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Results of 1987 hoki surveys of Hokitika Canyon and Cook Strait Canyon

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Introduction

Two acoustic surveys of spawning hoki populations were carried out during winter 1987 . The first survey was in the Hokitika canyon region , and the second was over the Cook Strait canyon . Both surveys were carried out by the research vessel James Cook . The survey at Hokitika canyon was from 17 July to 4 August 1987 , but due to several incidents happening during this cruise (cruise report J10/87) , the actual recording of acoustic data was only made between 24 July and 1 August . The survey at Cook Strait canyon was only carried out over two days , 1-2 September 1987 . It was an opportunity taken during an exploratory mid-water trawl survey carried out by the Deepwater section , on discovering a large concentration of hoki in the canyon . The acoustic equipment used was an echo recording system developed especially for deepwater surveys (Do et al 1987) . The recorded data have been analysed by the echo integration method, and the distribution of fish density is expressed by the backscattering strength . The biomass estimates are based upon an approximated mean target strength of -36 dB, the same value used for 1985 hoki acoustic survey of the West Coast of South Island (Cordue 1988) . This approximation agrees within 1 dB with the estimates of hoki target strength using a scattering model of the swimbladder currently developed by Do & Surti (in preparation) . Fisheries catch data and biological data were obtained from the Scientific Observers' Programme and others in Deepwater section.

The Survey at Hokitika Canyon

Survey Design

The survey was designed around three strata A , B , and C respectively towards the north , in the central area , and towards the south of the canyon (Figure 1) . Stratum A was clearly defined by the latitudes 42 10.10'S and 42 30.00'S , and the two contours of 350m and 650m depth . The recordings of fish echoes were carried out on ten transects denoted A1 to A10 . These transects run east-west , were spaced at 2 n.m. intervals , and of an average distance of 9 n.m. . The total area covered by stratum A was approximately 640 km2 .

Extensive searches across the Hokitika canyon , and between the latitudes 42 30' S and 43 15' S at the same depth range showed virtually no fish traces on the echo sounder ,except at the two small locations defined as strata B and C . Recordings were made for three transects of 5 n.m. mean distance on stratum B, and for three transects of 10 n.m. mean distance on stratum C. The directions of the transects were chosen to minimise the effect of wind on the course and speed of the vessel . The areas covered by the two strata were approximately 70 km2 and 190 km2 respectively .

All recordings on these transects were carried out during daytime, i.e. from 07:00 to 17:00 hrs. Some additional recordings were also made after dusk for comparison . Three CTD drops were made on stations S1 , S2 and S3 to obtain hydrological data for the correction of backscattering measurements . The mean results are given in Table 1 .

Ground Truth Data

It was observed that above the spawning hoki and nearer to the surface there existed a large abundance of feed consisting of mainly plankton , lantern fish (myctophidae) and hatchetfish (Maurolicus muelleri) . Overlaps between hoki and feed were common , particularly at night when both hoki and feed moved upwards and formed dense layers . The top layer in Figure 2 believed to be feed has a back scattering strength as high as that of the mid-water layer , and exceeds that of the bottom layer . During the day , although both hoki and feed moved downward , the hoki seemed to orientate themselves closer to the sea bottom . The scattered echoes from feed were partly filtered out (Figure 3) . Both Figures 2 and 3 were plotted at the same detection threshold equivalent to a backscattering strength of -73.7 dB , using data recorded on transect A1 at night and 12 hours later at day respectively . This threshold implies that the system was able to detect fish of target strength -36 dB distributed as sparsely as 0.17 fish/1000m3 . Figure 4 shows that echoes from feed in Figure 3 were mostly filtered out , while echoes believed from hoki were restricted to within 200 m of the sea bottom when the detection threshold was increased by 6 dB . The close distribution of hoki to the bottom during daytime is also shown in Figure 5 depicting a canyon in transect B1 .

During the period from 24 July to 2 August when the echo recordings were carried out at Hokitika canyon , about 35 fishing vessels were sighted in the same area . Catch data from 11 surimi vessels over this period were analysed . A total number of 405 tows were made by both bottom and mid water trawls. Only one tow was made at 270 m depth , the rest being at depths greater than

300 m . The total catch was 19,300 tons of which 91.7 % was hoki. The catch data was divided into four groups specified by time and sea bottom depth as follows :

(i) Daytime , bottom depth between 350 m and 650 m ,
(ii) Daytime , bottom depth greater than 650 m ,
(iii) Nighttime , bottom depth between 350 m and 650 m ,
(iv) Nighttime ,bottom depth greater than 650 m .

Where daytime is from 07:00 to 17:00 hours, otherwise nighttime .

The distance of the ground rope or foot rope of the trawl above the sea bottom is defined as "height above sea bed" and used for determining the vertical distribution of hoki catch . The headline varied from 35m to 70 m above the ground rope . The trawl results of each group of catch data were sorted according to height above sea bed , integrated in layers of 20 m each ,and normalised to the total catch of hoki (17,700 tons) as in Figures 6 a ,b ,c ,and d .The largest proportion of catch was very close to the bottom during daytime at bottom depths between 350 m and 650 m (Figure 6 a) . At greater bottom depths , the catch pattern spread out , hoki still being caught at depths less than 650 m (Figure 6 b) . Figures 6 c and d show the upward migration of hoki during nighttime .

The length distribution of fish sampled during winter 1987 is given in Figure 7 , based on 12,001 males and 12,820 females . The length frequency of the female distribution is stacked on that of the male distribution to produce the overall length frequency . The mean length and mean weight of the distribution were 85 cm and 2.2 Kg respectively .

Echo Integration and Estimates of Backscattering Strength

From the above observation of ground truth data , we have assumed that fish echoes recorded within 200 m of the sea bottom during daytime were from hoki . The fish echo voltages recorded on each transect were squared and integrated over 40 layers , each 5m thick , parallel to the sea bottom and numbered from the bottom upward . The MVBS (mean volume back scattering strength) of each layer was computed according to the method described by Do (1987) , and Do et al (1987) . Figures 8 a and b illustrate the vertical distribution of MVBS for transects A4 and A6 . In each transect ,it was found that the MVBS of the first layer was consistently higher than that of individual upper layers. It is very likely that this layer comprised mainly demersal species . It should be noted that conservatism was applied in the analysis to ensure only integration of fish echoes that were clearly

separated from the bottom echoes . The integration does not include all fish within approximately 3.5 m from the bottom since some of these echoes are not resolvable from the bottom echoes . The value of 3.5 m was calculated from the geometry of the transducer beam at 600 m , the resolution of the acoustic pulses, and a sea bottom slope of 1 degree .

The MVBS is a measurement of the volumetric density of backscattering from fish . The areal distribution of a population can be described by the MABS (mean areal back-scattering strength) derived from the integration of the MVBS over a certain column of water . Table 2 sumarises the results as three types of MABS , namely (i) the MABS over the first layer of each transect , (ii) the MABS over all layers of each transect , and (iii) the overall MABS of each stratum , and gives the inter-transect coefficient of variation (CV) of MABS within each stratum . It is noted that the MABS of layer 1 is usually between 10 and 13 dB lower than the MABS of all the layers . The biomass of layer 1 is , thus , less than 10 % of the total biomass of all the layers .

The conversion from MABS to areal population density and areal biomass density is given by :

$$\text{areal population density} = 10^{(\text{MABS} - \text{TS})/10}$$

$$\text{areal biomass density} = m * 10^{(\text{MABS} - \text{TS})/10}$$

where TS represents the mean target strength of the population , and m the weight corresponding to TS .

Assuming TS = -36 dB , and m = 2.2 Kg , the estimates of total biomass in strata A , B , and C are respectively 48000 t , 8300 t , and 8000 t .

The Survey at Cook Strait Canyon.

Survey Design

The survey was designed to map a large concentration of hoki located at Cook Strait canyon between latitudes 41 26' S and 41 36' S , and longitudes 174 29' E and 174 41' E . The hoki formed a dense mid-water school up to 150 m thick , 10 n.m. long and 3 n.m. wide , along the canyon . The survey was therefore structured as a set of 10 parallel transects , 1 n.m. apart , normal to the long axis of the school and covering an area of 100 km2 (Figure 9) . Recordings were also made along the axis of the school to give a comparison with the results obtained from the parallel transects.

Species Composition and Length Distribution

A mid-water trawl survey was carried out by Livingston and Berben (1987) at Cook Strait canyon region during 15 August - 5 September 1987 . The trawl results showed that hoki contributed almost 85 % of the total catch and ling were a major by-catch . As shown in Figure 10 , the length of hoki in Cook Strait canyon was distributed over a similar range as those in Hokitika canyon. Their length to weight relationship was :

$$m = 2.78 \times L^{2.91}$$

where m represents weight in Kg , and L the total length in m . The mean length and weight of hoki in Cook Strait canyon were 0.82 m and 1.6 Kg respectively .

Echo Integration and Estimates of Backscattering Strength.

In the analysis of data recorded at Hokitika canyon , we have mentioned the problem of detecting fish near to the sea bed. This problem became worse during the recordings of fish echoes on the steep slopes of the Cook Strait canyon . Figures 11 a and b show the echograms recorded on transects 5 and 8 respectively . The maximum slope on these transects is approximately 17 degrees. In extreme cases , echoes from fish at 26 m above the sea bottom were still not resolvable . The process of separating fish echoes from bottom echoes was tedious and time consuming . The analysis has been made for four transects . Fish echoes were integrated over the depth range from 90 m to the bottom in layers of 10 m thick . Figure 12 illustrates the vertical distribution of MVBS on transect 9 . The areal distribution of back scattering strength of the ten transects is shown in Table 3 .

The MABS of ten transects was - 40.8 dB , and the inter-transect CV was 50 % . Assuming TS = -36.3 dB and m = 1.6 Kg, the estimate of total biomass for the area covered by these transects is 57,000 tons . The biomass density in this area is about 10 times the density in stratum A of Hokitika canyon region.

Conclusion

This report presents the results of two acoustic surveys . Due to the failure of equipment during the survey at Hokitika canyon, acoustic data were obtained for only one week, between 24 July and 1 August . It was highly likely that the survey did not cover the main bulk of the population . The estimates of areal density of the aggregation at Cook Strait canyon agree with the 1985 estimates for the aggregation at Hokitika canyon.

Acknowledgements

We wish to thank R.F. Coombs , A.M. Surti , P. Cordue , and M. Hopkins for their participation in the surveys , M. Robinson and C. Lalas for providing the fisheries catch data , and M. Livingston for the collaboration during the survey at the Cook Strait canyon .

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Do,M.A. ,R.F. Coombs ,A.M. Surti and M. Hopkins 1987 : A Deepwater Acoustic Survey of The Population Of Orange Roughy (Hoplostethus atlanticus) in North Chatham Rise (N.Z.) . Paper no. 31 , Symposium on Fisheries Acoustics, Seattle, Washington, 22-26 June 1987.

Do,M.A. and Surti,A.M. (in prep): Estimation of dorsal aspect target strength of hoki (Macruronus novaezelandiae) using a new model of swimbladder scattering .

Livingston,M. and Berben,P. 1987 : East Coast spawning hoki confirmed . Catch ,November 1987, pp.7-9.

Table 1 . Variation of temperature and salinity with respect to depth .

Depth (m)	Temperature (C)	Salinity (ppt)
50	13.2	35.3
100	13.2	35.3
150	13.2	35.3
200	13.1	35.3
250	12.8	35.3
300	12.3	35.2
350	11.8	35.1
400	11.3	35.0
450	10.4	34.9
500	8.9	34.8
550	7.7	34.6
600	7.5	34.6

Table 2 . Distribution of MABS in three strata A , B , and C at Hokitika canyon .

Stratum	Transect	MABS (dB) layer 1	MABS (dB) all layers	MABS (dB) stratum	CV (%)
A	1	-65.6	-52.5	-50.7	52
	2	-64.1	-52.0		
	3	-62.6	-49.8		
	4	-63.5	-53.2		
	5	-62.7	-51.9		
	6	-62.8	-50.1		
	7*	n.a.	n.a.		
	8	-64.6	-52.3		
	9*	n.a.	n.a.		
	10	-60.0	-47.5		
B	1	-58.1	-48.2	-48.7	34
	2	-59.4	-47.7		
	3	-61.0	-50.8		
C	1	-70.9	-59.0	-53.3	64
	2	-57.0	-51.7		
	3	-62.9	-52.2		

* Due to the failure of equipment, data recorded on transects A7 and A9 were corrupted . Further analysis is required for filtering out the disturbance .

Table 3 . Distribution of MABS in ten transects at Cook Strait canyon.

Transect	MABS (dB) all layers
1	-46.1
2	-39.6
3	-40.5
4	-40.5
5	-41.4
6	-37.4
7	-41.0
8	-43.5
9	-41.2
10	-41.6

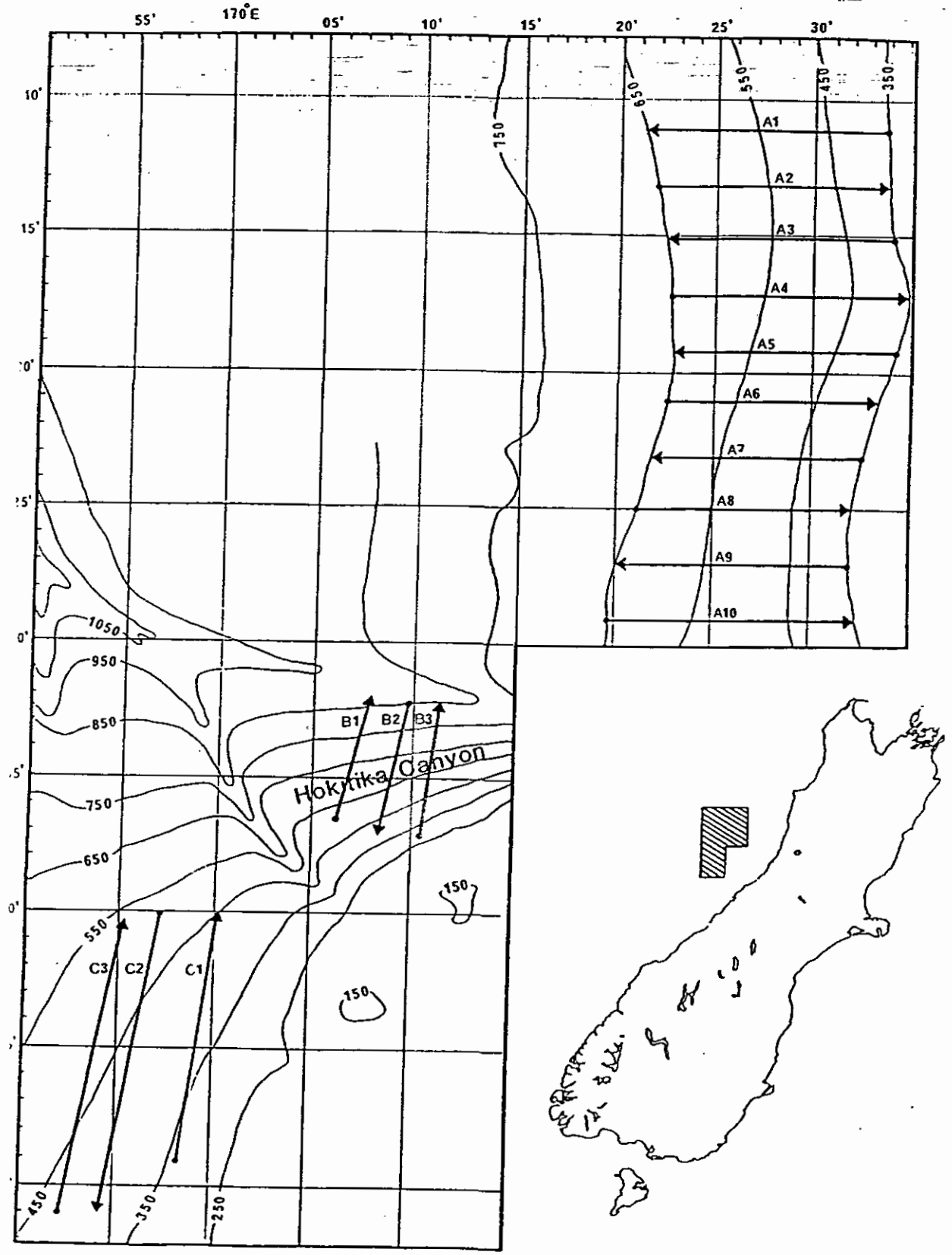


Figure 1. Survey area, strata, and transects in Hokitika canyon region.

Figure 2. Echogram recorded on transect A1, night time.

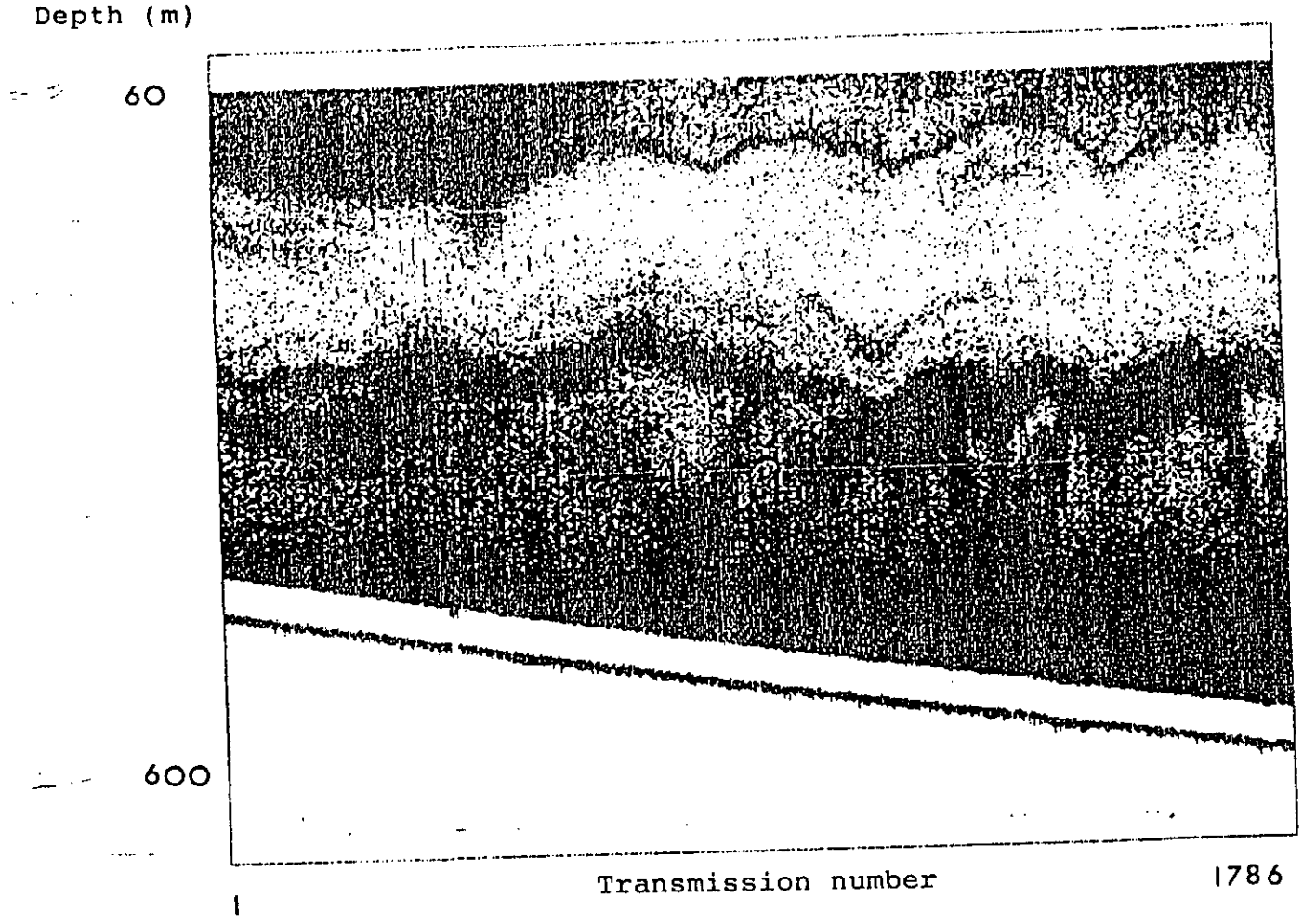


Figure 3. Echogram recorded on transect A1, daytime

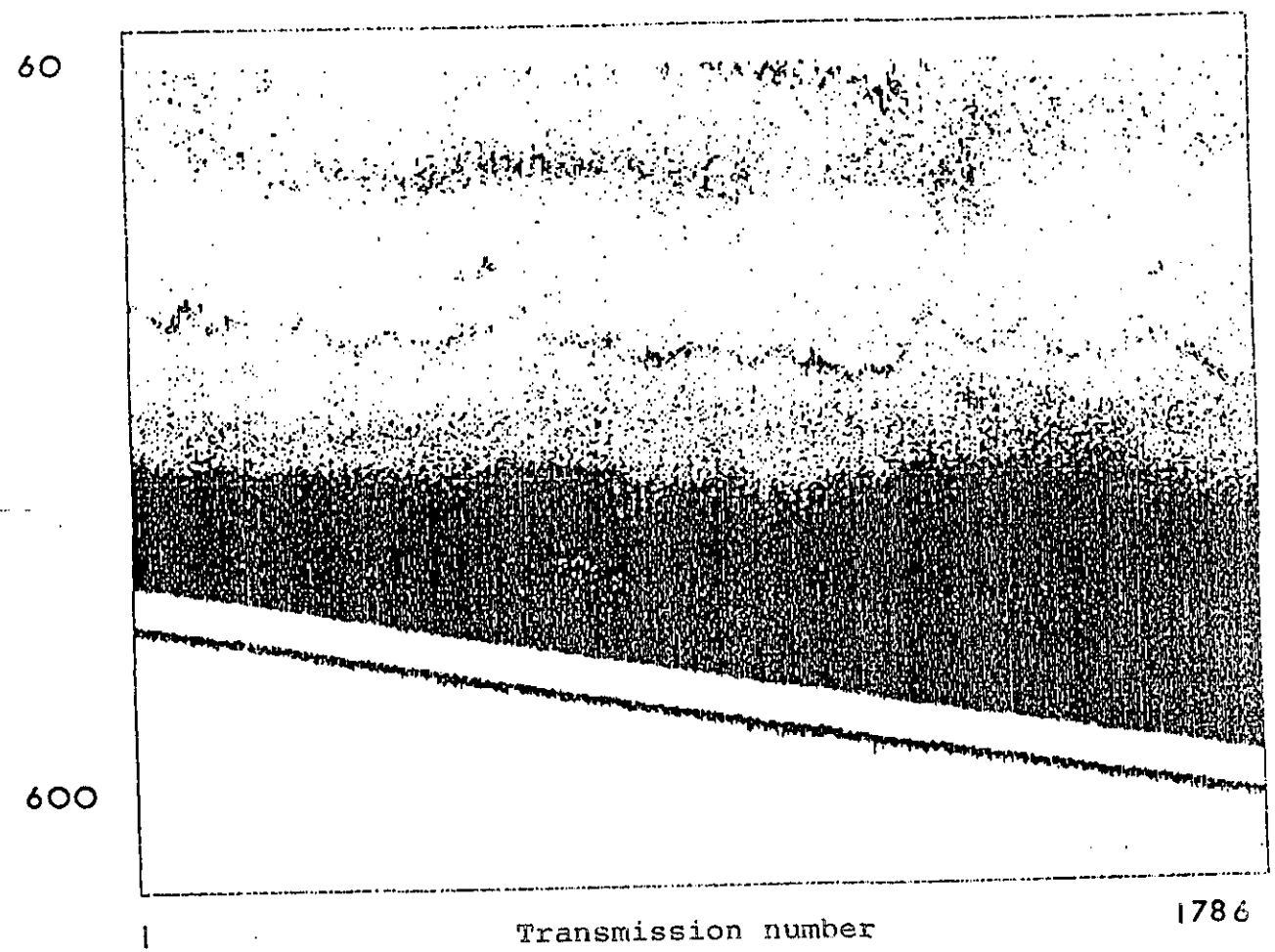


Figure 4. Daytime echogram of transect A1 replotted with 6 dB increment of threshold.

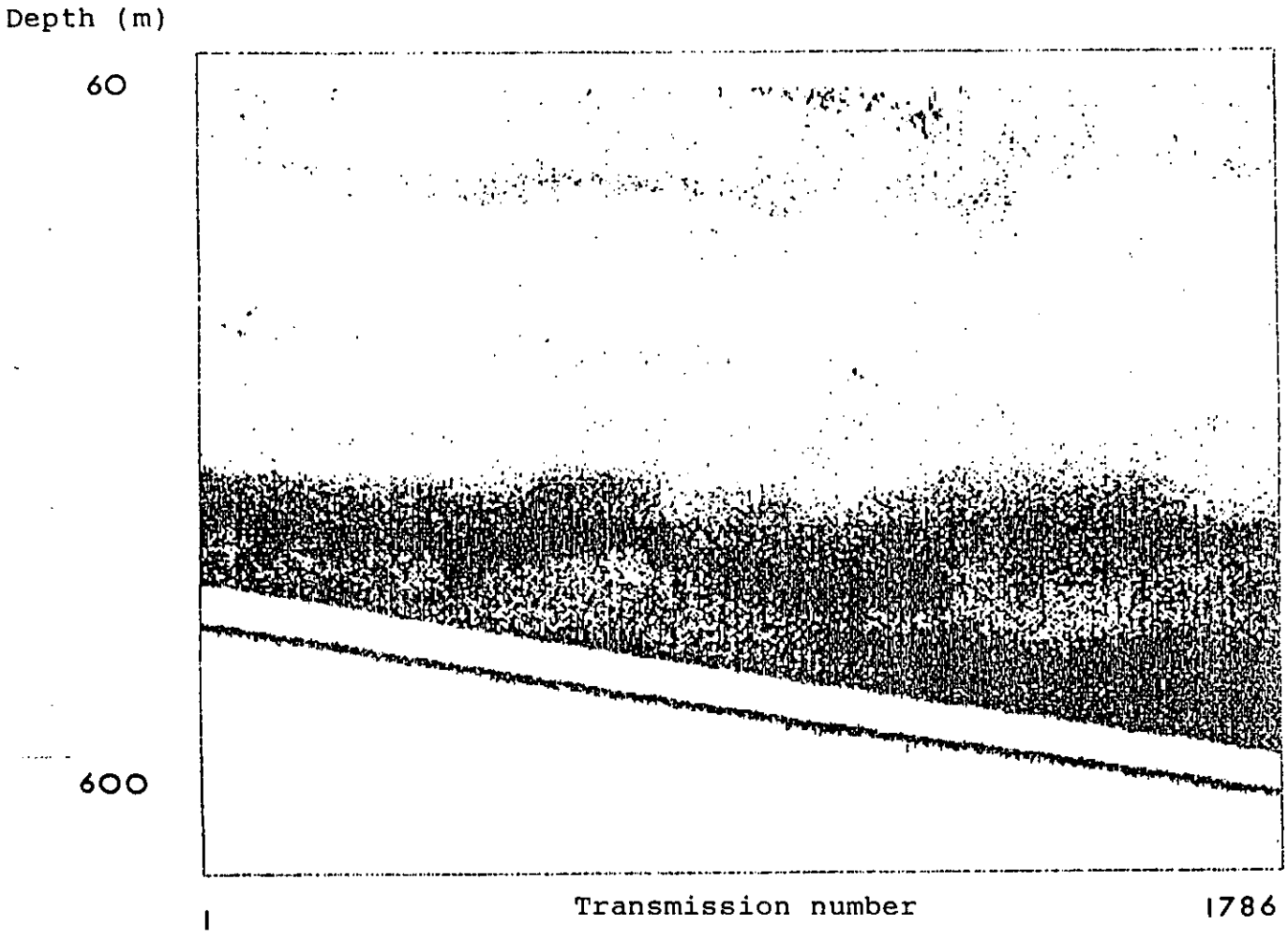
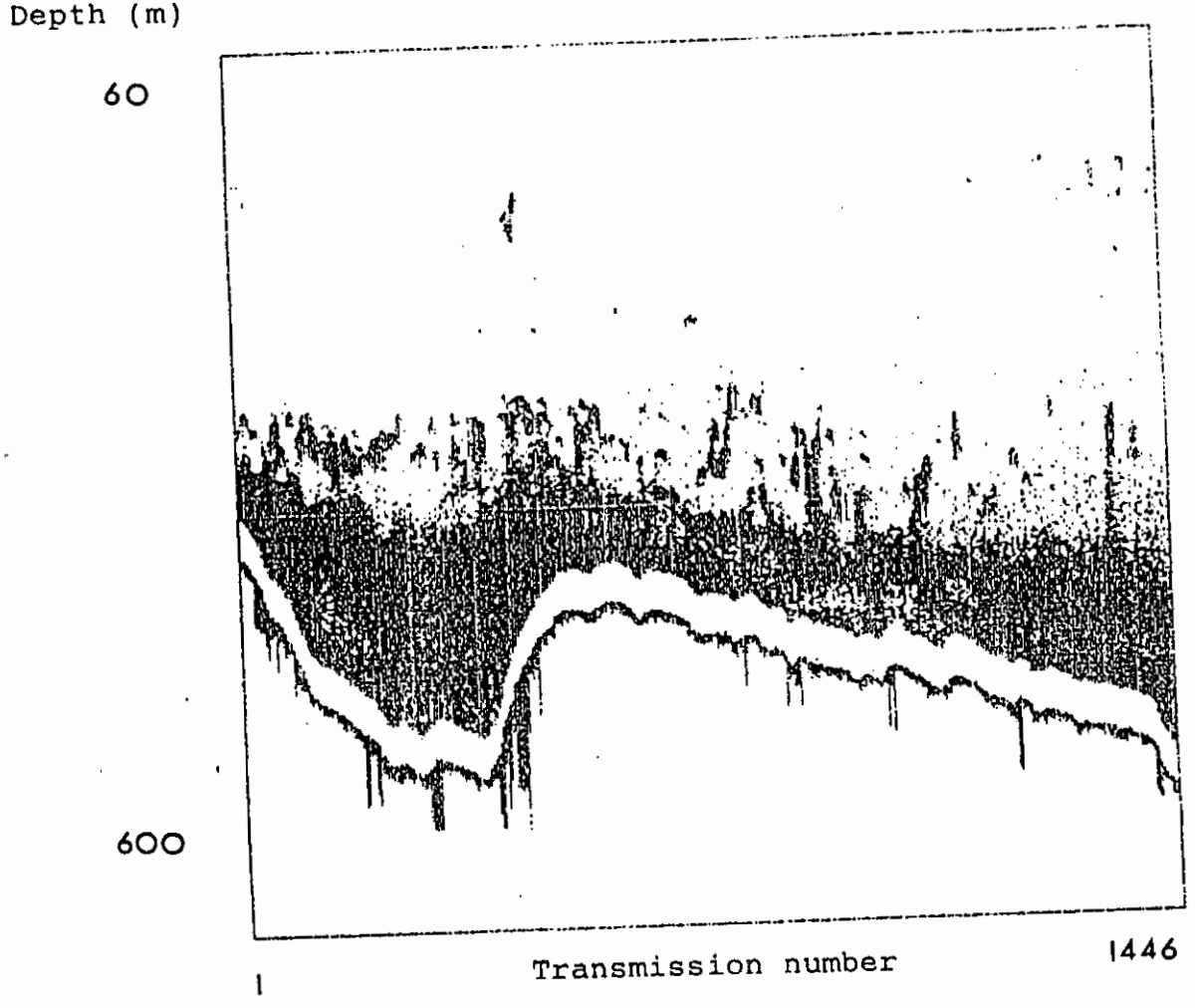


Figure 5. Daytime echogram of transect B1 on the Hokitika canyon.



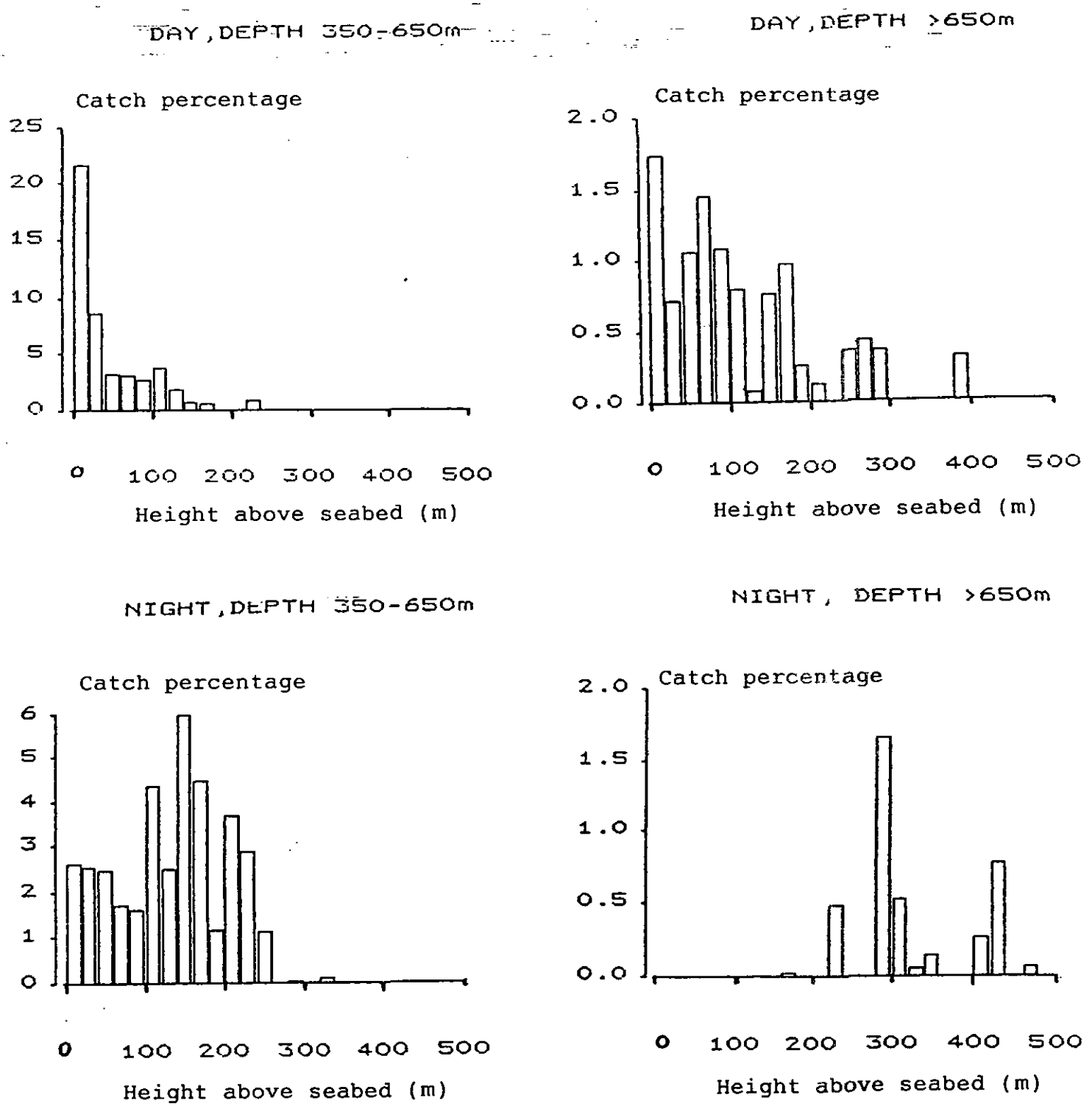


Figure 6. Vertical distribution of hoki catch referred to sea bottom.

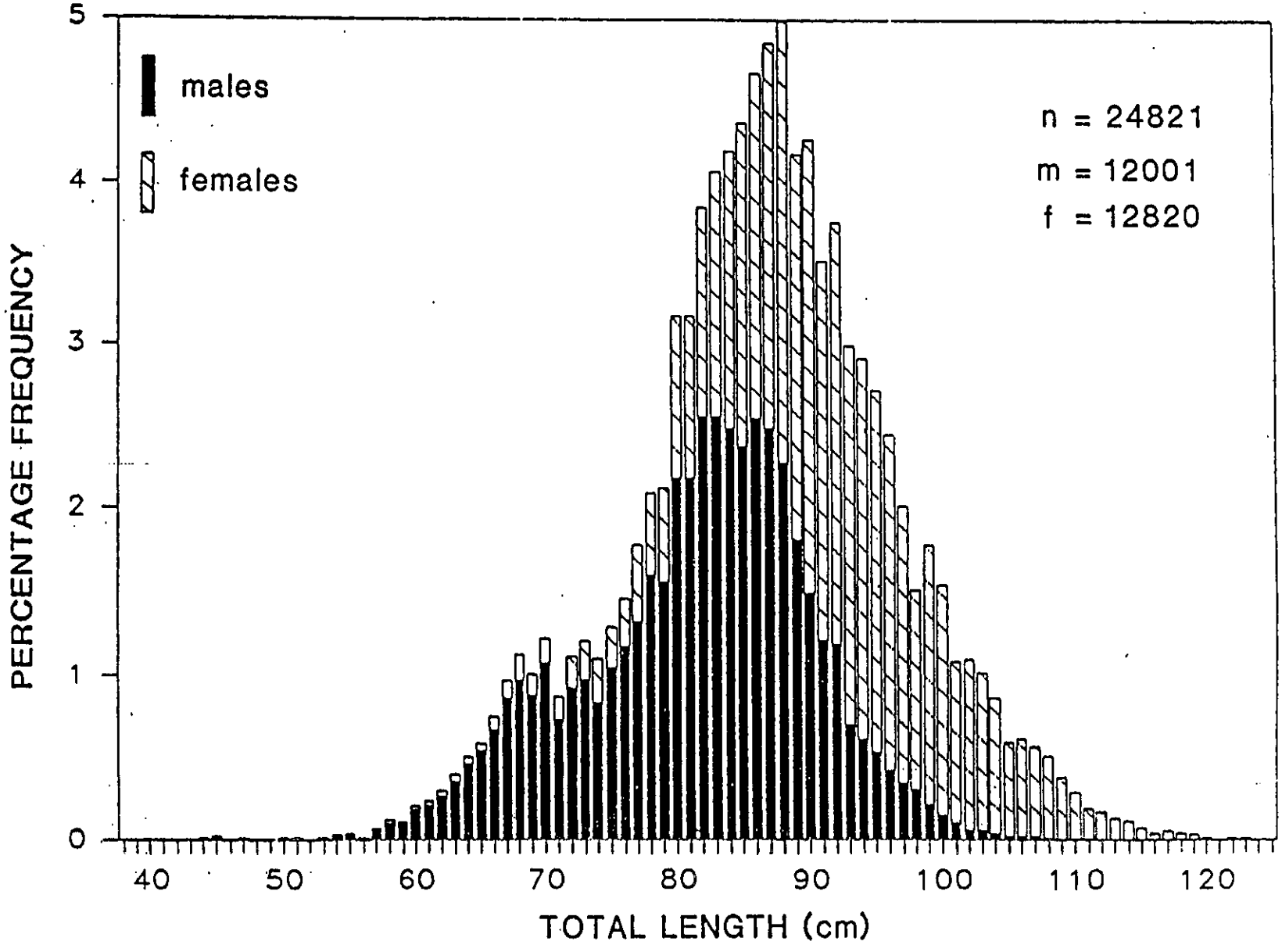
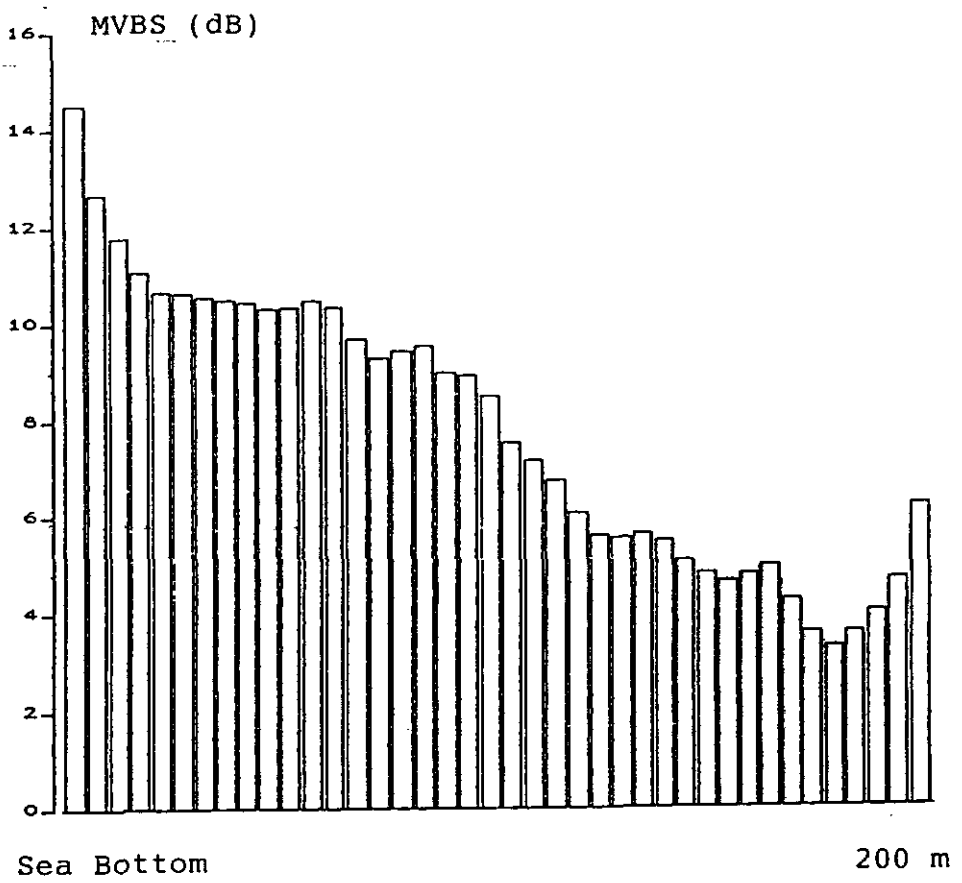
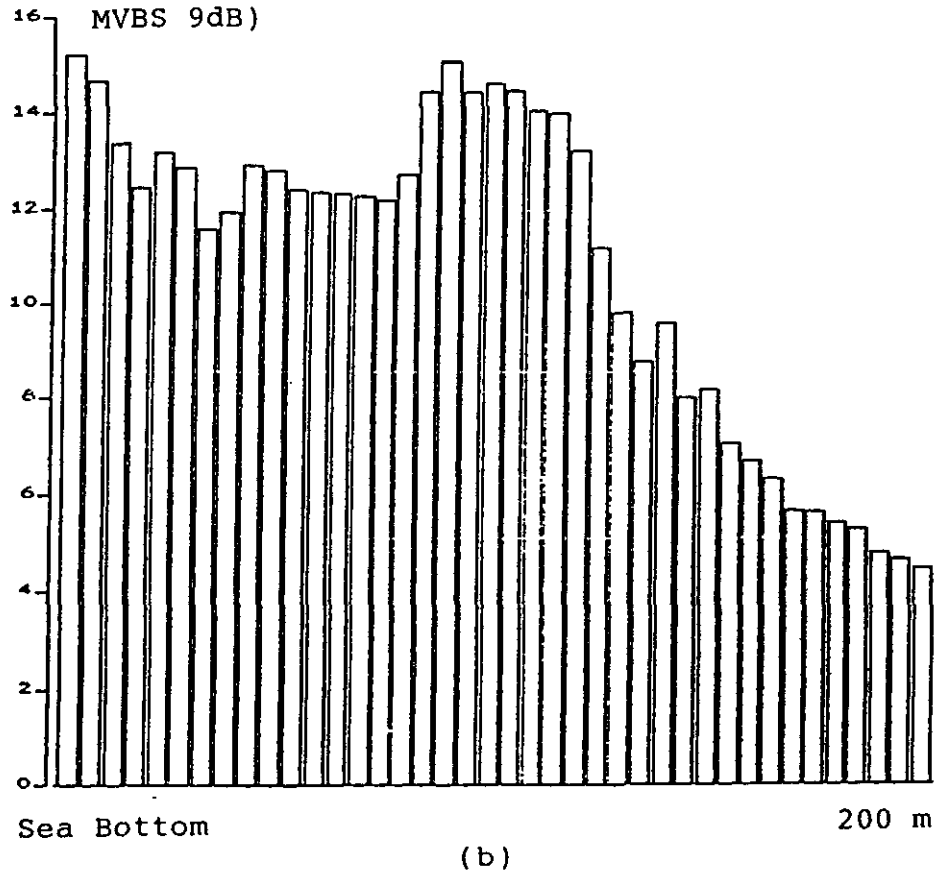


Figure 7. Length distribution of hoki at Hokitika canyon region.



(a)



(b)

Figure 8. Vertical distribution of MVBS on two transects (a) A4, and (b) A6.

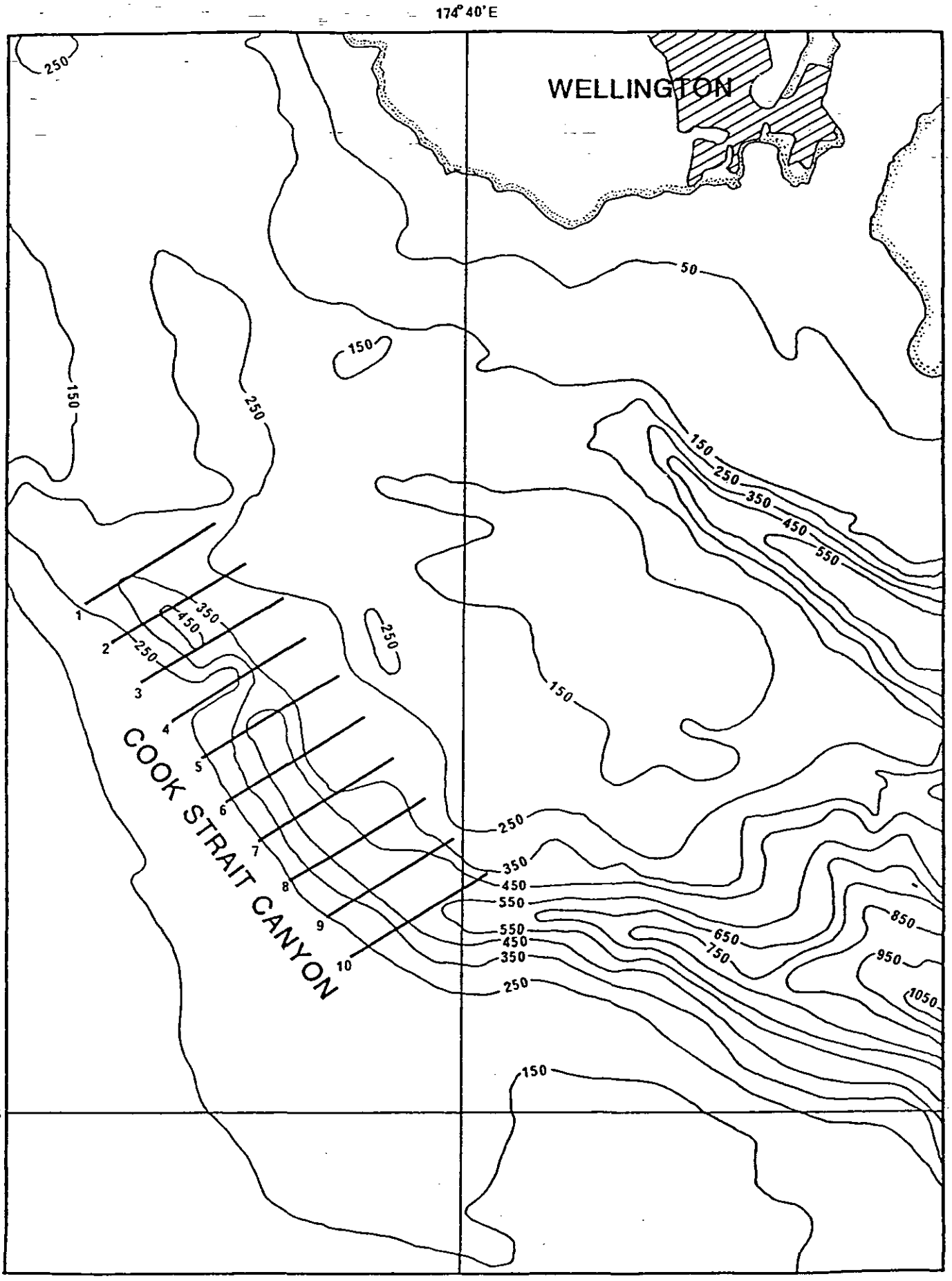


Figure 9. Survey area and transects in Cook Strait canyon.

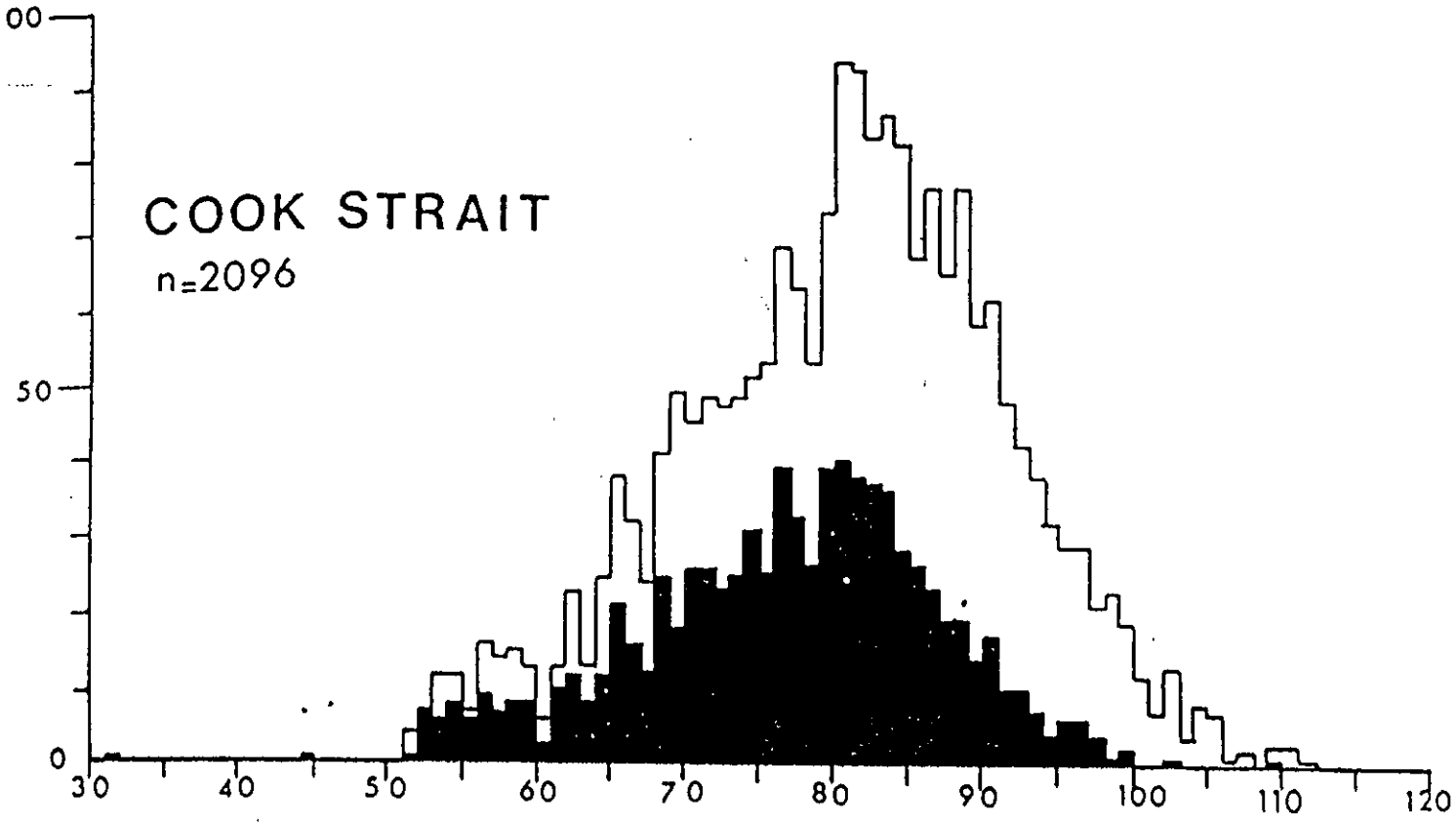


Figure 10. Length distribution of hoki in Cook Strait canyon.

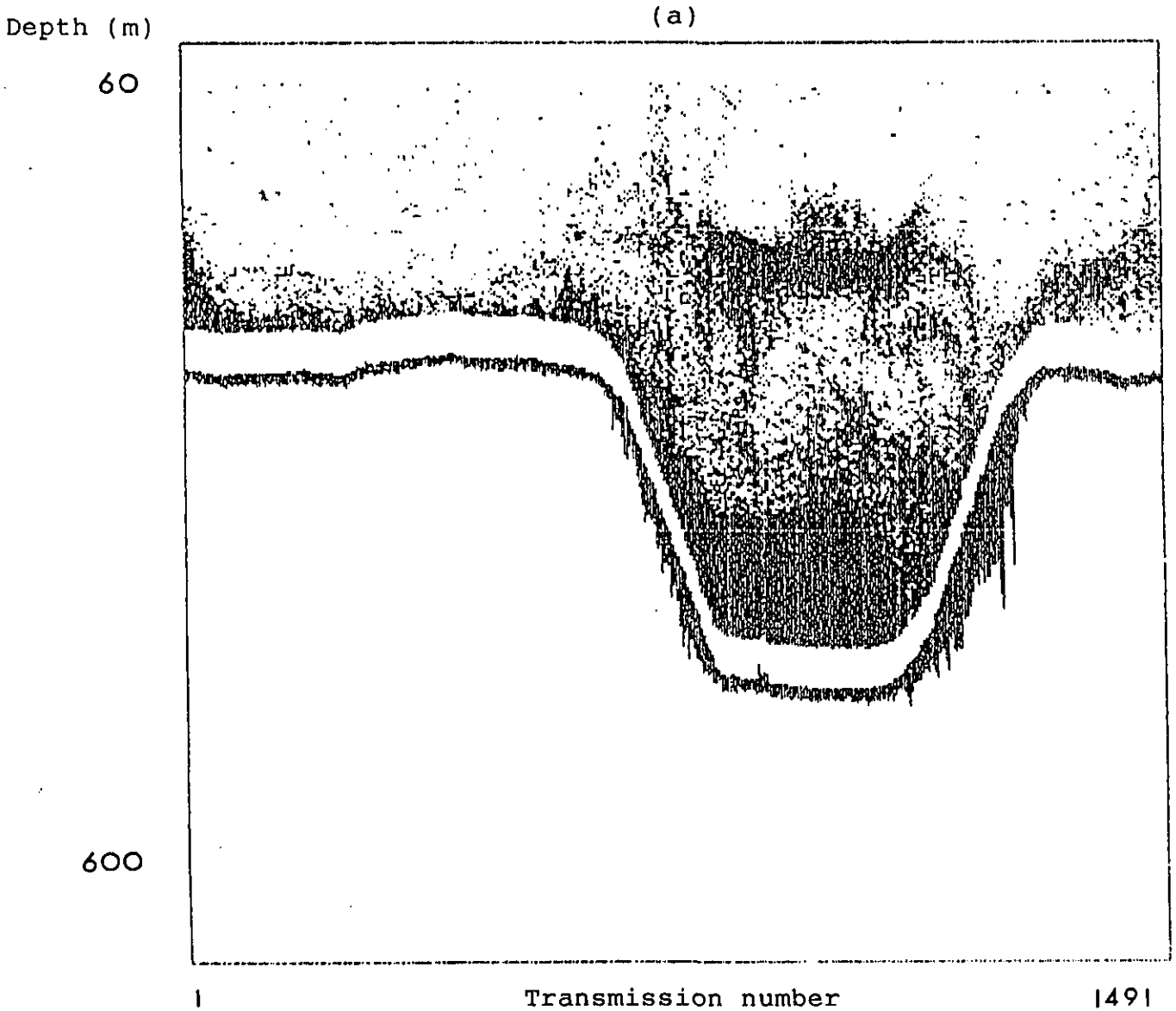
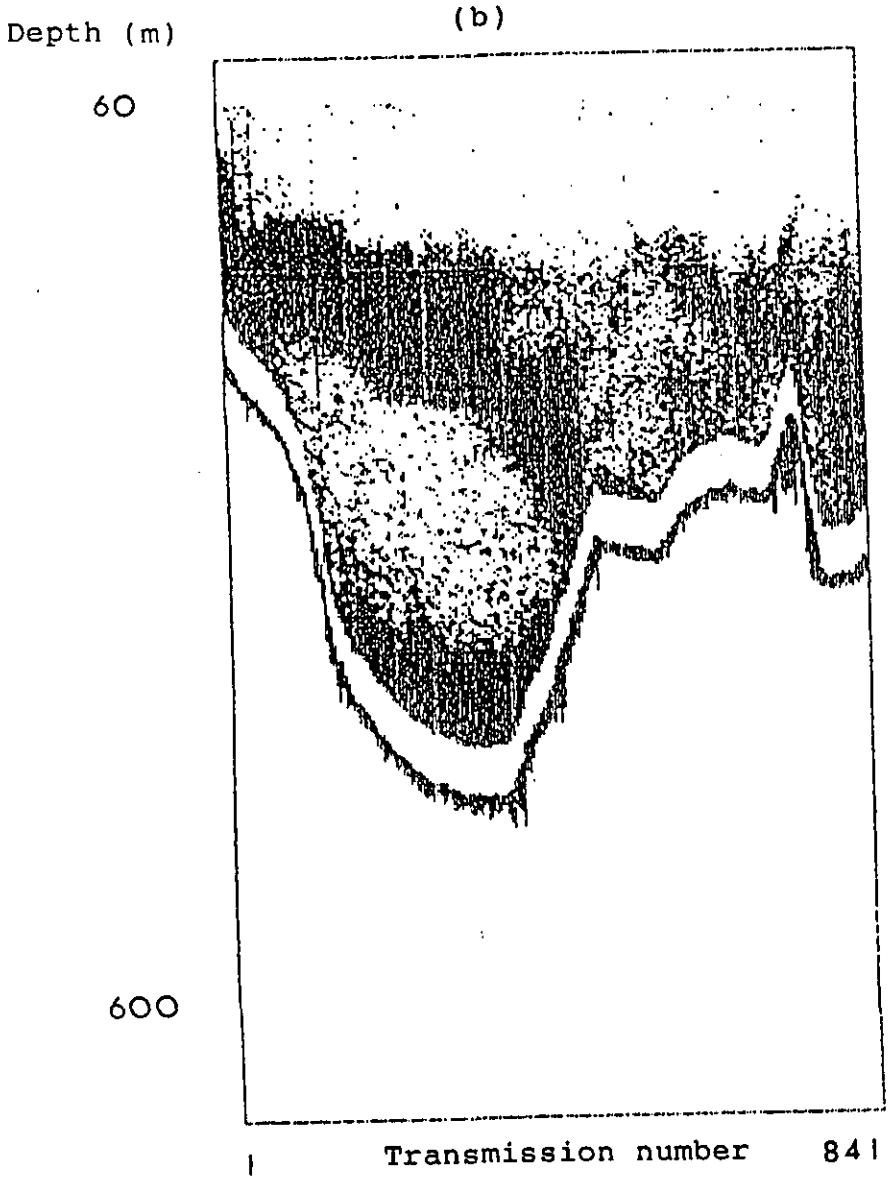


Figure 11. Echograms recorded on transects (a) 5, and (b) 8 in Cook Strait canyon.


Depth (m)
(b)
60
600
1
Transmission number
841

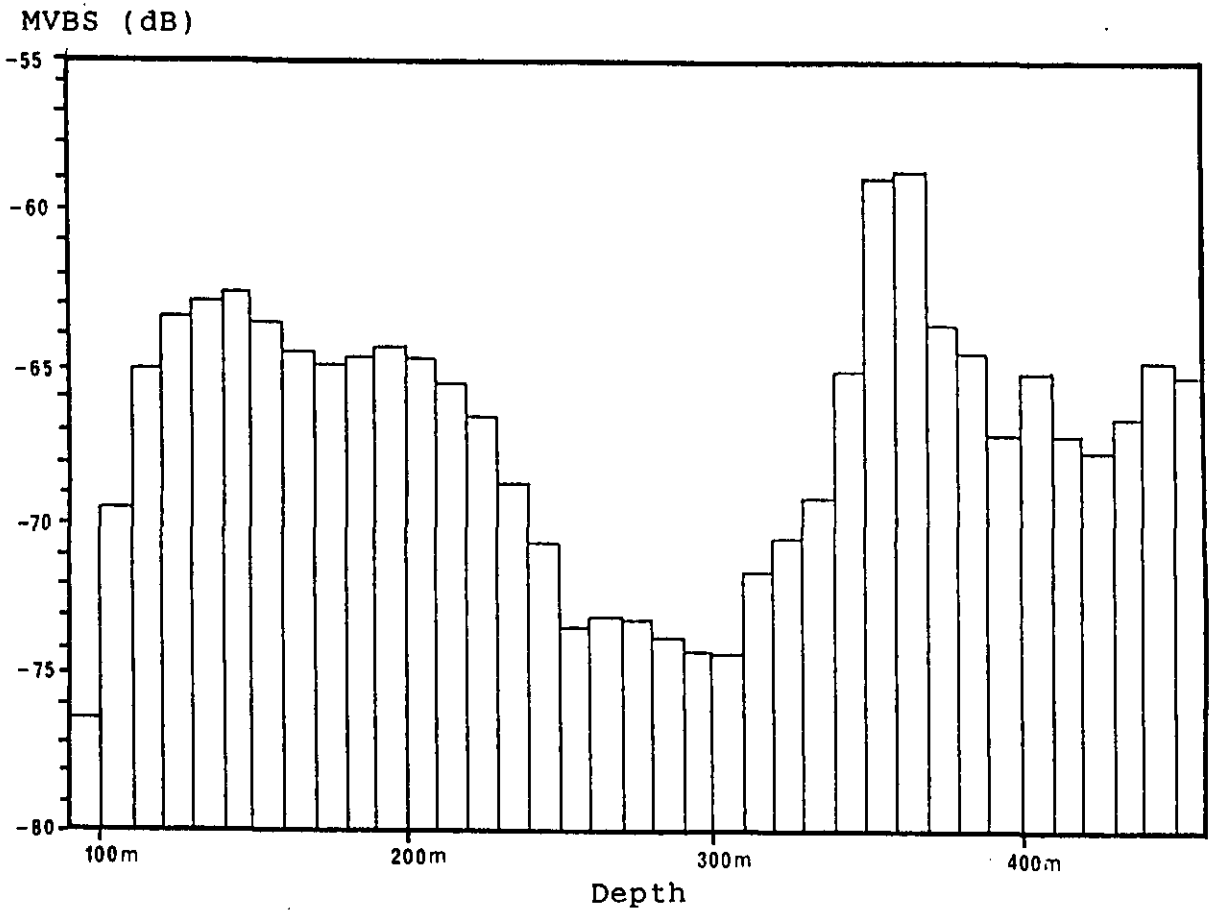


Figure 12. Vertical distribution of MVBS on transect 9 in Cook Strait canyon, depth referred to the position of the transducer.