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TRAWL AND ACOUSTIC ABUNDANCE COMPARISON

By

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INTRODUCTION

Both trawls and echointegrators have been used for stock surveys of cod and haddock, but there has been difficulty in relating the abundance estimates made by the two methods, and particularly when the fish is close to bottom. A new facility provides for integration within several narrow channels locked to bottom, and this seemed a possible way of establishing any relationship between trawl catches and near bottom echo abundance. At the same time catch ratios established by comparative fishing remain merely relative unless or until some measure of the effective spread of at least one of the gears is established. It was therefore hoped that some information could be obtained on this question also.

METHOD

The acoustic data is collected during a trawl station as in Table 1. In order to avoid, as much as possible, the ground echo from breaking through in the bottom channel, a back-step is used so that say echoes within 1 m from bottom are not integrated. Shallower water and better weather and smooth bottom may make it possible to use a lower back-step. Echoes in the deadzone cannot be integrated either, so there has to be a correction factor to the nearest to bottom channel, extrapolating for what echoes are probably in the deadzone and back-step volumes. The correction factor can be derived from the range shell principles, see Mitson 1982 and Fig. 1.

The correction factor to the nearest to bottom channel is:

KF = (volume integrated + deadzone volume + backstep volume)/(volume integrated)

In a similar way the next nearest to bottom 2-4 m channel may also be used to fill in gaps where the bottom channel is obviously giving misleading signals; that is after a relationship has been established for values which appear good in both channels. The correlation was quite good for the 5°x5.5° transducer recently used on G.O. Sars

$$QM \cdot KF_1 + M_{(4-2)} = 2.56 \cdot M_{(4-2)} \cdot KF_2 - 1.38 \quad m^2/(nm)^2$$

$$R = 0.96$$

and for the 8°x8° transducer used on Michael Sars

$$QM \cdot KF_1 + M_{(4-2)} = 2.76 \cdot M_{(4-2)} \cdot KF_2 + 9.85 \quad m^2/(nm)^2$$

$$R = 0.89$$

These relationships clearly show the importance of sampling as near to bottom as possible. Such relationships may also be expected to change from place to place and time to time with changes in near bottom vertical distribution.

Trawling and acoustic abundance estimates are not wholly independent viz:

Catch→length RMS→Target strength→conversion factor→integrator value→acoustic abundance
└→trawl abundance

The target strength used to establish conversion factor has been TS = 21.8 $\log L_{RMS}$ -74.96 and CF = $(10^{-TS/10})/4\pi$.

The trawl/acoustic abundance comparisons are made for cod, haddock and sometimes saithe lumped together. The other fish often present in significant numbers were one and sometimes 2 species of <u>sebastes</u>. Suppose for instance the integrator value within the trawl gape came to 28.3 $m2/(n.m.)^2$ and that from the catch the conversion factor for cod, haddock and <u>sebastes</u> came respectively to 550, 779 and 2754, while the numbers caught were respectively 136, 938 and 1441, then the cod and haddock abundance is estimated to be:

$$\text{Cod} = 28.3((136/550)/(136/550 + 938/779 + 1441/2754))\ 550 = 1900/\text{n.m.}^2$$

and similarly for haddock 13400/n.m.^{2}, giving total gadoid abundance $P_A = 153/(0.1\ \text{n.m.})^2$.

That is to say the integrator value is divided according to species and dependent on the number of that species present and its backscattering cross section derived from the root mean square length L_{rms}, the fish species conversion factor being inversely proportional to the backscattering cross section.

The bottom trawl is a shrimp trawl of 29.7 m headline length rigged with 40 m double bridles and 10 m backstrops to the doors. It is more fully described by Engås and Godø (1985). During these experiments the operating dimensions may be taken as:

Headline spread	19 m	The values measured by acoustic
Otterboard spread	55 m	Spread and height meters mostly
Mouth gape	4 m	Remained within ± 10% of these values

The bottom trawl abundance estimate within the headline gape is made on an initial assumption of 25 m effective spread. If trawl abundance estimates turn out to be systematically greater than acoustic abundance estimates within the bottom 4 m, then the effective spread can be raised accordingly until the two estimates balance.

In early experiments, and particularly in deeper water, the effective spread so derived often came out as great as the otterboard spread which seemed improbable. Since then Ona (1987) has pointed out that to better estimate abundance in any layer, account has to be taken of the change of solid angle ψ in the acoustic beam pattern with depth. This present report uses his data and advice, correcting the near bottom acoustic abundance estimates for beam pattern. For the 8°x8° (full angle) ceramic transducers which were used on R/V "G.O. Sars" and R/V "Eldjarn" with ψ = (8 8)/5800, a nominal value of 10logψ = -19.6 dB, the correction used above 225 m depth may be summarized as (ψnominal/ψactual)=1.8 depth/225 -0.8.

RESULTS

Results are now available from several cruises, "Eldjarn" 1986, "G.O. Sars" 1987, "Eldjarn" 1987, "G.O. Sars" and "Michael Sars" 1988. The bulk of the data is for hauls with what has been the standard bobbin groundrope with 40 m sweeps, but data is also available for hauls with the same gear with a rockhopper groundrope. Past experience has indicated that the ratio of catch expectancy (based on acoustics) to actual catch has great variance. Values are accepted which fall within $0.25 < P_T/P_A < 4$ for the bobbin gear. This helps to exclude cases where ground echo in breaking through. For the rockhoppers where the catching efficiency was obviously higher values are accepted in the ratio $0.25<P_T/P_A<6$.

Results for the bobbin and rockhopper rigs are given in Tables 2 and 3. These indicate an affective spread for the bobbin gear of 29 m within the wide 5% confidence limits of 23 to 36 m, and for the rockhopper gear 34 m in the range 26 to 45 m. Analysis of the results is according to the method proposed by Gulland (1967). The data are collected over a period of time with different boats and in different places. Two independent and separate comparative fishing experiments indicated catch ratios of 2.2:1 and 1.8:1 in favour of rockhoppers for cod and 1.2:1 for haddock. Interestingly enough on the last cruise of "G.O. Sars" using a bobbin groundrope, difficulties were encountered with the otterboard rigging, and catch rates were only some 60% of those of "Michael Sars" and the commercial trawler fishing along side, while the trawl/acoustic comparison on "G.O. Sars" itself indicated an effective spread of only 22 m in the range 16 to 30 m, as is shown in Table 4. In this case the narrow beam 5°x5.5° full angle magneto-striction transducer was used with a feeling that it was more satisfactory for the job.

DISCUSSION

With the corrections made to beam angle ψ related to depth over 225 m, the results begin to fit together better, that is to say the values for effective spread look more reasonable and their ratios to each other correspond roughly to the ratios as determined by comparative fishing experiments. In any case as the comparison of P_T/P_A are not necessarily made at the same place or time as the comparative fishing experiments, and the cod/hadock ratios can be different, one should not expect very close agreement between the ratios of effective spreads and comparative fishing ratios. These latter can be independantly established for cod and haddock, whereas the acoustic abundance cannot be. It is likely that the acoustic density estimate can be improved with some future refinement of the beam pattern correction. A variety of transducers, different backsteps and different near bottom channels were used, which would not improve the consistency of results. There are also different ways in which the results can be processed. For instance, calculating the fish conversion coefficient from the rockhopper catches leads to higher values of conversion coefficient because more small fish are captured, but this can only be used in cases where rockhoppers were used. Care was, however, taken to use the same conversion coefficients for both sets of gear when both were being used.

The effective spreads as indicated here are composite numbers in metre, whereas in reality every length group of every species will have a different effective spread, which will in itself vary with time and place. The composite effective spreads indicated will be for gadoids where the bulk of the fish ranged from 30 to 45 cm. Even although the effective spreads indicated are unlikely to be atall precise, they provide an approximate base line for calculations of trawl and sweep efficiencies from comparative fishing experiments.

At the moment too much is left to subjective judgement on which hauls to include and which to exclude. To improve effective trawl spread estimates will require more precise estimates of beam pattern within which fish echoes are received and improved methods of electronic processing near bottom signals on a ping by ping basis. Electronic data have been stored on disc so that analysis on this last point may begin. For the rather less precise requirement of generally bringing closer the trawl abundance estimate to the near bottom acoustic abundance estimate the result are more satisfactory. Even so, of all the hauls made, just about half fall within the range $0.5<P_T/P_A<2$, which leaves a big chance of there not being fairly good agreement if one relies on a single haul and acoustic comparison as being representative of a unit area of a survey.

REFERENCES

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A. Engås and Godø O.R., 1985. The influence of trawl geometry and performance and fish vertical distribution on fish sampling with bottom trawl. NAFO SCR Doc. 85/102.

R.B. Mitson., 1982. Acoustic detection and estimation of fish near the seabed and surface. Symposium on fisheries acoustics, Bergen, Norway, 21-24 June, 1984.

Table 1. Data sheet for trawl hauls, an example.

Station No BT 97 Date 17.02.88 Gear Campelen 1800 bobbins 40 m sweeps

Position N 71°34´ E 26°38´

Log	579.6	575	576		576.1	1.5 mile Total M		Mtot $m^2/(nm)^2$	cod
10-200		27	28	from printout				27.5	136
200-250		30	60					45	haddock
250-300		48	56					52	938
300-350		392	144					268	sebastes
350-400							average depth 394 m		1441
22-14	14.8	27.7	50.2		4.3	67.4		44.9	
14-10	12.1	15.9	17.1		2.8	23.7		15.8	
10-6	12.9	17.9	12.1		1.1	18.2		12.1	
6-4	6.9	9.3	3.7		1.2	7.3	KF	4.9	
4-2	7.5	11.7	3.4		1.3	8.9	2.15	5.9	← 28.1 12.7
2-B	1.5	2.3	6.2		1.2	8.2			
QM	82	82.6	9		5	14.6	2.28	22.2	

Backstep 1 m

$P_{A(0-4)}$ 153/(0.1 nm)^2

$P_{T(25\ m)}$ 530/(0.1 nm)^2

Table 2. Effective spread for 40 m sweep, bobbin groundrope.

		P_T and P_A No.Fish/n.m. 10^{-2}					
	Haul No.		P_T	P_T/P_A	P_A		Remarks
Eldjarn 86	437		72	1.53	47		Shallower than 225 m
G.O.Sars 87	100		503	1.70	296		Deeper than 225 m
	101		610	1.18	515		
	102		304	3.30	92		
	104		333	1.42	234		
	105		317	1.05	302		
	106		458	0.79	578		
	107		393	0.57	686		
	124	397				84	
	125		269	1.20	224		
	127		303	1.17	259		
	128		338	1.11	304		
	129	305				1974	
Eldjarn 87	576	213				47	
	593		60	0.84	80		
	607	302				35	
	608	4				37	
	613	2				260	Few fish
	614	2				116	
	623		19	0.83	23		
	627		3	0.38	8		
	634	1				88	
	643	19				302	
	645	22				301	
	646		57	0.37	156		
Eldjarn 87	578	290				14	Shallower than 225 m
	592		220	2.72	81		
	595	13				61	
	596	12				141	
	597		118	3.02	39		
	598		3	0.75	4		Few fish
	599		100	2.1	46		
	600		198	2.44	81		
	601		5	1.67	3		Few fish
	602		7	1.00	7		Few fish
	603	19				211	
	610	19				110	
	619	6				0	
	620	3				0	
	621	2				36	
	647		26	2.36	11		Few fish
	648		380	1.65	230		
	649		81	0.54	149		
M. Sars 88	74		1348	4.12	327		
	75		2242	1.17	1919		
	76		1152	0.99	1160		
	77		610	0.75	817		
	78		229	2.52	578		
	79		183	0.79	233*		
	93		210	2.69	78*		
	94		334	1.77	189		
	97		173	0.65	265		

P_T/P_A = 1.163 in range 0.935 to 1.448

Y_{eb40} = 29 m in range 23 to 36 m

* indicates where extrapolation from the 2-4 m channel was used.

Table 3. Effective spread for 40 m sweeps, rockhopper groundrope.

	Haul No.		P_T	P_T/P_A	P_A		Remarks
Eldjarn 86	441		19	0.35	54		Shallower than 225 m
	442		120	1.46	82		
	443		179	2.89	62		
	444		200	3.22	62		
	445	126				18	
	446		102	0.84	121		
	447	215				13	
	455	124				18	
	456		224	1.54	145		Survey period ends
	460		1222	4.23	289		Minisurvey mostly
	461		846	3.18	256		haddock
	463		671	2.62	256		
	467		948	5.96	159		
	473		787	3.69	213		
	478		397	1.17	338		
	479		201	1.36	148		
G.O. Sars 87	134		234	1.23	190		Deeper than 225 m
	138	403				57	
	142	248				1954	Ground
	148	274				1966	Ground
	150		244	0.55	444		
	152		235	0.33	705		
M. Sars 88	81		992	-1.67	593		
	82		424	0.75	562		
	83		328	1.61	204*		
	84		169	1.31	129		
	85		263	0.96	274		
	86		183	0.81	224		
	87		218	1.91	114*		
	88		517	1.25	412		
	89		1421	0.66	2151		
	90		303	1.43	241*		
	91		369	1.16	318*		

P_T/P_A = 1.351 in range 1.025 to 1.780

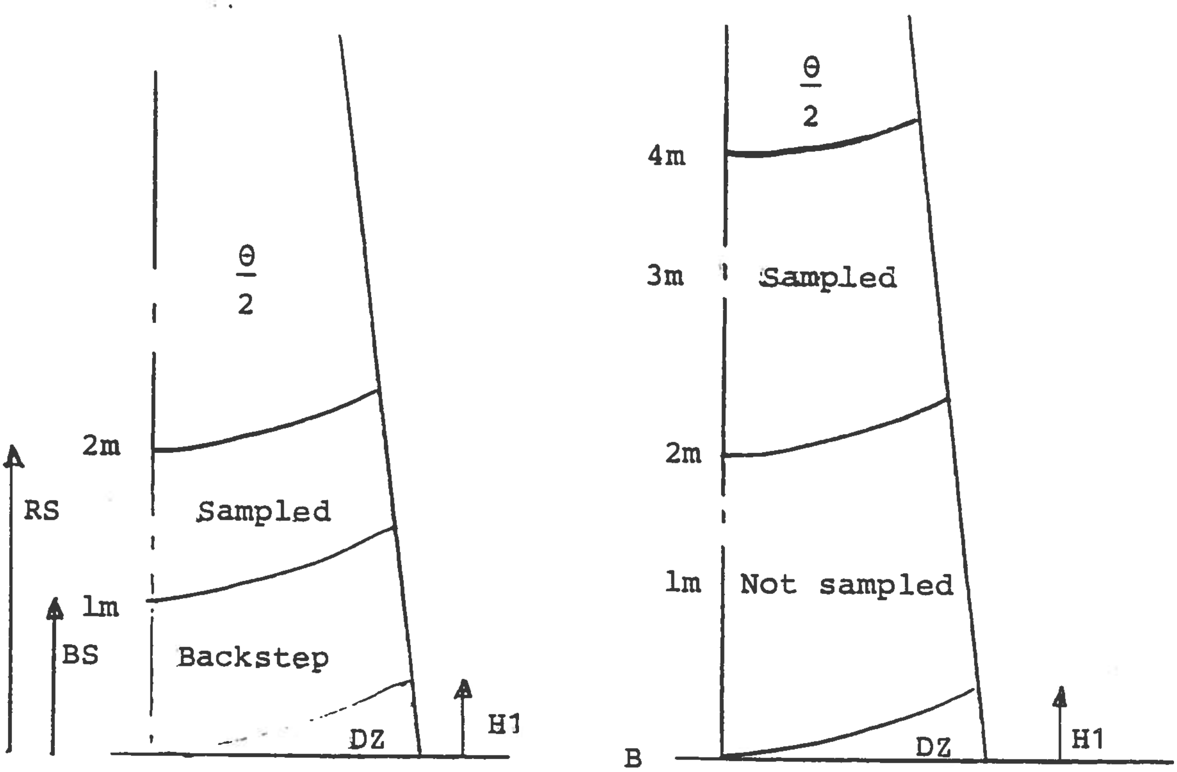
Y_{erh40} = 34 m in range 26 to 45 m

Table 4.

	Haul No.		P_T	P_T/P_A	P_A		Remarks
G.O. Sars 88	96		773	3.88	199*		
	97		530	3.46	153		
	98		573	0.50	1153*		
	99		942	0.70	1345*		
	100		454	1.11	408		
	101						Failed haul
	102						Failed haul
	103		95	0.66	144*		
	104		243	1.15	212		
	105	263				1150	
	106		143	0.99	144		
	107		98	1.06	92		
	108		169	0.73	230		
	109		136	0.99	138		
	110		131	2.18	60*		
	111		375	0.96	391		
	112	153				no realistic value	
	113		140	0.32	432		
	114		173	0.63	274		
	115		153	2.35	65		
	116	172				small value	
	117		191	0.30	627		
	118		80	0.95	84		
	119		231	0.86	270*		
	120		152	0.88	172		

P_T/P_A = 0.877 in range 0.649 to 1.184

Y_{eb40} = 22 m in range 16 to 30 m



QMchannel 2-B
with 1m backstep

4 - 2 m channel

Frustom height $H1 = R(1-\cos\frac{\Theta}{2})$

Bottom of frustom diameter $FBD = 2R \cdot \tan\frac{\Theta}{2}$

Top of frustom diameter $FTD = 2(R - H1) \cdot \tan\frac{\Theta}{2}$

Frustom volume $VF = 0.268\ H1(FBD^2 + FTD^2 + FBD \cdot FTD)$

Cap volume $VC = (\pi/3)(H1)^2(3R - H1)$

Volume of dead zone $VDZ = VF - VC$

Volume of backstep $VRS1 = (2/3) \cdot \pi(R^3 - (R - BS)^3) \cdot (1 - \cos\frac{\Theta}{2})$

Volume of rangeshell sampled $VRS2 = (2/3) \cdot \pi((R-BS^3 - (R-RS)^3) \cdot (1-\cos\frac{\Theta}{2})$

Correction factor = (volume sampled + volume not sampled)/(volume sampled)

$KF = (VRS2 + VRS1 + DZ)/(VRS2)$

Figure 1. Near bottom range shells with deadzone and backstep.