Semi-automatic classification of benthic habitats based on seafloor geomorphology in the French Exploration Contract for Polymetallic Nodules (CCFZ)

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Introduction

Ifremer, sponsored by the French government, holds since 2001 an Exploration Contract with the ISA for polymetallic nodules within the Clarion-Clipperton Fracture Zone (CCFZ) in the northern equatorial Pacific Ocean. In 2015, Ifremer acquired a detailed bathymetric coverage of about two thirds of the Contract with the hull-mounted EM122 multibeam echosounder (MBES) of the R/V *L'Atalante*.
In 2019, Ifremer attempted to characterize benthic habitats using GIS processing of the bathymetric dataset and semi-automatic classification. We explored several ways to address this problematic. Preliminary results presented below have been produced using ArcGIS tools and the different steps are described thereafter.

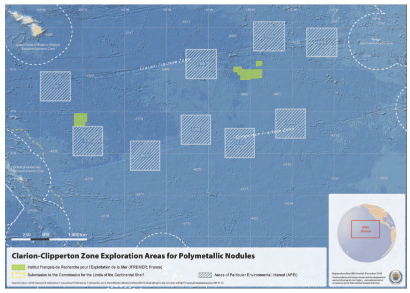

Figure 1: Location of the French Exploration Contract in the CCFZ

Methods and Results

STEP 1: Creation of a theoretical bathymetric DTM

We created a bathymetric DTM (Figure 3) according to a theoretical subsidence model calculated from the oceanic crust's age and the distance from the oceanic ridge. We used the empirical equations of Hillier and Watts (2005) and the worldwide oceanic crust age dataset (Figure 2) downloaded from:
http://www.earthbyte.org/Resources/agegrid2008.html

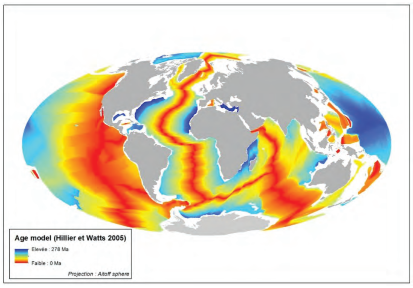

Figure 2: Oceanic crust's age model from Hillier and Watts (2005)

≤ 85Ma
Z = 3010 + (307 * SquareRoot("age_DTM"))

> 85Ma
Z = 6120 - (3010 * Exp(-0.026 * "age_DTM"))

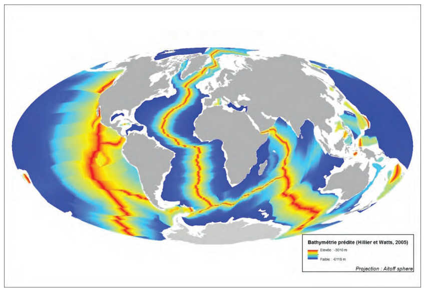

Figure 3: Predicted bathymetry DTM of the theoretical subsidence model

STEP 2: Theoretical bathymetric DTM smoothing

At the scale of the contract area, the resulting DTM shows discrete Z values (i.e. seafloor depth) dipping to the West (Figure 4). Z values were smoothed using IDW interpolation throughout the contract area and resampled to the cell size of the 2015 bathymetric dataset (i.e. 50m x 50m). The difference between the smoothed raster and the theoretical subsidence model represents the correction applied to this model (Figure 5).

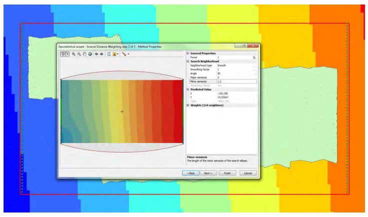

Figure 4: IDW interpolation above the contract area

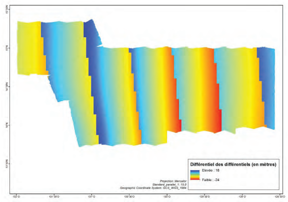

Figure 5: Correction applied to the theoretical subsidence model

STEP 3: Differential bathymetry and thresholds

The bathymetric dataset acquired in 2015 has been substracted to the corrected theoretical subsidence model in order to get a differential bathymetric DTM (Figure 6). We can easily identify both bathymetric highs and lows, corresponding respectively to crests-seamounts and troughs. The intermediate values can be divided into two sets of high and low plateaus. Different thresholds have been applied after visual analysis by geologists to better constrain these geomorphological features (Figure 7). The following ranges were selected: troughs [<-250m] ; low plateaus [-250m;-100m] ; high plateaus [-100m;100m] ; crests and seamounts [>100m]. In comparison to the theoretical subsidence model, the contract area shows in the eastern part an elevated bathymetry with elongated, asymmetrical crests and ridges oriented N-S to NNE-SSW, high plateaus and large sedimentary basins. In the western part, the bathymetry is deeper than the subsidence model with numerous thin, elongated troughs oriented NNW-SSE and large low plateaus. Seamounts protrude these structures in the northern part and some of these are aligned E-W.

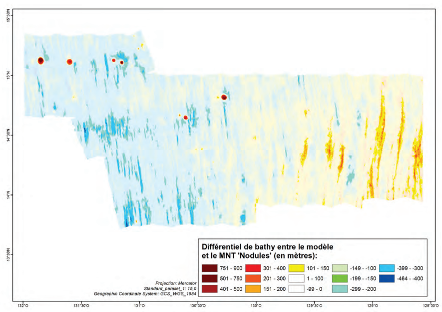

Figure 6: Differential bathymetry DTM

Selected thresholds for semi-automatic classification of benthic habitats:

Troughs: <-250m
Low plateaus: -250m ; -100m
High plateaus: -100m ; 100m
Crests and seamounts: >100m

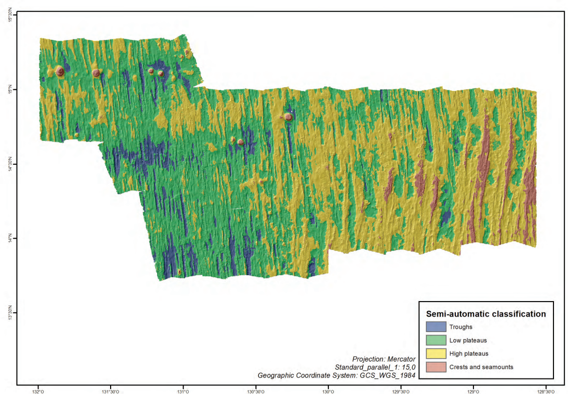

Figure 7: Semi-automatic classification obtained after applying selected thresholds

Discussion

The comparison between the bathymetric dataset acquired in 2015 and a theoretical subsidence model has led to the establishment of a differential bathymetric DTM. By applying several differential depth thresholds, we are able to delineate regional geomorphological features that could represent distinct benthic habitats.
Further work will include basic statistics for each geomorphological feature, as well as geostatistics of bathymetry, backscatter and other derivatives for each geomorphological province using Python scripts. These derivatives are those selected by Diesing (2015) in the EMODnet-Geology Case Study.
This preliminary work will serve as a basis for development of geomorphological feature semi-automatic recognition, scheduled for 2019-2020. The link between geomorphological provinces and benthic habitats will be verified with selected biological samples collected during previous cruises in the area.

Acknowledgements

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References

- Diesing, M., 2015. EMODnet-Geology Phase II. Case study: Quantitative spatial prediction of seabed sediment composition. CEFAS Report N°C5818. 31p.
- Hillier, J.K. and Watts, A.B., 2005. Relationship between depth and age in the North Pacific Ocean. Journal of Geophysical Research: Solid Earth, 110 pp. 1 - 22. https://doi.org/10.1029/2004JB003406
- Pelleau, P., 2015. NODULE 2015 cruise, RV L'Atalante, http://dx.doi.org/10.17600/15001400

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