Physical impacts induced by bottom trawling in the 'Grande-Vasière' area (Bay of Biscay)

Mengual Baptiste[1], Florence Cayocca[1], Pierre Le Hir[1], Thierry Garlan[2] and Pascal Laffargue[3]

[1] IFREMER, DYNECO/PHYSED, ZI pointe du Diable, CS10070, Plouzané, France
E-mail: mailto:Baptiste.Mengual@ifremer.fr

[2] SHOM, Hydrographic Center, PO Box 146, F-29280, Brest, France

[3] IFREMER, EMH, Rue de l'île d'Yeu, PO Box 21105, 44311 Nantes Cedex 03, France

Introduction

Bottom trawling in coastal environments is known to modify the upper sedimentary characteristics and to generate significant local resuspension. The impacts intensity depends on the nature of the substratum (more significant for fine sediment such as mud), the weight of the gear components, the trawl towing velocity, and the local hydrodynamic conditions (Jones, 1992). Some gear components such as doors or footropes can penetrate deep in the surficial sediment (from a few centimetres to a few tens of centimetres; Linnane *et al.*, 2000) and can generate significant local resuspension. Only a few percents of the reworked sediment are really injected into the water column as suspended sediments (Durrieu de Madron *et al.*, 2005). This sediment resuspension is mainly due to doors impact (about 70% to 80% of the total mass resuspended; O'Neill and Summerbell, 2011). This process results in the formation of a turbid plume in the trawl wake. The typical plume vertical height corresponds to 2 to 3 times the vertical opening of the net (Main and Sangster, 1981; Durrieu de Madron *et al.*, 2005) and the resulting near bottom suspended sediment concentrations can reach several hundreds of milligrams per litre (e.g. Durrieu de Madron *et al.*, 2005; Dellapenna *et al.*, 2006; Martin *et al.*, 2013). Palanques *et al.* (2014) showed that the suspended sediment concentration in a trawled area is about three times higher than in a protected area. Concerning bottom impacts, the surficial sediment reworking due to bottom trawling leads to the modification of the sediment properties in terms of grain size, silt content and organic content, which all increase upwards in the upper part (20cm) of the surficial sediment layer (Dellapenna *et al.*, 2006; Palanques *et al.*, 2014). Besides, trawl marks can persist from several months for up to one year for a fine sediment substratum (Palanques *et al.*, 2014; Linnane *et al.*, 2000). The 'Grande-Vasière' (G-V) area (about 8000km²) is subjected to deposition and remobilization cycles controlled by river discharges, tidal currents, storms and anthropic factors in particular bottom trawling. The balance between these deposition and erosion factors controls its temporal evolution. Bourillet *et al.* (2006) have proposed a first estimation for the contribution of each factor to the G-V evolution. They suggested that the trawling-induced fine particle remobilization represents about 10% to 30% of the storm-induced erosion. However, this estimation was based on several hypotheses required in order to make up for the lack of quantitative *in situ* measurements. This underlines the necessity of quantifying the physical processes so as to verify these first conclusions and to characterize the local mass of sediment resuspended by bottom trawls.

Methodology and results

This study is based on two field experiments investigating two separate zones and testing two types of trawl (classical versus less damaging one). The two zones differ by the nature of the bottom sediment, with different mud contents (from 25% to 75% respectively). The first set of experiments investigated the typical trawl used by the regional common fleet whereas the last experiments investigated an alternative trawl configuration characterized by an innovative technology for the doors ('Jumper'). These doors don't have a permanent contact with the seabed, which makes them potentially less damaging for the benthic environment. Measurements located in the water column followed a similar strategy as proposed by Durrieu de Madron *et al.*, (2005) with Conductivity Temperature Depth sensors, turbidity sensors, and a high frequency Acoustic Doppler Current Profiler. Different sensors were also directly fixed to the most impacting parts of the trawl, thus permitting to quantify the turbidity generated just behind the trawl. Finally, bottom impacts were observed in terms of penetration of the different parts of the net thanks to high definition video cameras and laser systems, and the surficial reworking thanks to interface cores.

These experiments allowed quantifying the local resuspension and the surficial sedimentary modifications generated in the trawl wake. Results show a turbid plume 3 to 4 metres high, concentrated very near of the seabed. This observation is consistent with the vertical opening of the net of approximately one metre. Temporal variability of local concentration profiles near the seabed has permitted to estimate the particles settling velocity in the two different zones. Furthermore, the turbid plume transversal dispersion and its turbidity gradients in the trawl wake have been estimated, including just behind the trawl. Turbidity measurements revealed values about 4 times

higher behind the doors than in the clump wake, which confirms the importance of their impact. Sea experiments have also permitted to observe and quantify the trawl furrow depth and the reworking of the surficial sediment layer induced by bottom trawling. The links between furrow volumes and the local quantity of sediment injected in the water column are also investigated.

Conclusions

This study allowed quantifying physical processes induced by bottom trawling in an intensely trawled area of the Bay of Biscay. It also assesses the added value of innovative technologies of doors regarding environmental impacts. The investigation of the turbid plume dynamics during sea trials has permitted to evaluate its three-dimensional behaviour in the trawl wake and the deposition fluxes. These *in situ* measurements allow to better understand the different physical processes at stake and to accurately calibrate a future model. Indeed, this work will be used as the basis of a modelling approach integrated in a pre-existent hydro-sedimentary model so as to quantify the influence of bottom trawling at a regional scale and for long periods.

Acknowledgments

This study was supported by the SHOM (Service Hydrographique et Océanographique de la Marine) and IFREMER (Institut Français de Recherche pour l'Exploitation de la Mer). Sea trials were funded by the BENTHIS project.

References

Bourillet J.F., J.M. Jouanneau, C. Macher, P. Le Hir and F. Naughton. 2006. 'La Grande Vasière' mid-shelf mud belt: Holocene sedimentary structure, natural and anthropogenic impacts. X International Symposium on Oceanography of the Bay of Biscay, April 19-21 2006. Vigo, Galicia. Spain. http://archimer.ifremer.fr/doc/00000/6243/

Dellapenna T.M., M.A. Allison, G.A. Gill, R.D. Lehman and K.W. Warnken 2006. The impact of shrimp trawling and associated sediment resuspension in mud dominated, shallow estuaries. Estuarine, Coastal and Shelf Science, 69 (3–4), 519–530.

Durrieu de Madron X., B. Ferré, G. Le Corre, C. Grenz, P. Conan, M. Pujo-Pay, R. Buscail and O. Bodiot. 2005. Trawling-induced resuspension and dispersal of muddy sediments and dissolved elements in the Gulf of Lion (NW Mediterranean). Continental Shelf Research 25:2387–2409.

Jones J.B. 1992. Environmental impact of trawling on the seabed: a review. New Zealand Journal of Marine and Freshwater Research 26:59–67.

Linnane A., B. Ball, B. Munday, B.V. Marlen, M. Bergman and R. Fonteyne. 2000. A review of potential techniques to reduce the environmental impact of demersal trawls. Irish Fisheries Investigations (New Series) 7:39.

Main J. and G.L. Sangster. 1981. A study of sand clouds produced by trawl boards and their possible effect on fish capture. Scottish fisheries Research Report no 20. Dept of Agriculture and Fisheries for Scotland, 19.

Martín J., P. Puig, A. Palanques and M. Ribó 2013. Trawling-induced daily sediment resuspension in the flank of a Mediterranean submarine canyon. Deep-Sea Research II. http://dx.doi.org/10.1016/j.dsr2.2013.05.036.

O'Neill F.G. and K. Summerbell. 2011. The mobilisation of sediment by demersal otter trawls. Marine Pollution Bulletin 62:1088-1097.

Palanques A., P. Puig, J. Guillén, M. Demestre and J. Martín. 2014. Effects of bottom trawling on the Ebro continental shelf sedimentary system (NW Mediterranean). Continental Shelf Research 72:83-98.