The impact of seabed disturbance on the diversity of meiofauna communities – linking field and laboratory observations

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Background

Benthic habitats are subject to a range of man-made activities which can lead to significant alterations in sedimentation patterns (Fig. 1). The rates and magnitudes of these alterations often greatly exceed those of natural occurrences (Fig. 2). Physical disturbance is a key factor in controlling the diversity of benthic communities.

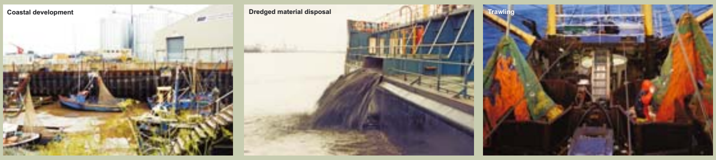

Fig.1. Man-made activities leading to seabed disturbance

We addressed two questions:

1. Are there consistent patterns in the response of nematode communities to physical disturbance regardless of disturbance type?
2. Can statistically significant field observations be linked to ecologically significant cause-effect relationships established in the laboratory?

Fig.2. Natural occurrence leading to seabed disturbance

Approach

A combined analysis was carried out, including six independent data sets arising from large-scale field surveys and small-scale laboratory experiments. Disturbance response of nematode communities was documented as a function of:

- Disturbance type (coastal development, disposal, trawling, glacial fjord).
- Disturbance intensity (low, medium, high).

Integrated data set

Field investigations targeted subtidal assemblages in the Aegean Sea, the Irish Sea, the North Sea and the North Atlantic (Fig. 3). Sampling stations were located either along a gradient or transect through areas of known natural disturbance or man-made activity or randomly within areas characterised by different intensities of known man-made activity.

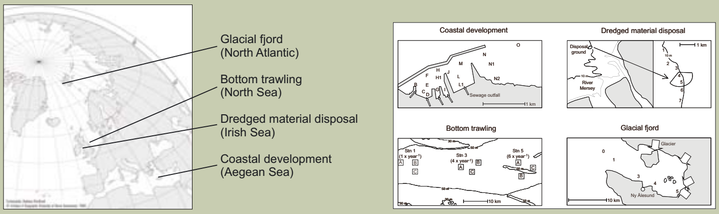

Fig.3. Location of field sampling sites

Experimental data originated from microcosm experiments where estuarine nematode assemblages were exposed to various disturbance treatments for two months (Fig. 4). Treatments simulated sediment resuspension and deposition, respectively (Table 1).

Whilst short-term, small-scale laboratory experiments quantified the immediate effect of disturbance on benthic communities, larger-scale field surveys offered the capacity to examine the prolonged effect of an impact and its manifestation over several generations.

The combined data set consisted of a total of 199 samples. Species abundance data was aggregated to genus level prior to analysis to reduce region- and study-specific differences in species identities, resulting in 156 genera.

Fig.4. Experimental microcosms

Table 1. Type of seabed disturbance present at field sampling sites or simulated in laboratory experiments and mechanisms potentially affecting nematodes

Type of study	Seabed disturbance present/simulated	Mechanisms potentially affecting nematodes
Coastal development	Seabed disturbance due to boat traffic and discharge of untreated domestic sewage	Increased turbidity, high rates of sedimentation and burial confounded with toxicity of contaminants in sewage
Dredged material disposal	Deposition of clean and contaminated dredged material	Direct burial by dredged material confounded with toxicity of contaminants in dredgings
Bottom trawling	Irregular passage of trawls causing scouring, resuspension and deposition of surface sediment	Mortality or displacement and burial, changes in sediment structure and geochemistry
Glacial fjord	Regular sediment deposition, discharges of meltwater, ice and till	High turbidity, frequent resuspension, sedimentation and burial by unconsolidated, easily eroded, sediments
Resuspension exp.	Sediment resuspension and subsequent deposition	Resuspension and subsequent burial by unconsolidated sediment
Deposition exp.	Deposition of clean and contaminated sediment	Burial by differing volumes of clean and contaminated sediment

Taxonomic and functional diversity

Only patterns of genus diversity were consistent, decreasing with increasing level of disturbance regardless of disturbance type (Fig. 5).

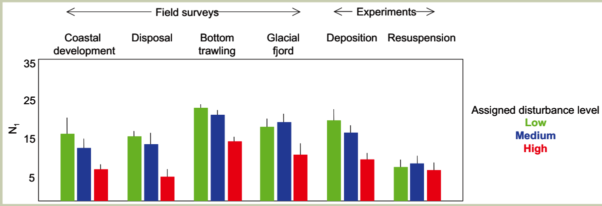

Fig. 5. Mean genus diversity (+/- 95 % pooled confidence interval) of nematode assemblages from field surveys and laboratory experiments coded by level of disturbance

The genus composition of assemblages from geographically separate seas converged with increased level of various types of man-made disturbance. The response of nematodes from the deposition experiment followed the same trajectory (Fig. 6). Communities from the resuspension experiment and along a disturbance gradient in a glacial fjord followed an opposite response vector, suggesting that changes induced by man-made activities inherently differ from those of natural origin.

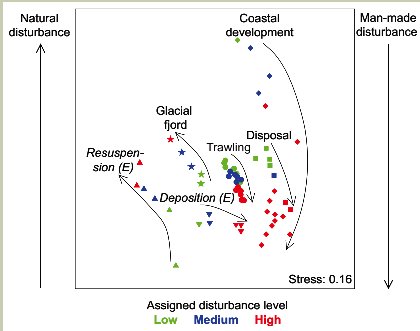

Fig.6. Non-parametric multidimensional scaling (MDS) ordination of samples coded by level of disturbance. The plot is based on relative abundance of genera. Arrows indicate community change in response to increasing level of disturbance

Natural and man-induced seabed disturbance exerted differential effects on exposed populations, generating changes in the taxonomic and functional diversity of their assemblages. The magnitude and direction of effects was variable and depended on the origin and nature of the stress-generating factors (Table 2).

Table 2. Main drivers for changes in the taxonomic and functional diversity and composition of nematode communities in response to seabed disturbance

	Response	Main driver
Genus diversity	Consistent decline with increased level of disturbance, irrespective of disturbance type or origin	Disturbance level
Genus composition	Assemblages exposed to various types of man-induced impacts and those present along a gradient of natural disturbance followed opposite response vectors	Disturbance origin
Trophic Diversity	Decline in sediments where heavy metal contamination confounded the effects of physical disturbance	Type of man-made activity
Feeding type composition	Dominance of non-selective deposit feeders and reduction of epigrowth feeders in sediments where heavy metal contamination confounded physical disturbance	Type of man-made activity

Discussion and conclusions

The more episodic and unpredictable nature of many man-induced changes (i.e. high amplitude-low frequency) tends to differ from the chronic and predictable character of most natural disturbances (i.e. low amplitude-high frequency). Hence, dominant genera display differential adaptive strategies and disturbance responses (Table 3).

Table 3. Differential adaptation and response of dominant genera to man-made and natural disturbance of the seabed

	Man-made disturbance	Natural disturbance
Adaptive strategy	Rapid growth rate, tolerance to wide range of environmental conditions	High agility and dispersal potential, small body size, surface-dwelling
Response	Prompt establishment in newly exposed or created habitat	Non-continuous dispersal and recolonisation of frequently disturbed areas

The use of multiple data sets and the agreement, to an extent, of the results derived from large-scale field surveys and small-scale laboratory experiments corroborates the idea that, although serving different purposes, both approaches combined can provide better insights into the complexity of ecological processes.

Acknowledgments

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