Annex 4: Biodiversity science: a case study from Belgian marine waters

Facts from history - The former ecological value of gravel grounds in Belgian marine waters: their importance for biodiversity and relationship with fisheries

Jean-Sébastien Houziaux[1], Jan Haelters[2] & Francis Kerckhof[2]

Royal Belgian Institute of Natural Sciences

[1] Dept of Invertebrates. Rue Vautier, 29 B-1000 Brussels

[2] Management Unit of the North Sea Mathematical Models. 3e en 23e Linieregimentsplein, B-8400 Oostende

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Introduction

Gravels form a patchy and heterogeneous habitat in the southern bight of the North Sea, generally dominated by a sandy seafloor. These deposits are found in the Dover Strait area up to the Belgian border (Davoult et al, 1988) and off the Thames estuary. On the Belgian Continental Shelf, the historic literature (19th century) and unpublished data from surveys by G. Gilson[3] (RBINS, 1899-1910) point at former co-existence of several important ecosystem functions associated to forgotten offshore “boulder fields” (Van Beneden, 1883). In the area of the Westhinder sandbank, some 15-25 nautical miles off the western Belgian coast, high levels of epibenthic species richness and taxonomic breath, wild beds of the European flat oyster (*Ostrea edulis*) as well as a spawning ground for the North Sea herring (*Clupea harengus*) seemingly used to occur. The area was also known as a good trawling spot in the early 20th century.

Recent information on gravelly habitats within Belgian waters is scarce. Multibeam echosounding surveys carried out under the auspices of the mapping programme of the marine aggregate resources on the Belgian Continental Shelf have clarified the location of several gravel fields in the Flemish sandbanks area (Roche, 2002). These can be delimited using acoustic backscatter imaging and classification in combination with morphological maps. An exploratory acoustic survey recently mapped the presumed extension of gravel fields along the south-eastern flank of the Westhinder sandbank (Deleu, 2002). However, the nature of this coarse deposit remained unclear (it was defined by Veenstra (1964) as small rounded pebbles of fluviatile origin), and the current state of its associated biodiversity was undocumented.

Benthic habitats and communities

Investigating the former (baseline) ecological value of this area, its long-term trajectory was performed using a wide range of data sources and methods. Firstly, the collection of sediments and benthos of G. Gilson (1899–1910), held at the Royal Belgian Institute of Natural Sciences (RBINS), was investigated to identify the extent of the gravelly grounds and describe their associated diversity within the surveyed area. More than 2000 sediment descriptions were used to derive thematic maps of sediment constituents: sand grain-size, mud content, shell and shell debris content, and gravel content. Additional cobbles collected with towed gears indicated highest densities of cobbles in the surface sediment along the south-eastern flank of the Westhinder sandbank (Figure A4.1a). Sand was also collected in this area, pointing at a

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[3] Prof. G. Gilson has also lead the Belgian contribution to ICES cooperative research programmes with hydrographic, planktonic and fishery data, in the first decade of the 20th century.

sandy cobble field. On the other hand, the epibenthic invertebrates stored in the RBINS repositories, which resulted from about 900 dredgings carried out in the same area, was digitised and processed.

Reconstructing the species lists of every sample demonstrated highest levels of species richness and taxonomic breadth in the same area, although species typical for gravels were collected in other gravel fields as well (Figure A4.1b). In particular, some large colonies of branching species such as the bryozoans *Alcyonidium* sp. and *Flustra foliacea*, the sponge *Haliclona oculata* or the anthozoan *Alcyonium digitatum* were found in the area as well as specimens of flat oysters (*Ostrea edulis*).

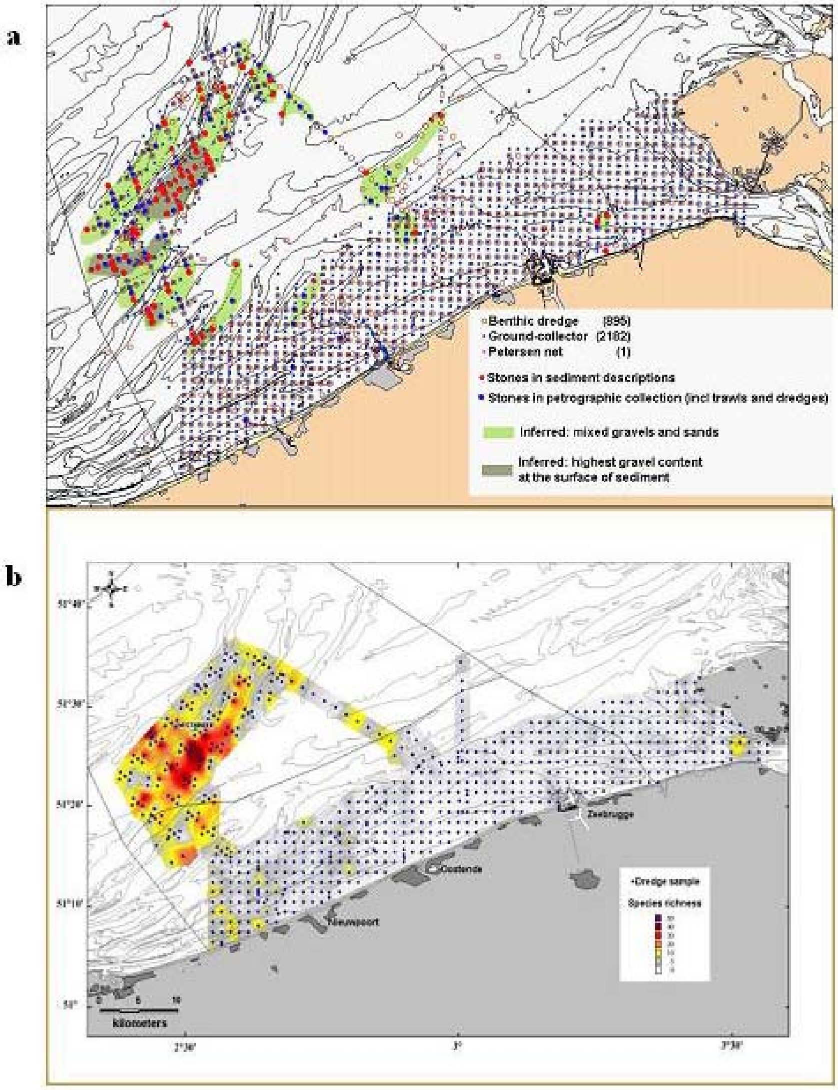

Figure A4.1. Results of re-processing historic sediment and benthos information of the collection of Gilson (RBINS, 1899–1910). a. (left). Overall sampling grid of G. Gilson, with the reconstructed distribution of gravel fields derived from information on gravel occurrence in sediment descriptions and from cobbles collected with towed gears. b. (right) Interpolation of species richness values within the dredge sampling grid. Highest values coincide with largest taxonomic breadth. Figures from Houziaux (2007).

From a compilation of older literature and archives, it has been possible to derive the former position of wild beds of the European flat oyster *Ostrea edulis* (Houziaux and Kerckhof, in prep). These were overexploited and exhausted in the area in the 1870s within five years. A large bed existed along the south-eastern flank of the Westhinder bank. Low numbers of live oysters were collected by Gilson in the same location in the 1900s. Since it is likely that no fishery activity was exerted on this ground in between, this indicates a trend to a very slow re-colonisation process. This is in agreement with indications provided by oystermen in historic reports about oyster fishery, namely that some exhausted “deep-sea” beds in the English Channel did not recover over a 40-year period. Offshore beds went commercially extinct during the 19th century and the overall coastal stock collapsed across Europe in the early 20th century. In contrast, before the 19th century, depleted coastal beds in historical production centers (e.g. French Brittany) recovered within 10–15 years (e.g. during war periods).

Our investigation of the oyster literature of the 19th century thus indicates that the importance of these offshore beds for the overall population has most probably been overlooked so far. It points at very slow recovery rates, probably exceeding 50 years. This is an important outcome of the work regarding future management of this species, which is regarded as a key-species for ecosystem functioning and thus a priority species for conservation and restoration actions, e.g. within the OSPAR framework (OSPAR, 2003).

Since no data was yet available regarding the present status of the benthos in the surroundings of the Westhinder sandbank, a targeted re-sampling of some remarkable historic stations was performed by combining epibenthos sampling (2m beam trawl), underwater video-recordings and multibeam echosounding within a collaborative framework (Houziaux *et al*., submitted).

Scuba-operated video footages revealed that the seafloor indeed consists of a field of cobbles and larger boulders partly covered with a thin (5–10 cm) sand layer (Figure A4.2a). It still hosts high levels of epibenthic species richness. The epibenthic survey, although incompletely analysed yet, evidenced the large taxonomic breadth in this fauna, illustrated by the fact that several new or rare species, some new to the North Sea, have been observed. However, several taxa are hard to identify without specialist skills. For instance, bryozoans exhibit a remarkable species richness, with up to about 70 species identified at one single station, but this diversity could only be highlighted thanks to the strong involvement of a taxonomic expert (De Blauwe *et al.*, 2006). Part of the investigated material was obviously collected alive, part consisted of dead colonies. As a large part of these were found on shells, it is now planned to reinvestigate the shells of the historic collection to specifically analyse changes in the bryozoan fauna in the long run, a topic which could provide interesting insights in questions related to climate change and invasive species. Regarding the latter issue, the amount of invaders so far identified was found to be very low (e.g. one or two specimens of *Crepidula fornicata*) as compared to what is observed in coastal waters. There is a need to strengthen the available capacity for identification of difficult taxa in order to monitor local biodiversity patterns and their long-term trends.

Flat oysters were not collected at all. There is a sharp decrease in the abundance of large colonies of branching species as compared to the historic situation, with some species virtually disappeared (e.g. the sponge *H. oculata*) and some others represented mostly by very small colonies (e.g. the dead man’s finger *A. digitatum*).

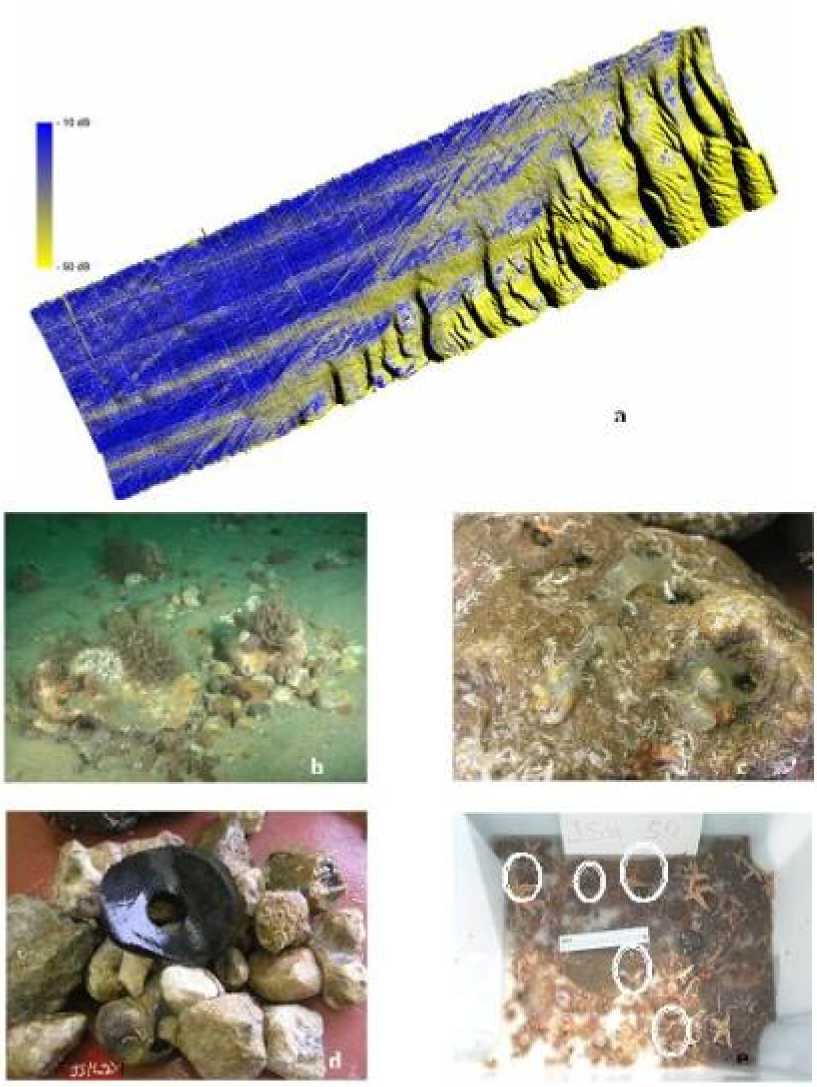

Figure A4.2a. Extract of underwater video footage of the seafloor at the gravel field of the Westhinder bank (images acquired thanks to the project "BeWreMaBi", Belgian Science Policy). b. Multibeam echosounding: distribution of backscatter strength values in one of the surveyed areas (high backscatter correspond with hard substratum), evidencing abundance of trawl marks in the transition area between the sandbank and the central gully. Multibeam echosounding data kindly provided by the Fund for Sand Extraction, Belgian Ministry of Economy (M. Roche and K. Degrendele). c. Damaged *Pomatoceros* tubes colonized by ascidians on a cobble collected with the small beamtrawl. d. A trawl bobbin with collected cobbles. e. High proportions of starfish with missing arms.

The surveys evidenced direct impacts by bottom trawling on the gravel field. A large proportion of cobbles bear traces of mechanical disturbance in the form of damaged tubes of the worm *Pomatoceros triqueter*, damaged barnacles or broken cobbles (Figure A4.2c). A large fraction of the starfishe *A. rubens* exhibits missing or regenerating arms (Figure A4.2e). Coverage of the sampled areas with multibeam echosounding evidenced the abundance of trawl marks on the seafloor of the transitional zone between the sandbank and the central gully (Houziaux *et al.*, submitted; Figure A4.2b). Video footages did not reveal direct impacts, but they evidenced frequent encounters with loose cobbles in sandy areas outside the gravel fields, which were most probably thrown overboard by trawlers. Aerial surveys further confirmed the regular presence of large trawlers in the area. All these observations, combined with the sound knowledge accumulated on effects of bottom trawling on benthic habitats (e.g. Kaiser *et al*., 2002), strongly suggest that the observed degradation of the local biodiversity can be attributed to bottom trawling pressure.

Fish spawning

Another aspect of the ecological value of these gravels can be found in their role for fish foraging and spawning. The Down's herring in particular was identified to spawn in the area of the Hinder sandbanks, e.g. by Postuma (1977) within an ICES cooperative research framework. As an outcome of this ICES meeting, a proposal was made for implementation of protection measures against the detrimental effect of aggregate extraction (Figure A4.3). The potential impact of bottom trawling itself was not mentioned; however, during a previous ICES symposium on early stages of herring, Burd and Wallace (1971) had concluded that the low amounts of Down's herring larvae observed in field samples, as compared to expected amounts based on spawning stock assessments, could be due to direct trawling impacts on spawn. This tends to indicate subjectivity in the way certain management measures were proposed (i.e. traditional confrontation between users of the sea) independently from "true impact" assessments. It is important to note that the artificially fecundated eggs of Burd and Wallace were obtained from ripe males and females gathered, among others, from the Hinder fishery onboard UK commercial vessels. This information thus points at a serious trawling pressure on the Hinderbank gravel fields since at least the 1950s.

We can trace impacts of this fishing practice further back in time. Indeed, Gilson (1921) made the following statement: "*Herring lays its eggs but on these stony substrates, where fishing with trawls is difficult, a condition which protects these eggs against the destructive action of this kind of net. But there exists amongst these steam trawlers a* <u>*growing tendency to fish on these grounds*</u>*, and to invent gears that allow them to scrape even this rocky bottom; it is not impossible that for this* <u>*and other*</u> *reasons their protection becomes necessary one day*.". The concern about impact of trawling (or aggregate dredging) on ecological functions associated with offshore gravels is thus nothing new, and it can be stated that gravels of the southern bight have been significantly impacted by bottom trawling since at least the 1920s. Despite repeated warnings and accurate questions, no measure was thus ever effectively undertaken. One probable cause accounting for this situation can be found in the situation of such ground outside the territorial sea. The current need of an "ecosystem approach" to fishery management might change this situation in the near future, provided commitments of the past are taken into consideration and re-evaluated.

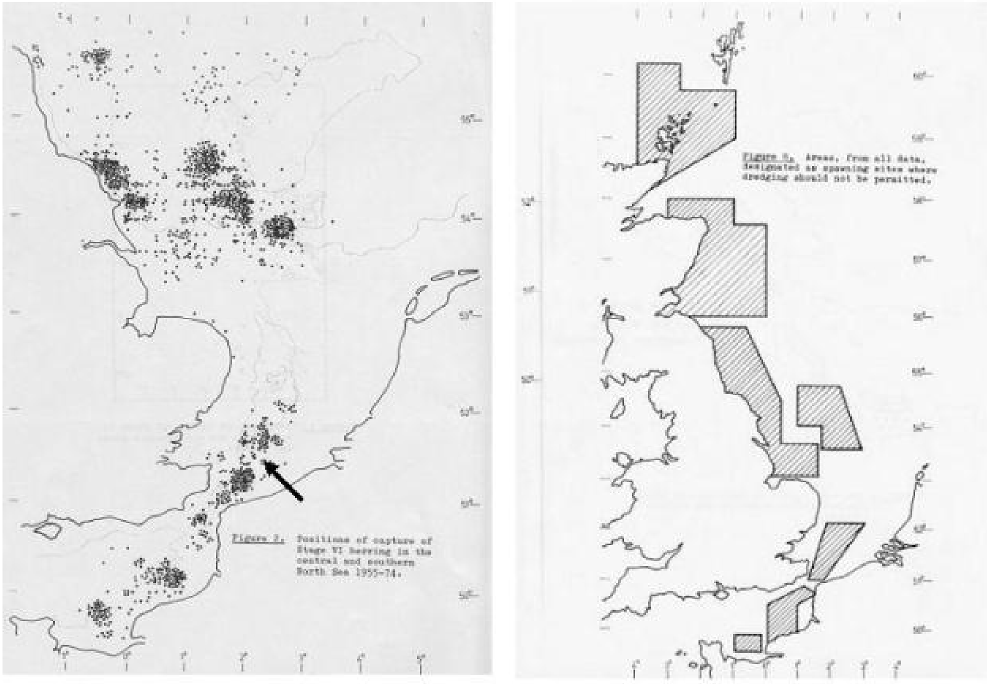

Figure A4.3a. Herring spawning grounds of the English Channel and North Sea. The arrow points at the position of the Westhinder bank. b. Proposal of area closures to aggregate dredging activities in order to protect herring spawning. Source: Postuma *et al.*, 1977.

One question addressed as a result of this work is the role played by large epilithic branching species in the success of herring spawning, since this fauna had never been taken into consideration since Gilson's work. Postuma *et al.* (1977) have put forward that herring needs clean gravels to lay down its eggs, but we can now state that gravels of the Westhinder area are of a very different nature. Seaweeds seem to be preferred by some near-shore spawners, suggesting that in highly dynamic areas such as the southern bight, the presence of a dense cover of large branching species on cobbles could be an important parameter in stabilizing the deposited egg-mat. The removal of large branching species through bottom trawling could thus have indirect effects on herring reproductive success as well. This topic seems to be little documented if at all.

Noticeably, these large colonies are also most probably important for egg-laying in the lesser spotted dogfish *Scyliorhinus canicula*, as highlighted by the observation of egg-cases attached to samples of *Haliclona oculata* from the Westhinder area, in the historic collection. Scyliorhinids, which are important predators of benthic invertebrates, thus also probably depend on the health of gravel field fauna for their reproduction.

General considerations on the results

A key outcome of the overall investigation is that questions about flat oyster and herring conservation are directly related to offshore gravel habitat health. In the southern bight at least, bottom trawling has started to affect this habitat in the early 20th century and increased since then. This implies that bottom trawling could have played a major role in the non-reinstallation of natural offshore beds of the flat oyster in the 20th century, a hypothesis echoed in formerly productive areas elsewhere (e.g. French Brittany). To what extent has bottom trawling contributed to fragmenting the populations of herrings after World War 2 is unknown, but it could have played a significant role in the successive collapses observed since then.

The North Sea is probably one of the most studied seas in the world since the 19th century. Herring and flat oysters are both species nowadays considered as “well-known”. This study highlights the possible outcome of re-investigating and crossing former studies on topics generally considered as “well-understood”. Poorly documented links between biodiversity components are put forward, which might be of crucial importance within an “ecosystem-based” approach to fishery management. By application of criteria for the designation of Marine Protected Areas (MPAs), agreed under the OSPAR Convention, Haelters et al (in prep) further suggest that the considered area qualifies as an MPA under OSPAR Recommendation 2003/3 on the creation of a network of MPAs, and potentially also under the European Habitats Directive.

The study also shows that data collected in the early 1900s correspond to a situation of “shifted baseline”: Belgian coastal waters had already been impacted by bottom trawling since the 1820s, while offshore gravels, traditionally avoided by sailors, had been visited by oystermen who have destroyed natural biogenic reefs. Assessing the “ecological value” of a marine habitat thus calls for establishing a well-documented baseline situation, which furthermore provides important insights in the evaluation of the chances of recovery of its associated biodiversity. This advocates for increasing work in the field of historical ecology.

Through its long-established position as leading body for fishery science, ICES can be regarded as the most comprehensive source of information for the interactions between the marine ecosystem and human activities during the 20th and 21st centuries. For instance, it is likely that re-processing old hydrographic and planktonic data as well as fisheries statistics could provide important information for what regards long-term trends in the system. It provides ground for promising analyses aimed at a better understanding of the interactions between biodiversity, ecosystem functioning and the human component to ensure sustainability of marine resources.

Acknowledgements

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