strong 'roughy' signature but it is unlikely that many of these are roughy and only small catches of roughy were made in the area.

11.3 Chirps

Figure 6 is an echogram of some chirp data from Paul's Spot showing dense aggregations of what seem to be large swimbladdered fish (these are responsible for the 'red flecks'). The data were recorded alternately with standard target strength pings and the echograms from both look closely similar. Figure 7 shows a comparison of a section of transmit 230 from Figure 6 crossing the distinct layer mark between about 30 and 40 m from the transducer. These also look closely similar although they are separated in time by 1.4 s. The chirp response shows a roughy-like double-pulse at 32 m range, with peaks about 20 cm apart. However, its target strength is too low and if this were truly an aggregation of roughy then all the responses would be similar. Figures 6 and 7 are typical of all the data from both Paul's Spot and the Rock Garden. Most responses are from individual large scatterers or mixtures of echoes. There are occasional double-pulse responses but none are consistent over several transmits.

Figure 9 shows an echogram of chirp data from the deep background layer with typical scattered marks at this resolution. The data were recorded alternately with standard target strength pings as above and a comparison of the two is shown in Figure 8. The comparison is for transmit 690 over the depth range 30-50 m from the transducer. Again, the two are closely similar. The scatterers involved all have target strengths of less than -55 dB.

11.4 Video

Video data were recorded during all drops. There were occasional fish to be seen and some of these were visible in the acoustic trace. However, the narrow-beam angle transducer and standard target strength transmissions were being used on all of these occasions so it was not possible to measure their target strength (because the fish was in the near field and the high signal level saturated the receiver.)

12. DISCUSSION

As noted earlier, although the data described here played a useful role in making decisions about mark-types and species composition during the survey, they have not allowed either an update of the roughy target strength relationship or confirmation of chirp signatures. In particular, the 'roughy arc' was used as an indication of the presence of roughy but recent work has shown that a wider range of scatterers can produce this pattern than previously thought (Barr & Coombs submitted). The data have provided some support for the Johnson's cod target strength relationship although even here there was a mix of species in the area with similar target strengths. However, the data do represent a collection of new target strength and chirp data from a new area with different characteristics from previous data which have all come from the Chatham Rise.

13. REFERENCES

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Table 1: **Target strength calibration data for the systems used. G_{ts} is the gain of the target strength system at a range of 1 m. V_T is the in-circuit voltage at the transducer terminals for a target of unit backscattering cross-section at unit range. C_{ts} is the overall calibration constant.**

System	**TB2**	**Frame**
Transducer serial no.	28327	28331
Operating frequency (kHz)	38.156	38.156
Transmitter pulse length (ms)	0.315	0.315
Filter bandwidth (kHz)	4.9	3.1
Initial sample rate (kHz)	100.000	62.500
Decimated sample rate (kHz)	10.000	15.625
V_T (V)	1396	303
G_{ts}	299	1045
C_{ts}	418132	316337
Transducer depth (m)	1000-1150	600-800

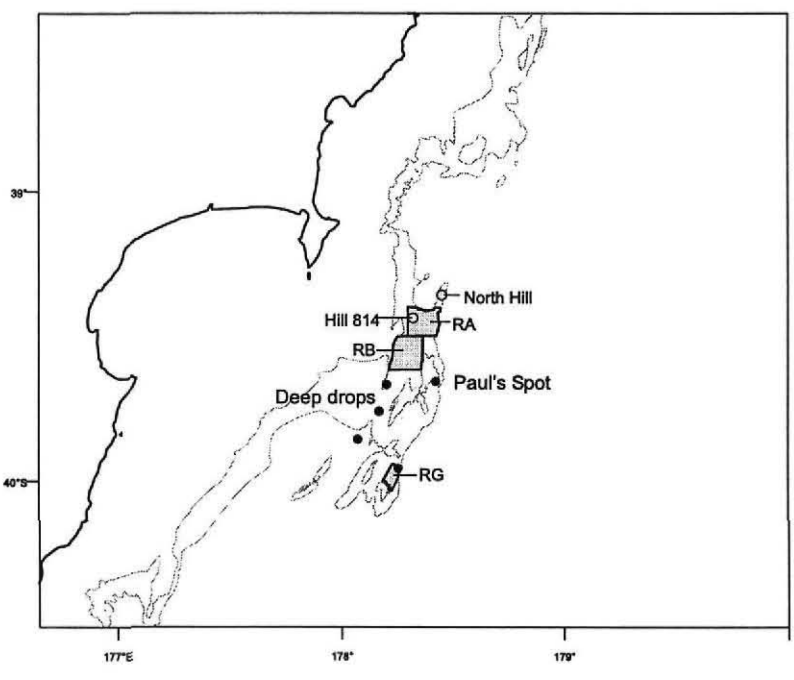

Figure 1: **The survey area. The shaded areas are the main strata: RA and RB are strata on Ritchie Hill whilst RG is the Rock Garden. The black filled circles mark the positions of the target strength and target identification drops.**

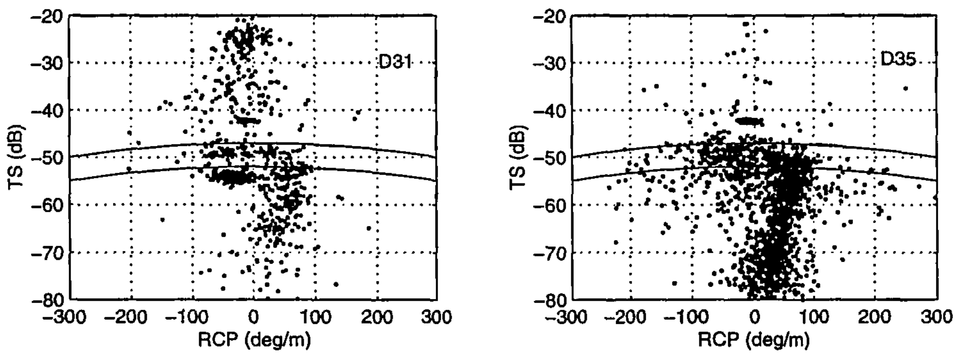

Figure 2: **Target strength (TS) and rate-of-change-of-phase (RCP) for two files recorded in the Rock Garden. The distinct mark visible just above the upper 'roughy arc' is a standard sphere.**

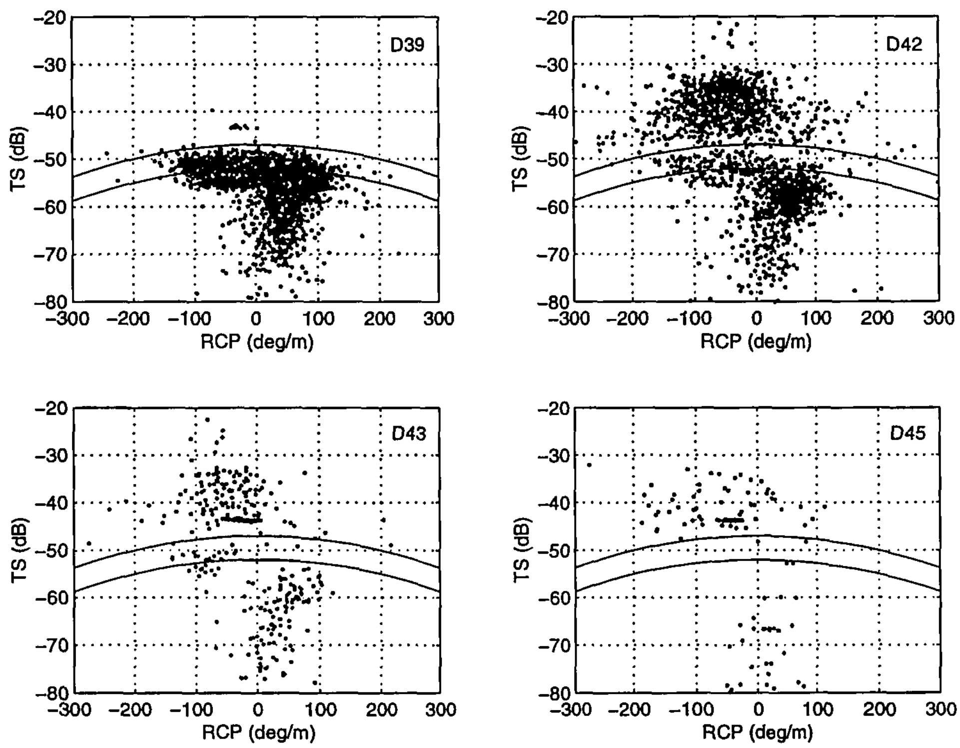

Figure 3: **Target strength (TS) and rate-of-change-of-phase (RCP) for four files recorded in 'Paul's Spot' in the vicinity of Ritchie Hill. The distinct mark visible just above the upper 'roughy arc' is a standard sphere.**

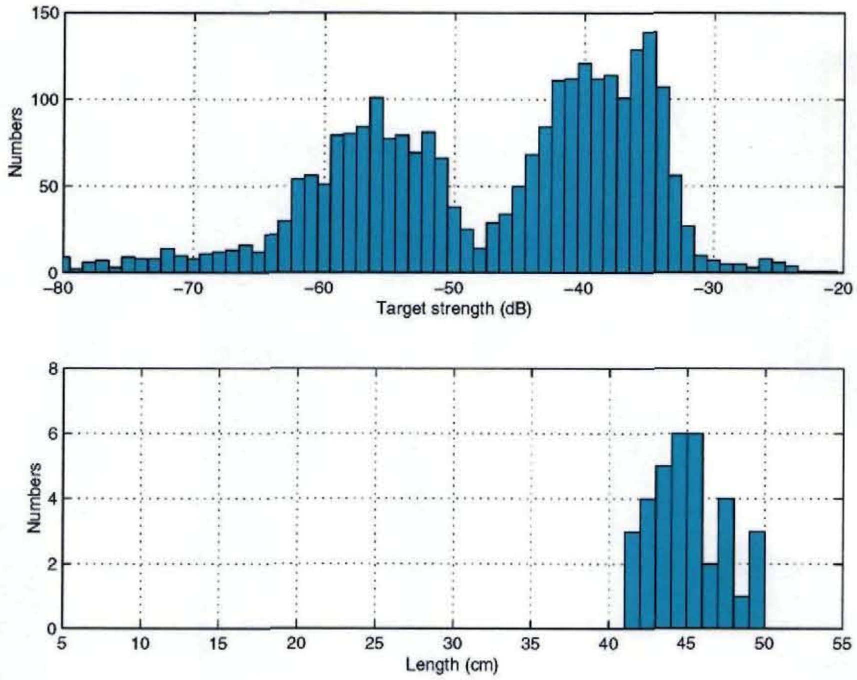

Figure 4: The upper histogram shows the target strength distribution from file D42 in Figure 3. The length distribution in the lower histogram is for Johnson's cod which were the main species caught (59 %) in a trawl crossing the track of D42.

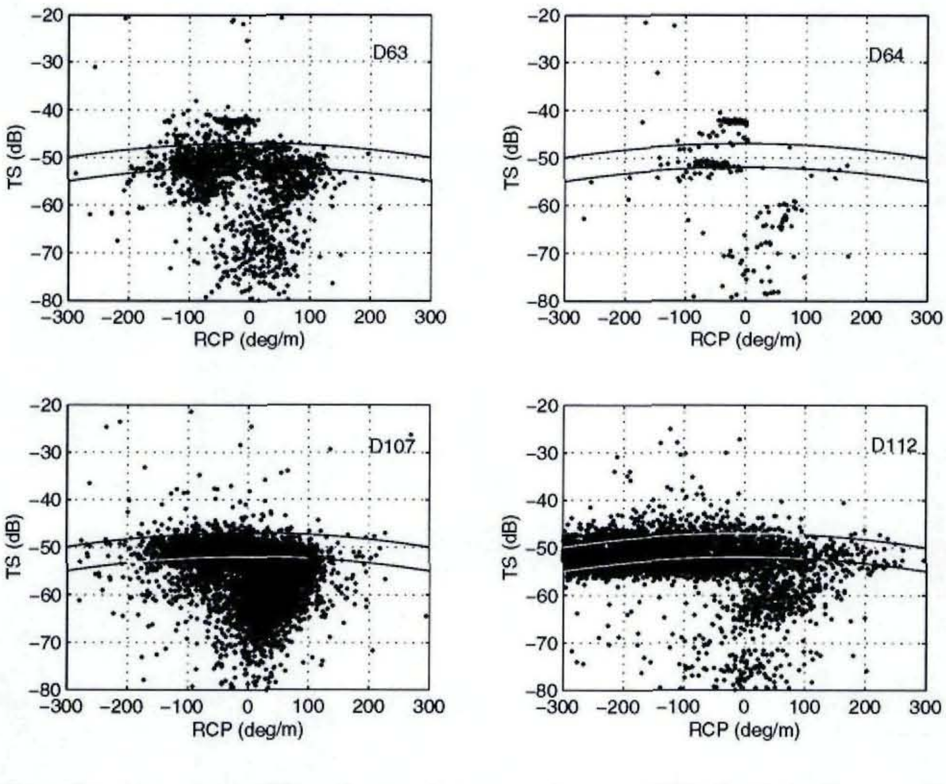

Figure 5: Target strength (TS) and rate-of-change-of-phase (RCP) for four files recorded in deep water in the valley between the Rock Garden and the main shelf. The distinct mark visible just above the upper 'roughy arc' is a standard sphere.

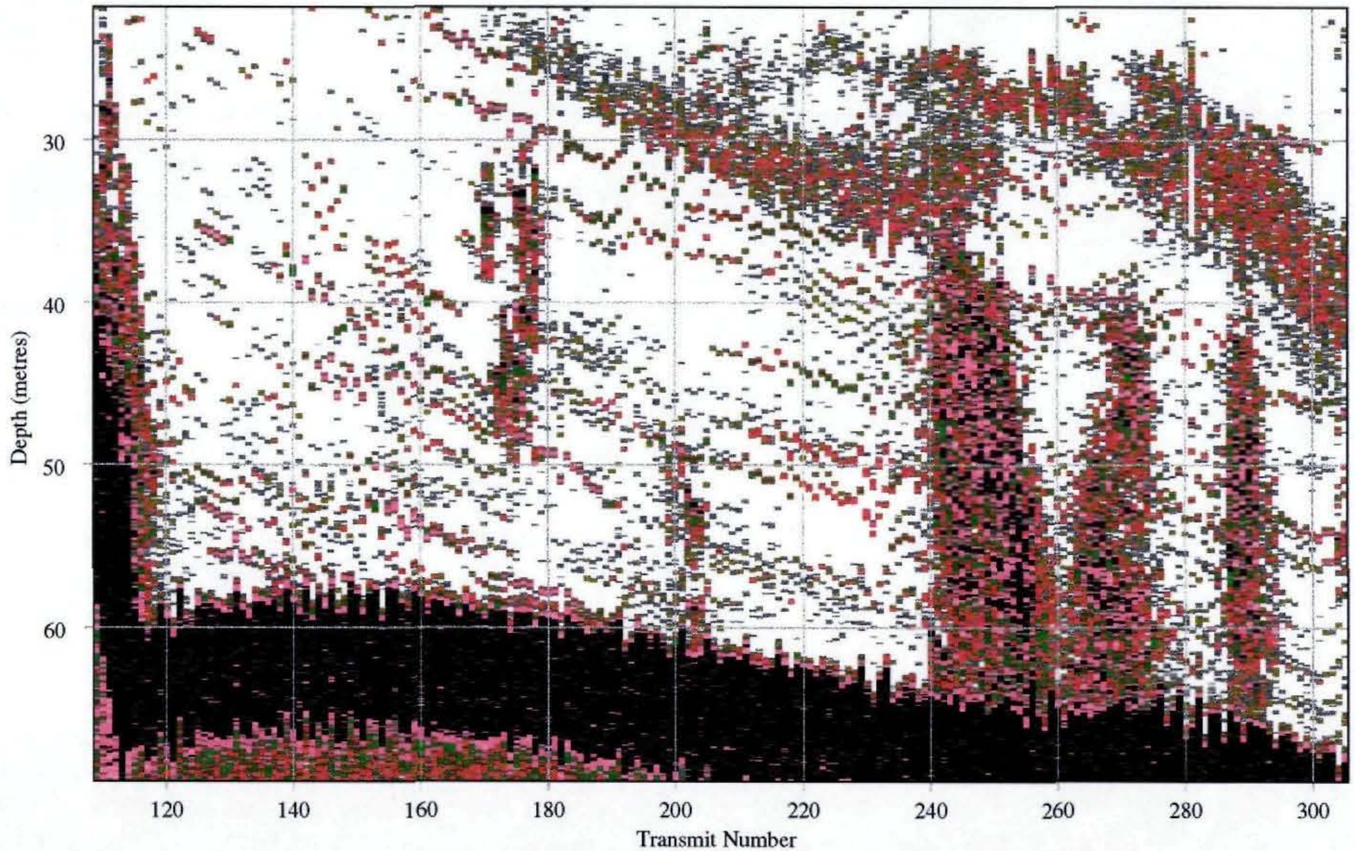

Figure 6: **Chirp echogram of part of file D43 recorded in Paul's Spot.**

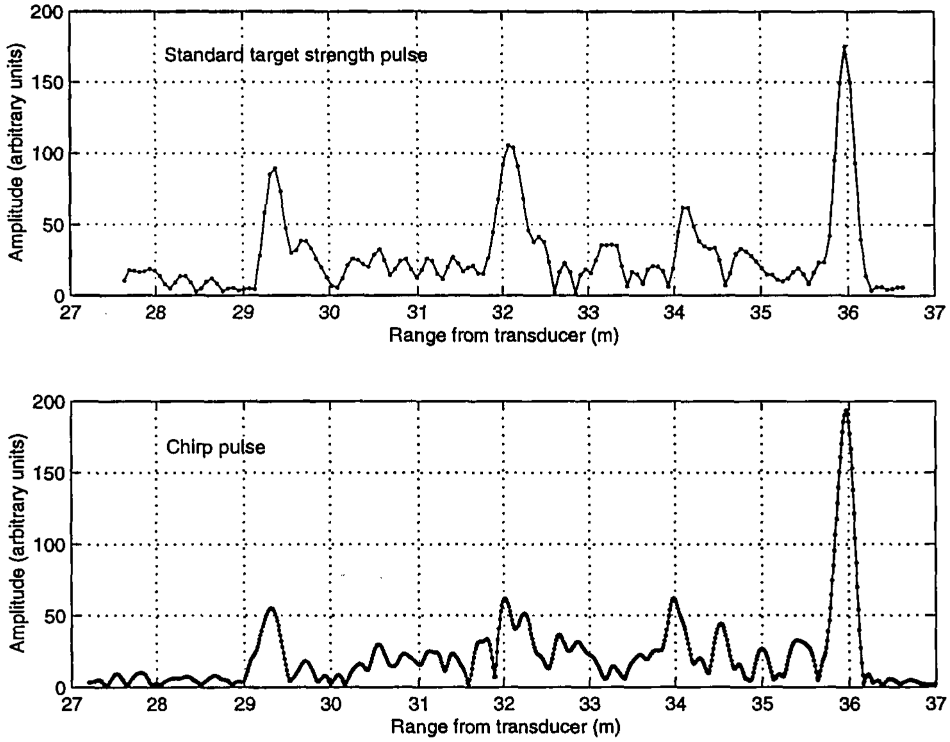

Figure 7: **Pulse data from D43, transmit 230 between 27 and 37 m for both standard target strength transmissions and for chirps.**

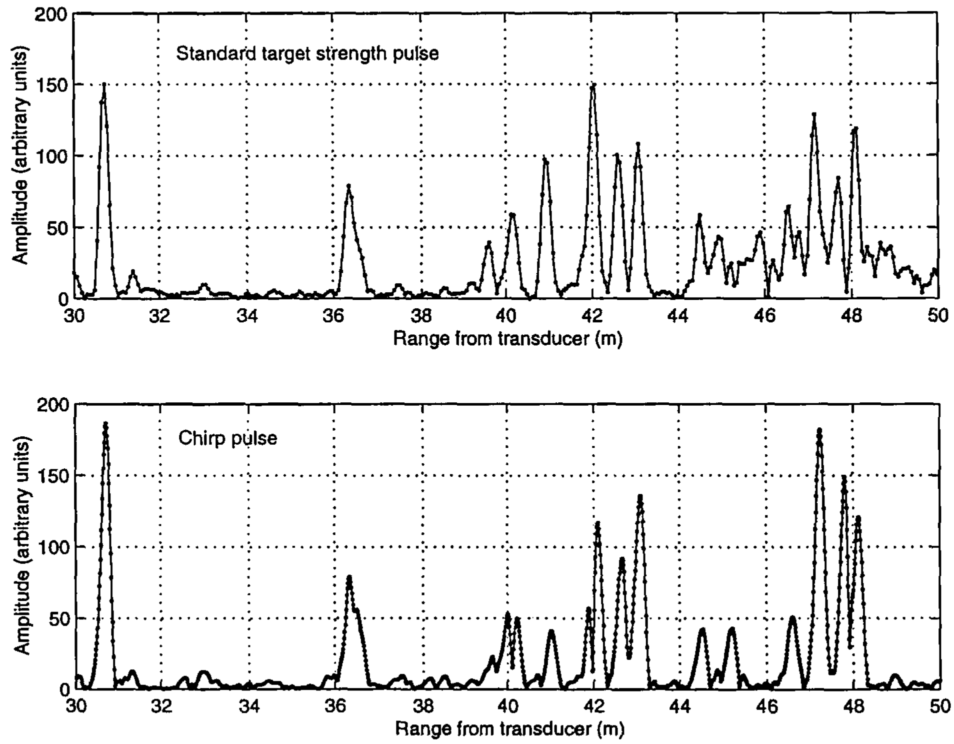

Figure 8: **Pulse data from D107, transmit 690 between 30 and 50 m for both standard target strength transmissions and for chirps.**

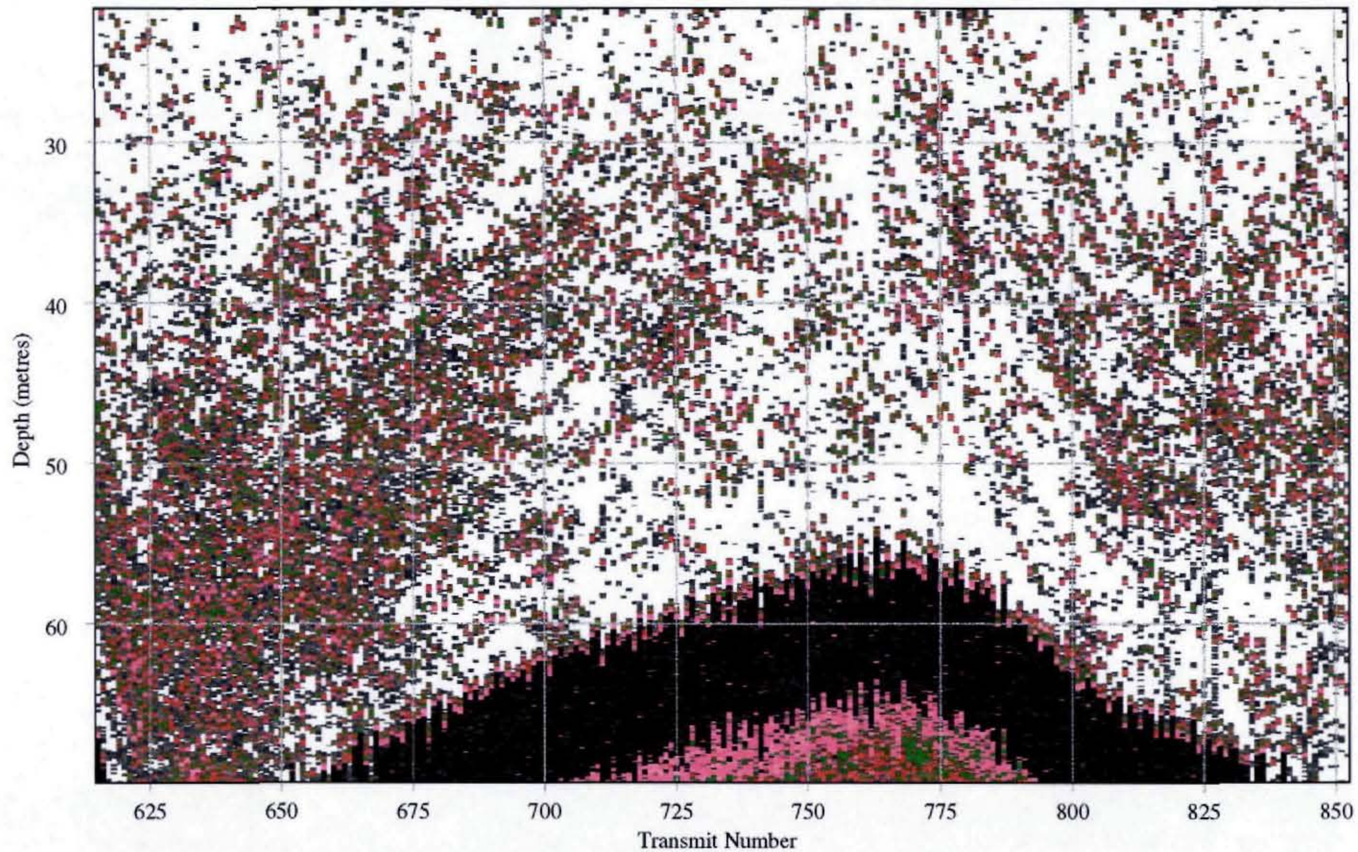

Figure 9: Chirp echogram of part of file D107 recorded in a deep background layer.