Supplementary material for: **Using underwater video to assess megabenthic community vulnerability to trawling in the Grande Vasière (Bay of Biscay)**

Laurène Mérillet\*1,2, Maud Mouchet1, Marianne Robert2, Michèle Salaün2, Lucie Shuck2, Sandrine Vaz2, Dorothée Kopp2.

1 UMR 7204 MNHN-UPMC-CNRS Centre d’Ecologie et de Sciences de la COnservation, 43 rue Buffon, 75005 Paris, France

2 Ifremer, Unité de Sciences et Technologies halieutiques, Laboratoire de Technologie et Biologie Halieutique, 8 rue François Toullec, 56100 Lorient, France

3 Ifremer, Laboratoire Halieutique Méditerranée, UMR MARBEC, Avenue Jean Monnet, 34200 Sète, France

The following documents give precisions about: (1) the scoring of the vulnerability for the 5 biological traits considered (Tables S1 and S2); (2) the calculation of the swept area and trawling frequency in each grid cell; (3) the packages used to perform analysis and the outcomes of the GLM models for the commercial and non-commercial species separately (Table S3) and the plotted relationship between the GLM models fitted values and the explanatory variables selected in these models (Fig. S1).

1. **Scoring of the vulnerability for the 5 biological traits considered**

Table S1 Five categories of biological traits and their respective scoring scheme (from de Juan *et al.* 2009).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sensitivity scores | Position | Feeding | Motility | Size | Fragility |
| 0 | Deep burrowing | Scavengers | Highly mobile (swimming) | Small < 5 cm | Hard shell, burrow, vermiform, regeneration |
| 1 | Surface burrowing (first cm) | Deposit feeders/predators | Mobile (crawling) |  | Flexible |
| 2 | Surface |  | Sedentary | Medium 5-10 cm | No protection |
| 3 | Emergent | Filter feeders | Sessile (attached) | Large > 10 cm | Fragile shell/structure |

The lowest scores were assigned to the less vulnerable taxa. For a total score value under 8, taxa were assigned to the least vulnerable group, group A. Likewise, taxa were allocated to group B if their total score value fell between 8 and 9, to group C if it was between 10 and 13, or to group D if it was above 13.

Table S2 Vulnerability scoring for each biological traits and their sum per taxa. The higher scores indicate a higher vulnerability to trawling.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Species** | **Taxonomic level** | **Position** | **Feeding** | **Motility** | **Size** | **Other attributes** | **Total score** |
| Paguroidae  | Superfamily | 2 | 0 | 1 | 0 | 1 | 4 |
| Gobiidae  | Family | 2 | 1 | 0 | 0 | 2 | 5 |
| Crabs unidentified (Brachyura)  | Infraorder | 2 | 1 | 1 | 2 | 1 | 6 |
| Shrimps unidentified (Decapoda)  | Order | 2 | 1 | 1 | 0 | 2 | 6 |
| *Nephrops norvegicus*  | Species | 0 | 1 | 2 | 3 | 1 | 7 |
| *Goneplax rhomboides*  | Species | 2 | 1 | 1 | 2 | 1 | 7 |
| Blenniidae  | Family | 2 | 1 | 0 | 2 | 2 | 7 |
| Sea star unidentified (Asteroidea)  | Class | 2 | 1 | 1 | 3 | 0 | 7 |
| *Munida rugosa*  | Species | 2 | 3 | 1 | 0 | 2 | 8 |
| *Aphrodita aculeata*  | Species | 2 | 1 | 1 | 3 | 1 | 8 |
| Jelly fish unidentified (Cnidaria)  | Phylum | 3 | 1 | 0 | 3 | 1 | 8 |
| *Callionymus* sp.  | Genus | 2 | 1 | 0 | 3 | 2 | 8 |
| *Lepidorhombus* sp.  | Genus | 2 | 1 | 0 | 3 | 2 | 8 |
| Triglidae  | Family | 2 | 1 | 0 | 3 | 2 | 8 |
| *Microstomus kitt* | Species | 2 | 1 | 0 | 3 | 2 | 8 |
| *Lophius* sp.  | Genus | 2 | 1 | 0 | 3 | 2 | 8 |
| Flat fish unidentified (Pleuronectiformes) | Order | 2 | 1 | 0 | 3 | 2 | 8 |
| *Octopus* unidentified  | Genus | 2 | 1 | 0 | 3 | 2 | 8 |
| Rajiformes | Order | 2 | 1 | 0 | 3 | 2 | 8 |
| Soleidae  | Family | 2 | 1 | 0 | 3 | 2 | 8 |
| *Scyliorhinus* sp. | Genus | 3 | 0 | 0 | 3 | 2 | 8 |
| Actinopterygii ni | Class | 3 | 1 | 0 | 2 | 2 | 8 |
| *Capros aper*  | Species | 3 | 1 | 0 | 2 | 2 | 8 |
| *Cancer pagurus* | Species | 2 | 1 | 1 | 3 | 1 | 8 |
| Ophiuroidea  | Class | 2 | 1 | 1 | 2 | 3 | 9 |
| Anguilliforme unidentified  | Order | 3 | 1 | 0 | 3 | 2 | 9 |
| *Cepola* sp.  | Genus | 3 | 1 | 0 | 3 | 2 | 9 |
| *Trachurus trachurus*  | Species | 3 | 1 | 0 | 3 | 2 | 9 |
| *Conger conger* | Species | 3 | 1 | 0 | 3 | 2 | 9 |
| *Loligo* sp.  | Genus | 3 | 1 | 0 | 3 | 2 | 9 |
| Gadiformes | Order | 3 | 1 | 0 | 3 | 2 | 9 |
| *Argentina sphyraena* | Species | 3 | 1 | 0 | 3 | 2 | 9 |
| Sepiidae unidentified  | Family | 3 | 1 | 0 | 3 | 2 | 9 |
| *Spirographis* sp.  | Genus | 2 | 3 | 2 | 0 | 3 | 10 |
| *Cerianthus* sp.  | Genus | 3 | 3 | 3 | 3 | 2 | 12 |
| Crinoidea  | Class | 3 | 3 | 1 | 2 | 3 | 12 |
| Pennatulacea  | Order | 2 | 3 | 3 | 3 | 2 | 13 |
| Hydrozoa  | Class | 3 | 3 | 3 | 3 | 3 | 15 |
| Alcyonacea  | Order | 3 | 3 | 3 | 3 | 3 | 15 |

**(2) the calculation of the swept area and trawling frequency in each grid cell**

Fishing hours in a 3’x3’ grid cell was taken as a proxy of fishing intensity. However, this metric does not give information on the area of the seabed impacted. Following Eigaard *et al.* (2016), the swept area and the trawling frequency were calculated in each grid cell. Fig. 11 gives a value of the hourly swept area (surface impact) for otter trawl targeting *Nephrops* (OT\_CRU) of 0.35km2 for an average vessel. We checked this value correspond to the fishing practices in our study area. The swept area per hour for OT\_CRU is given by

Aswept per hour  = W \* S

Where W the average distance between the doors (considering the gear path width impacts 100% of the surface), and S the average fishing speed.

For an average fishing speed of 3 knots, the average width is 63m. These values are in line with the ones of the standard fishing practices of OT\_CRU vessels in the Grande Vasière.

Swept area was obtained multiplying fishing hours data by 0.35km2.h-1, following:

Aswept  = Aswept per hour \* E, where E is the trawling effort in fishing hours.

Area of each grid cell was computed under Qgis versions 2.12.1-Lyon according to the variation with latitude. Trawling frequency was calculated as swept area divided by grid cells area.

Supplementary Reference:

Eigaard, O.R., Bastardie, F., Breen, M., Dinesen, G., Hintzen, N.T., Laffargue, P., Mortensen, L.O., Nielsen, J.R., Nilsson, H.C., O’Neill, F.G., Polet, H., Reid, D.G., Sala, A., Sköld, M., Smith, C., Sorensen, T.K., Tully, O., Zengin, M., Rijnsdorpa, A.D., 2016. Estimating seabed pressure from demersal trawls, seines, and dredges based on gear design and dimensions. ICES J. Mar. Sci. 73, 27–43. doi:10.1093/icesjms/fst176

**(3) information on the packages used to perform analysis and the outcomes of the GLM models for the commercial and non-commercial species separately and the plotted relationship between the GLM models fitted values and the explanatory variables selected in these models**

All analyses were performed using packages car (Fox and Weisberg, 2011), MASS (Venables & Ripley 2002), fmsb (Nakazawa 2007) and plotrix (Lemon 2006)

Supplementary References:

Fox J. & Weisberg S. (2011) An R Companion to Applied Regression, Second Edition, Sage.

Lemon J. (2006) Plotrix: a package in the red light district of R. *R-news* **6:** 8–12

Nakazawa M. (2014) fmsb: Functions for medical statistics book with some demographic data. *R package version 0.4*.

Venables W.N. & Ripley B.D. (2002) Modern applied statistics with S Fourth Edition. Springer New York. ISBN 0-387-95457-0.

Table S3 Outcomes of the stepwise selection procedure on the GLM models for commercial and non-commercial taxa in sensitivity groups A and B. The departure of the deviance of the model from deviance of the null model was tested with a χ2 test. The significance of each variable was then tested with a χ2 test whose p-value is given in the column “Significance”.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|   | **Explanatory variable** | **Estimate** | **Deviance** | **Significance** |
|
| GROUP Acommercial | Trawl | 1.19.e-3 | 6.32 | 1.19.e-2 |
| *χ2 between null and selected model = 6.12, p=1.32.e-2* |
|  |  |  |  |  |  |
| GROUP Anon commercial | Depth2 | -1.34.e-4 | 11.30 | 7.77.e-4 |
| *χ2 between null and selected model = 14.55, p=0.005* |
|  |  |  |  |  |  |
| GROUP Bcommercial | Trawl | -9.39.e-4 | 9.60 | 1.95.e-3 |
| *χ2 between null and selected model = 9.24, p=2.37.e-3* |
|  |  |  |  |  |  |
| GROUP Bnon commercial | Lon2  | -5.94.e-2 | 11.80 | 5.92.e-4 |
| *χ2 between null and selected model = 11.43, p=7.23.e-4* |



Fig S1 Relationships between the fitted values of the final GLM and the explanatory variables selected (trawling intensity, depth, longitude, current and sediment type) for each vulnerability group. Linear or order 2 polynomial smoothing was fitted to the data, depending on whether the relationship with the variable was linear or quadratic.