



Statistical Inference, Decision and
Operations Research (SiDOR)

Universidade de Vigo

Connecting Knowledge:

SiDOR (Universidade de Vigo) and METMAR (IEO-CSIC)

Facultade de Ciencias Económicas e Empresariais, Universidade de Vigo

Salón de Grados

March 18 2025

Programme

9:00 – 9:05 Welcome

9:05 – 9:50 METMAR: An overview of our framework. Santiago Cerviño (METMAR)

9:50 – 10:15 Using statistical simulation for fisheries management. Anxo Paz (METMAR)

10:15 – 11:00 Interactive Session: playing with a model to assess fish population status. Marta Cousido Rocha (METMAR)

11:00 – 11:30 Coffee break

11:30 – 11:55 SiDOR: Statistical Inference, Decision and Operations Research for a better world. Jacobo de Uña Álvarez (SiDOR)

11:55 – 12:20 Regression analysis with spatially-varying coefficients using generalized additive models (GAMs). Francisco de Asís López Álvarez (SiDOR)

12:20 – 12:45 Analysis of complex data in marine resource assessment. Ana Pérez González (SiDOR)

12:45 – 13:10 Advances in statistical methods for the management of marine resources: A review. Marta Sestelo Pérez (SiDOR)

13:10 – 14:00 Summary and debate

Abstracts

METMAR: An overview of our framework. Santiago Cerviño (METMAR)

The overexploitation of fish stocks is a global concern, with a significant portion of marine populations currently under unsustainable fishing pressures. This has led to damaging ecological consequences, affecting biodiversity and destabilizing marine ecosystems. In response, the assessment of fishery resources is essential for achieving sustainable management. This process involves the use of statistical and mathematical models to make quantitative predictions about how populations respond to different management measures. Within this context, METMAR focuses on two key research lines: (a) Improvement of methods and models for the assessment of fishery resources: This line of research aims to develop and refine mathematical and statistical models for assessing the health and abundance of fish populations. Examples of different types of models, along with real-world applications, will be presented to illustrate their role in supporting informed decisions in fishery management. And (b) Digital twin: Simulation and evaluation of management strategies under uncertainty: Given the impossibility of conducting experimental designs in marine environments to assess management measures, this research line focuses on using statistical simulations as an alternative. It seeks to develop management strategies that are robust to the uncertainty inherent in the assessment of fishery resource. Exploring these lines of research (a) and (b) will enable us to explain how statistical and mathematical approaches are key to sustainable fisheries management practices.

Using statistical simulation for fisheries management. Anxo Paz (METMAR)

Statistical simulation is a fundamental tool for developing management strategies that are robust to the uncertainty inherent in the assessment of fishery resources. To achieve this, a digital twin of the fish population is created and used to evaluate the performance of different management strategies to identify those that are robust to different sources of uncertainty and balance multiple ecological, economic and social objectives. This talk focuses on the simulation framework developed to test different management strategies for the hake population (*Merluccius merluccius*) in the Cantabrian Sea and Atlantic Iberian waters. The management strategies tested in this framework were proposed by stakeholders, representatives from the fishing sector. Specifically, stakeholders suggested testing strategies aimed at providing more stability in annual catch advice: 1) maintaining the same catch advice for two or three consecutive years instead of issuing new advice every year, and 2) limiting the changes in catch advice from one year to the next. Additionally, they proposed investigating the impacts of reducing fishing pressure on small versus large fish. The results of our simulation framework allow stakeholders to assess whether their proposals achieve the expected outcomes and if these strategies could be effectively implemented in practice.

Interactive Session: playing with a model to assess fish population status. Marta Cousido Rocha (METMAR)

In this interactive session, participants will work with an R code provided by the instructor to run an assessment model directly on their own computers. The session will focus on a surplus production model (SPM), an assessment model that explains the biomass of a population in the

following year as the biomass from the previous year plus a production function in terms of population biomass, which accounts for recruitment of new individuals, growth of current individuals, and natural mortality, minus the catches from that year. Among the different implementations of SPMs, we will focus on SPiCT, a surplus production model in continuous time, which can be easily applied through its R package. The session will begin with a brief introduction to the SPM framework, highlighting its key features without getting too technical. Participants will then explore the outputs from SPiCT, including the current status of the population and projections for its future under different fishing scenarios. The case study will focus on the hake population (*Merluccius merluccius*) in the Cantabrian Sea and Atlantic Iberian waters.

SiDOR: Statistical Inference, Decision and Operations Research for a better world. Jacobo de Uña Álvarez (SiDOR)

SiDOR group, Universidade de Vigo, was founded in 1998 to foster basic and applied research in the area of Statistics and Operations Research. Being the only group with such a deep statistical knowledge in Southern Galicia, its activity throughout the years has been key for the development of cutting-edge methods and their dissemination in the scientific community. Currently, SiDOR is formed of ten permanent researchers, three postdocs, several PhD students and a technician. Besides, SiDOR has plenty of collaborators in other Spanish and foreign universities who complement and reinforce the abilities of the group. Within SiDOR several competitive research projects in the area of Mathematics are carried out; these projects make the advance of knowledge in Statistics and Operations Research possible. The group has also a strong commitment with applied research, by developing software packages and by participating in collaborative research projects and networks with companies and institutions. SiDOR researchers belong to the Department of Statistics and Operations Research, where they teach courses at undergraduate and graduate levels. They are deeply involved in the Statistics Master Programme, jointly organized with the neighbouring universities of Santiago de Compostela and A Coruña. All these aspects, together with the specific, basic research lines that are developed by SiDOR, will be discussed throughout the talk.

Regression analysis with spatially-varying coefficients using generalized additive models (GAMs). Francisco de Asís López Álvarez (SiDOR)

Regression models for spatial data have attracted the attention of researchers from different fields given their widespread application. In this work we analyze the utility of generalized additive models (GAMs) as regression methods with spatially-dependent coefficients. Particularly, three different aspects of the regression analysis were addressed: model definition and estimation, testing spatial heterogeneity, and variable selection. Spatial heterogeneity was addressed through bootstrapping, while an algorithm using the Bayesian Information Criterion (BIC) was implemented for variable selection to reduce computation time. In addition, this study makes a comparison of GAMs with two of the most common methods for regression with spatially-varying coefficients: Geographically Weighted Regression (GWR) and Multiscale Geographically Weighted Regression (MGWR), using both synthetic and real data.

Analysis of complex data in marine resource assessment. Ana Pérez González (SiDOR)

When the sample contains complex data ordinary statistical techniques may not be appropriate. This is the case for incomplete data and also for compositional data. Often, the variables cannot be observed for all the individuals, positions, time periods, etc., resulting in missing observations. Different perspectives on the problem of missing data have been presented in the literature. The advantages and disadvantages of these methods depend on the nature of the missing data and the statistical analysis to be performed. On the other hand, a type of complex data that is very common in different research areas like geology, chemistry, biology or economics, among others, is the compositional data. These data are often presented as proportions or percentages. The sum of the components of a compositional datum is a constant, usually one, and therefore standard statistical techniques cannot be applied. This talk focuses in the general guidelines for the processing of this type of complex data.

Advances in Statistical Methods for the Management of Marine Resources: A Review. Marta Sestelo Pérez (SiDOR)

This presentation will provide a brief overview of some methodologies developed and applied in the management of marine resources, such as barnacles, bivalves, and octopuses. Among the proposed methods, we will discuss nonparametric estimation procedures in regression models with or without factor-by-curve interactions, procedures for testing features of the estimated regression curves (i.e., comparisons between curves which may vary across groups defined by levels of a categorical variable and comparisons of critical points of the curves), techniques for variable selection, and algorithms for clustering regression curves. Throughout the presentation, illustrative applications will be provided.