Course Title: Experimental Design and Analysis of Multivariate Data

Modality: CFT- Transversal Training Course

Orientation:
- ☐ Ocean Observation and Global Change
- ☐ Sustainable use of Marine Resources
- ☐ Integral Management of the Sea
- ☐ Technological progress. Engineering and Business Management

Dates: 16 to 20 January 2023

Timetable: Daily, 9:00 – 13:00 and 14:00 – 17:00

Duration: 35 Hours contact

Location: On-line

Language: English

Academic coordinators:

Name	Institution	e-mail
Victor Quintino	University of Aveiro	victor.quintino@ua.pt

Lecturers:

Name	Institution	e-mail
Victor Quintino	University of Aveiro	victor.quintino@ua.pt

General description:

The course will be delivered on-line, using Zoom sessions. The course follows a problem-solving approach, exploiting teaching and learning case studies. The teaching case studies present the baseline theoretical concepts and the software (PRIMER v7 with the add-on PERMANOVA+). The learning case studies use real datasets and allow participants to apply the theoretical concepts and acquire autonomy in the choice and workflow of the methods. PhD students that already have their own data sets should find enough time to exploit their data and discuss the methods.

Contents:

1. Introduction. From univariate to multivariate data collection and analysis.
2. Resemblance. Resemblance functions for the analysis of variables – association and correlation coefficients – and samples – similarity and distance functions. Appropriateness of the resemblance functions to the dataset. Choosing a resemblance function.

3. Clustering. Advantages and limitations. The panoply of methods. Agglomerative and divisive methods. Agglomerative hierarchical clustering: single, complete, average and flexible algorithms. Construction and interpretation of dendrograms.
4. Ordination. Advantages and limitations. The panoply of methods. Principle coordinate and component analysis (PCO and PCA), correspondence analysis (CA) and non-metric multi-dimensional scaling (MDS). Biplots and interpretation of factorial axes.
5. Multivariate hypothesis testing. Fixed and casual factors, orthogonal and hierarchical designs. Implications on the estimation of variance components. Hypothesis testing with multivariate data using analysis of similarities (ANOSIM) and permutation multivariate analysis of variance (PERMANOVA).

Teaching methodologies:

The syllabus covers baseline components of multivariate analyses. Special attention is given to the first stages of the analyses and to the adequacy of the methods to the data, namely the specificity usually required by biological data, often characterized by data matrices with many zeros. Emphasis is given to the properties and choice of resemblance functions, for the study of relationships between samples as well as between variables. This stage of the analysis is at the basis of the subsequent application of descriptive exploratory methods (cluster and ordination analysis) as well as hypothesis testing methods. The syllabus should supply the necessary basis to allow participants to become autonomous to analyze their own data and to be able to design experiments and sampling campaigns critically, instead of blindly apply a panoply of methods to the data obtained during their research work. The teaching methodology relies on problems resolution approach, by exploiting case studies most of which use real data sets. The teaching case studies supply the basis of the theoretical concepts and the analyses methods, as well as a demonstration of their applications and the use of appropriate software. The learning case studies are all based in real data sets, and it is their main purpose to give participants the opportunity to put the concepts and methods to practice. This should build the necessary confidence and autonomy for the subsequent design and analysis of data obtained during own research work.

Evaluation system:

Assessment is restricted to participants attending doctoral programs and includes group work rendered at the end of the course (6 ECTS advanced course). To register, send an e-mail to Prof. Victor Quintino (victor.quintino@ua.pt), no later than January 5, 2023.

Brief CV of the lecturers:

Victor Quintino completed his PhD in Biological Oceanography in 1988 at the University Pierre et Marie Curie, Paris VI, France. He is currently Assistant Professor at the University of Aveiro, Department of Biology, in Portugal. He specializes in the ecology of coastal and estuarine macro-benthic communities and their responses to natural and anthropogenic factors, integrating environmental, biological and eco-toxicological descriptors in bioassessments. Victor Quintino lectures topics in experimental design and the analysis of multivariate biological data to post-graduate students for over 30 years. He has authored more

than 90 peer-reviewed papers in international journals. He played the role of Editor-in-Chief for Marine Pollution Bulletin and is currently Associate Editor for Estuarine, Coastal and Shelf Science, for Journal of Sedimentary Environments and for Biology.

Relevant references:

Anderson, M.J., Gorley, R.N. and Clarke, K.R. 2008. PERMANOVA+ for PRIMER: Guide to Software and Statistical Methods. PRIMER-E, Plymouth, UK.

Clarke, K.R. and R.M. Warwick, 2015. *Change in Marine Communities: An Approach to Statistical Analysis and Interpretation.* 3rd Ed. Primer-E: Plymouth, UK.

Jongman, R. H. G., C. J. F. ter Braak e O. F. R. van Tongeren (Eds.), 1987. *Data Analysis in Community and Landscape Ecology.* Pudoc, Wageningen.

Legendre, L. e P. Legendre, 2012. *Numerical Ecology.* 3rd Edition. Elsevier.