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Short communication

Further analysis of the effect of bioturbation by *Nephrops norvegicus* (L.) on the acoustic return of the RoxAnn™ seabed discrimination system

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An investigation into the effect of *Nephrops norvegicus* bioturbation on the acoustic indices of RoxAnn™ was carried out over three commercial fishing grounds; the Firth of Forth, Moray Firth and the North Minch. The results obtained in the present study suggest that the relationship between burrow density and the acoustic output of RoxAnn™ is significantly more complicated than was previously reported. The differences in the findings in the present study and those previously reported are discussed.

Key words: RoxAnn™, mapping, acoustic survey, *Nephrops*, shellfish stock assessment, bioturbation.

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Introduction

Recently, the application of acoustic methods, such as using the seabed discrimination system RoxAnn™, for mapping seabed habitats and their associated benthic communities has become very common, e.g. Magorrian *et al.* (1995), Greenstreet *et al.* (1997), Southeran *et al.* (1997) and Pinn *et al.* (1998). Whilst conducting work on scale and complexity in benthic communities, Rees (1993) indicated that bioturbation may affect the acoustic signal of RoxAnn™. More recently, Pinn and Robertson (1998) reported that over a similar sediment type, changes in *Nephrops norvegicus* burrow density could be detected using RoxAnn™. Changes in burrow density resulted in variations in the E1 part of the RoxAnn™ signal whilst E2 remained unaffected. These authors suggested that RoxAnn™ might be used to reduce both the cost and time of *N. norvegicus* stock assessment surveys which are presently carried out using numerous time-consuming camera tows (Bailey *et al.*, 1993). The relationship between burrow density and the RoxAnn™ acoustic signal was further investigated for the present study on three traditional Scottish *N. norvegicus* fishing grounds.

Materials and Methods

As part of Fisheries Research Services (FRS) studies, stock assessment work is carried out over a number of *N. norvegicus* commercial fishing grounds on an annual basis. For the present investigation three grounds were chosen; the Firth of Forth, the Moray Firth and the North Minch. These three areas were selected because of differences in sediment type and distribution, and the variations exhibited by their resident *N. norvegicus* populations. In terms of granulometry, the North Minch grounds generally have the finest and most heterogenous sediments, whilst the Moray Firth and Firth of Forth grounds are relatively similar with slightly coarser and more homogenous sediments. Despite the similarity of the Moray Firth and Firth of Forth sediments, the *N. norvegicus* population of the Moray Firth is comprised of fewer, smaller individuals than that of the Firth of Forth (Anon., 1988; Anon., 1996).

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Table 1. Summary of the sediment characteristics for the Firth of Forth (FF), Moray Firth (MF) and the North Minch (NM) *N. norvegicus* fishing grounds.

Ground	Minimum grain size (phi)	Maximum grain size (phi)	Mean grain size (phi)	s.e.	Variance
FF	3.80	5.67	4.67	0.09	0.26
MF	3.23	5.56	4.61	0.11	0.27
NM	3.61	6.78	5.59	0.14	0.69

Table 2. Spearman's correlation test results.

	Firth of Forth		Moray Firth		North Minch	
	r_s	p value	r_s	p value	r_s	p value
E1 and burrow density	−0.249	0.21	−0.357	0.06	−0.160	0.35
E1 and mean grain size	0.451	0.03*	0.106	0.61	0.243	0.15
E2 and mean grain size	−0.706	0.01*	−0.391	0.05	−0.739	0.01*

*Significant result.

Data on *N. norvegicus* burrow density were obtained using closed circuit television (CCTV) and recorded on U-matic video tape. The CCTV system used is described by Pinn *et al.* (1998). *Nephrops norvegicus* burrow density was counted by four observers on board the vessel whilst the tow was recorded and then again by a further two observers at the laboratory from the video tape. Because counts did not vary significantly between observers, the mean burrow count for each tow was used in the data analysis. For each CCTV tow, sediment was collected using a 0.1 m^2 Day grab for particle size analysis. These samples were stored in 60% alcohol and analysed back at the laboratory using a Malvern Multisizer/E sediment particle size analyser. Acoustic data were collected during each CCTV tow track using RoxAnn™. A detailed description the RoxAnn™ system is given by Chivers *et al.* (1990). The RoxAnn™ system was interfaced with a hull mounted echo-sounder (see Pinn *et al.* (1998) for specifications) and the acoustic output recorded individually for each tow track. Use of Differential Global Positioning Systems (DGPS) enabled selection of the most appropriate acoustic data for each CCTV track. For each tow track, burrow density, E1 and E2 values and mean grain size and variance data were obtained. The relationship between the parameters was investigated statistically using Spearman's correlation coefficient.

Results

Table 1 gives a summary of the sediment characteristic for each fishing ground. According to the Wentworth scale all sites were classified as having "silt" type sediments, however, some differences were observed. The range of particle sizes observed for the Firth of Forth (FF) and the Moray Firth (MF) grounds were relatively similar (FF mean=42 μm, range=20–72 μm; MF mean=42 μm, range=21–106 μm). The North Minch (NM) sediments were generally much finer (mean=24 μm, range=9–82 μm).

The highest *N. norvegicus* burrow densities per CCTV tow were recorded in the Firth of Forth. Here the burrow density ranged from 0.02 m^{-2} to 1.07 m^{-2} with a mean of 0.48 $m^{-2} \pm 0.29$ m^{-2} (n=27). The mean burrow density recorded in the Moray Firth was 0.26 $m^{-2} \pm 0.14$ m^{-2} (n=27), with burrow densities ranging from 0.02 m^{-2} to 0.58 m^{-2}. In the North Minch, *N. norvegicus* burrow density ranged from 0.08 m^{-2} to 0.82 m^{-2} with a mean of 0.27 $m^{-2} \pm$ 0.16 m^{-2} (n=36).

For the Firth of Forth sites, a significant correlation was observed between the acoustic indices and mean grain size, but no correlation was found between E1 and burrow density [Table 2, Figure 1(a)–(c)]. No significant correlation was found between the various parameters tested for the Moray Firth sites, although the relationship between E2 and mean grain size is very close to significant [Table 2, Figure 1(d)–(f)]. For the CCTV tows conducted on the North Minch fishing grounds, a significant correlation was observed between E2 and mean grain size, whilst E1 and burrow density were not found to be significantly correlated [Table 2, Figure 1(g)–(i)].

Discussion

At present, annual fisheries-independent stock assessment surveys are carried out to monitor stock

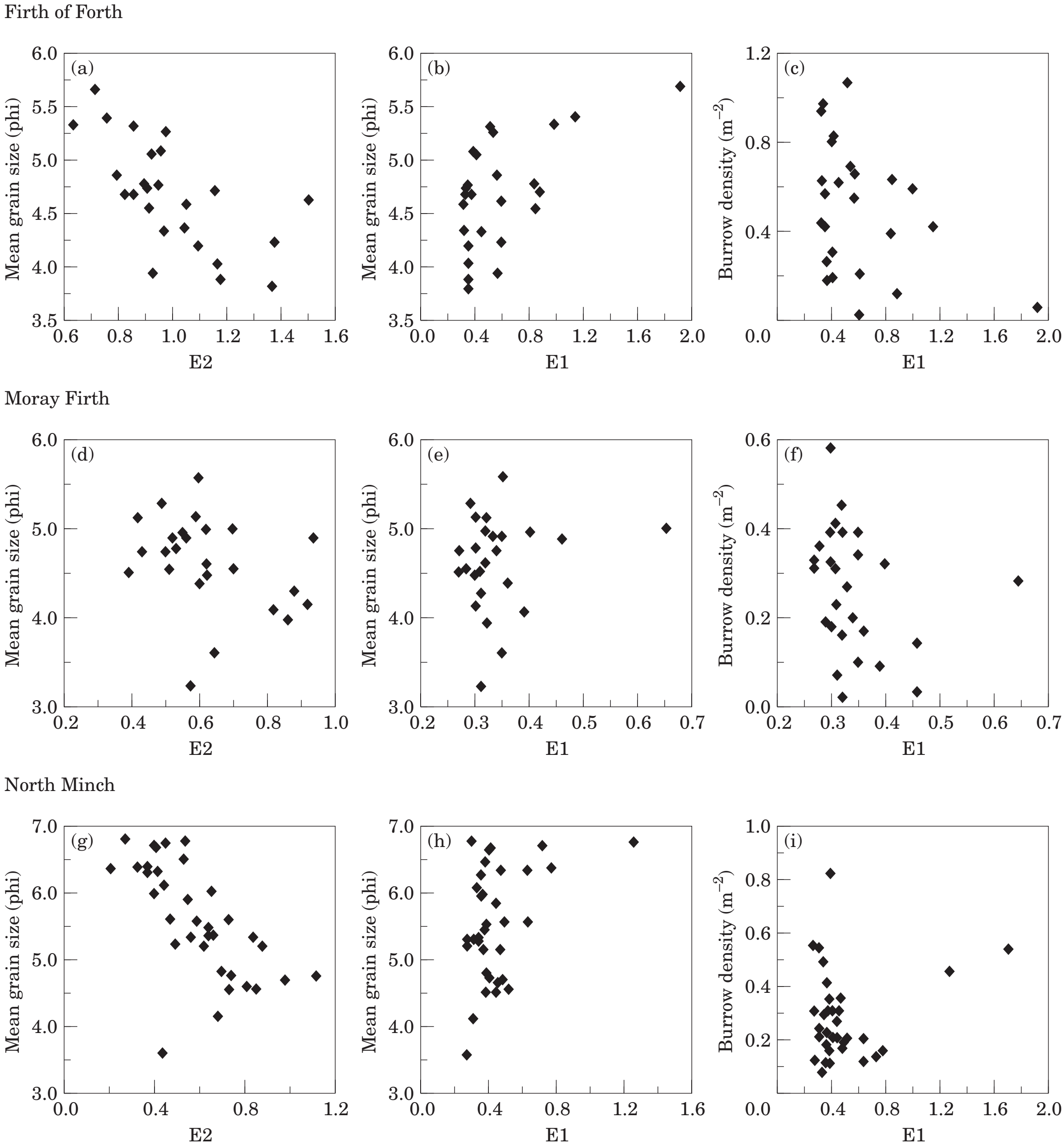

Figure 1. The relationships between mean grain size, E1 and E2 and *N. norvegicus* burrow density for the Firth of Forth (a–c), the Moray Firth (d–f) and the North Minch (g–i) fishing grounds.

populations and to improve management of the fishery. In Scotland, this work is conducted using an extensive series of CCTV surveys based on a stratified design, where stations are randomly located within particular sediment types, at each fishing ground (Anon., 1997). This process is very time consuming and expensive in terms of both sea time and labour. Pinn and Robertson (1998) suggested that conducting a RoxAnn™ acoustic survey of each area under investigation would dramatically reduce both the costs and the time required to complete each stock monitoring program.

The results obtained in the present study, however, indicate that the relationships between *N. norvegicus* and the acoustic signal of RoxAnn™ are much more complicated than was originally reported by Pinn and Robertson (1998). These authors observed that over a single, homogenous, sediment type, changes in *N. norvegicus* burrow density resulted in variations in the E1 component of the RoxAnn™ output and that these variations were attributable to burrow topography rather than to changes in the water content of the sediment. However, in the present study, when a wider range of sediment types and burrow densities are considered, the relationship between E1 and burrow density could not be detected. The results obtained here suggest that the changes in the acoustic signal due to changes in sediment type were much greater than the changes due to variations in burrow density. For example, the relationship between burrow density and E1 appears to be better on the more homogenous grounds (see Tables 1 and 2, Moray Firth and Firth of Forth data) than on the heterogeneous grounds (see Tables 1 and 2, North Minch data). Further investigations need to be undertaken before the usefulness of acoustic surveying techniques in *N. norvegicus* stock assessment can be properly assessed.

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