Benthic recovery after dredging

authors Diane Jones
(Jay Willis)
John Harris
Michiel Knaapen
Stefania Schiania

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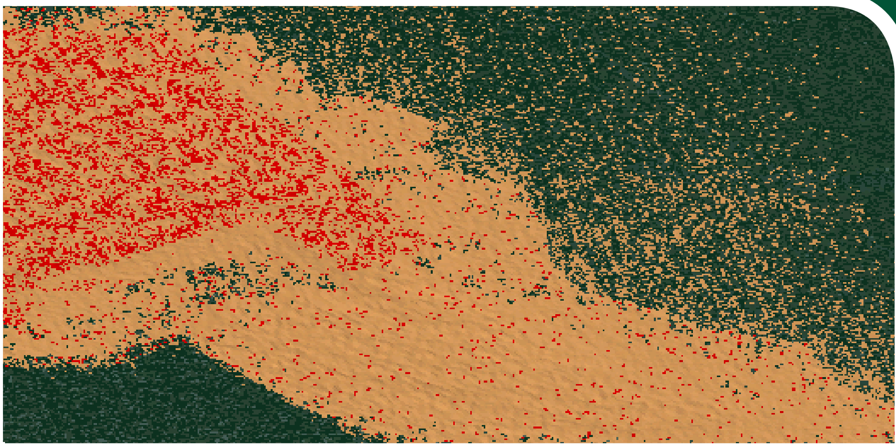

HR Wallingford modelled patterns of habitat and ecosystem recovery on the seabed after a major human induced disturbance using cellular automata

The primary aim of this study was to outline what information is required to develop a practical model of a dredging site, and the processes that are required to build the model. New methods have been developed for variable flow fields, multiple grain sizes, and simplified ecological rule systems so that realistic hydrodynamic models can be used to drive cellular automata models.

Cellular automata (CA) are capable of capturing complex sandwave, ripple and dune shapes which have proven particularly difficult for conventional methods of modelling sedimentary transport to capture. Building on earlier studies, we examined the potential of CA to model patterns of habitat and ecosystem recovery on the seabed after a major human induced disturbance.

The sediment CA model is initialised with a stack of slabs making up each cell of a square grid. A cell is chosen at random and the top slab is moved in the direction of the current. The current magnitude determines how many cells forward the slab moves. A slab reaching a destination cell may ‘stick’ and remain there, or ‘bounce’ and move again. A single model step is deemed to have passed once the number of random selections of cells is equal to the total number of cells in the grid - i.e. on average each cell has been selected once.

Eight different types of slab, 6 types of sediment, the absence of a slab and immoveable bedrock, were defined for the model. The sediment type in each vertical stack was determined from a linear (nearest neighbour) interpolation of sediment fractions from Boyd et al. (2004). In locations where there has been no, or only light dredging activity, the bed particles were selected randomly from a distribution similar to the measured bed composition. In dredged locations, the sediment was composed of randomly selected 'light' and 'heavy' particles, simulating the removal of the sand. The model was run and outputs compared to side-scan sonar images from Boyd et al. (2004). The results were similar to the sediment bedform actually observed, suggesting the CA realistically modelled sediment movement in the area.

The biological model is based on the information provided from a spatial survey of area 222 in 2001 (Boyd et al., 2004). This survey shows that the area is divided into three habitats approximately related to benthic data and dredging activity. The model was designed as a simple and quick proof-of-concept method rather than a predictive model. It is a simple individual based model, where each animal or plant is represented by a group of values in a vector. The values are updated as the model progresses and include, species, age and location. They are linked to a set-up matrix of values for each species which include initialisation parameters such as fecundity, lifespan and reproductive style. The biological model was run at the same time as the sediment model, with the results showing little re-colonisation of the dredged area. However, this is in contrast to field observations. It may be that the model did not accurately reflect potential species colonisation and migration due to a lack of data. This model would benefit from use of real species data to predict recovery of the benthos after dredging.

References

BISHOP, S. R., MOMIJI, H., CARRETERO-GONZALEZ, R. & WARREN, A. 2002. Modelling desert dune fields based on discrete dynamics. Discrete Dynamics in Nature and Society, 7, 7-17.

BOYD, S. E., COOPER, K. M., LIMPENNY, D. S., KILBRIDE, R., REES, H. L., DEARNALEY, M. P., STEVENSON, J., MEADOWS, W. J. & MORRIS, C. D. 2004. Assessment of the seabed following marine aggregate dredging. Sci. Ser. Tech. Rep., CEFAS, Lowestoft, 121: 154pp.

HAMMOND, F. D. C. 1979. A grain-by-grain computer simulation of sand ripple formation. Marine Geology, 31, 53-60.

NIELD, J. M. & BAAS, A. C. W. 2008. Investigating parabolic and nebkha dune formation using a cellular automaton modelling approach. Earth Surface Processes and Landforms, 33, 724-740.

SCHINAIA, S. A., MOMIJI, H., BISHOP, S. R., SIMONS, R. R. & SAUNDERS, J. 2009. PREDICTING THE RECOVERY OF BIOLOGICAL COMMUNITIES ON THE SEABED AFTER MARINE AGGREGATE DREDGING, Singapore, World Scientific Publ Co Pte Ltd.

WILSON, I. G. 1972. Aeolian bedforms - their development and origins. Sedimentology, 19, 173-210.

HR Wallingford
Howbery Park
Wallingford
Oxfordshire OX10 8BA
United Kingdom

tel +44 (0)1491 835381
fax +44 (0)1491 832233
email info@hrwallingford.com

www.hrwallingford.com