

Tutorial: Risk assessment of fishing impacts on benthic state

The tutorial is freely available at the SEAwisE Github page of Task 4.3 under [tutorial_BenthicRisk_NSFLBEIA](#), while the development version is maintained at https://github.com/JochenDepestele/tutorial_BenthicRisk.

SEAwisE largely built upon the assessment methodology from the ICES Working Group on Fisheries Benthic Impact and Trade-offs ([WGFBIT Github tutorial](#)) and applied it to several regional seas ([Van Hoey et al. 2023](#)). SEAwisE also connected these benthic impact risk assessments to (1) spatial modelling approaches to evaluate spatial management scenarios (see [Van Hoey et al. 2024](#); Bastardie et al. [2023](#), [2024](#), [2025](#)) and to (2) mixed fisheries models to evaluate effort-related management scenarios developed in a Management Strategy Evaluation framework ([Kempf et al. 2024](#), [2025](#), [Garcia et al. 2025](#)). Three steps will showcase benthic impact risk assessments using outputs from effort-related fisheries management scenarios of the mixed fisheries model FLBEIA in the North Sea.

1. Simulating [depletion scenarios](#) by matching métier resolutions of benthic impact assessments (Benthis-métiers) with fisheries métiers of mixed fisheries models (e.g. NS FBLEIA métiers).
2. Fast [RBS estimation](#) for many simulated scenarios using a vectorized methodology from the [terra](#) package.
3. [MSFD assessment](#) of seafloor integrity.

1.1 Depletion scenarios

Depletion is estimated from the times that a location is fished (fishing frequency) and the proportion of biota that are killed by a single pass of a mobile fishing gear (depletion rate d). Benthic impact risk assessments have categorized fishing métiers to discriminate for the width and penetration depth of the gears, such as the **Benthis-métiers** ([Eigaard et al. 2016](#), [Rijnsdorp et al. 2020](#)). Mixed fisheries models typically categorize fisheries using fleet and métiers, whereby fleets are based on country, broad gear groups and vessel length while **mixed fisheries métiers** are defined within fleets in terms of catchability of a commercial fish stock ([Garcia et al. 2017](#), [Kühn et al. 2023](#)).

To estimate depletion of mixed fisheries scenarios, we first estimate the depletion of Benthis métiers following the standard assessment methodology of ICES-WGFBIT (see [quarto-link](#) and [source code](#)). Second, we matched the Benthis métiers with the fisheries métiers that are used in mixed fisheries models and alike, and we scaling effort levels following the changes resulting from the mixed fisheries scenarios (see [quarto-link](#) and [source code](#)).

1.2 RBS estimations

Relative Benthic State (RBS) was estimated using the standard methodology (see [quarto-link](#) and [source code](#)). Benthic sensitivity was either taken from existing studies (e.g. [Rijnsdorp et al. 2018](#) for the North Sea) or developed within SEAwisE ([Van Hoey et al. 2023](#)). RBS estimation followed the methodology stipulated in the [ICES-WGFBIT tutorial](#), but re-arranged the script to facilitate the use of Spatrasters which speed up the calculation process. This enabled the estimation of RBS using a high number of simulated depletion scenarios from the mixed fisheries models (see [quarto-link](#) and [source code](#)).

1.3 MSFD assessment

Seafloor integrity (Descriptor 6 of the MSFD 2008/56/EC) sets thresholds to protect marine habitats. Good Environmental Status requires limits for both habitat extent and quality. For extent, no more than 25% of a benthic broad habitat type may be adversely affected (EUSeaMap 2023, Commission Notice C/2024/2078). Assessments can be made for the Greater North Sea, or by jurisdictions like the UK, EU and Norwegian waters or by national EEZs. There are no official agreed thresholds and indicators for habitat quality, although RBS is presented as a relevant candidate indicator. This tutorial tested three RBS thresholds (0.75, 0.8, 0.9) to illustrate how RBS can be used to assess the effectiveness of mixed fisheries management scenarios to protect seafloor integrity (see [quarto-link](#) and [source code](#)).