geosciences

*Supplementary*

# Origin of High Density Seabed Pockmark Fields and Their Use in Inferring Bottom Currents

## 1. Geomorphic analysis and automated pockmarks characterisation

This section provides details to the GA1 method that was developed to identify and characterise pockmark and illustrated in Figure 4 of the manuscript.

### *1.1 Stage 1- Pockmark identification and classification:*

We first identified pockmarks located within plains by using and broad-scale BPI to identify plain, then within these, we used a fine BPI to identify pockmarks. The BPI input radius values used to classify and extract the features were adjusted manually to determine realistic outputs. For example, until the BPI classification matched the edge of the bank feature that was pre-mapped or when pockmarks were well delimited. The resulting classified BPI rasters were exported to irregular polygons. Incorrect pockmark identification due to data noise was eliminated by removing small polygons (<25 $m^2$). Thin long random non-pockmark-related depressions were eliminated by removing polygons with length >2000 $m^2$. The remaining pockmark polygons were then converted into rectangles using the ESRI minimum boundary tool to determine basic geometry, such as length, width, and scour bearing of each pockmark. The bearing value resulting from this tool reflected the general direction of the long-axis of the rectangle, i.e. within 0-180 degrees. The 'real' bearing of the pockmark scours was calculated in Stage 2 -Step 5 (Figure 5). Finally, we differentiated pockmarks with and without scour depressions using a 30 m length cut off. Thus polygons <30 m were classified as non-scoured pockmarks and polygons longer than 30 m were classified as scoured pockmark.

### *1.2 Stage 2 – Scour orientation:*

It was noted during the previous stage that some polygons resulting from noise correlated with overlap of outer beams from adjacent survey lines. These were removed by selecting rectangles representing pockmarks with scours that had bearings within the range of survey line bearings. The centroids of the remaining rectangles were then calculated. To determine the scouring orientation, we used a combination of hydrological ESRI tools (flow accumulation and stream) on the initial irregular polygons from step 1 (Figure 5) that were co-located with the centroids determined in the previous step.

### *1.3 Stage 3 – Density calculation:*

Pockmark densities were calculated per square kilometer areas to enable international comparison of density fields. These were then classified into four density classes based on visual interpretation of natural boundaries between density class and converted to polygons. Boundaries were manually smoothed.

### *1.4 Stage 4 – Confidence assessment:*

This final stage was executed in a two-stage process. First, by considering the sample size of the pockmark dataset and secondly, by comparing results with two other semi-automated methods: BGS and GA2

## 2. Pockmarks: Density, Scour direction results

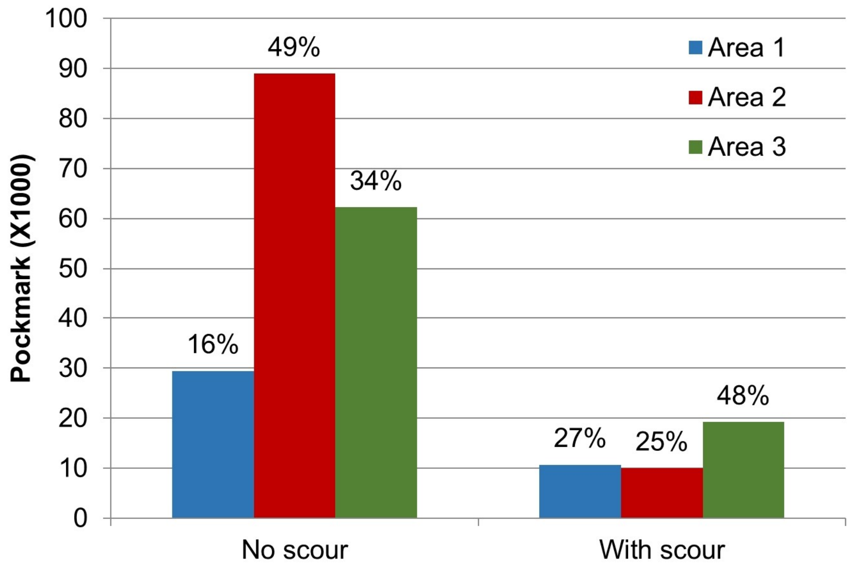


**Figure 1.** Summary of individual pockmark characteristics per type of pockmarks. The total number of each type of pockmarks that the values in the graph are based on were as followed: 180,645 pockmarks with no scour and 39,863 pockmarks with scour.

**Table 1.** Distribution of pockmark across all areas and pockmark scour directions according to eastern versus western quadrants

| Area | Without scour | With scour | | | Ratio |
|---|---|---|---|---|---|
| | Count | Count | Direction Western quadrants (>180) (%) | Direction Eastern quadrants (<180) (%) | without/with scour |
| 1 | 29445 | 10685 | 46.3 | 53.7 | 2.8 |
| 2 | 88972 | 9980 | 43.4 | 56.6 | 8.9 |
| 3 | 62228 | 19198 | 54.8 | 45.2 | 3.2 |
| Total | 180645 | 39863 | 49.7 | 50.3 | 4.5 |

**Table 2.** Scour direction summary.

| Direction | Area 1 (%) | Area 2 (%) | Area 3 (%) |
|---|---|---|---|
| N-NE (0-45) | 6.1 | 1.8 | 1.3 |
| NE-E (45-90) | 17.1 | 21.8 | 8.6 |
| E-SE (90-135) | 23.0 | 31.8 | 35.4 |
| SE-S (135-180) | 8.0 | 2.3 | 2.5 |
| S-SW (180-225) | 2.8 | 0.8 | 0.9 |
| SW-W (225-270) | 11.3 | 15.1 | 8.1 |
| W-NW (270-315) | 21.0 | 23.6 | 40.6 |
| NW-N (315-360) | 10.7 | 2.9 | 2.7 |

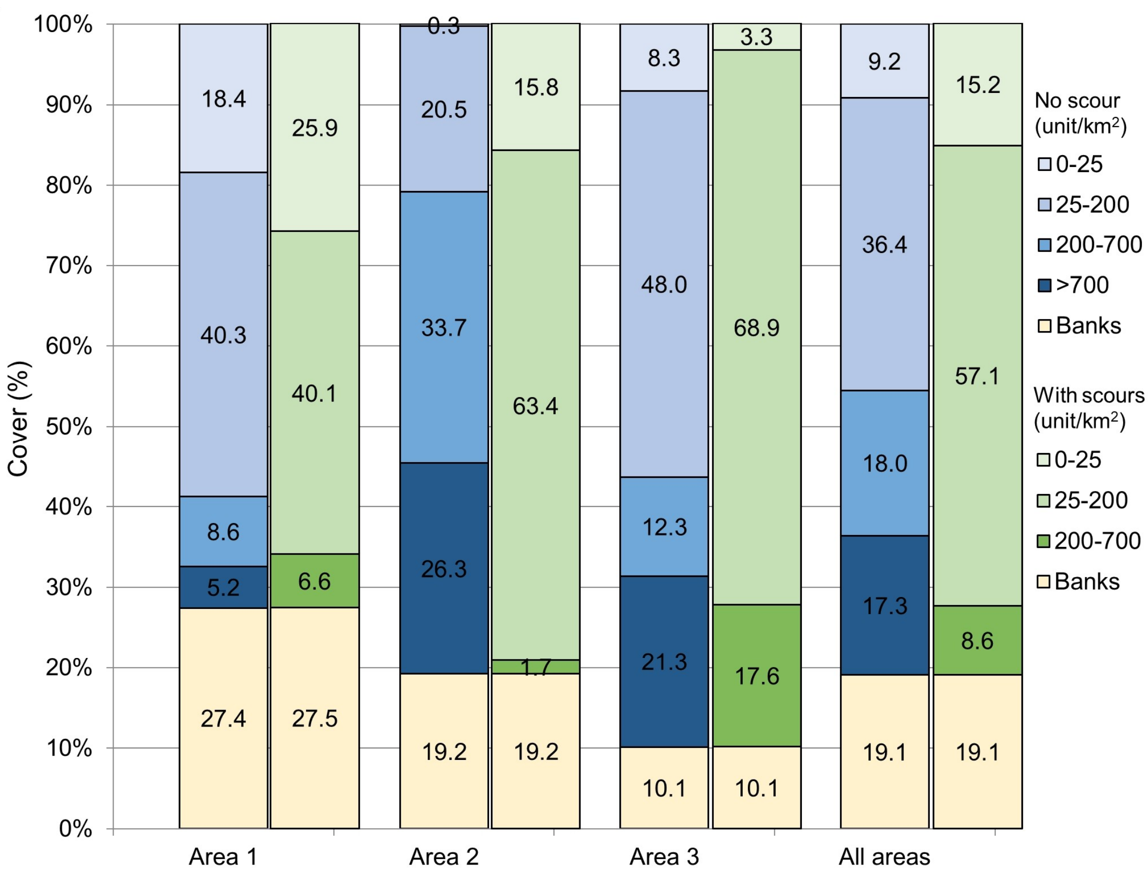


**Figure 2.** Area (%) covered by each density of pockmark field and for each type of pockmarks (blue shades: without scours; green shades: with scours).

**Table 3.** Coverage area for each non-scoured pockmark density class per survey area.

| Area ($km^2$) | 1 (0-25) | 2 (25-200) | 3 (200-700) | 4 (>700) | Banks | Total |
|---|---|---|---|---|---|---|
| Area 1 | 30.8 | 67.5 | 14.4 | 8.6 | 45.9 | 167.4 |
| Area 2 | 0.4 | 32.5 | 53.5 | 41.6 | 30.4 | 158.5 |
| Area 3 | 13.2 | 76.2 | 19.5 | 33.7 | 16.1 | 158.7 |
| Total | 44.4 | 176.3 | 87.4 | 84.0 | 92.5 | 484.6 |

**Table 4.** Coverage area for each scoured pockmark density class per survey area.

| Area ($km^2$) | 1 (0-25) | 2 (25-200) | 3 (200-700) | Banks | Total |
|---|---|---|---|---|---|
| Area 1 | 43.3 | 67.1 | 11.1 | 45.9 | 167.4 |
| Area 2 | 25.0 | 100.4 | 2.7 | 30.4 | 158.5 |
| Area 3 | 5.2 | 109.4 | 28.0 | 16.1 | 158.7 |
| Total | 73.5 | 276.8 | 41.7 | 92.5 | 484.5 |

## 3. Geochemistry analyses

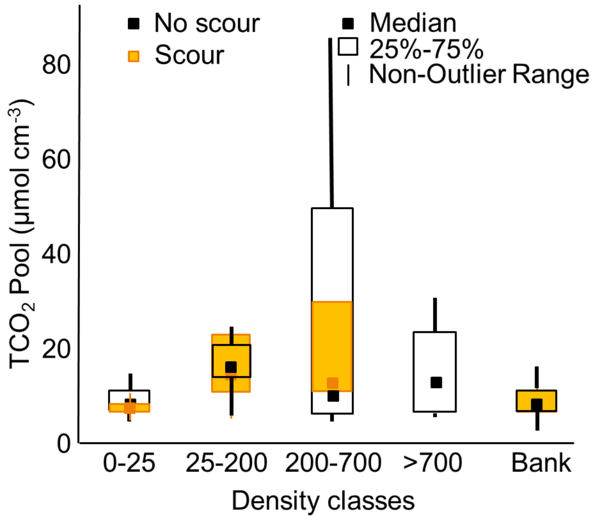


**Figure 3.** Box plots of the $TCO_2$ porewater pool concentrations per pockmark density class for both scour and non-scour pockmarks.

## 4. Polychaetes analysis

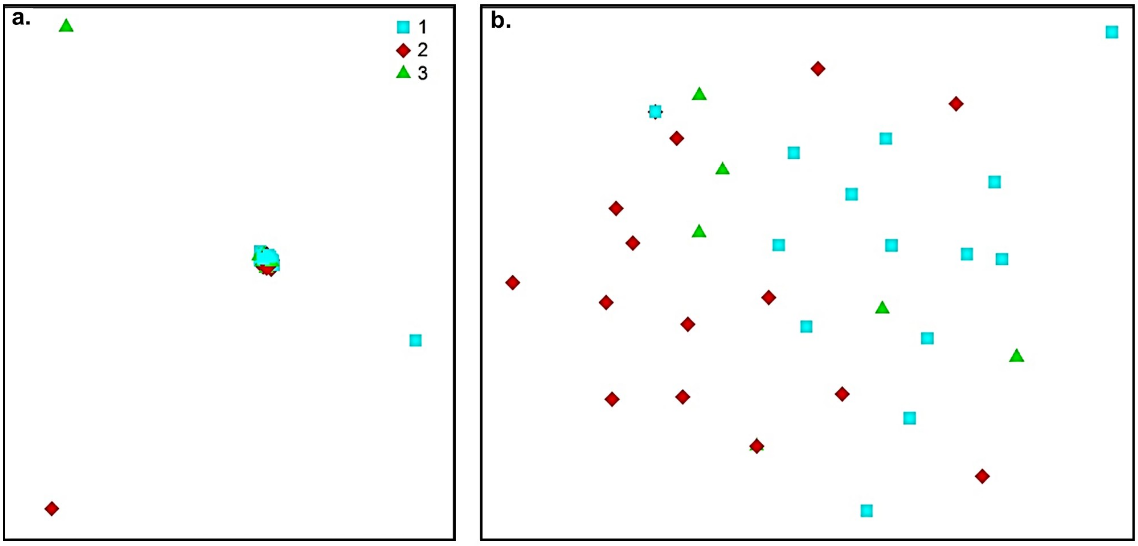


**Figure 4.** Non-metric multidimensional scaling (n-MDS) plots showing (**a**) all datapoints (stress = 0.01), and (**b**) excluding outliers (stress = 0.08). Each point represents a polychaete assemblage, with the distance between points representing similarities between assemblages.