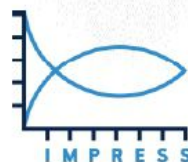


# SIMERPE

## 2021

Vigo, Spain



**MERVEX**  
Modeling and Evaluation  
of Exploited Resources

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# Programme Overview

	Tuesday 19th	Wednesday 20th	Thursday 21th	Friday 22th
9:00	OPENING			
9:30-10:30	<b>Plenary</b> Manuela Azevedo	<b>Plenary</b> Carmen Fernández	<b>Plenary</b> Marta Coll	<b>Synthesis and future</b>
10:30-11:00	Coffe break	Coffe break	Coffe break	Coffe break
11:00-13:20	<b>Oral Presentations</b> Data-limited methods	<b>Oral Presentations</b> Data-rich models and MSE	<b>Oral Presentations</b> Ecosystems	<b>Round table stakeholders</b>
13:20-15:00	Lunch break	Lunch break	Lunch break	CLOSING
15:00-18:30	<b>Thematic Session 1</b>	<b>Thematic Session 2</b>	<b>Thematic Session 3</b>	

The **telematic oral presentations** will be pre-recorded and made available on the SIMERPE 2021 website so that attendees can enjoy them at any time, so they will not have a specific schedule in the symposium, i.e., they will be available throughout the symposium.

**Poster of presential attendants** will be held at the poster board during all the symposium. Besides, **posters of both presential and telematic attendants**, will be upload to the website in a PDF format.

<b>Timetable</b>	<b>Tuesday 19th</b>
9:00	OPENING
9:30-10:30	<b>PLENARY</b> <b>Manuela Azevedo</b> Stock Assessment and Fisheries Management: evolving methods and approaches
10:30-11:00	Coffe break
11:00	DATA-LIMITED METHODS <i>Chairs: M. Cousido (IEO)</i>
11:00-11:20	<b>Silva, et al.</b> Dealing with spatial differences in data-richness: an example using Atlantic chub mackerel in the Iberian Peninsula.
11:20-11:40	<b>Soto, et al.</b> Effects of underestimating landings and discards in state-space production models: the case of black hakes in North West Africa.
11:40-12:00	<b>Ghoufrane, et al.</b> Links between the environment and Surplus production model outputs: The case of Morrocan chub mackerel stock.
12:00-12:20	<b>Paz, et al.</b> Surplus production models. A comparative analysis of model performance with simulated data.
12:20-12:40	<b>Cerviño, et al.</b> Aplicación de modelos de producción de biomasa conocida para la evaluación de recursos de interés para España en aguas atlánticas.
12:40-13:00	<b>González Herraiz, et al.</b> Development of MSY advice for Nephrops Functional Units 25 (North Galicia) and 31 (Cantabrian Sea) using SPiCT.
13:00-13:20	<b>Cousido-Rocha, et al.</b> Surplus Production Models: a practical review of recent approaches
13:20-15:00	Lunch break
	<b>Thematic section</b> <i>Chairs: F. González (IEO) and M. Soto (IEO).</i>
15:00-18:30	The evaluation process in the Scientific Councils of Regional Fisheries Organisations

<b>Timetable</b>	<b>Wednesday 20th</b>
9:30-10:30	<b>PLENARY</b> <b>Carmen Fernández</b> <i>Management Strategy Evaluation (MSE)</i>
10:30-11:00	Coffe break
11:00	<b>DATA RICH MODELS AND MSE</b> <i>Chairs: V. Trujillo Gorbea (IEO)</i>
11:00-11:20	<b>Sánchez-Marroño, et al.</b> Harvest rate-based control rules for data-limited short-lived stocks
11:20-11:40	<b>Uriarte, et al.</b> Recruitment-based harvest control rules to manage stocks of uncertain productivity: Application to the Iberian sardine.
11:40-12:00	<b>Citores, et al.</b> Full feedback vs. shortcut approach MSE for the sardine in the Bay of Biscay.
12:00-12:20	<b>González-Troncoso, et al.</b> Evaluación de las Estrategias de Gestión (MSE) del Bacalao de la División 3M de NAFO.
12:20-12:40	<b>Izquierdo et al.</b> Development of a Sex-Separated Stock Synthesis (SS) model for the South Atlantic hake ( <i>Merluccius merluccius</i> ) stock
12:40-13:00	<b>Hasse et al.</b> Shape your fish stock: Using a length- and age-based population model to find the optimal harvest strategy.
13:00-13:20	<b>Rodríguez-Ezpeleta, et al.</b> Towards a genetics-informed fisheries management.
13:20-15:00	Lunch break <b>Thematic section</b> <i>Chairs: D. González-Troncoso (IEO)</i>
15:00-18:30	The future of stock assessment



<b>Timetable</b>	<b>Thursday 21th</b>
9:30-10:30	<b>PLENARY</b> <b>Marta Coll</b> <i>Integrating knowledge and projecting future trajectories of change of commercial stocks</i>
10:30-11:00	Coffe break
11:00	<b>ECOSYSTEMS</b> <i>Chairs: E. Andonegi (AZTI)</i>
11:00-11:20	<b>Andonegi, et al.</b> Synthesis of results from the ICES workshop on operational EwE models to inform IEAs and stock assessment?- WKEWIEA
11:20-11:40	<b>Lopez de Gamiz-Zearra, et al.</b> Potential use of ecosystem models to inform stock assessments and advice in the Bay of Biscay.
11:40-12:00	<b>Mendes, et al.</b> Horse mackerel spatio-temporal distribution patterns supporting an integrated approach of fisheries and biological data to improve spatial management.
12:00-12:20	<b>Garriga-Panisello, et al.</b> Temporal persistence and spatial differentiation of the bottom-trawl fishery métiers in the northwest Mediterranean.
12:20-12:40	<b>Otero, et al.</b> Spatio-temporal models for European hake catch and effort data: multiple index standardization to improve the accuracy of inputs to stock assessment.
12:40-13:00	<b>Martín-Sosa, et al.</b> Describing (and assessing) artisanal fisheries in the Canary Islands through fishery essentiality.
13:00-13:20	<b>Rosa, et al.</b> A bioeconomic model for the Portuguese purse seine fleet: towards an ecosystem-based management.
13:20-15:00	Lunch break
15:00-18:30	<b>Thematic section</b> The extension of the assessment to ecological, social and economic considerations

<b>Timetable</b>	<b>Friday 22th</b>
9:30-10:30	<b>Synthesis and future steps</b>
10:30-11:00	Coffe break
11:00	<b>Round table stakeholders</b> Beyond the data: Challenges in fisheries management for the industry-science-policy interface. <i>Moderator: M. Ballesteros (CETMAR)</i> <i>Table members: S. Cerviño (IEO), G. Rodríguez (USC), M. Rodríguez (Consellería de Pesca), B. Otero (Federación Nacional de Cofradías de Pescadores de España), E. Ulloa (ARVI), and P. Vara (SGP).</i>
13:20-15:00	<b>CLOSING</b>

## 1 Plenary Speakers

### Management Strategy Evaluation (MSE)

**Carmen Fernández Llana**

Carmen Fernández Llana, graduated in Mathematical Sciences and PhD in Statistical Methods from the Autonomous University of Madrid. After defending her doctoral thesis in 1994, she carried out research stays and later became a tenured professor of Statistics at various universities in Belgium, the Netherlands and the United Kingdom. During her years at the University of St Andrews (Scotland), she established a relationship with scientists from the IEO, an organization in which she obtained a position as a senior researcher in 2006. In the period 2006-2011 she was assigned to the IEO in Vigo, working on the evaluation of stocks of commercial species (cod, rooster and hake) in ICES and NAFO areas. Between 2012 and 2017 she held the position of vice-president of the Advisory Committee of the International Council for the Exploration of the Sea (ICES). She is currently Deputy Director General for Research at IEO.



#### **Abstract**

The presentation will provide an overview of Management Strategy Evaluation (MSE) for fisheries management, covering from basic concepts to recent techniques. It will discuss key similarities and conceptual differences between fisheries management based on a “best assessment” versus a “management procedure” approach, including the treatment of uncertainty and the interpretation and use of biological reference points, considering implications for management and policy. The presentation will also include an overview of main current methodological approaches and implementations of the MSE framework in various organizations around the world.

# Stock Assessment and Fisheries Management: evolving methods and approaches

**Manuela Azevedo**

Manuela Azevedo is a senior scientist at the Portuguese Institute for the Sea and Atmosphere (IPMA). She graduated in marine biology in 1982 and has a MSc in statistics and probabilities. She develops and applies quantitative methods for fish and fisheries dynamics and for fisheries advice and management. She started her career with the stock assessment of bigeye tuna (ICCAT) and with studies to support the development of the Portuguese swordfish long-line fishery. She has been engaged with ICES for almost 30 years in several capacities: as an active member and chair of several ICES expert working groups and workshops, as member of the Advisory Committee, as Vice-Chair of the Advisory Committee and as Portuguese member of ICES Council. She was invited Professor at the University of O'Porto for a decade, teaching statistics.



## **Abstract**

Since the early times when cohort analysis and virtual population analysis were used for stock assessments, statistical stock assessment methods have been developed and applied for several commercially exploited stocks in the Northeast Atlantic to estimate stock key parameters with confidence intervals, determine the stock status by comparison to adopted biological reference points and management targets and, project sustainable catches. There are, however, a large number of stocks with limited biological and fisheries data, lacking full analytical assessments and reliable estimates of stock status. Starting in 2010 an ICES dedicated expert group (WKLIFE) explored and evaluated several methods and approaches for data-limited stocks, including simulation testing of generic harvest control rules to ensure that exploitation was within precautionary bounds. This research and the challenges that the precautionary approach and the MSY concept, incorporated into the management objectives of the current Common Fisheries Policy of the European Union, still poses to deliver catch-based advice that is risk adverse and drives data-limited stocks to MSY will be addressed and discussed. More information is generally better than less but for some stocks the investment in collecting more data may require evaluating the trade-off between the quantity and quality of information required by end-users and managers and the level and cost of risk protection that is likely to result, which is not always straightforward.

# Winners, losers and shifts of the pelagic ecosystem in the western Mediterranean Sea: integrating knowledge and projecting future trajectories of change of commercial stocks

Marta Coll

Her research focuses on understanding patterns and processes that characterise marine ecosystems and, in particular, changes of, and threats to, marine biodiversity. She studies population, community and food-web dynamics linked with human activities (such as fisheries, climate change, eutrophication, and invasive species), and how these translate into changes in ecosystem structure and functioning, and services that humans obtain from the ocean. She develops and applies a variety of ecological analyses such as ecosystem modelling techniques and statistical tools, and she uses historical data, fisheries statistics, experimental results and field data sets.



## Abstract

Nowadays the single-stock assessment approach is the most used one for the management of marine resources. However, the consequences of fishing on the dynamics of exploited stocks are not necessarily the only ones. Environmental and ecosystem dynamics, and economic and social aspects are also highly relevant, and can interact with fishing impacts. However, these factors are often overlooked when making management decisions. In particular, small pelagic fish species (SPF), such as European sardine (*Sardina pilchardus*) and European anchovy (*Engraulis encrasicolus*), are some of the most commercial species the NW Mediterranean Sea. They have shown important changes in the last decade as shifts in abundance, biomass, body condition, growth, reproduction and spatial distribution. Different hypotheses have been formed to explain these changes: such as an increase in fishing impacts; changes in environmental conditions that have affected annual recruitment, growth, general conditions of organisms, and planktonic productivity and quality; the recent recovery of pelagic predators; and competition for food with jellyfish or round sardinella (*Sardinella aurita*) that has been increasing in abundance in the area. During three consecutive projects, SPELMED, PELWEB and PELCAT, we aimed at generating new knowledge and integrating the available one into a multi-modelling platform to quantify the impacts and project future trajectories of change. Specifically, we aimed at (1) quantifying the ecological and socio-economic consequences of changes in SPF population distributions on iconic predator species, their fisheries and ecosystem dynamics, and (2) identifying robust future management options to achieve resilient SPF populations in order to ensure healthy populations of small pelagic fish and sustainable exploitation under climate change. During this talk I will showcase the tools that we used to generate and integrate results, going from stock assessments to species distribution models and process-oriented ecosystem spatial-temporal models. I will present main results of our endeavour and I will illustrate the importance to consider environmental, ecological and socio-economic factors when managing exploited resources from an ecosystem-based management perspective considering the effects of climate change.

## 2 Thematic Sessions

### The evaluation process in the Scientific Councils of Regional Fisheries Organisations

**R. Alpoim (NAFO), M. Bernal (FAO), R. Fernández(ICES),  
M. Ortiz (ICCAT)**

The needs to incorporate various international agreements (e.g. Rio Summit, Code of Conduct for Responsible Fisheries, Johannesburg Summit) have determined how to incorporate aspects such as Maximum Sustainable Yield or the Precautionary Approach in the assessment process. In addition, other elements, such as the collection and storage of information, the models used, the quality control of the assessment process or the way in which scientific advice is provided to managers, have been developed differently in each organisation. In this session we will have relevant scientists from organisations such as NAFO, GFCM, ICCAT or ICES, whose will present how they have solved these considerations.

# The future of stock assessment

**D. García, L. Ibaibarriaga, P. Presa Martínez, M. Rincón  
Hidalgo**

Nowadays, the assessment of single-stocks is the main scientific basis for the management of fishery resources. Since Beverton and Holt settled the scientific foundations for management in the 1950s, the assessment process has continuously evolved, supported by the development of computers and scientific knowledge. Recently, several lines of work are being developed in new topics such as Management Strategy Evaluation (MSE), integrated models, state-space models, spatial considerations, models for mixed fisheries, Bayesian models, etc. In this session we will have leading researchers in these lines of assessment to enlighten us on what we can expect from these developments.

## **Mixed fisheries modelling: Bringing the gap between single stock assessment and bio-economic modelling of fishing activity *by Dorleta García***

Traditionally, scientific advice for fisheries management has been based on single stock assessment. However, in the light of ecosystem fisheries approach the need of a holistic approach to fisheries management has been acknowledged. In this context, several years ago, ICES started to provide mixed-fisheries management advice in different areas. Furthermore, in 2019, mixed-fisheries multiannual management plans were implemented in the Northeast Atlantic, from the North Sea to the Iberian Waters. The provision and implementation of mixed-fisheries management advice faces several challenges: most of the stocks are data-limited and enough data to conduct a traditional assessment is not available, the definition of métiers and provision of data at this level of disaggregation, the definition of management targets or the emergence of choke species among others. But mixed fisheries modelling also represents an unvaluable opportunity to advance in the economic modelling of fishing activity. It gathers most of the necessary data to model the fishing activity with a disaggregation level not available until now. Attempts have been made to provide bio-economic advice based on the models used to generate mixed-fisheries advice. However, bio-economic advice, as we know stock advice, is far from being operational. The disaggregation level of economic data available is not enough detailed, the economic objectives are country and fleet dependent and the time available since the single stock advice is given is very limited. In this presentation the recent developments and challenges in mixed fisheries modelling will be presented from the perspective of single stock assessment, economic modelling and advice, and ecosystem based fisheries management.

## **Quo vadis stock assessment? *by Leire Ibaibarriaga***

First stock assessment models date from early 1900s. Since then, stock assessment models have been continuously evolving. This has allowed to incorporate new statistical methodologies and to answer more complex scientific questions for management purposes. Based on the literature and several discussions held at international level, we'll review the main challenges faced nowadays by stock assessment and we'll point to some of the model features needed to address them adequately. The new perspective brought up by the covid-19 disruption will be also discussed.



## **Evaluation of the genetic and ecological consequences of fishery size *by Pablo Presa Martínez***

*In silico* assays show that a downtrend of the population effective genetic size  $N_e$  would be a warning genetic flag on the evolutionary strength of populations. Therefore, the development of  $N_e$ -based assessment algorithms would become a useful biostatistical tool in fishery management for its relationship to fitness risk. Despite the advancement achieved on genetic methods to estimate  $N_e$ , its relationship to the census size  $N_c$  is still elusive in marine fisheries. For instance, knowledge of such ratio would allow making inferences on the evolutionary consequences of overfishing after estimates of  $N_c$ . The joint estimation of  $N_e$  and CKMR abundance upon close relatives, using the same dataset, would allow to optimizing resources and efforts to assess the ecological and evolutionary consequences of fishing pressure. In this study, I outline some crucial properties to be accomplished on sampling and analytical protocols in order to produce meaningful estimates of  $N_e$  and  $N_c$ .

## **A visit to the mathematical foundations of fisheries science *by Margarita Rincón Hidalgo***

Usually when doing stock assessment we easily use Baranov's catch equation or the Beverton Holt model, among others, but we don't realize that there is a story behind. Looking into that stories makes it easier to understand how those equations are linked to natural interactions and how they respond to real needs on the time they were defined. At the same time these stories remark the close link between mathematics and natural sciences and put on the table different concerns about the scientific background needed by a stock assessor and how to optimally combine the knowledge of natural scientist and mathematicians for the best use of fisheries science into management and decision making.

# The extension of the assessment to ecological, social and economic considerations

**J. M. da-Rocha, M. Hidalgo, A. Pérez Rodríguez, J. L. Santiago**

The scientific basis for advice based on the assessment of individual stocks is the most developed and the basis for current management. However, the consequences of fishing activity on the biomass of these stocks are not necessarily the most relevant impact for deciding on management measures. Ecosystem, economic and social impacts are equally or more relevant. However, these considerations are often overlooked when making management decisions. Why is this due to? Is this due to a lack of methodological development? or maybe due to a lack of relevant data for these analyses? To answer these questions we will have leading researchers in these fields who will try to lay on the table the keys to this limitation and its possible solutions.

## **Dynamic Integrated Model for Assessing Fisheries *José-María da-Rocha***

Dynamics Integrated models aggregate economic phenomena, building on explicit micro-foundations involving rational and forward looking optimising behaviour of individual economic agents. This type of framework has been extensively used to assess macroeconomic policies and has recently become popular for assessing climate change. For example, the United States Environmental Protection Agency uses the Dynamic (or Regional) Integrated Climate Economy (DICE-RICE) framework by Nordhaus. More specifically, our Integrated Model for Assessing Fisheries shows four intrinsic characteristics: Dynamic (studying how the economy evolves over time), Stochastic (taking into account the fact that the economy is affected by dynamic random shocks), General (able to endogenously determine prices and fishing mortality), and Equilibrium-based (i.e forward looking). In this talk, I will make a succinct review of Models of this kind have already been introduced into fisheries literature: the opportunities but also their challenges.

## **Opportunities, limitations and challenges of the implementation of key ecological and ecosystem processes into stock assessments *Manuel Hidalgo***

Computational and methodological advances have considerably fueled stock assessment process during the last decades, while the implementation of environmental- and ecosystem-dependent processes has been more limited hampering the long-lasting attempt of the ‘ecosystem-based fisheries management’. The influence of the habitat, climate, diet, predation and competition, life history variation, the spatial structure of the populations or the spatial dependence of key demographic processes, among others, have been demonstrated for many species worldwide. However, the inclusion of these processes in regular fisheries stock assessments is generally reduced, and it cannot be necessary translated into an assessment improvement due to diverse reasons. In this talk, I will make a succinct review of the opportunities but also limitations challenged in this line by the new generation of stock assessment models.

## **Los modelos multiespecíficos en la evaluación de los recursos pesqueros y el desarrollo de estrategias de gestión. El caladero FlemishCap y el modelo Gadget GadCap como caso de estudio. *Alfonso Pérez Rodríguez***

El enfoque multiespecífico trata de cuantificar la magnitud de las interacciones ecológicas entre las especies comerciales, el impacto en su dinámica y productividad, e incorporar esta información

en la evaluación de los recursos pesqueros y en la toma de decisiones a corto, medio y/o largo plazo. La forma en la que este enfoque se ha desarrollado en los distintos caladeros en los que se ha aplicado es variada, desde el uso de modelos de consumo, hasta modelos ecosistémicos end-to-end de elevada complejidad, pasando por los conocidos como Modelos de Complejidad Intermedia para el enfoque de Ecosistema (MICE). Los MICE son modelos de evaluación de stocks propiamente, que utilizan datos de campañas científicas y de pesca comercial para modelar la dinámica de varias poblaciones de interés y sus interacciones. Además, pueden ser usados como modelos operativos en marcos para la evaluación de estrategias de gestión MSE considerando la incertidumbre en los principales procesos ecológicos.

Gadget (Globally applicable Area Disaggregated General Ecosystem Toolbox) es un claro ejemplo de modelo MICE, con gran flexibilidad potencial en su estructura y complejidad, y con capacidad para usar fuentes de datos muy variados. En Flemish Cap (área NAFO 3M), se desarrolló un modelo multiespecífico Gadget, incluyendo a los stocks de bacalao, gallineta y camarón (modelo denominado GadCap). Posteriormente, GadCap se incorporó como modelo operativo dentro del marco MSE gadget-a4a-FLR. Esta herramienta se utilizó para probar el rendimiento de multitud de combinaciones de reglas de control de la explotación (HCRs) para las tres poblaciones. Los resultados demostraron la dinámica interdependiente de estos tres stocks, y las fuertes interacciones existentes entre el reclutamiento, la pesca y la depredación (incluido el canibalismo), concluyendo que ignorar las interacciones de las especies conduciría a subestimaciones de la mortalidad natural y sobreestimaciones de la biomasa explotable en las predicciones a corto plazo. Las simulaciones en el MSE multiespecífico indicaron que, debido a las fuertes interacciones tróficas, la incertidumbre en el proceso de reclutamiento y el error de evaluación no es posible la explotación sostenible de los 3 stocks al mismo tiempo. Mantener el camarón a niveles explotables sostenibles requeriría una alta presión de pesca sobre el bacalao y la gallineta para reducir la mortalidad por depredación. La implementación de una HCR alternativa de dos etapas, donde la mortalidad por pesca del bacalao se aumenta por encima del objetivo  $F$  tradicional a niveles elevados de biomasa de bacalao, reduciría la depredación, resultando en una mayor productividad y una menor probabilidad de colapso del bacalao y la gallineta.

Los resultados de los trabajos desarrollado con el modelo Gadget GadCap son un ejemplo de la utilidad de los MICE en soporte del enfoque tradicional monoespecífico, sirviendo de apoyo tanto para las decisiones tácticas como estratégicas en la gestión de un caladero en el que se dan interacciones ecológicas que son determinantes en la dinámica de los stocks comerciales.

### **Ex-ante, ex-post or in-between: what role for socioeconomic assessment in stock evaluation** *Jose L. Santiago*

Fisheries management necessarily considers the biological status of the resources. However, the economic implications of the management strategies and the social context within which those decisions are affected are key factors to be consider. This socioeconomic dimension is conditioned by diverse factors that determine and limit the capacity to decide the fishing strategies and the decisions making. Some are endogenous and can be managed or controlled but other are completely out of control for fishers and policy makers. When and how to carry out these considerations will be the core of the session. The key indicators to measure this economic and social aspects and the pros and cons to consider them after, before or during the stock assessments will be introduced and exemplified with real situations.

### 3 Round table discussion

#### Beyond the data: Challenges in fisheries management for the industry-science-policy interface

**M. Ballesteros (moderator), S. Cerviño, G. Rodríguez, M. Rodríguez, B. Otero, E. Ulloa, P. Vara.**

Scientific advice supports fisheries management. Hence, scientists provide evidence for decision-makers to design and assess the performance of measures and tools which shape how the industry operates in a given fishery. This process is far from linear: scientists, industry and decision-makers act, interact and react at multiple levels, from daily-basis issues to tactic management and strategic policy-making.

Uncertainty and complexity are inherent to fisheries management. Even more complex now that managers have to tackle multiple society demands, the industry faces tangled regulations and science acknowledge fisheries take place within complex social-ecological systems. In this context, our panellists will identify what challenges and opportunities may arise from the science-policy-industry collaboration.

What solves the manager's needs? What harness the sector's capability to participate? What enhances scientists' capacity to generate evidence? These are some of the questions the 6 panellists will address to reflect on how we generate, exchange, share and use scientific and experience-based knowledge in management. For the main challenges in the short term, the panel will jointly propose concrete actions.

## 4 Oral contributions

### A food-web comparative modeling approach highlights ecosystem singularities of the Gulf of Alicante (Western Mediterranean Sea)

E. García-Rodríguez, M. Coll, M. Vivas, J. M. Bellido, A. Esteban, M.  
A. Torres

A food-web comparative modeling approach using Ecopath with Ecosim (EwE) was built to characterize the ecosystem of the Gulf of Alicante (GoA) and investigate its singularities. In our study we model a study area representing early 2010s, covering a total surface of 7,085 km<sup>2</sup> with depths from 50 to 800 m. In total, 45 functional groups including fish, marine mammals, seabirds, invertebrates, primary producers, and detritus were selected to build the ecological model. The fishery was represented by the four main fleets operating in the area (i.e., bottom trawl, purse seine, longlines, and small-scale fisheries) and we included official landing data and estimated percentage of discarded species. Results were then compared with available outputs of available models representing adjacent ecosystems such as the Gulf of Cadiz (in the Atlantic side) and the North Western Mediterranean Sea (north of the study area). The study revealed that the major differences found between models were due to the lower primary production in the GoA. This led to lower catches and higher importance of the demersal compartment, where the most biomass was associated to the detritus. The main trophic flows in the GoA were originated at the basis of the food web, likely related to bottom-up flow control. Interactions between pelagic and demersal groups were weaker than in neighboring areas. Despite the high values of ecotrophic efficiencies and mortality rates, results showed a lower fishing pressure than in neighboring areas, suggesting a moderate exploitation level of marine resources in the GoA. This study fills a knowledge gap in the area and sets the baseline to develop future studies to test scenarios of change and management options.

# Performance of natural mortality estimators for the stock assessment

A. Tifoura, M. G. Pennino, S. Cerviño

Natural mortality ( $M$ ) is considered a substantial parameter in the stock assessment process. This means that a misestimation of this parameter impact directly the results of stocks 'evaluation and then the decision making based on the scientific advice. Incorrect  $M$  conduct to an overestimate or underestimate the main references to define stock and exploitation status, i.e., biomass ( $SSB$ ) and fishing mortality ( $F$ ) that could be contemplated in fisheries management as a reference point.

Hence, it is difficult to estimate a single constant  $M$  within a stock assessment, several methods exist to estimate  $M$  externally to an assessment model. These studies have attempted to estimate the natural mortality based on various factors such as growth parameters ( $L_\infty$  and  $k$ ) or the maximum age ( $t_{max}$ ) for the empirical models or even by estimating  $M$  within age as it was assumed by the age-dependent methods. Unfortunately, there is no typical pattern or consensus to use a typical method, based on a scientific evaluation of its performance and error consideration.

For that, a database was set up for the analysis of performance of these multiples methods of estimation of  $M$ , from the annual reports of the General Fisheries Commission for the Mediterranean (GFCM) and the International Council for the Exploration of the Sea (ICES). The data collected concerns the targeted species by both bodies since the year 2012, in the Mediterranean fisheries, and the objective of this study is to analyze to what extent the different theories behind the  $M$  estimation is implemented in different institutions and stocks.



# Comparison of spatiotemporal modelling frameworks in the development of crustacean indices of abundance.

G.F. Martin Gonzalez, O. Tully, S. Clarke

The Brown crab (*Cancer pagurus*) offshore fishery in the North West of Ireland is one of the largest and most important commercial species exploited by Irish vessels. Stock status and reference points are currently unknown and the management is limited to technical measures such as minimum/maximum landing sizes. Existing data to derive trends in stock abundance is available from historical commercial catch-per-unit-effort (CPUE) and self-sampling schemes. “Standardization” techniques to derive unbiased indices of abundance have been long implemented in fisheries science. Yet, dependency among CPUE observations in space and time, inherent in fisheries-dependent data, is often overlooked or difficult to integrate within these “traditional” frameworks. Spatiotemporal correlation is likely to be significant in species such as crabs given their limited movement, habitat patchiness, in-seasonal changes in catchability and the spatial extent of inshore fishing operations. Using frequentist (Generalized Additive Models (GAM)), Bayesian (Integrated Nested Laplace Approximation (INLA)) and machine-learning (Random Forest (RF)) techniques, we implemented several spatiotemporal structures, and compared the performance across methodologies and model formulations using 5-fold Cross-Validation. Our work emphasizes: 1. the improvement in model predictive performance across methodologies when including spatial or spatiotemporal correlation, 2. the overestimation of the uncertainty in the standardized index when spatiotemporal correlation is not accounted for. It also highlights the flexibility in model formulation within the INLA approach and the potential of machine learning algorithms in CPUE standardization.

# Assessment of slipping patterns of small pelagic in the Portuguese purse-seine fleet

D. Feijó, A. Rocha, I. Riveiro, A. Silva

The purse-seine fishery is the most important Portuguese fishery, accounting for 55% of total landings by weight in 2019 (DGRM, 2020), targeting small pelagic species primarily sardine (*Sardina pilchardus*). With the decline of the sardine stock and the reduction of annual quotas, this fleet has supplemented its yields with chub mackerel (*Scomber colias*), horse mackerel (*Trachurus trachurus*) and anchovy (*Engraulis encrasicolus*). In 2019, major landings were split between these four species, mainly chub mackerel (57%) and sardine (14%). Ten years ago, the main species was sardine (80%) and chub mackerel percentage was equivalent to present-day of sardine. To minimize landings of low-value or unmarketable fish and maximize the value of their overall landings, fishers slip unwanted catches. Compared to typical discarding, slipping leads to a lower fishing mortality rate as part of the catch is released alive. With the reduction of sardine quota, daily limits and long periods of sardine capture ban, the frequency and volume of sardine likely slipped will increase as the fleet directs the fishing effort to other pelagic species that are found typically mixed with sardine. Slipping is considered to be variable throughout the country and the year. Using onboard observed data in Portugal, we intend to describe and assess its occurrence at the fleet level, considering its variability. We present slipping patterns of sardine and chub mackerel in the Portuguese purse-seine fleet. We argue for the need of practices minimizing the need for slipping, such as sharing catch between vessels and improving identification of shoals.

# Testing length-based indicators to assess the status of *Scyliorhinus canicula* Iberian stock (syc.27.8c9a).

C. Rodríguez-Cabello, T. Moura, J. Teruel, J. Castro, G. Diez, B. Serra-Pereira, J. Gil, I. Figueiredo

The lesser spotted dogfish *Scyliorhinus canicula* is a frequent and abundant catshark species in the Atlantic Iberian Waters. Its stock (syc.27.8c.9a) is assessed since 2014 under category 3 of ICES DLS (Data limited stocks) using biomass indicator trends estimated from survey data. Recently, the need to provide management advice, especially in relation to maximum sustainable yield (MSY), has led to the proposal of reference biological points to DLS stocks. Length-based indicators (LBI) are widely applied to estimate biological parameters length-based reference points to evaluate the status of fish stocks particularly those included in DLS category. In this study we present the results obtained after applying LBI to the *S. canicula* stock in the Iberian waters. Length-frequency distributions associated with landings were obtained from fish market sampling, while those for discards were collected from observer programmes on commercial fishing vessels (mainly trawl fleet), both collected under data collection framework (DCF). Comparison of LBI estimates based on different input values by country and area, as well as using length frequency distributions separately or combined were performed. Estimates based on landings and catch data were also examined. The suitability of these indicators and their expected values for this stock are discussed.

# Improving the commercial CPUE standardization model used for the stock assessment of Norway lobster from southwest and south of Portugal

B. Serra-Pereira, C. Silva

Norway lobster (*Nephrops norvegicus*) is a very valuable and important resource for the demersal trawl fisheries operating in the southwest and south coasts of Portugal. Together with the deepwater rose shrimp (*Parapenaeus longirostris*), *Nephrops* constitutes the main target species of most of the crustacean trawl fleet. The status of this stock is evaluated under the ICES framework and based on trends of the commercial CPUE series of that fleet. Until 2019, that series was obtained from a Generalized Linear Model built with positive records of *Nephrops* only. The main objective of this work was to develop a new standardization model approach to incorporate both positive and null records of *Nephrops* and improve the configuration of the explanatory variables included in the model. The data used for the standardization were the crustacean trawlers logbooks and VMS records (1998–2020). The best selected model was a Generalized Additive Model (GAM) including the “vessel” as a random effect. The variability explained by the new model increased from 51% to 60% compared to the previous. Some other model improvements include: i) incorporating a variable to account for the spatial dimension of the *Nephrops* distribution, ii) replacing the variables used to mimic the target fishing by a cluster-based variable estimated from the catch composition of the main crustacean species caught by the fishery; and iii) the estimation of the mean standardized annual CPUE considering all the factor levels. Important to highlight that the trend followed by the new selected model including zero catches was similar to that of the old model, although as expected, the mean values were lower than the latter containing only positive catches.

# Are teleosts length-based indicators and reference points adequate to be applied to Rajiformes species?

B. Serra-Pereira, C. Maia, I. Figueiredo

In recent years, several studies have been conducted to develop quantitative assessment methodologies for data-limited stocks (DLS), yet these methods are mostly tested with short-lived teleost species, and poorly or not tested with elasmobranchs. Elasmobranchs are known by their life-history traits, that makes them particularly vulnerable to high levels of fishing mortality, including being long-lived and slow growing species, with late maturity and low fecundity. Additionally, the life-history parameters are not always known, and are commonly poorly monitored, either in scientific surveys or from fisheries, so that the length data available may not adequately translate the population length structure. With the eminence of new assessment methods being mandatory for all DLS stocks under the ICES framework, and the concerns on their suitability when applied to elasmobranch species, the present study aims to evaluate the pros and cons of applying the proposed length-based indicators (LBI) and reference points for the main skate and ray species caught by the Portuguese fleets. Some of the concerns include: i) the high impact of the uncertainty of the estimated input parameters, ii) consequences of the insufficient or inaccurate length sampling, iii) contrasting diagnoses from LBIs, iv) violation of the assumption regarding the population dynamics, i.e., constant recruitment, selectivity, and fishing mortality for most stocks, and v) heterogeneous spatial distribution of the different ontogenic stages.

# Investigating Portugal’s mainland purse seine fishery spatiotemporal activities footprint based on georeferenced data

G. Araújo, R. Rosa, A. Silva, D. Feijó, M. Azevedo, J. M. S. Gonçalves

Increasing fisheries and ocean zoning intelligence is fundamental to improve knowledge of spatial displacement and pressure on marine species. Knowledge of fisheries spatial activity is, however, underdeveloped. This study aims to address this by evaluating Portugal’s mainland purse seine fisheries spatial footprint and its pressure on critical spatial areas. Also, estimates for fishing grounds economic value are provided.

To overcome challenges associated with low-frequency data, Automatic Identification System data was used. Individual vessel trips spatial data was matched with the official at auction reported landed revenue by species and commercial size. High-resolution spatial polygons were developed to extract positions at specific locations, with vessel trips being identified based on port exit and entry. Vessel trips corresponding to the official at auction reported landings were isolated as official fishing trips, with revenue estimation. Using observer data, supervised machine learning algorithms were trained to classify fishing vessel’s operational phases. Preliminary results indicate similar spatial patterns for vessel groups with similar technical characteristics, equipment levels and targeted species. It is expected that fishing activity might overlap critical spatial areas and fishing grounds with higher generated revenue to be closer to shore, associated with higher primary production areas.

Pressure on critical spatial areas should be considered in fisheries management. Designing regulatory frameworks, assessing fishing grounds values is key for a successful policy implementation. This study is part of a broader framework to assess fishermen’s spatial footprint of any fishing gear or métier.



# Assessing status of fish by-catch species for the bottom trawl fishery in the NW Mediterranean

J. G. Ramírez, F. Maynou.

Demersal fisheries in the Mediterranean Sea are essentially multi-species, challenging their monitoring, assessment and management. Target species in GSA 06 landed almost 60.000 tons since 2000 while the most important eight fish bycatch species landed 61.000 tons in this period. Bycatch lacks complete dataset required to perform stock assessment by catch-at-age or surplus production models. In order to assess the impact of bottom trawl fishery on these bycatch species, the length-based spawning potential ratio model (LB-SPR) was used to assess their status. Horse mackerel, Bogue, Common Pandora, Gilthead seabream and Poor cod presented a median spawning potential ratio above or near reference point before 2012. Atlantic horse mackerel, Axillary seabream and Blue whiting exhibited different vulnerability to exploitation during this period. From 2013 to 2015, both single species SPR decreased and combined relative SPR dispersion increased. The LB-SPR modeled changes in selectivity for several species. Accordingly, it may be hypothesized that the interplay between changes in fishing effort (annual reduction of the vessel number and probable changes in fishing area) and catchability (technology improvements) may contribute to SPR variations. Since 2016 the SPR dramatically fell for most of the species and by-catch is less-uniformly responding to a too high fishing pressure. Length structure derived from mixed fisheries for the main bycatch fish species in GSA 06 points out that their current reproductive potential is lower than those observed in the first period (2009-2012) and species are less-uniformly responding to pretty high fishing pressure.

# Describing (and assessing) artisanal fisheries in the Canary Islands through fishery essentiality

P. Martín-Sosa, C. Dorta

Fishery essentiality, a new tool to assess and manage small-scale fisheries (SSFs) has been developed (Dorta and Martín-Sosa, in rev., Dorta and Martín-Sosa, 2021). Essentiality measures the relative importance of a certain species from an economic perspective. The time dedicated to the capture of a species, the number of units that fish it and the economic yield obtained from the sale of the catch: Frequency, Fleet recruiting and Profit, define essentiality. We come up with an overall index of essential capacity of the whole fishery. Essential potentiality is defined as a measure of dispersion of the essentiality.

In this presentation we describe SSF at the Canary Islands with this tool. We analyze essentiality parameters for most of the Canary Islands fishing nucleus through 2017-2020 official landing data. We explore the reasons for the differences found among fishing nucleus and for the trends in essentiality figures along the period.

These data is being useful to the Fishery Office for introducing management measures that allow the behavior of the fishery to change towards a situation of greater essentiality, and therefore, of greater economic viability, bringing about a reduction of the pressure focused on a few specific fishing resources.

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# Towards a genetics-informed fisheries management

N. Rodriguez-Ezpeleta

Achieving sustainable fisheries production relies on appropriate understanding of the status of resources which, in turn depends on the accuracy and completeness of scientific information. Yet, often the appropriateness of the information collected is compromised by economical or technological limitations. Thus, there is a need to explore alternative or complementary approaches that can improve fisheries assessments. Genetics-based approaches offer the most promising alternatives as they allow the capture of information that cannot be measured otherwise and provide cost-effective alternatives to traditional approaches. Yet, despite this potential, the uptake of genetic methods by the fisheries assessment process is not a reality. Here, I will use six highly valuable commercial fish species as case studies (mackerel, hake, anglerfish and bluefin tuna within the Atlantic Ocean and skipjack and bigeye tunas within the Indian Ocean) to reveal the power of genetics to assist fisheries management. Using genome-wide based information we have found conservation and management important phenomena such as mismatches between administrative and natural populations, reproductively isolated stock mixing, interspecific hybridization, mislabeling and genetic adaptation. I will discuss the potential impact of these new findings on species conservation and review the lessons learnt from the course of communicating and integrating genomic data into fisheries assessment. If time allows, I will also provide results on innovative methods based on environmental DNA (eDNA) for species detection and on close kin mark recapture (CKMR) for abundance estimation as promising solutions for modernizing fisheries management.

# Development of a Sex-Separated Stock Synthesis (SS) model for the South Atlantic hake (*Merluccius merluccius*) stock

F. Izquierdo, S. Cerviño, M. Cardinale, M. G. Pennino

The South Atlantic hake stock has been assessed using GADGET for the last 10 years. However, in 2020 this model was rejected due to convergence problems and a switch was made to other alternative methods. In this framework, it was necessary to look for alternative assessment models, where Stock Synthesis (SS) is one of the most widely used at present. As an integrated model, SS allows the input of incomplete trends of data from different sources, such as catch data, catch per unit effort (CPUE) or surveys. Among the multiple configurations of SS we can find the single biology (gender, growth and natural mortality) or the separate sex alternative. In addition, each population entity starts to grow at the beginning of the year, but different recruitment peaks can be specified. European hake is a highly dimorphic species (as females are considerably larger than males) that has different spawning peaks throughout the year. Due to these reasons, sex-separated models were tested and compared with a single-sex approximation. Results are presented and discussed jointly in order to find the best alternative for the assessment of this stock.

# Spatio-temporal models for European hake catch and effort data: multiple index standardization to improve the accuracy of inputs to stock assessment

J. Otero, F. Izquierdo, M. Cousido-Rocha, M. G. Pennino, J. Rodríguez,  
M. Marín, J. Castro, S. Cerviño

Stock assessment models are typically calibrated using time series of abundance indices. Commonly, these abundance indices are obtained from standardized scientific surveys. However, indices can be derived also from fishery-dependent data such as logbooks, onboard observers or vessel monitoring systems. Despite that fishery-dependent sources may incorporate certain biases, they are powerful to complete the view of the scientific surveys by means of providing a greater spatio-temporal coverage. This is particularly important for species exploited by multiple fleets operating in contrasting grounds and time periods, and using differing fishing gears targeting distinct size-ranges of the population. Here, we fit hierarchical Bayesian spatio-temporal models to fishery-dependent catch and effort data from long-liners, gillnetters and trawlers fishing European hake (*Merluccius merluccius*) in the Northern Iberian Peninsula. Data were obtained from both logbooks and onboard observers for seven métiers covering the period 2003-2020, and catch and effort data were standardized using methods based on the Integrated Nested Laplace Approximation implemented in R software and including spatial, temporal and environmental predictors. Our results showed that hake catch typically increases with fishing capacity and effort, and observer-based models provided evidence of a negative relationship with haul depth. Standardized catches were seasonally variable depending on the métier, and annual trends showed certain stability (if not a slight increase) in recent years. Finally, in general, the western most area tended to concentrate most of the catches, though hotspots were also apparent eastwards depending on the métier. We argue that using explicitly spatio-temporal abundance indices sourced from a pool of different métiers provides a broader view of the fished stock status and can improve the accuracy of inputs to stock assessment models.

# Effects of underestimating landings and discards in state-space production models: the case of black hakes in North West Africa

M. Soto, L. Fernández-Peralta, M. G. Pennino, A. Kokkalis, J. Rey, F. Salmerón, M. Liébana, L. Kell

State-space models have become among the Surplus Production Models (SPM) one of the recent developments to manage Data Limited Stocks (DLS) because they only need as input data catch and biomass time series and are able to manage simultaneously process and observation error in the fitting procedure. Nevertheless, declared catches can be underestimated and discards even ignored, making that inputs of the SPM produce biased and uncertain reference points for management. In this study we use as state-space models a stochastic surplus production model in continuous time (SPiCT) and Just Another Bayesian Biomass Assessment (JABBA) to explore new assessment methods of DLS for the black hakes in North West Africa (NWA) and use them to evaluate the effect of the major uncertainties arising from underreporting catches, discards and bycatch in the management quantities. Standardized Catch Per Unit Effort (CPUE) and total declared catches were used as input in the production models simulating different levels of underreporting. Also, we compared the importance of underreporting between total catches and discards, the type of underreporting trend (constant, cyclic or monotonic) and the initial and final levels of underreporting. Both models showed similar diagnostics of current stock status and we conclude that the stock is in a risk situation with a high probability that if current catches are maintained, stock will approach into the red quadrant of Kobe plot (overfished and overexploited). Also, simulation results reveal that ignoring the existence of non reported catches and discards will bias the derived model estimates. In particular, the maximum sustainable yield shows the higher bias for both models when underreported discards were maintained constant. This means that if an improvement in discards sampling is not occurring estimates of harvest will be probably being underestimated. Furthermore, we observed that an improvement in catch data sampling would be better reflected in biomass estimates reference points and also in SPiCT than in JABBA. Initial percentages of underestimation affect to estimates more than the final percentages at the end of the series and, hence, more investigation of priors for the initial levels of exploited biomass ( $B_0/K$ ) are needed. Improvements in the CPUE index would lead to better fits to the SMP models. Simulations on default priors should be conducted to test the robustness of the results of this study in JABBA and SPiCT models.



# Harvest rate-based control rules for data-limited short-lived stocks

S. Sánchez-Maróño, A. Uriarte, L. Citores, L. Ibaibarriaga

ICES classifies the stocks depending on their data availability. Category 3 stocks are those for which at least one index indicative of stock trends is available. In this case, the harvest control rule (HCR) adopted for short-lived fish stocks adjusts the most recent advised catch based on the ratio of the last available index and the average of the two previous years capped by a maximum change limit of 80%. However, this rule implies long-term losses of catches and, consequently, should be considered as interim.

In the present work, we compare several harvest-rate (HR)-based (model-free) HCRs using a management strategy evaluation approach implemented in the FLBEIA software. First, we test several HCRs from the literature (catch-based: Itarget, Islope, Gcontrol and F-based: DynF) adapted to become HR-based. In addition, we test a Perturbation Reaction rule designed to amend initial HRs towards levels consistent with maximum sustainable yield (MSY) according to the reaction of the abundance index to a 25% reduction of the mean HR prior to management, lasting for at least 5 years. We examined the rules for two types of short-lived stocks (anchovy-like stocks: characterised by full maturity at age 1, high natural mortality and large interannual variability; and sardine and sprat-like stocks: full mature at age 2, with medium natural mortality and intermediate interannual variability) and three contrasting initial depletion levels. The HCRs performance is evaluated based on biological risks ( $SSB < B_{lim}$ ) and the expected yields relative to the MSY. Sensitivity to the index observation error level and to the time lag between index availability and management implementation is also tested.

# Potential use of ecosystem models to inform stock assessments and advice in the Bay of Biscay

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The current EU fisheries framework in NE Atlantic waters is based almost exclusively on single-species stock assessment to inform management decision making process for several target species. Marine organisms, environment and anthropogenic activities interact and influence each other, but these interactions are usually not considered when providing management advice. Therefore, there is an urgent need to move towards more comprehensive frameworks that consider the entire ecosystem, such as the ecosystem-based fisheries management (EBFM) framework. Ecosystem models are useful tools to inform EBFM, though their use in the advisory process is still limited.

Within this context, two different ecosystem models (Atlantis and Ecopath with Ecosim - EwE) have been developed in the Bay of Biscay (BoB), which includes Spanish and French waters. Although this area includes three different ICES divisions (8abc), some ecological and management features (e.g., the presence of several shared stocks) motivates the development of a larger model covering the whole BoB. The two models were built with a similar structure and using same data sources. Remarkably, in both cases the main target species were modeled separately as a functional group, and they both incorporate manageable (anthropogenic activities – fishing) and non-manageable (environmental) pressures.

In this study, we explore how the information derived from these ecosystem models can be used to complement current advice. Specifically, we explore: i) the potential of using predation mortalities in single-stock assessment, and ii) how fishing mortalities used for advice can be rescaled within predefined fishing mortality ranges based on the insight provided by ecosystem models.

# Evaluación de las Estrategias de Gestión (MSE) del Bacalao de la División 3M de NAFO.

D. González-Troncoso, F. González-Costas, A. Urtizberea, C. Fernández

El MSE es una herramienta para buscar y testar estrategias de gestión que sean robustas a las incertidumbres y que posean un balance adecuado entre los objetivos de gestión y los intereses de las partes interesadas. EL MSE se está usando actualmente en diferentes Organizaciones Regionales de Pesca para evaluar estrategias de gestión adecuadas en diferentes pesquerías. El MSE suele conllevar procesos que demandan gran cantidad de recursos y tiempo, y no siempre se alcanzan los resultados esperados.

La actual presentación versa sobre los trabajos desarrollados durante el año 2018 en el MSE del bacalao de la División 3M de NAFO: Elección de los diferentes modelos operativos (OMs), reglas de explotación (HCRs) testadas e indicadores estadísticos (PSs) usados para valorar las diferentes estrategias de gestión. Este MSE no ha sido finalizado debido a los problemas encontrados durante su desarrollo, que no han permitido encontrar una HCR que satisficiera simultáneamente todos los PSs exigidos.

El objetivo de esta presentación es presentar someramente los resultados obtenidos, y centrarse en los problemas encontrados y posibles soluciones para solventar los mismos. Los mayores problemas encontrados en el MSE de este stock han estado relacionados con las simulaciones de los reclutamientos y parámetros biológicos futuros y su incertidumbre asociada, y la idea es discutir posibles desarrollos de futuros OMs y HCRs para solventar los problemas hallados.

# Synthesis of results from the ICES workshop on operational EwE models to inform IEAs and stock assessment?– WKEWIEA

E. Andonegi, M. A. Torres, M. Tomczak, D. Pedreschi, M. Llope

This work aims at providing the outcomes of the first Workshop on operational Ecopath with Ecosim (EwE) models to inform Integrated Ecosystem Assessments (IEAs)-WKEWIEA held in 2018, originated within the scope of the ICES WGEAWESS. The main goal was to identify, analyze and provide light on the potential use of ecosystem models to inform the scientific advice currently provided by ICES. The workshop focused on EwE models, since EwE is the most widely used ecosystem modelling tool across ICES IEA regional groups. Different works were shown during the workshop, some providing a general overview of the way EwE models have and/or are being used for solving management and policy related issues, some others showing practical examples on how existing models could be used to inform the Ecosystem Overviews (EOs), advice products produced by ICES. Interesting discussions related to the need for a well-accepted protocol that would establish the base requirements for these ecosystem models to be used to inform fishing opportunities advice. The main recommendations provided by the WKEWIEA group to the ICES community are: i) to develop a key-run and model quality protocol for using EwE models to inform IEAs and ICES advice (together with WGSAM); ii) adopt EwE and equivalent models in the Terms of Reference of the ICES IEA groups; iii) provide advice about the use of indicators from EwE models in IEAs to inform on the state of different ecosystem components; iv) provide guidelines about visualizing trade-offs. Additionally, WKEWIEA strongly recommended setting up a series of workshops to continue working on how to make EwE (and other ecosystem models) operational for ICES advice.

# Surplus production models. A comparative analysis of model performance with simulated data.

A. Paz, M. Cousido-Rocha, S. Cerviño, M. G. Pennino

Surplus production models (SPMs) were among the assessment methodologies recommended for improve the reliability of stock assessments in data-limited situations, which only require time series of an index of exploitable biomass and catch data. In our study we analyze two well-known SPMs: SPiCT (A Stochastic surplus Production model in Continuous Time) and ASPIC (A Stock-Production Model Incorporating Covariate). The main difference among these models is that ASPIC assumes that errors come from the observed biomass, whereas SPiCT considers errors in both observation and processes. Data is simulated imitating the real dynamic of a fishery system, through the “Rfishpop” package (available in [Rfishpop](#)) and the SPM’s equations. Sampling of catches and biomass index are also simulated under different sampling scenarios. The obtained data is used as inputs in the mentioned models to evaluate the accuracy of their assessment. Different settings have been simulated, testing (1) the intensity of observation errors; (2) fisheries for which available historical data started after the start of the exploitation period; (3) the process error’s impact. A Montecarlo procedure has been used to compute the veracity of the estimated biomass trajectory, parameters and reference points. The derived results are compared to real values of our simulated population through measures such as the root of the mean square error (RMSE) and mean absolute percentage error (MAPE) to understand which factors affect the model performance and our ability to advise on sustainable management. The results obtained show how SPiCT allows obtaining more accurate estimates than ASPIC in almost all situations considered.

# Horse mackerel spatio-temporal distribution patterns supporting an integrated approach of fisheries and biological data to improve spatial management

H. Mendes, M. Azevedo, C. Silva

Understanding fish stocks spatial and temporal variability is key to evaluate changes in stock size, demography, and abundance, as well as to understand the dynamics of stocks and fishing fleets. Based on an innovative framework of combining species sales notes by commercial size category, the length and age composition of commercial sizes from onshore sampling and the fishing ground and fishing effort from vessel monitoring system records it was possible to obtain high resolution mapping of daily horse mackerel landings from 2010-2020. The use of this high-resolution fisheries data for the bottom trawl, purse seine and polyvalent fleet was analyzed by three distinct Portuguese oceanographic areas. The analysis revealed fisheries seasonal patterns and ontogenic migrations contributing to the characterization of the spatial distribution of abundance of this stock off the Portuguese coast. The implications of this new understanding are explored focusing on integrated fisheries and biological data for developing spatial management models and conservation measures. Expanding this approach to incorporate multispecies data for the assessment of biotic and non-biotic species interactions is discussed in the context of mixed fisheries and ecosystem-based management.

# Links between the environment and Surplus production model outputs: The case of Moroccan chub mackerel stock.

G. Derhy, D. Macías, K. Khalil, K. Elkalay, M. M. Rincón

Small pelagics are characterised by highly-fluctuating dynamics forced by the environment. In the case of chub mackerel in Moroccan Atlantic coast, there is a limited knowledge about this environmental forcing. Considering that chub mackerel (*Scomber colias*) is one of the most important small pelagic fishery resources in the Moroccan Atlantic coast (attaining 16% in 2018), the understanding of its environmentally driven dynamics is of paramount importance. To advance into this knowledge we decided, first, to estimate population fluctuations through a Surplus Production model in Continuous Time (SPiCT), and then to search for mathematical relationships between the model-estimated biomass and different environmental covariates. Exploratory implementations point out to a seasonal influence of the upwelling strength but different relationships should be tested to see if there is a combined effect of different variables. Those relationships can be further incorporated directly into stock-assessment models to improve management and decision making, or they can also be used to forecast different scenarios, including climate change scenarios. We hope this assessment will provide a step forward for an ecosystem-based fisheries management in the area.

# Development of MSY advice for Nephrops Functional Units 25 (North Galicia) and 31 (Cantabrian Sea) using SPiCT (ICES WKMSYSPiCT)

I. González Herraiz, M. Cardinale, C. Berg, H. Winker, M. Azevedo, A. Kokkalis, T. Mildemberger

Nephrops catches from Functional Units 25 (North Galicia) and 31 (Cantabrian Sea) (Division 8c) have decreased by 98% in the last forty years. Their recruitment proxies are decreasing since 1991, with persistent recruitment failures. ICES advice for those FUs has been to reduce catches to zero since 2002. Finally, the total allowable catch (TAC) for the division 8c is zero since 2017. In the period between 2000 and 2006 these stocks were assessed with eXtended Survivors Analysis (XSA) which required age data. For Nephrops stocks age data were inferred from length distributions. Since 2007 the assessment has been based on trends from commercial CPUEs. Different methods (Length Based Indicators, Length Based Spawning Potential Ratio, Mean Length-based estimators Z, Separable Cohort Analysis) were tried during 2019 with the aim of obtaining reference points for these stocks with non satisfactory results. During 2020 and 2021 an ICES workshop on development MSY advice using Surplus Production Model in Continuous time (WKMSYSPiCT) took place. SPiCT models were fit for FU 25 and FU 31 in that workshop and later accepted in ICES Working Group for the Bay of Biscay and Iberian Waters Ecoregion (WGBIE). Input data review, model fit and results for both FUs will be presented.



# Temporal persistence and spatial differentiation of the bottom-trawl fishery métiers in the northwest Mediterranean

M. Garriga-Panisello, J. Gabriel Ramirez, C. Campins, A. Subirà, J. Sala-coromina, L. Recasens, T. Lombarte, J.B. Company

The multi-annual plan of demersal fisheries in the northwest Mediterranean Sea mainly considers the reduction of fishing effort and spatial closures to achieve fishery sustainability. Enforcing undifferentiated management measures on contrasting fishery tactics (métiers) may prevent achieving the sustainability goal. This study is aimed at distinguishing the bottom trawl (OTB) fleet by métier considering main target species, by-catch harvested community, temporal persistence and spatial deployment. Multivariate technics were applied on around 17 million daily trips reported by the Catalan Government since 2002 for 14 fishing ports along the Catalan Sea. Annual basis analysis indicates that the contribution of the harvested targets by métier has changed along with the time series (Villanova case study). The métier targeting Norway lobster has constrained the fishing ground areas. The fleet segment of vessel length 18-24 m has reduced the trips in favor of smaller vessels (12-18 m). The coastal shelf métier that targets mullet has seen increased the trips performed by larger vessels (18-24 m). For this métier, fishing ground has increased between early and late years. The métier that targets hake and white octopus has seen reduced landings, fishing effort and ground areas, suggesting re-allocation of part of the trips in other métiers. The blue and red shrimp métier has increased the trips contribution of the fleet segment of 18-24 m while ground areas were either expanded or constrained among years. Our findings suggest that spatial closures should both consider the impact of each métier on target species and extension of fishing ground by métier along the Catalan Sea.

# Recruitment-based harvest control rules to manage stocks of uncertain productivity: Application to the Iberian sardine

A. Uriarte, A. Silva, S. Sanchez, M. Azevedo, L. Ibaibarriaga, I. Riveiro,  
L. Wise

Recruitment is one of the key drivers of stock productivity, in addition to growth and natural mortality. Variability around the stock-recruitment (S-R) relationship is usually high for most stocks and quite often irregular with some sporadic high/low recruitment levels above/below “normal” expected levels. For a given functional S-R relationship, every recruitment realization can be seen as the effect of a different yearly change on the average productivity, affecting the steepness of the relationship for that year. As steepness is directly related to sustainable fishing levels, every recruitment level can be used to define an  $F_{MSY}$  level. In present work, we propose to test the performance of a harvest control rule which sets the fishing mortality according to a weighted mean of recruitment-based  $F_{MSY}$  estimates inferred from the assessment of the recruits of the preceding years, where the weighting factors are a decreasing function of the time elapsed between the year when every cohort was born and the interim year, according to the lifespan of the stock and the presumed duration of homogeneous productivity regimes. Such a rule could be adaptable to changes on productivity reflected either on changes of the average level of recruitments or on the frequency of sporadic recruitments. The rule is tested on the Iberian sardine stock for which productivity is suspected to be changing. We evaluate its performance in comparison with the ICES MSY advisory rule under low and high productivity regimes as well as in changing productivity regimes (from high to low and from low to high).

# A bioeconomic model for the Portuguese purse seine fleet: towards an ecosystem-based management

R. Rosa, J. Vaz Patto, M. Azevedo, D. Feijó, S. Garrido, H. Mendes, A. Silva, L. Wise

Defining management plans for sustainable exploitation of fish stocks requires an effective multi-disciplinary approach to combine detailed biological knowledge with economic modelling. Evidence of species ecological interdependence and the sensitivity of fish stocks to climate change emphasizes the need for an ecosystem-based approach to design harvest plans. Fisheries management, however, is still mostly grounded on single-species models and disregards broader biological, environmental, and economic interactions between different fish stocks.

We build an ecosystem-based bioeconomic model to optimize harvest rates of the Ibero-Atlantic purse-seine fishery targeting three major pelagic species: sardine, Atlantic horse mackerel and chub mackerel. An age-structured multispecies model is thus parameterized to account for the trophic relationship between species and for the sensitivity of sardine recruitment to environmental variables.

Results of the model are then compared to single-species optimization and used to assess the current harvest control rules, highlighting the importance of ecosystem-based fishery management to ensure climate-resilient and economically sustainable fish populations.

# Aplicación de modelos de producción de biomasa conocida para la evaluación de recursos de interés para España en aguas atlánticas

S. Cerviño, M. Y. Zanni, M. Cousido-Rocha, M. Grazia Pennino

Con el fin de comprender la dinámica poblacional de los recursos marinos se pueden emplear diferentes modelos de evaluación. En este trabajo nos centramos en los modelos de producción excedentaria los cuales incluyen todos los aspectos de la producción en una sola función. En concreto en los modelos de producción de biomasa conocida que son una alternativa a los modelos de producción tradicionales, y un complemento a los modelos estructurados. Emplean una serie temporal de biomasa conocida obtenida de un modelo estructurado, en lugar de estimarla a partir de una serie de capturas. En particular analizamos las especies gallo (*Lepidorhombus whiffiagonis*), rape blanco (*Lophius piscatorius*), merluza europea (*Merluccius merluccius*), y sardina (*Sardina pilchardus*) en el oeste atlántico de la zona ICES “International Council for the Exploration of the Sea”. Los pasos del estudio han sido: (1) ajuste de los modelos de producción excedente monoespecíficos (a cada stock individual); (2) análisis retrospectivo para identificar posibles cambios de regímenes; (3) ajuste de los modelos de producción excedente multiespecíficos (stocks agregados en sur y norte); y (4) estimación de los efectos de la variabilidad ambiental.

Los resultados del estudio permiten concluir que: (1) la productividad estimada es comparable entre los stocks, siendo la sardina sur el de menor productividad, (2) en la población de merluza del norte se aprecia un cambio de régimen a principios de los años 2000 y en la sardina sur un cambio de régimen gradual. La merluza y el rape en toda la zona de estudio (norte y sur) tienen una alta productividad. Finalmente se han detectado relaciones entre la productividad y las variables ambientales (la Oscilación Multidecadal del Atlántico y la temperatura superficial del mar).

# Dealing with spatial differences in data-richness: an example using Atlantic chub mackerel in the Iberian Peninsula.

A. Silva, C. Nunes, A. Machado, F. Ramos, S. Garrido

Data richness is often variable among areas of the same stock. This may arise because the commercial importance of the species, the resources to collect data or both, are different between countries. The consequence may be that the assessment category is levelled by the data-poorer area or simply, that the data-poorer area is not included in the assessment of the stock. In this study we investigate the use of prior information derived from biomass dynamic models (SPiCT) applied to long time series of data in part of the stock, in the assessment of the whole stock using short and poorly contrasted data. Our example, Atlantic chub mackerel, is a by-catch of purse seine fisheries in Iberian waters and has become increasingly important since the early 2000s. The dynamics of chub mackerel is first modeled in the Portuguese waters where a long time series of catches (1960-2020) and survey indices spanning the three most recent decades are available. Seasonal SST indices spanning the whole period are also explored as indices of chub mackerel abundance within the model. Estimates of the intrinsic rate of population growth ( $r$ ) and of the initial exploitation level ( $B_1/K$ ), which are likely to be identical to those of the whole stock, were then used as priors in models fitted to 1993-2020 data of the whole stock area (ICES 9a). For the stock model with the best performance, the use of  $r$  and  $B_1/K$  priors increased the precision of relative biomass in the interim year in 9%, and particularly that of the relative fishing mortality (42%). The stability of the model was also improved, as shown by a decrease of more than 25% in the Mohn's Rho of both relative biomass and fishing mortality.

# Full feedback vs. shortcut approach MSE for the sardine in the Bay of Biscay

L. Citores, S. Sanchez-Marono, L. Ibaibarriaga, A. Uriarte

Depending on the way assessment is included in a Management Strategy Evaluation (MSE) two main approaches are differentiated. The “full-feedback” approach incorporates the assessment model in the MSE aiming at the correct characterization of the entire fishery process and the related uncertainty. However, its implementation can be tedious and computationally intensive. As a simpler alternative, the “shortcut” approach which tries to mimic the stock assessment model error can help for fast explorations of a wide set of options.

The objective of this work is to compare the performance of the “full-feedback” and “shortcut” approaches for MSE using the FLBEIA framework, taking as case study sardine in the Bay of Biscay, which is assessed every year through the Stock Synthesis (SS) model. We introduce process, observation, parameter and assessment uncertainties gradually in order to study the effects of each of these uncertainty sources in the MSE process and explore the impact on the performance of the HCRs for this stock in terms of biological risk, expected biomass or catches.

The performance of the HCRs was sensitive to the configuration of the assessment in the MSE framework. The full-feedback MSE showed that assessed biomass tends to be positively biased with reduced uncertainty in the last years. This led, for instance, the ICES MSY advisory rule to become non precautionary in the long term, as it makes use of an  $F_{msy}$  defined assuming unbiased assessment. In general, the gradual incorporation of the uncertainty sources, resulted in a successive increase of the biological risks and a decrease of the expected average catches. Moreover, the full-feedback MSE shows to be powerful tool for testing stock assessment models.

# Shape your fish stock: Using a length- and age-based population model to find the optimal harvest strategy

S. Haase, S. Kraak, J. Santos, D. Stepputtis

Exploitation patterns and rates influence the size and demographic structure of fish stocks. A dynamic population model is used to evaluate possible consequences of different management strategies. Western Baltic cod (*Gadus morhua*, L.) is used as a case study, since this stock is heavily exploited and below  $B_{lim}$  since 2008. Despite an increased mesh size from 110 mm to 120 mm in bottom trawls in 2010, the stock did not recover under high fishing mortality  $F$ . Accounting for size-dependent selectivity we use a length- and age- based population model. It simulates how selectivity of bottom trawls, intensity of  $F$ , and gillnet proportion affect (i) the SSB, (ii) catches above minimum conservation reference size (MCRS), (iii) catches below MCRS and (iv) the  $F$  at the length of full retention in the short- to long-term. Larger meshes result in short-term losses of catches which are compensated in the next years. The SSB increases and catches below MCRS decrease with mesh size. Reduced  $F$  leads to increased SSB, but also to short- to medium-term losses in catches above MCRS. Additionally, reduced  $F$  leads in the long-term to increased yield per recruit (YPR) and reduced fishing effort. Under larger mesh sizes when only larger cod are retained, the  $F$  achieving maximum YPR is higher. Increased gillnet proportion results in lower catches above MCRS and higher fishing efforts, but only slightly influences the SSB. For recovery of SSB to within safe biological limits,  $F$  needs to be reduced significantly and adapted to the fishing gears used.

# Surplus Production Models: a practical review of recent approaches

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Tifoura, M. Y. Zanni, S. Cerviño

Increasing the knowledge of approaches for estimating the status of data-limited stocks is of crucial importance since over 90% of stocks are data limited, i.e., there is not enough data to conduct a conventional stock assessment. Among the different data-limited methods, the surplus production models (SPMs) are usually considered among the most appropriate data-limited assessment methods since they are the unique data-limited method which provide a full stock assessment. Due to the high interest on the application of SPMs for assessing data-limited stocks, our contribution focuses on providing a review of such models. Additionally, the termed known-biomass production models are addressed highlighting their potential through examples of several relevant applications.

After introducing the general SPM formulation, framework and features, the review focuses on the most relevant SPMs, on basis of their number of recent applications on well-known marine research organizations: ASPIC (A Surplus-Production Model Incorporating Covariates), SPiCT (Surplus-Production model In Continuous Time) and JABBA (Just Another Bayesian Biomass Assessment). For each of them details of their formulation, main features and quality and characteristics of the available software are provided. From such information a comparative study is carried out highlighting the advantages and disadvantages of each one of three SPMs.

To conclude, recommendations for their use in the assessment of data-limited stocks are provided allowing to decide whether SPM can be an appropriate option for a specific stock assessment and advice, and then which of the addressed SPMs must be applied.



## 5 Poster contributions

### Automatic echotrace classification of pelagic species in the Bay of Biscay

A. Lekanda, G. Boyra, M. Louzao

There is a permanent quest to develop ecosystem-based management methods, which requires a better understanding of ecosystem structure and functioning. Multifrequency acoustic studies have shown potential in continuous monitoring and spatio-temporal characteristics analysis of pelagic populations. Currently, it is possible to discriminate acoustic scattering groups (as fish with swim bladders, fish without swim bladders, and certain plankton groups) based on its acoustic properties, but visual interpretation or scrutiny by experts is still widely extended. Fish schools may be identified and isolated according to intensity thresholds of the signal. It is generally possible to distinguish between echoes of different species based on acoustic descriptors. These descriptors can be grouped into three categories, morphological (related to the geometry of the school), energetic (associated with the properties of the backscattered signal) and positional (describing the latitude, longitude, time, depth from surface, altitude from bottom). The traditional visual scrutiny of echograms is subjective, time-consuming, and may differ between operators. Automatic echotrace classification is a well-established, non-invasive method and combined with the objectivity and reproducibility of machine learning techniques, may provide information not only about population status but also about different components of the pelagic ecosystem. The present study has the aim of developing a method to identify the pelagic fish species of the Bay of Biscay based on different automatic classification methods. We used data from three long-standing multi-disciplinary surveys in the Bay of Biscay (JUVENA, BIOMAN and TRIENAL) from 2003 to 2020. The echograms with >70% of same species composition and with a higher abundance than 1000 individuals were pre-processed using Echoview software and used as train set for a posterior species classification by classification models. In this way we contribute to an objective, reproducible and relatively fast identification of species for a multiparametric characterization of the of pelagic components.

# Impact of climate change on four socio economically important species of bivalves for Rías Baixa, Galicia

A. Castro, M. Des, M. T. de Castro

The infaunal bivalves *C. edule*, *R. decussatus*, *V. corrugata*, y *R. philippinarum* are part of the most socioeconomically important gathered shellfish species in the Galician coast (NW Iberian Peninsula). The increase in greenhouse gas emissions, CO<sub>2</sub> in particular, disrupts environmental conditions affecting terrestrial and marine habitats. Therefore, it is necessary to analyze future changes induced by ocean warming in this area. The Delft3D model, forced with climate data from CORDEX and CMIP5 projects, was used to calculate the July-August sea bottom temperature for the historical (1999-2018) and future (2080-2099) periods in the Rías Baixas. Bottom water temperature was used to analyze the geographic distribution of comfortable areas for *C. edule*, *R. decussatus*, *V. corrugata*, y *R. philippinarum* based on their optimal thermal thresholds. Results show that the future increase in deep waters temperature may modify the geographic areas of thermal comfort for these four species of bivalves. The total area will increase towards deeper zones of the Rías Baixas and decrease in the shallow areas.

# Wave trends along the galician coast and evaluation of their potential impact on the quality of stalked barnacle, *Pollicipes pollicipes*

R. Peñas Torramilans, N. Weidberg, E. Vázquez

Due to climate change, several studies show upward trends in maximum wave in the North Atlantic. These variations in wave climate are linked to the evolution of climate indices, such as the NAO, and lead to changes in wave patterns over kilometres. Changes in wave height, wave period and orbital currents can be translated to marked shifts in the shape of intertidal organisms such as the stalked barnacle *Pollicipes pollicipes*, whose quality and market price is known to decrease with the relative length of its peduncle. This study evaluates wave trends in Galicia from SIMAR modelled data between 1958 and 2020 and trends in stalked barnacle morphology and quality in the “cofradías” of A Coruña, Baiona and A Guarda between 2011 and 2020. The results show positive trends in all wave variables. For stalked barnacle, 28 significant morphological trends towards more elongated and low quality individuals were observed at different sites and intertidal levels. In addition, the coupling between shifts in wavedriven orbital currents and stalked barnacle morphology was also studied, finding very significant reductions in quality with decreasing eastward orbital currents that explain up to 90% of the variability in the relative length of the peduncle. In conclusion, it appears that changes in stalked barnacle morphology depend on shifts in wave climate modulated by topographic variables, such as the intertidal level and shore orientation.

# Looking for environmental drivers of blue whiting recruitment in the Porcupine Bank (NE Atlantic)

F. Baldó, M. Chowdhury, G. González-Nuevo, F. Velasco, I. Laiz

Although temporal and spatial match and mismatch of fish larvae with their potential prey organisms is considered the main factor regulating the year-class strength in marine fish populations, different environmental forcings also influence the survival rate of larvae and therefore recruitment. In 2020, the highest abundance of year-class recruits (total length  $< 20$  cm) of *Micromesistius poutassou* was observed in the record of the Spanish Bottom Trawl Survey on the Porcupine Bank (September) from 2001-2020. Various environmental parameters, namely chlorophyll concentration, surface salinity, temperature, ocean currents, and wind data were used to study their potential impact on the blue whiting eggs and larvae survival. Our results showed that in 2020, during the blue whiting-spawning season (March-April), the calm wind situation along with weaker ocean currents above the Porcupine Bank helped to accumulate phytoplankton biomass, thus promoting secondary productivity. The optimal salinity concentration, as well as surface temperature during this time, helped the buoyancy of eggs and larvae to the food-rich surface, thus improving the larval condition and enhanced the survival rate, which in turn resulted in the largest recruitment since 2001.

# Adapting the sampling design of research surveys to improve the biomass estimation of non-target species - the case study of *Raja clavata*

D. Silva, R. Menezes, I. Figueiredo, B. Serra-Pereira, M. Azevedo

Research surveys are important to monitor the spatial distribution and abundance of fishery resources. Their sampling design is usually conceived with the focus on specific species. However, an efficient design may reconcile this objective with the collection of non-target species data. This study evaluates the adequacy of different sampling designs for the bottom trawl survey off the Portuguese continental coast, aiming to maximize the accuracy of *Raja clavata* biomass estimates while maintaining the quality of the abundance estimates of *Merluccius merluccius*, one of the target species of the survey. A model-based geostatistics is developed taking into account the semi-continuous nature of the data and the excess of zero values for *R. clavata*. Species abundance is modelled as two independent processes: one dealing with the presence/absence data and the other with the intensity given a nonzero response. The selection of sampling designs rely on the prediction process results and eight optimization measures. Eight survey designs are evaluated, each adding 11 sampling stations to the 65 survey stations. Species estimates are compared to those obtained from a baseline design with the location of sampling stations randomly selected from on a homogeneous spatial Poisson process. Three sampling designs resulted in higher accuracy of *R. clavata* biomass and *M. merluccius* abundance estimates than that obtained with a random selection of stations. The sampling design maximizing the accuracy of *R. clavata* biomass estimates shows an acceptable trade-off between bias and variance of *M. merluccius* abundance estimates. The approach presented in this study is easily replicated to other group of species caught by the research survey.

# Procedimiento de recopilación de datos para la inferencia de stocks de las poblaciones de moluscos bivalvos sometidas a explotación marisquera.

J.M. Parada

La captura de almejas y berberechos constituye uno de los principales recursos del marisqueo artesanal. En 2020, fueron extraídas cerca de 5700 t que alcanzaron un valor en primera venta de 60 millones de euros ([Anuario de pesca 2020](#)).

Aunque el decreto Decreto 153/2019 que regula la explotación y gestión de los recursos marisqueros en Galicia no se centra en la estimación del volumen del stock de las especies explotadas, la evaluación de las poblaciones y la inferencia de su evolución sigue siendo de gran importancia para el diagnóstico de su estado y el asesoramiento en la gestión de su explotación.

En este documento se muestra un procedimiento empleado en el seguimiento de diferentes bancos marisqueros explotados para obtener modelos de mortalidad y crecimiento, así como tasas de reclutamiento. Para ello, se emplean datos del seguimiento diario de las capturas y su estructura de tallas; evaluaciones semestrales del stock de las poblaciones; y, opcionalmente, seguimiento mensual de la mortalidad y el crecimiento de individuos confinados. Esta recopilación de datos de las poblaciones de moluscos bivalvos y su explotación permite realizar diagnósticos sobre su estado e inferir su evolución futura.

El documento muestra la estimación de la evolución futura de una población de almeja babosa (*Venerupis corrugata*) en un período de varios meses y su validación con una evaluación de stock al final del mismo.

# Spatio-temporal variability of mid-size pelagic fishes in the Gulf of Cadiz shelf waters in relation to climatic and environmental drivers

J. A. Canseco, M. A. Torres, E. Niklitschek, F. Ramos

Understanding spatio-temporal distribution patterns of mid-size pelagic fish species (MSPF) is of great interest from the standpoint of both their management and conservation. MSPF inhabiting in the Gulf of Cadiz (SW Iberian Peninsula, Atlantic Ocean) are relevant because they contribute to a large number of individuals captured by the different fishing métiers operating in the area. So far, information on their spatial distribution and temporal changes remain scarce in the study area despite their implications in their stock discrimination and management. Herein, temporal changes of the distribution patterns of abundance and their response to environmental drivers of five MSPF (*Scomber colias*, *Scomber scombrus*, *Trachurus trachurus*, *Trachurus mediterraneus* and *Trachurus picturatus*) off the Gulf of Cadiz (GoC) are analyzed from acoustic surveys data for the period 2007-2017. In particular, we evaluated intra- and inter-specific overlapping over time and space using four spatial indices. The species' abundance and distribution were estimated and mapped by applying geostatistical techniques taking into account autocorrelation between observations. Furthermore, analyses including environmental variables were tested to explain such spatial fluctuations. The main findings showed a progressive reduction of their distribution area in all species over time except for *T. trachurus*. The only species overlapping in space and time was between *T. picturatus* and *S. colias*. The distribution areas of *S. colias* and *T. mediterraneus* were notably reduced and showed northern/southern preferences over the years. The main environmental variables shaping the abundance and distribution of each species were found to be chlorophyll and temperature. Climatic indices such as NAO and AMO affected MSPF by reducing or increasing their spatial distribution. Finally, we discuss implications of our findings to contribute to the implementation of the Marine Strategy Framework Directive in the frame of implementing an effective ecosystem approach to fisheries management in the region.

# Towards effort quantification through VMS and observers' data: the case of shrimp trawlers in Mauritanian waters.

M. Quinzan, I. Czerwinski, E. García-Isarch

The Spanish shrimp trawlers is one of the most important fleets operating in Mauritania and an accurate catch per unit of effort (CPUE) obtained from these vessels could be considered good abundance indices of its target stocks (*Penaeus notialis*, *Parapenaeus longirostris* and *Aristeus varidens*). Vessel Monitoring System (VMS) data provide a valuable source to investigate fishing effort and fleet activity, whereas combined with fisheries logbooks have the potential to produce abundance indices, particularly in the lack of fishery independent information and highly uncertain CPUE. A critical challenge is to define suitable metrics of effective fishing effort, when logbooks only provide information of catches by day. The objective of this study was to develop and validate a methodology to use VMS information to robustly infer fleet activity as well as estimate units of efforts directed to each of the target species of the Spanish shrimp trawlers operating in the EEZ Mauritania. We integrated several data sources (VMS, GEBCO, observers on-board) for this approach. The methodology comprised: 1) discrimination between non-fishing and fishing pings in VMS data; 2) computation of effort to each target species with respect to depth; 3) comparison with fisheries-dependent as observers' on-board data for its validation. This methodology is the base to subsequently estimate unbiased CPUE indices for those stocks.



# Influence of oceanic climate on the hake southern stock variability: study of regime shifts.

A. Cabrero, G. González-Nuevo, E. Tel, J. Gago

Se analiza un conjunto de series temporales océano-meteorológicas (1967-2015) a diferentes escalas; global, regional y local, con el fin de detectar cambios de régimen ambientales, que sean capaces de explicar parte de las fluctuaciones de la pesquería de merluza (*Merluccius merluccius*) en la región de la plataforma ibérica atlántica y sus aguas oceánicas adyacentes (36° N - 44.5° N).

Se detectan tres cambios de régimen ambiental; en los años 1977/80, 1994, 2005/06, también detectados en otras regiones del Atlántico Norte y en ecosistemas marinos de otras partes del mundo.

El cambio de régimen positivo en las descargas de merluza del año 2006/07, se analiza en profundidad dada su consistencia en otras series biológicas de la especie (reclutamiento y biomasa) y su correspondencia con el cambio de régimen ambiental del año 2005/06. Este no parece estar desencadenado por ninguna de las variables a escala global utilizadas. Lo que se observa es que variables regionales como la diferencia entre la temperatura del mar y del aire (SMINA) o el parámetro de calor latente (LFLX), sufren un segundo cambio positivo, reforzando el cambio de mediados de los años 90. Por el contrario, la mayoría de las áreas de cría vuelven a una situación de afloramiento promedio, anterior al cambio negativo sufrido a finales de los 90, lo cual, junto con el resto de las variables, parecen favorecer tanto el reclutamiento como las descargas de merluza. Esta recuperación se iniciaría con el cambio ambiental de 1994 que, aunque no tan propicio, habría favorecido el éxito del reclutamiento de la merluza evitando así un deterioro más acusado del stock en esos años.

A la hora de estudiar el reclutamiento y su relación con las variables ambientales, se estudia si es más conveniente utilizar el reclutamiento absoluto o el éxito del reclutamiento, esto es, teniendo en cuenta la variabilidad debida a cambios en la biomasa de adultos. Los resultados son contradictorios.

Las variables ambientales utilizadas, casi todas ellas superficiales, no ofrecen buenas correlaciones con el reclutamiento de la merluza. El reclutamiento absoluto alcanza la mejor correlación ( $r^2 = 0.27$ ) con el flujo de calor latente en verano y el modelo lineal obtenido es capaz de predecirlo. Esta variable relacionada con los intercambios de calor océano-atmósfera, agrupa en una sola variable varios procesos ambientales relevantes, tales como variaciones de temperatura y turbulencia. Lo que se observa es que a mayor parámetro de calor latente (LFLX), temperatura superficial del mar (SST) y Oscilación Multidecadal del Atlántico (AMO) mejor es el reclutamiento.

# Discard indices based in on-board observers data in the Spanish fresh trawlers targeting black hake in NW Africa.

M. Soto, J. Rey, R. García-Cancela, M. Liébana, L. Fernández-Peralta

Quantification of discard per unit effort rates (DPUE) has been proposed by the European Commission as a measure to manage the discarding of commercially fished organisms. In the Spanish fresh trawling fleet operating in North West Africa, both target species of black hakes, *Merluccius polli* and *Merluccius senegalensis* are data limited stocks. Hence, discards of these fleets are even more unknown but not unimportant part of the total catch (retained and discarded). Onboard observer data from commercial surveys from 2016 to 2018 provide a detailed source of scientific information about catches, discards, effort and technical factors in this fleet. This is the first quantitative analysis to model DPUE through generalised linear mixed models, based on the explicit distinction between abundance and technical factors coming from information of observer surveys. We describe the relationship between discards and the environment, catches of target and other species, effort of the fleet, spatial and temporal variation in discard accessibility, vessel characteristics, strategy of the skippers and market decisions. Unlike hake catches, discards were higher and more dispersed in shallower than in deeper waters. We identified two separate métiers for the Spanish fresh trawling fleet determined by depth and treated total discards as a stock unit susceptible of being monitored, managed and assessed. The strategy of the skipper appears to have a more important effect on discards than vessel characteristics. This study shows the importance of observer data for this fishery and identifies recommendations for the improvement in the scientific usefulness of logbook information.

# Implementación con enfoque exploratorio de un modelo de producción excedentaria en tiempo continuo (SPiCT) para el dorado del océano índico

M. Aramburu, K. Stobberup, K. Erzini, M.M Rincón

El dorado (*Coryphaena hippurus*) es una de las principales especies bycatch de las pesquerías de túnidos y de pez espada en el Océano Índico, y a su vez también es de gran importancia para la pesca artesanal de estados insulares como Seychelles, donde además, algunas empresas de productos pesqueros también compran dorados capturados por flota extranjera. Entender la dinámica poblacional y el estado actual de esta especie permitiría mejorar las recomendaciones científicas y avanzar hacia una explotación sostenible. La Comisión del Atún del Océano Índico no ha implementado aún ningún plan de manejo para esta especie y hay un nivel alto de incertidumbre sobre su explotación. En este estudio se implementó un modelo para pesquerías con datos limitados para el dorado del Índico. Un modelo de producción excedentaria en tiempo continuo (SPiCT) capaz de proporcionar estimaciones de biomasa, mortalidad por pesca y puntos de referencia a partir de tan solo datos de capturas y al menos un índice de abundancia. Los resultados muestran que este recurso no se encuentra sobreexplotado. Sin embargo, debido a la limitación de información es necesario evaluar posteriormente la calidad y consistencia de los datos de entrada. Esperamos que este ejercicio exploratorio sirva de base para la realización de futuros estudios sobre el estado y el nivel de explotación de esta especie bycatch en el Océano Índico.

# Discard survival of coastal elasmobranchs in a small-scale fishery using acoustic telemetry

A. Alonso-Fernández, G. Mucientes, D. Villegas-Ríos

Discards reduction, a worldwide challenge for marine fisheries, has been set as a cornerstone of the latest European Common Fisheries Policy. The discard ban policy, which aims to reduce discards in all types of commercial fisheries by means of the landing obligation, is particularly challenging for the small-scale fishing fleet because of its multispecies nature and technical limitations. For this fleet, demonstrating high survival rates of discarded individuals may provide flexibility to accommodate to the discard ban. This study focused on a set of elasmobranch species targeted by the SSF in one of the most important fishing regions in Europe, i.e. Galicia (NW Spain). Using a fixed acoustic telemetry array and recapture data, we estimated short and long-term survival of a community of coastal elasmobranchs from family Scyliorhinidae (*Scyliorhinus canicula*,  $n = 15$ ) and Rajidae (*Raja undulata*,  $n = 2$ ; *R. clavata*,  $n = 10$ ; *R. brachyura*,  $n = 3$ ). Survival rates ranged between 70%/66% (short/long-term) in *R. clavata* and 100% in *R. brachyura* and *R. undulata* (100%/92% in *S. canicula*); with an overall long-term survival rate of 90/85%. Body size and time on board decreased the probability of survival in the *R. clavata*. This is the first study that estimates discard survival of coastal elasmobranch in the Galician small-scale fishery using acoustic telemetry techniques. Our results are critical to support the application of survival exemption of discards in SSF, and for the design of management plans for elasmobranch species and their habitats.

# What do shrimper trawlers fish in North West Africa? The issue of discards.

V. Duque-Nogal, E. García-Isarch

A Spanish shrimper trawler fishery has been traditionally carried out in Mauritania (NW Africa), targeting three species (*Penaeus notialis*, *Parapenaeus longirostris* and *Aristeus varidens*) at three different depth ranges. During the period March 2016-March 2017, discard information from 234 fishing days was taken by observers onboard this fleet. An estimation of the discard fraction weight was registered for every single haul and discard composition was registered from 158 randomly selected hauls.

Discards rates and composition were analysed globally and for each type of fishing haul (coastal, intermediate and deep waters). In total, 377 discarded taxa were registered, most of them being fish (71%), followed by crustaceans (18%). Discards diversity decreased with depth, from around 212 species in coastal trawls to 103 species in deep waters trawls. In addition, coastal hauls produced the biggest proportions of discards (78% of total catch), while discards in intermediate and deep waters were around 70%.

Discards rates were estimated for all species, globally and by type of fishing haul. These rates indicated that the fishing 984 tonnes for commercialization in 2016 produced around 9500 tonnes of discards. Discards were also estimated for commercial species, being especially relevant for black hakes (275 tonnes).

Seasonal and inter-annual variations of discards have been registered by this IEO Programme of observers onboard shrimper trawlers in West Africa. The long-term implementation of this Programme is a requirement to improve the knowledge on this fishery and its effects on the whole ecosystem and to obtain better estimates of commercial species for assessment purposes.

# Pilot experiment to evaluate the survival of chub mackerel (*Scomber colias*) after slipping in the purse seine fishery

I. Dias, D. Feijó, A. Silva

Chub mackerel is one of the main species captured by the Portuguese purse seine fishery, but also one of the species most subject to slipping. A pilot experiment was carried out to study the survival of chub mackerel after the practice of slipping. The experiment was conducted in the summer of 2020 off the southwestern Portugal (mean SST=19.7°C), one of the main distribution areas of chub mackerel in Iberian waters. A purse seine vessel carried out a fishing set and simulated a typical slipping manoeuvre. Fish were transferred from the net, in the initial (control) and final (treatment slipping) stages of the drying of the net, to two experimental net pens moored in the open ocean. Both nets pens were monitored daily for 5 days. At the end of the period, survival of chub mackerel (19-29cm) was high on both net pens, with rates of 97.6% in the control and 94.3% in the slipping treatment. Horse mackerel (9-23 cm), unintentional introduced into the net pens, showed substantially lower survival rate in the slipping treatment, 35%, compared to 85% in the control. For both species, death individuals from the slipping treatment generally presented a poorer physical condition compared to those from the control including skin damage, fin erosion and lower body condition factor. This first evaluation suggested that slipping has a low impact on the mortality of medium sized (young adult) chub mackerel in the short term, supporting the use of landings as a reliable proxy of catches in an assessment of this species. However, the present results should be confirmed with longer experiments and evaluation of the impact of higher catch volumes and different environmental conditions.

# Analysis of landings data and LPUE standardization of soleid species from official logbooks in Iberian Atlantic waters

M. Pan, M. Marín, M. G. Pennino, J. Castro

Time series of abundance indices are the main source of information to calibrate stock assessment models. Standardized LPUEs (Landings per unit effort) derived from fishery-dependent data can be used as a proxy of the species abundance. In this study we present a first attempt of standardization of landings per unit of effort (LPUE) for soleid species. Soleid species, in particular the common sole (*Solea solea*), are important fisheries resources with high economic value, targeted by the Spanish fleet in Iberian Atlantic waters. Nevertheless, information on these resources is scarce. Time series data from 2009 to 2020 from the official logbooks of the Spanish fleet operating in the ICES subdivisions 8.c and 9.a. have been analysed in order to provide some insights into this fishery. Uncertainties in the accuracy of the identification of the species led to the aggregation of 6 taxa: *Solea solea*, *Solea senegalensis*, *Solea elongata*, *Solea spp.*, *Pegusa lascaris* and *Pegusa cadenati*, as one single category, being the common sole, *Solea solea*, the most important taxon in terms of economic value and landings. Landings per unit of effort (LPUE) based on the estimated soleid species landed weight by fishing days (unit effort), for the most important métiers in terms of landings, were used as response variable. Generalised linear mixed models, fitted with a Gamma distribution, were employed, and several explanatory variables were tested to be included in the models: year, quarter, month, ICES division, statistical rectangle, landing port, vessel characteristics (LOA category, vessel power), depth, fishing time and number of fishing operations.

# Study of the life traits of demersal fish in Atlantic Iberian waters

D. Lojo, S. Cerviño, M.G. Pennino, M. Cousido-Rocha, R.  
Domínguez-Petit, M. Sainza

European hake (*Merluccius merluccius*) is a resource of great commercial importance in Atlantic Iberian Waters. Despite of the recovery plan implemented in 2006 and the Multiannual management plan for Western Waters, the fishing mortality is still above to the one corresponding to the maximum sustainable yield ( $F_{msy}$ ). Understanding biological processes underlying stock dynamics and providing updated information about life traits is essential for efficient assessment and management of marine resources.

In this study, temporal variability of the size at first maturity ( $L_{50}$ ) and the main environmental and biological impacting on it.

Individual's weight and length distribution as well as macroscopic maturity stage of the hake were obtained from samplings of the commercial fleet that operates in Atlantic Iberian waters (Subdivisions 8.c and 9.a of ICES), for the period between 1982 and 2019. The variability of the  $L_{50}$  for each sex was modeled with Generalized Additive Models considering as explanatory variables, environmental factors (Atlantic Multidecadal Oscillation, AMO, North Atlantic Oscillation, NAO, and Sea Surface Temperature, SST), biological variables (biomass, spawning biomass at length and relative factor condition) to test possible density-dependent effects, and the temporal variable year. The variables included in the final model has been selected though the backward stepwise procedure.

Preliminary results show a decrease of the size at first maturity for both sexes through the time series. In particular, for females the significant explanatory variables were year, spawning biomass at length, biomass, and NAO, whereas for males the temporal effect was the unique significant variable. These results could be the key to understand the European hake stock status.



# Growth of the deep water rose shrimp *Parapenaeus longirostris* in Mauritanian waters (NW Africa)

I. A. Czerwinski, E. García-Isarch, J. M. García-Rebollo, V. Duque-Nogal, M. Quinzán, Z. Romero

The deep water rose shrimp *Parapenaeus longirostris* is the main target species of a Spanish fleet of shrimp bottom trawlers operating in the Mauritanian EEZ. The life history of this species is well known in north eastern Atlantic and Mediterranean waters, while the information is quite limited for the eastern central Atlantic. Biological samplings of the species were conducted by scientific observers onboard this fleet, from catches obtained during 17 fishing trips performed between March 2014 and June 2019. The carapace lengths (CL) of 91662 specimens (54% females and 46% males) were grouped in 33 monthly length frequency distributions. For the study of the length–age relationship, the Von Bertalanffy Growth Function (VBGF) was fit to the monthly length distributions by using the ELEFAN I routine followed by separating the frequency histograms into normal components through the Bhattacharya’s method and the NORMSEP routine. These analyses were carried out separately for males, females, and combined sexes, using the FISAT II automatic calculation program. CL of females and males ranged from 11.6 to 39.2 mm and 10.5 to 30.5 mm, respectively. Three and five modal components (annual cohorts) were identified for females and males, respectively. The growth function estimated parameters were  $CL_{\infty}=41.74$ ,  $k=0.51$  for combined sexes,  $CL_{\infty}= 41.67$ ,  $k= 0.51$  for females and  $CL_{\infty}= 32.24$ ,  $k=0.84$  for males. Estimated growth performance indices were around 2.95 for combined sexes, females and males. The estimated parameters may be used as input to test length-based methodologies for the assessment of this data-limited stock, for which only production models have been used so far.

# Discards from a deep-sea shrimp fishery in Angolan waters (SW Africa)

J. M. Garcia-Rebollo, I. A. Czerwinski, V. Duque Nogal, M. Quinzán, E. García-Isarch

A programme of observers on board Spanish shrimp trawlers in Angola was initiated by IEO in 2018 in order to improve the scientific information required by Sustainable Management of External Fishing Fleets (SMEFF Regulation of the EU). In this context, discard studies are considered very relevant, both for assessment purposes and for obtaining information on adverse ecological impacts in marine ecosystems. Most fishing hauls performed during the observed period November 2018 to December 2019 were carried out at depths between 384 and 649 m, with classic bottom otter trawl targeting the striped red shrimp *Aristeus varidens*. Discards accounted for 60% of the total catch during the analysed period. The estimated global discard rate for 2019 (2.2 discard/retained catch) indicates that 1915 tonnes of retained catch produced 4213 tonnes of discards, of which a small amount is of commercial species, as *A. varidens* (3.8 tonnes) and *Merluccius polli* (153 tonnes). A total of 131 discarded species were identified, with the highest group contribution being fish (70%), followed by crustaceans (20%). The most abundant species in discard weight were *Ariomma melanum*, *Lamprogrammus exutus*, *Chaunax pictus*, *Centroscymnus owstonii*, *Hoplostethus cadenati*, *Lophius vaillanti*, *Yarrella blackfordi* and *Ariomma bondi* (all together accounting for 55% of discards). The most frequent species were *H. cadenati* and *L. exutus*, discarded in 95% of the analysed fishing hauls. Discards estimations of commercial species obtained through a long-term observers program might result in improving the assessments of main commercial species from Angolan deep sea waters.

# Estandarización espacio-temporal de índices CPUE para evaluar la incertidumbre en especies demersales de interés pesquero

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G. Martín, J. Otero, I. Paradinas, P. Sampedro, M. Soto, M. G. Pennino

Los índices de captura por unidad de esfuerzo (CPUE) son una de las principales fuentes de información empleadas en los modelos de evaluación de los stocks pesqueros (Zhou et al., 2019). Existen múltiples técnicas para la estandarización de dichos índices, desde modelos lineales generalizados (GLMs) o modelos aditivos generalizados (GAMs) hasta la inclusión de modelos más complejos como los geoestadísticos (Zhou et al., 2019).

El objetivo del presente trabajo es evaluar la precisión e incertidumbre asociada a los índices CPUE derivados de fuentes de datos con distinta información espacial. Para ello, se realiza una estandarización de los índices CPUE utilizando modelos geoestadísticos en diferentes escenarios espaciales, comparándolos con modelos GLMs y GAMs.

Respecto a la simulación, las capturas (por año) se simulan dentro de un área en base a los siguientes escenarios espaciales: (1) datos de campañas georreferenciados, (2) datos georreferenciados provenientes de pesquerías, y (3) datos obtenidos de la pesca con referencia espacial lattice/areal data. En el caso del escenario (1) el muestreo es aleatorio, mientras que, para los escenarios (2) y (3) el muestreo es preferencial.

Una vez simulados los datos, se ajustan los modelos empleando la técnica Bayesiana Integrated Nested Laplace Approximation (INLA) mediante el software estadístico R. Finalmente, los índices CPUE obtenidos para cada escenario se introducirán en un modelo de evaluación, con el fin de valorar la precisión en la evaluación.

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# Improving information of data-poor stocks and fisheries: a new scientific observer programme onboard a shrimp fleet in Angola (SW Africa)

E. García-Isarch, J. M. García-Rebollo, V. Duque-Nogal, I. Czerwinski,  
M. Quinzan

The EU's Regulation on the Sustainable Management of External Fishing Fleets (SMEFF, 2017) was established within the framework of the External Fisheries dimension of the Common Fisheries Policy (CFP). Since the 1960s, Angola has been a traditional fishing ground for a Spanish fleet of deep-sea shrimp trawlers, mainly targeting *Parapenaeus longirostris* and *Aristeus varidens*. Since 2004, this fishery has been conducted through direct fishing authorizations and currently, in compliance with the SMEFF, scientific evaluations to demonstrate the sustainability of the fishery must be provided to fish in a third country with this system. Only *P. longirostris* has been assessed so far by the Fishery Committee for the Eastern Central Atlantic (CECAF), with great limitations due to the lack of consistent fishery information and biological data. Since 2018, the IEO has implemented a scientific observer program onboard this fleet with the aim of obtaining the most reliable fishery and biological information for assessment purposes. This involves the collection of information such as: catch by species and biological data enabling the estimation of volume and length frequency of all catch fractions, biological parameters of target stocks, information for assessing the fishing impact on the marine ecosystem and detailed data on the activity of the fleet. A summary of the designed programme and the main fishery and biological information obtained during the first observed annual cycle is presented, as a starting point of a long-term monitoring program that together with other sources (logbooks, VMS) would increase the quantity and quality of the data needed for improving the assessments of these Angolan stocks.

# Improving CPUE standardisation for Iberian hake: modelling approaches using reference fleet and Tweedie distribution

A. V. Silva, H. Mendes, C. Silva

Iberian hake (*Merluccius merluccius*) is targeted by the trawl and artisanal fleets off the Portuguese Continental waters (ICES Division IXa). Since the last decade, the average total landings of hake in Portugal corresponds about 36% to trawl fisheries and 64% to artisanal fisheries. These landings represent 21% of the total landings of Southern hake stock. The Portuguese trawlers standardized landing per unit of effort (LPUE) has been used for stock assessment purposes since 2010. The LPUE uses a generalized linear model with a gamma and log-normal distributions and exclude the observations with no catch of hake, which represent about 64% of the total data set.

Recent advances in modelling techniques have enabled the possibility of applying more complex models and statistical distributions that allows for frequent zero valued observations which are common in commercial-catch logbook data. In this work we modelled the Portuguese hake trawl LPUE using the Tweedie distribution to handle zero-catch data. We compared the results of the two methods of standardizing LPUE's with the CPUE from the Portuguese Autumn groundfish surveys to evaluate alternative abundance indices to inform stock assessment. This additional index based on the Tweedie considers the relevant information provided by the zero values that could also be used in the context of spatial management.

# Fishing technical measures and landing obligation in northwest Spanish demersal fisheries

J. Valeiras, E. Velasco, M. G. Pennino, G. Pierce

Different types of technical measures are used in different ways. They have been mainly used to protect juveniles and improve the selectivity of fishing gears, reducing the amount of fish that is discarded. Historically the measures have focused on individual stocks but in recent years they have been used to reduce the impact of fishing on multiple aspects of the marine ecosystem, including habitats and non commercial species. In northwestern Iberian waters, technical measures research has focused on the bottom trawl fisheries, as most of the discard choke situations affect these fleets and there are difficulties in improving selectivity. Over the last few years several pilot projects onboard commercial vessels have tested different selective trawl gears, including a variety of selectivity devices and changes in mesh size and geometry in the codends. The DESCARSEL project works on the aim to improve fishing strategies, gear selectivity and discard survival through the use of better practices and technological development of more selective fishing gears, to improve compliance with the landing obligation under the reformed CFP. This research follows a collaborative approach, working with fisher associations and the stakeholders related to landing obligation rules. The selectivity of mixed bottom trawling fleets with the highest discard rates of quota species in Iberian Spanish waters have been studied with the aim of increasing selectivity and reducing unwanted catches for the implementation of the landing obligation. Pilot projects on theoretical selectivity measures and selectivity trials have been conducted, focussing on square mesh and changes in mesh netting geometry and mesh size, in order to reduce bycatch.

# Bottom trawl selectivity and reduction of fisheries discards in European North Western Waters

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Spanish otter bottom trawlers in European North Western Waters operate mainly in ICES 7 area called “Gran Sol fishing ground”. Vessels target demersal species, namely megrim, monkfish and hake. This métier is reported to have discard rates of quota species: megrim, European hake, haddock, horse mackerel, mackerel, blue whiting and boardfish. Main reasons for discarding are quota restrictions and undersized fish. Several species of gadids (haddock and cod) with no quota are considered “choke species” in this fishery in the framework of the “Landing obligation”. The scientific evidence indicated that an increase in selectivity is not easily achievable in the short term, and the “de minimis exemption of Landing obligation” was apply to this fishery.

A series of fishing trials have been carried out by IEO and Fishers organization “OPP7” to study experimental codends with the objective to decrease the catch for gadids. The data obtained in “RAPANSEL” trials are positive and indicate that an important fraction of the unwanted catch of the target species with small size escapes through the experimental codend and selectivity devices as square mesh windows. The new fishing gear designs could be a possible solution for reducing the discard rates of juveniles of the target species and also of several unwanted species in the fishery minimizing the economic loss of the fishery and improving the Landing obligation compliance.

# Reduction of discards in the bottom trawl fishery: fishing selectivity and effect of the morphology and size of the species.

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Research of fish stocks requires the study of the composition of species, sizes and ages of the catches, which should be similar to those of the population. Therefore, it is very important to know the selectivity of the gear and of the species, since in this way it is easier to establish regulatory measures in the fisheries and allows studies on the populations and their degree of exploitation to be more precise. The objective of this work has been to study whether the morphology and size of the individuals of the different species studied European hake (*Merluccius merluccius*), blue whiting (*Micromesistius poutassou*), mackerel (*Scomber scombrus*), horse mackerel (*Trachurus trachurus*) and four spotted megrim (*Lepidorhombus boscii*) is related to the selectivity of the fishing gear. Therefore, we analyzed the shape of the fish, its size and features related to swimming capacity which influence their catchability and, therefore, the selectivity of the gear. These species were selected since they are the main commercial ones caught in the bottom trawling north Iberian fishery, all of them having their respective fishing quotas and subject to “landing obligation” regulation. Knowledge of the selectivity-related characteristics of the different species (flat fish, circular shape, pelagic swimming) is important for the establishment of adequate technical measures in mixed fisheries that target a large number of demersal species.



# REM technology to help fulfill the landing obligation in European fisheries towards more sustainable fishing

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The main control measures used in EU fisheries are the use of logbooks, monitoring of vessel geographic positions and the inspections of the vessels at sea (patrol vessel surveillance) and at the ports (inspection of the landings). Many studies indicate that this traditional control measures are not effective within the current Landing Obligation rules. The Remote Electronic Monitoring (REM) is currently considered as one of the best future alternatives for the control of fishing activity. In fact, many fleets have already incorporated this technology into their activity to respond to the requirements of regional fishing organizations and control authorities in many countries of the world.

The aim of this work was to test the implementation of innovative technologies based on artificial vision devices for catch composition determination and data management technologies installed on board. A study case including onboard observer trials and an automatic device was carried out to characterize discards and record unwanted species occurrence in commercial vessels. The “iObserver system” was implemented to improve the quality and availability of data and consequently to deepen knowledge on the status of the fisheries resources. This technology is aimed to be able to identify and quantify the catch (targeted and discarded) without interfering with the activity of fishermen. Once the data (species and biomass estimation) is acquired by iObserver, information is pre-processed and transmitted to land (to management servers). This system will allow real-time decision making for the fishing activity in order to eventually perform a more selective fishing. Automatic estimates of discards by species allow to take real-time decisions, avoid areas/times with high discards rates and potentially to comply with landing obligation.

# Eledone cirrhosa and SPICT or why it is not easy to assess a short lived cephalopod species.

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Although some cephalopods have had always commercial value and others started to increase in value in recent years, unlike European Atlantic stocks of many commercially important finfish and crustaceans, they are not routinely assessed and no specific management measures are applied to fleets catching cephalopods, with the exception of some regional harvest control rules for artisanal fleets. Among the species that has been gaining importance in landings is the horned octopus *Eledone cirrhosa*. This octopus represents an important bycatch for several North Spanish otter trawl fisheries, appearing in landings but also in discards. Like other cephalopods, *E. cirrhosa* is a short-lived and fast growing species, and previous studies showed that its abundance varies in relation to physical and environmental conditions.

As a first step towards its possible future inclusion in the ICES annual assessment system, a simple assessment model has been tested in the ICES Working Group on Cephalopod Fisheries and Life History (WGCEPH). The chosen model was SPICT (Surplus Production model in Continuous Time). Using landings and two abundance indices (from a commercial fleet and a scientific bottom trawl survey), preliminary results have been obtained. Overall, although the model converged and all the diagnostics were acceptable, the estimated parameters obtained very wide confidence intervals, suggesting that improvements in the model are needed. Further work, including testing other assessment models or selecting other tuning indices, will help in the assessment process for this species.

# When uncertainty is for the better: a4a, the option for the southern megrims stocks.

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Both southern megrims stocks (*L. whiffiagonis* and *L. boscai*) divisions 8c and 9a are assessed in ICES Working Group for the Bay of Biscay and the Iberian Waters Ecoregion (WGBIE). The model used in the assessment is Extended Survivors Analysis (XSA) (Shepherd, 1992). The XSA is a deterministic model and do not consider the uncertainty in its operation. To this day, it is known that uncertainty is fundamental when establishing any reference point and management derived from a biological process. Megrims are caught in mixed fisheries of bottom trawlers generally targeting a heterogeneous group of valuable demersal white fish. As megrims have significant commercial value in the Spanish market and they are regulated species in the area by a total allowable catch (TAC) quota system, they must have the more appropriate tools to assess them. In order to improve this, a4a (assessment for all), a non-linear catch-at-age model implemented in the R software and FLR (Fisheries Library in R), using AD Model Builder (ADMB), has been tested in these stocks. The results for both stocks are promising and show that the a4a model is a strong candidate to be chosen for the assessments. A comparative approach between XSA and a4a results is also presented.