SPF-2026

BOOK OF ABSTRACTS

May 4-8, 2026
La Paz, Mexico

Last update May 8, 2026

Table of Contents

PLENARY SESSION

Oral Presentations

Plenary, AbstractID=18787, (ECOP)

(S09) Small pelagics in the Blue Economy: Steppingstones from research into implementation

Andrés M. **Cisneros-Montemayor** and Sieme M. Bossier

Simon Fraser University, Burnaby, BC, Canada. E-mail: a_cisneros@sfu.ca

The study and management of small pelagic fisheries have been at the center of some of the most foundational lessons in ocean development and conservation. The highs and lows of herrings, the rise and fall of Pacific sardine, the death and life of Monterey Bay, las Niñas y Niños, fishing down (or maybe not). In short, the big impacts of little fish. As we all face a new climate and new economic and political interactions, the lessons—and questions—from small pelagic fisheries can continue to be essential for establishing a Blue Economy that is adaptive but ultimately responsive to people's needs (and wants). Better data and new insights from natural sciences are critical, but so are the new (and sometimes very old) insights from the social sciences that are key for understanding what those human needs are. This talk builds on recent research proposing steppingstones to complement traditional fisheries models with ones that deeply integrate social concerns and highlights key opportunities for research on small pelagics and their fisheries to inform the implementation of the Blue Economy around the world.

Plenary, AbstractID=18794

(S07) Sustainable management of fisheries should explicitly incorporate safety and well-being of fishers

Cor **Blonk**

Pelagic Freezer Trawler Association, Zoetermeer, The Netherlands.
E-mail: cblonk@pelagicfish.eu

In global fisheries discourse, sustainability is predominantly framed around responsible management of fish stocks and marine ecosystems. While these efforts are vital, they overshadow the equally critical social dimension of sustainability: the well-being, safety, and rights of the people who work at sea. This presentation challenges the prevailing narrative by highlighting the need to restore balance in the sustainability triad of *People, Planet, Profit*.

Fishers have one of the most dangerous jobs in the world. The Food and Agriculture Organization revised its global estimate in 2019 to 32,000 deaths per year. However, international conventions designed to protect fishers are ratified and implemented much less frequently than conventions applicable to the merchant shipping sector. This inequality contributes to a persistent lack of protection and oversight, resulting in alarmingly high rates of fatal accidents and poor living conditions on board fishing vessels.

Sustainability in fisheries must go beyond stock assessments and quotas. It requires a comprehensive approach that ensures:

- Ecological sustainability through science-based management of fish populations;
- Social sustainability by guaranteeing safe, fair, and dignified working and living conditions for fishers;
- Economic sustainability that enables vessel owners to invest in environmentally friendly technologies and to attract motivated crew members.

This presentation calls on scientists, policymakers, and industry leaders to advocate for stronger ratification and enforcement of international labour standards, and to integrate social indicators into sustainability assessments. Only by recognizing and protecting the people behind the fisheries can we build a truly resilient and sustainable sector.

Plenary, AbstractID=18854 (Pre-recorded Plenary)

(S01) Small fish, big models and complex fisheries management: Are we there yet?

Éva **Plagányi**

CSIRO Environment, Brisbane, QLD, Australia. E-mail: eva.plaganyi-lloyd@csiro.au

Small pelagic fish and other forage species are vital for human and marine ecosystem wellbeing, yet pose inordinately complex management challenges. How many can be caught without negatively impacting the ecosystem? How do we account for food-web mediated trade-offs? Do they need customized reference level settings? Should we account implicitly or explicitly for environmental variability? What about predators, local depletion, cultural considerations? And are our management systems robust to climate change? To ensure fisheries decision-making is based on robust and balanced advice, necessitates broader approaches than conventional stock assessments, which may in turn require broader ecological, environmental, social and climate data to validate models. In this talk I review how far we've come and explore how far we still need to go to effectively bridge the gap between data, models and fisheries decision-making. I summarize advances in operational modelling approaches for forage fish, commencing with early research to enhance understanding of environmental drivers through to a greater emphasis on the need for food-web and spatial models, progress applying more fully integrated MICE (Models of Intermediate Complexity for Ecosystem assessments), use of MSE (Management Strategy Evaluation) and more recently, need for climate-integrated models, consideration of dynamic reference points and need for trade-off analyses to balance multiple competing conservation and socio-economic priorities. Importantly, pragmatic advances are also needed to support less data-rich and well-resourced fisheries, to strengthen decision making for vitally-important forage species globally.

Plenary, AbstractID=18879

(General) Rise and fall of the big SFP Fisheries: The human dimensions

Juergen **Alheit**

No affiliation, Geestland, Germany. E-mail: juergen.alheit@web.de

SPF are prone to boom-and-bust fisheries usually accompanied by a dramatic rise and fall of the respective fishery community. Whereas there are numerous articles comparing the big SFP fisheries of different regions of the world including their ecologies and statistics, comparisons of the inherent human dimensions are rare. This presentation compares the human dimensions problem of the temporary "world fisheries capitals" of four famous SPF fisheries: (1) the historical medieval herring fishery off Bohuslän in the Skagerak between the North and Baltic Sea which centred around Marstrand, (2) the fishery for Norwegian spring spawning herring focused on Siglunfjördir in Iceland, (3) the Californian sardine fishery off Monterrey, and (4) the Peruvian anchovy (anchoveta) fishery off Chimbote. The impacts of the three phases typical for boom-and-bust fisheries on the people involved, such as fishermen and factory workers, exhibit surprising similarities between the four fisheries, in spite of their different historical and socio-economic backgrounds. First, when the catches increased, there was by far not enough men power and fishing know-how available. Experts and equipment were needed from far away areas. Young inexperienced people from poor agricultural backgrounds were attracted to work in the fish industry because of better payments. During the boom phase, lifestyle improved considerably. Money flowed freely, and it was understood that resource and wealth were inexhaustible. During the final phase, strong markets, improved technology and excessive fishing pressure, often combined with adverse environmental conditions, resulted in the decline of the resource. The fisheries communities of the region, even the whole country, suffered badly from mass unemployment and insolvency.

Plenary, AbstractID=18900

(S02) Plastics and small pelagic fishes in surface ocean

Shin-ichi **Ito**[1], Haodong Xu[1,2], Ziqin Wang[1,2], Shike Gao[1] and Yoshimasa Matsumura[3]

[1]Atmosphere and Ocean Research Institute, The University of Tokyo, Chiba, Japan
E-mail: goito@aori.u-tokyo.ac.jp
[2]Graduate School of Agriculture and Life Sciences, The University of Tokyo, Tokyo, Japan
[3]National Institute for Environmental Studies, Ibaraki, Japan

Microplastics is an emerging issue for marine ecosystem and its increasing trend and expanding distribution in the ocean are increasing the probability of marine organisms encountering microplastics. However, microplastic observations remain limited in spatiotemporal scales, especially in severe weather seasons, and their distribution itself is not fully understood. Furthermore, our understanding of the probability of fish encountering microplastics remains unclear. Previous studies showed that more than half of the produced plastics has lighter density than seawater. These lighter density plastics can be distributed in surface layers because of their buoyancy even if they are fragmented into microplastics. We developed a particle tracking model for floating microplastics and integrated it from 1951 to 2015 in the North Pacific. Riverine emission scenarios were applied to the simulation and biofouling effects were imitated using accumulated chlorophyll experience. The model parameters of criteria to remove microplastic from the surface by biofouling is estimated via comparison with 65-years extended historical observations. The model derived microplastics distribution was coupled with a growth-population dynamics model to estimate the encounter rate between chub mackerel and microplastics. The accumulated microplastics in model chub mackerel showed clear seasonal variation with peak in winter, but the peak value was not high. The model results indicated that seasonal migration of chub mackerel effectively reduces their encounter with microplastics. Correct knowledge of the encounter probability between fish and microplastic allows identification of seasons and locations where less contaminated fish can be obtained, which contributes to food safety.

Plenary, AbstractID=19014

(General) Exploring hypotheses of mechanisms behind population dynamics of small pelagic fish: Perspectives for comparative and collaborative research

Akinori **Takasuka**

Graduate School of Agricultural and Life Sciences, The University of Tokyo, Tokyo, Japan
E-mail: atakasuka@mail.ecc.u-tokyo.ac.jp

Biological and ecological studies on small pelagic fish have advanced through proposing and testing hypotheses by field, laboratory, and modelling approaches. In the first half, I will briefly review major hypotheses of mechanisms behind population dynamics of small pelagic fish on behalf of the members of the former working group's activity on "critical review, evaluation, and testing of hypotheses." Each hypothesis is theoretically reasonable in addressing how its focal factor/process controls population dynamics within the target system. However, controversies remain regarding their applicability to other ecosystems. Debates framed as dichotomies have also emerged: temperature vs food availability, density-dependent vs density-independent processes, climate variability vs fishing, etc. There is a pressing need to establish integrative frameworks that reconcile such dichotomies through meta-analyses or modelling. In the last half, I will focus on specific topics that have yet to be incorporated into fisheries management despite progress based on the major hypotheses: climate impacts, maternal effects, and interspecific interactions. I will introduce some of our ongoing projects as examples of challenges in these topics to share several messages. For example, the existence of density-dependent egg production could change the current understanding of density-dependent effects in the life history; the concept of growth autocorrelation could reconcile the classic "critical period" hypothesis and the current "growth–survival" paradigm; non-commercial species may impact small pelagic fish as potential competitors in pelagic ichthyoplankton communities. I hope that these examples will serve as possible ideas or references for comparative studies and promote further international collaboration within our community.

Plenary, AbstractID=19030

(General) "The Rolling Stocks": A metapopulation perspective on the multiscale spatiotemporal dynamics of the Pacific sardine (*Sardinops sagax*) in the California Current System

Ruben **Rodriguez-Sanchez**

CICIMAR-Instituto Politécnico Nacional, La Paz, B.C.S., México. E-mail: rrodrig@ipn.mx

Multiscale climate variability is widely recognized to have significant impacts on the environmental dynamics of the California Current System (CCS), as well as on the biology, abundance, and distribution of its resident fish species. A key component of this system is the Pacific sardine (*Sardinops sagax*), whose latitudinal differences in life-history traits and demographic parameters suggest a structured population along its range. However, analyses based on other biological and ecological characteristics, or using different methodological approaches, often indicate a contrasting or even absent population structure.

Because most stock assessment models assume that fish groups have homogeneous vital rates and closed life cycles, determining whether self-sustaining population units exist remains a central issue in fisheries science and management. Recent fluctuations in Pacific sardine abundance within the CCS have intensified debate over the presence and persistence of such self-sustaining components.

Recognizing that oceanic and ecological conditions are changing, and that sardine population responses to climate variability can be framed within the "adapt or move" paradigm, recent studies of life-history flexibility and phenotypic plasticity over time within putative population units have advanced our understanding of adaptation. In contrast, research on sardine movements in response to climate variability has remained limited, focusing mainly on multidecadal range/habitat expansions-contractions, and on seasonal migrations linked to temperature and upwelling dynamics. This study addresses that gap of Pacific sardine movements by exhibits their variability across temporal and spatial scales relevant to fisheries (seasonal, interannual and multidecadal). Results reveal that such variability is not arbitrary but follows coherent patterns that allow the construction of a conceptual framework.

By examining the results at each spatial and temporal scale in relation to the number of population units revealed, including their geographic location, size, and persistence, it becomes evident that the concept of "stock" depends partly on both the methodology and the population status when the method was used. This provides complementary insights across scales and supports the interpretation that sardine population structure is inherently dynamic.

The proposed conceptual framework provides an integrative way to incorporate life-history variability and demographic feedback over time through a dynamic spatial map that represents changing occupancy patterns. This framework helps to explore how and why these patterns emerge through dispersal and connectivity under different climate scenarios, ultimately improving our understanding of the distribution and abundance variability of Pacific sardine within the CCS.

In addition to improving our understanding of the ecology of this fishery resource, cross-scale analysis also provides complementary insights that will help strengthen short-, medium-, and long-term planning and management of the sardine fishery.

Plenary, AbstractID=19054

(S05) Hidden diversity, moving stocks: Genomic insights on connectivity and adaptation in small pelagics

Nina Overgaard **Therkildsen**

Department of Natural Resources and the Environment, Cornell University, Ithaca, New York, U.S.A. E-mail: nt246@cornell.edu

Small pelagic fishes underpin marine food webs and major fisheries, yet their mobility, episodic recruitment, and variability complicate stock definitions and forecasts. Genomic approaches now illuminate multiple management-critical dimensions: connectivity *(who mixes with whom, and when)*, adaptive differentiation *(which populations persist under changing environments)*, demography/effective size *(how large populations are and where bottlenecks occur)*, and temporal stability in stock composition *(how stable catch contributions are across seasons and years)*. I will synthesize how genome-wide data are revolutionizing our ability to refine biologically meaningful stock boundaries, estimate exchange rates and seasonal mixing, detect selection on traits tied to thermal regime, growth, and phenology, and track genetic composition through time. As examples, I will highlight (i) work in Atlantic silverside that demonstrates strong, repeatable genomic signatures of local adaptation to temperature and season length—including large-effect regions (chromosomal inversions) linked to growth and reproductive timing—and (ii) applications of low-coverage whole-genome sequencing that deliver unprecedented power for genetic assignment and mixed-stock resolution in highly migratory taxa. These approaches scale directly to small pelagics, where fine-scale structure and adaptive differences are often cryptic to conventional methods. Integrating genomic evidence into assessment and management enables practical advances: more accurate apportionment in mixed fisheries, earlier detection of shifting stock boundaries, explicit tracking of adaptive capacity under warming, and prioritization of vulnerable units. Together, these developments move us toward dynamic, genomically informed management units that better reflect the biological processes driving small-pelagic population dynamics and resilience.

Plenary, AbstractID=19057

(S03) Implications of life history variation across ontogeny, space and time on survival to recruitment in small pelagic fishes

Dominique **Robert**

Institut des sciences de la mer, Université du Québec à Rimouski, Rimouski, Canada.
E-mail: dominique_robert@uqar.ca

Small pelagic fishes (SPFs) are generally characterized by rapid growth, high developmental rates, early maturation, and short lifespans. Their fast-paced life histories imply that variability in early ontogenetic traits—shaped by both environmental and intrinsic factors—plays a pivotal role in regulating adult population dynamics. Otolith-derived growth indices integrate the cumulative influence of environmental conditions on larval survival and thus provide a powerful tool to infer sources of mortality and the characteristics of individuals that survive to recruitment. Otolith growth indices are particularly relevant for SPFs, which often exhibit strong growth autocorrelation from the early larval stage, highlighting the importance of post-hatching growth performance in determining year-class strength. The relationship linking early growth characteristics to the number and traits of survivors from a given year class is conceptualized under the framework of the "Growth-Survival Paradigm". This paradigm predicts that conditions enhancing fast early growth generally result in high survival to the adult stage, but the relationship can change in space and time as the advantage of fast growth becomes constrained by trade-offs affecting larval survival and the fitness of survivors. Advancing our understanding of how early life history variation influences SPF population dynamics requires population-level assessments of the respective roles of spawner characteristics, intrinsic factors, and predation in driving early growth variability. Equally important is the precise identification of the developmental stage marking the end of the pre-recruitment phase—often referred as the "endpoint"—when the traits of survivors become representative of those that characterize a given cohort at the adult stage.

Plenary, AbstractID=19059 (Pre-recorded Plenary)

(S04) From design to detection: Integrated food web studies in a changing ocean

Heidi **Pethybridge**

CSIRO, Hobart, Tasmania, Australia. E-mail: Heidi.Pethybridge@csiro.au

Detecting meaningful ecological change requires well designed food web studies that align objectives, scale and available resources, and carefully consider what to measure, how, and where. This talk will outline key principles for designing empirical food web studies that generate reliable and comparable data for ecosystem monitoring and management. It examines trade-offs in method selection, sampling design and replication, and highlights approaches to improve statistical power, data quality and change detection. These principles are illustrated through the Southeast Australian Marine Ecosystem Surveys (SEA-MES), which resampled an ecosystem last assessed in the 1990s to examine how fishing and environmental change have affected food web structure and productivity in one of the world's fastest warming marine regions. SEA-MES analysed more than 2,000 stable isotope samples and over 5,000 stomachs from key demersal and pelagic species, including jack mackerel (*Trachurus declivis*) and redbait (*Emmelichthys nitidus*), to investigate shifts in trophic pathways and prey composition. By integrating these data within a spatially balanced sampling framework, SEA-MES provides the first updated view of regional food web dynamics in more than 30 years and demonstrates how strategic study design enhances our ability to detect and interpret ecological change.

Plenary, AbstractID=19061

(General) International collaboration advancing ecological understanding and sustainable management of small pelagic fish

Myron A. **Peck**[1], Ignacio A. Catalán[2], Ryan R. Rykaczewski[3], Akinori Takasuka[4], Susana Garrido[5], Rebecca G. Asch[6], Christopher N. Rooper[7] and Motomitsu Takahashi[8]

[1]Royal Netherlands Institute for Sea Research, 't Horntje, The Netherlands.
E-mail: Myron.peck@nioz.nl
[2]Institut Mediterrani d'Estudis Avançats, IMEDEA (UIB-CSIC), Illes Balears, Spain
[3]NOAA National Marine Fisheries Service, Pacific Islands Fisheries Science Center, Honolulu, Hawaii, U.S.A.
[4]Department of Aquatic Bioscience, Graduate School of Agricultural and Life Sciences, The University of Tokyo, Bunkyo, Tokyo, Japan
[5]Portuguese Institute for Marine and Atmospheric Science (IPMA), Lisbon, Portugal
[6]East Carolina University, Department of Biology, Greenville, North Carolina, U.S.A.
[7]North Pacific Research Board, Anchorage, Alaska, U.S.A.
[8]Fisheries Resources Institute, Japan Fisheries Research and Education Agency, Nagasaki, Japan

International collaboration has been instrumental in advancing our understanding of the boom and bust dynamics of small pelagic fish (SPF) populations and the sustainable management of these living marine resources. This presentation briefly summarizes this effort including the ongoing and upcoming activities of the most recent global working group. International collaboration was spearheaded by the launch of the GLOBEC Small Pelagic fish and Climate Change (SPACC) Program in 1994. That 12-year program focused on how climate-induced changes in physical and biological processes impacted SPF population dynamics and yielded retrospective analyses, comparisons of reproductive and population dynamics across regions, and economic implications of climate variability on SPF. Momentum to restart formal international collaboration was gained from discussions at symposia held in Nantes (2012) and Victoria (2017) and a new international (ICES-PICES) working group was formed in 2019. This group has facilitated international exchange by organizing symposia in Lisbon (2023) and here in La Paz (2026). Between 2019 and 2024, the group collaborated on six activities to increase knowledge on ecological processes, and three activities to better translate that knowledge to improve SPF management. New avenues of collaboration include advancing knowledge on SPF as both predators and prey, and demonstrating equitable harvesting strategies. We provide examples of key products that have helped identify these and other priorities for continued, coordinated international collaboration on SPF.

Plenary, AbstractID=19063

(S08) Global markets and trade of small pelagics: Supply, demand and future outlook

William **Griffin**

Food and Agriculture Organization of the United Nations, Rome, Italy.
E-mail: william.griffin@fao.org

Small pelagic species account for approximately 30 percent of global marine capture fisheries landings, making them a cornerstone of both food security and industrial applications worldwide. This presentation provides a comprehensive analysis of the structure, dynamics and future trajectory of global small pelagic trade, encompassing direct consumption as well as fishmeal and fish oil derivatives. Drawing on current data and time-series analyses, the talk examines the major producers, exporters and importers of small pelagics, tracing product flows from capture to end-use across diverse consumption industries including direct human consumption, aquaculture feed, pet food, pharmaceuticals and terrestrial agriculture.

The presentation explores significant shifts in trade patterns over recent decades, highlighting the progressive reallocation of small pelagic catches away from terrestrial livestock feed and industrial uses toward aquaculture feed and direct human consumption. Key emerging markets in Asia, Africa and Latin America are examined, along with their implications for global trade flows and regional food security. Short-term forecasts look at future trends and the impact of climate change, as well as the future direction of balance between direct and indirect utilisation of small pelagics in coming years.

Plenary, AbstractID=19068

(General) From science to industry and back

Claus Reedtz **Sparrevohn**[1], Niels T. Hintzen[2], Steve Mackinson[3], Ed D. Farrell[4] and Martin Pastoors[5]

[1]Danish Pelagic Producers Organisation, Copenhagen, Denmark. E-mail: crs@pelagisk.dk
[2]Pelagic Freezer Trawler Association, Zoetermeer, The Netherlands
[3]Scottish Pelagic Fishermen's Association, Peterhead, Scotland
[4]Killybegs Fishermen's Organisation, Killybegs, Ireland
[5] Martin Pastoors Fish & Fisheries, Wijster, The Netherlands

For many years and even still to this day, a gap between fisheries science and industry has remained within Europe as well as other parts of the world. Traditionally, the gap did materialize in that the industry did in some respects failed to fully acknowledge and understand the importance of fisheries research and thereby did limit the uptake of scientific advice. In contrast, science has also contributed to the gap, by focusing on catch recommendations or technical fishery regulations, paying limited respect to the importance of how the fishing industry functions and how scientific advice impacts the industry. To bridge this gap, in 2010 the European pelagic sector began employing scientists with the dual task of translating motive and method behind scientific advice and to mobilize data and knowledge from within the fishing industry to be made available to and well received by scientists. In this discussion I will give an account of the role that industry scientists have taken up, the pitfalls there might be and follow with examples of where improvements in data availability have been made. In the second part of this talk I will, as industry scientist, take the opportunity to introduce what happens internally in the industry after the scientific advice has been given. Focus will be on questions like how the pelagic quotas are decided and distributed to individual fishers using Europe as an example, but also how fish are caught, and which gear are used? Which species are used to produce fishmeal, fillets, whole frozen fish, or egg-products and why. Finally, I will detail key aspects of the global fish trade and provide insight into the mechanisms behind a products journey from the great oceans to our marketplace.

Plenary, AbstractID=19096

(General) Beyond boundary currents: Toward dynamic understanding of mesopelagic communities

Ryan R. **Rykaczewski**

NOAA Pacific Islands Fisheries Science Center, Honolulu, HI, U.S.A.
E-mail: ryan.rykaczewski@noaa.gov

Research focused on small pelagic fishes in coastal boundary currents has reached a level of maturity where we now aspire to describe temporal variability and utilize mechanistic models to offer predictive biomass estimates. In contrast, mesopelagic forage communities, the backbone of open-ocean food webs, remain poorly described with global biomass estimates varying by an order of magnitude. A primary challenge in mesopelagic research is the absence of fisheries-dependent data, a resource that has motivated development of hypotheses describing the boom-and-bust dynamics and climate-driven regime shifts in coastal systems. By adapting spatially-explicit and trait-based modeling approaches developed for small pelagic fishes, we can begin testing hypotheses about how mesopelagic communities respond to environmental forcing. These frameworks are essential for resolving ecosystem responses to climate change and emerging deep-sea extraction activities. This talk highlights specific areas where coastal pelagic expertise can advance mesopelagic science. The goal is to move beyond static, snapshot biomass estimates toward a dynamic, mechanistic understanding of the mesopelagic frontier, improving characterization of its sensitivity to ocean and climate variability and its capacity to support critical ecosystem functions.

Pre-Recorded Plenary, AbstractID=18896 (Pre-recorded Plenary)

(S06) From mapping to measures: Operational EAF for small pelagics now

Mark **Dickey-Collas**

DickeyCollas Marine, London, United Kingdom. E-mail: mark.dickeycollas@gmail.com

Small pelagics power marine food webs and economies. Ecosystem approach is about effective and impactful management. This talk moves from principles to practice, by defining the finish line: 100% managed under proportionate, risk-based rules. I challenge key blocks to further progress, namely: balance as a mantra, false equality of objectives, science stalling management; and governance naivety. I replace these blocks with operational steps, including the use of lean indicators, stress-tested harvest rules for shifting productivity and an acceptance that transparency of the science process is key. EAF must be a cycle of learning, understanding what changed in the system, why, and with what effect. We cannot afford to wait for perfect data, holistic understanding and we highlight our priorities. EAF is achievable, and our aim must be 100% management across small pelagic fisheries now.

SESSION 1

Bridging the Gap: From Ecological Data and Models to Fisheries Decision-Making

Oral Presentations

S01, Invited, AbstractID=18928

Model-derived scenarios of forage fish productivity and distribution for management strategy evaluation

Desiree **Tommasi**[1,2], Robert Wildermuth[2], Barbara Muhling[1], Isaac Kaplan[3], Jerome Fiechter[1], Pierre-Yves Hernvann[1], Stefan Koenigstein[4], Mercedes Pozo Buil[1,5], Caitlin Allen Askelrud[2], Steven Bograd[5], Ana Guerra[3], Elliott L. Hazen[5], Stephanie Hopkins[1], Michael Jacox[5], Alexander Jensen[2], Peter Kuriyama[2], Nerea Lezama-Ochoa[1,5], Owen Liu[6], Felipe Quezada Escalona[1,7] and Stephen Stohs[2]

[1]Institute of Marine Sciences, University of California Santa Cruz, San Diego, CA, U.S.A.
E-mail: detommas@ucsc.edu
[2]Fisheries Resources Division, NOAA Southwest Fisheries Science Center, La Jolla, CA, U.S.A.
[3]Conservation Biology Division, NOAA Northwest Fisheries Science Center, Seattle, WA, U.S.A.
[4]Leibniz Centre for Tropical Marine Research, Bremen, Germany.
[5]Ecosystem Science Division, NOAA Southwest Fisheries Science Center, Monterey, CA, U.S.A.
[6]School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA, U.S.A.
[7]Departamento de Economía, Universidad de Concepción, Concepción, Chile.

Climate change is affecting marine ecosystems from small pelagic fish (SPF) to the human communities that depend on them. There is growing interest by decision makers to assess how current management systems perform under such projected changes. While a range of ecological models, from species distribution models to end-to-end ecosystem models, have been used to assess future changes in SPF productivity and distribution, few studies have leveraged these outputs to quantify uncertainty in future trends and inform Management Strategy Evaluations (MSEs). MSEs use closed loop simulation to assess robustness of management frameworks to uncertainty. In these simulations, operating models (OMs) serve as mathematical representations of the true dynamics of the system, to allow testing of management strategies under different OMs (i.e., uncertainty scenarios). Here, using Pacific sardine (*Sardinops sagax*) in the California Current as a case study, we demonstrate how output from ecological models can be leveraged to develop quantitative uncertainty scenarios for MSE-like closed-loop simulations. More specifically, we use output from a set of regional ecological models to build alternative OMs, representing possible future scenarios of sardine recruitment, growth, natural mortality, fisheries selectivity and catchability. Ultimately, this work supports the development of proactive, sustainable, and climate-responsive management strategies for highly variable SPF stocks.

S01, Pre-RecordedOral, AbstractID=19047, (ECOP)

Multivariate Health Index of the anchovy: Understanding the dynamics of small pelagic fish under environmental variability

Elmer **Quispe-Salazar** and Jorge Tam

Instituto del Mar del Perú (IMARPE), Lima, Perú. E-mail: oquispe@imarpe.gob.pe

The Peruvian upwelling system, one of the most productive globally, is characterized by marked environmental and climatic variability that regulates its productivity and shapes the population dynamics of anchovy (*Engraulis ringens*) at different temporal scales. In particular, the north–central stock constitutes the most productive population unit of the pelagic system and supports one of the world's largest small pelagic fisheries. Environmental fluctuations drive changes in stock structure, physiological condition, and spatial distribution, affecting the stability of recruitment processes and resource availability for fishing. Given this variability, a comprehensive assessment of stock health is needed, since interpreting its state through individual indicators is limited and does not capture the multivariate nature of its niche or its diverse responses to environmental changes. To address this complexity, a Multivariate Health Index (MHI) was developed based on data from pelagic resource assessment surveys conducted by IMARPE between 1996 and 2024. The MHI integrates six functional dimensions using indicators of population magnitude, size structure, somatic condition and growth, reproductive activity, and spatial distribution. Indicators were standardized and collinearity assessed through the Variance Inflation Factor (VIF) to ensure independence. A Factorial Analysis of Mixed Data (FAMD) combined continuous, proportional, and categorical variables to generate an interpretable axis of biological–population state. Index robustness was tested through bootstrap stability analysis, and its temporal evolution assessed using Trajectory Analysis and Redundancy Analysis (RDA) relative to productivity and climatic indices. The MHI provides a comprehensive, integrative framework synthesizing over four decades of biometric, biological, and acoustic data to support adaptive management of small pelagic fisheries in the southeastern Pacific.

Keywords: anchovy, health index, environmental variability, adaptive management.

S01, Oral, AbstractID=18819

Testing the performance of small pelagic fish stock assessments, using an end-to-end model incorporating environmental and trophic interactions

Isaac **Kaplan**[1], Holly Perryman[2], Sarah Gaichas[3], Mercedes Pozo Buil[4,5], Stephanie Hopkins[1,4], Robert P. Wildermuth[6], Desiree Tommasi[4,6] and Caitlin Allen Akselrud[6]

[1]NOAA/ NMFS Northwest Fisheries Science Center, Seattle, WA, U.S.A.
Email: isaac.kaplan@noaa.gov
[2]DNV AS
[3]Hydra Scientific LLC
[4]University of California Santa Cruz, Santa Cruz, CA, U.S.A.
[5]NOAA/NMFS Southwest Fisheries Science Center, Monterey, CA, U.S.A.
[6]NOAA/NMFS Southwest Fisheries Science Center, La Jolla, CA, U.S.A.

The population dynamics and growth of small pelagic fish fluctuate in response to environmental drivers and trophic interactions, potentially presenting challenges for fisheries stock assessments that assume static patterns of growth, mortality, and recruitment. Modern fisheries stock assessments provide some potential solutions, for instance estimating natural mortality (M) that varies by age or through time, including time-varying weight-at-age empirically rather than via fixed growth curves, and allowing for shifts in reference points to capture trends in productivity. We test the performance of these potential solutions for small pelagic fish with a dynamic simulation framework that includes multiple scenarios of future fishing and climate. We fit a Stock Synthesis assessment model to a simulated Pacific sardine (*Sardinops sagax*) population time series for the California Current. Simulated sardine dynamics are taken from Atlantis ecosystem model projections, which include 1) trends in predator abundance and therefore mortality on sardine as prey, 2) time-varying growth response to the availability of plankton as forage for sardine, 3) shifts in spatial distributions, recruitment, and growth of sardine, each forced by projections under climate change. We consider three such climate projections, driven by downscaled Earth System Models. We pass these projections via the *atlantisOM* R package into the stock assessment to identify cases leading to poorly estimated stock status metrics as compared to the 'true' stock status simulated in Atlantis, including instances of poor estimation precision, and bias in perceived stock status. Overall the *atlantisOM* package offers a method to utilize the many Atlantis models available globally as operating models for testing new stock assessment configurations and innovations.

S01, Oral, AbstractID=18830, (ECOP)

The booms-and-busts of modeling forage fish population dynamics

Éamonn Joeín **Mac Donnachá**[1], Tyler Eddy[1], Ron Lewis[2], Paul Regular[2] and Matthew Robertson[1]

[1]Fisheries and Marine Institute of Memorial University of Newfoundland, St. John's, Newfoundland and Labrador, Canada. E-mail: eamonn.jmacdonnacha@gmail.com
[2]Fisheries and Oceans Canada, Northwest Atlantic Fisheries Centre, St. John's, Newfoundland, Canada

Forage fish have high ecological and economic value, making implementation of ecosystem-based fisheries management (EBFM) of their fisheries vital. However, forage fish population dynamics are naturally volatile and difficult to predict making them challenging to manage. Often strong top-down and bottom-up forces drive these volatile dynamics. This suggests that inclusion of ecosystem effects in forage fish population dynamics models will be more successful when compared to other functional groups. As a result, examining global progress incorporating ecosystem effects into forage fish population dynamics models may provide important insights into the state of EBFM implementation. This study aimed to investigate global forage fish population dynamics modeling practices and whether ecosystem effects are being included in these models. We conducted a systematic quantitative review examining published scientific articles on the population dynamics modeling of the 10 forage fish species with the highest annual global capture production in contemporary history (1950 onwards). Our review revealed that there has been an increase in the diversity of species modeled, effects from ecosystem covariates, and population dynamics models used, specifically with an increase in state-space models. The review also demonstrated areas where inclusion of ecosystem effects in population dynamics models is high (e.g., North-Atlantic) and low (e.g., North-West Pacific). The increase in diversity of models, modeled forage fish, and effects from ecosystem covariates indicates that more research is being conducted to understand forage fish population dynamics which may better support the implementation of EBFM.

S01, Oral, AbstractID=18841, (ECOP)

The jack mackerel fishery in the southeastern Pacific (1973–2024): Interdecadal changes in maximum sustainable yield with the environmental projections under climate change

Francisco **Plaza-Vega**[1], Eleuterio Yáñez[2*], Karen Walker[3] and Pierre Freon[4]

[1]Universidad de Santiago de Chile, Santiago, Región Metropolitana, Chile.
E-mail: francisco.plaza.v@usach.cl
[2]Profesor Titular Pontificia Universidad Católica de Valparaíso, Chile.
E-mail: eleuterio.yanez@pucv.cl
[3]Instituto de Fomento Pesquero, Chile
[4]Fisheries Researcher, France

The jack mackerel (*Trachurus murphyi*) fishery in the Southeastern Pacific (SEP) between 1973 and 2024 was analyzed considering the influence of environmental variability on its dynamics. Maximum Sustainable Yields (MSY) of about one million tonnes were estimated for the cold interdecadal period 1999–2024, and around four million tonnes for the warm period 1977–1998. These estimates were obtained using the CLIMPROD software, incorporating annual averages of Sea Surface Temperature (SST) and standardized fishing effort (fe) as explanatory variables. Additionally, monthly simulations were developed using deep learning models (Convolutional Neural Networks and LSTM networks), integrating monthly SST and fishing effort series with time lags up to 60 months. Results indicate that warm periods exhibit higher projected monthly catches, while cold periods show significant decreases. Both methodological approaches yield consistent results and highlight the importance of integrating environmental variables into the assessment and projection of highly migratory fisheries.

Keywords: Fisheries, Jack mackerel, Deep Learning, Environment, Global Production Models, Convolutional Neural Networks, Long-Short Term Memory Networks.

S01, Oral, AbstractID=18856, (ECOP) (CANCELLED)

Breaking the time-series trap: AI pathways to adaptive fisheries management

Chelsey **Karbowski**

Teem Fish Monitoring, Dartmouth, Nova Scotia, Canada. E-mail: chelsey@teem.fish

Fisheries science is entering a moment of transformation. For decades, stock assessments have relied on long-term surveys and models that assume stability in ecosystems that are anything but stable. As climate change accelerates, these approaches struggle to keep pace, leaving managers and communities without the tools they need to make timely, adaptive decisions.

At the same time, we are witnessing an explosion of new data streams: electronic monitoring from fishing vessels, satellite tracking, and near real-time oceanographic indicators. When paired with artificial intelligence, these data offer the foundation for a new kind of stock assessment, one that is dynamic, flexible, and responsive to the conditions fish and fishers are experiencing today.

This plenary session will explore how AI can help us move beyond outdated, hierarchical models toward systems that are not only more accurate, but also more inclusive.

By co-developing AI tools with coastal and Indigenous communities, we can ensure that resilience priorities and local knowledge shape the science, rather than being sidelined by it. Instead of waiting years for traditional assessments, fisheries could access rapid, adaptive insights that improve equity, sustainability, and climate readiness.

This vision of AI is not simply faster models, it is a reimagining of how knowledge is created, shared, and acted upon in fisheries governance. In this vision, stock assessment becomes a living, participatory process, where science keeps pace with change and communities have the tools to chart their own resilient futures.

S01, Oral, AbstractID=18864, (ECOP)

Integrating predation mortality into Pacific Hake Assessment

Raquel **Ruiz-Diaz**[1], Grant D. Adams[2], Sophia N. Wassermann[3], Isaac C. Kaplan[4], Kristin N. Marshall[4] and André E. Punt[1]

[1]School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA, U.S.A.
E-mail: raquelrd@uw.edu
[2]Resource Ecology and Fisheries Management Division, Alaska Fisheries Science Center, Seattle, WA, U.S.A.
[3]Resource Assessment and Conservation Engineering Division, Alaska Fisheries Science Center, Seattle, WA, U.S.A.
[4]Conservation Biology Division, Northwest Fisheries Science Center, Seattle, WA, U.S.A.

Pacific hake (*Merluccius productus*) is the largest commercial fishery on the U.S. West Coast and a keystone species of the California Current ecosystem. The stock is assessed annually throughout the Pacific hake/ Whiting treaty using a catch-at-age single species model. However, these types of models often overlook predation as a major source of mortality, potentially leading to biased estimates of population dynamics. This research overcomes this gap by using the multispecies model CEATTLE (Climate-Enhanced Age-based model with Temperature-specific Trophic Linkages and Energetics) to explicitly quantify predation mortality for Pacific hake. By partitioning natural mortality into predation (from key predators included in the model) and residual sources (e.g., disease, senescence), our approach provides more robust, time- and age-varying mortality estimates. Our model incorporates predation from two major predators, Arrowtooth flounder (*Atheresthes stomias*) and Sablefish (*Anoplopoma fimbria*), as well as hake cannibalism. We found cannibalism to be the dominant source of predation mortality, with consumption peaking at 2 million tonnes in the 1980s and declining to 0.5 million tonnes currently. While Arrowtooth flounder showed a higher dietary preference for hake (20%) than Sablefish (5%), the high abundance of Sablefish resulted in greater predatory impacts, with its consumption peaking at 0.15 million tonnes compared to 0.06 million tonnes for Arrowtooth flounder. Our results demonstrate that different predators impact distinct aspects of the hake population, with cannibalism primarily influencing recruitment estimates, whereas predation by Arrowtooth flounder and Sablefish has a greater effect on total biomass and spawning stock biomass (SSB). The outputs from the CEATTLE multispecies model can be directly compared with single-species assessments and used to derive more realistic biological reference points. By quantifying the distinct roles of different predators, this work provides critical insights for advancing ecosystem-based fisheries management and offers a more comprehensive foundation for decision-making.

S01, Oral, AbstractID=18880

Toward identifying the critical ecological habitat of larval fishes: An environmental DNA window into fisheries management

Erin V. **Satterthwaite**[1], Andrew E. Allen[2], Robert H. Lampe[2], Zachary Gold[3], Andrew R. **Thompson**[4], Noelle Bowlin[4], Rasmus Swalethorp[5], Kelly D. Goodwin[4,6], Elliott L. Hazen[7], Steven J. Bograd[7], Stephanie A. Matthews[5] and Brice X. Semmens[5]

[1]California Sea Grant & Scripps Institution of Oceanography, La Jolla, CA, U.S.A.
E-mail: esatterthwaite@ucsd.edu
[2]Scripps Institution of Oceanography, UCSD, and J. Craig Venter Institute, La Jolla, CA, U.S.A.
[3]Scripps Institution of Oceanography, UCSD, La Jolla, CA, U.S.A.; Southern California Coastal Watershed Research Project, Costa Mesa, CA, U.S.A.; NOAA Southwest Fisheries Science Center (SWFSC), La Jolla, CA, U.S.A.; and Pacific Marine Environmental Laboratory, Seattle, WA, U.S.A.
[4]NOAA SWFSC, La Jolla, CA, U.S.A.
[5]Scripps Institution of Oceanography, UCSD, La Jolla, CA, U.S.A.
[6]NOAA Atlantic Oceanographic & Meteorological Laboratory, Miami, FL, U.S.A.
[7]NOAA SWFSC, Monterey, CA, U.S.A.

Marine larvae are important to marine ecosystems and fisheries, but predicting recruitment remains a fundamental challenge in fisheries science. Previous work has focused on characterizing physical conditions that defines critical oceanic habitats for important fisheries as well as key groups of prey, but the complex network of species associations that define larval ecological habitat is unexplored. Now, ecological aspects of the larval habitat can be examined through biomolecular techniques. Using anchovy larvae (*Engraulis mordax*) as a case study, the goal of this study was to examine how eDNA data can be coupled with traditionally sampled larval fish abundance data to develop ecological co-occurrence networks that provide insight into the larvae's microscopic world and work toward elucidating communities, species, and mechanisms that control larval dynamics. We correlated the presence/absence (P/A) of ASVs from biomolecular 16S and 18S data with visually enumerated counts of larval fishes to create a correlation matrix that we visualized as an ecological co-occurrence network. We found that 'anchovy water' can be characterized by eDNA analysis to reveal potential prey field, predators, microbiome associates, or a general fingerprinting of anchovy ecological habitat. Biomolecular approaches provide insight into the larval habitats of important fisheries species and provide working hypotheses to explore through future research. Thus, there is great potential for eDNA methods coupled with ecological network analyses to provide a holistic understanding of community composition and species interactions and to develop indicators for fisheries and ecosystem-based management.

S01, Oral, AbstractID=18884 (ECOP)

Size matters: The implications of small herring populations on management and ecology

Aaron **Brazier**

Centre for Environment Fisheries and Aquaculture Science (Cefas), Lowestoft, United Kingdom.
E-mail: aaron.brazier@cefas.gov.uk

Small-scale, localised populations of Atlantic herring (*Clupea harengus*) present unique challenges and opportunities for fisheries ecology and management. Whilst herring, generally, are often treated as larger, more widely distributed stocks e.g., North Sea herring, fine-scale structuring can yield distinct spawning components, differential levels of mixing, and localised recruitment dynamics. We shall explore the ecological implications of such populations: how micro-scale variations in spawning timing, habitat choice, and movements can influence connectivity, genetic differentiation, and resilience to environmental change. From a management perspective, recognising small-scale stock structures may improve spatially explicit catch advice and quota allocation, reduce overfishing of vulnerable components, and support local conservation strategies. However, fisheries management may be hindered by setting catch limits to solely protect the population in the worst condition.

S01, Oral, AbstractID=18889, (ECOP)

Individual Based Modelling to aid spatial management of small pelagic fish

Joseph W. **Watson**[1], Rebecca E. Holt [2], Matthew Thomas[1], Stephen Gregory[2], Tiago Silva[1], Nicola Walker[1], Lianne Harrison[1] and Richard D.M. Nash[1].

[1]Centre for Environment, Fisheries & Aquaculture Science, Lowestoft Laboratory, U.K.
E-mail: joseph.watson@cefas.gov.uk
[2]Centre for Environment, Fisheries & Aquaculture Science, Weymouth Laboratory, U.K.

The northeast Atlantic is home to several small pelagic species with wide ranging migrations that pose challenges to management. Northeast Atlantic Mackerel (NEAM - *Scomber scombrus*) are one of these highly migratory species and support one of the regions most valuable fisheries. NEAM distribution shows strong inter-annual variability, but drivers are not fully understood. Recent shifts are linked to climate variability, raising questions about future changes in distribution and productivity, and highlighting the need for spatially explicit approaches to stock assessment and management. To address this, we present the development of a spatially explicit Individual Based Model (IBM) that integrates survey data, biological knowledge, and environmental data to fill gaps in the understanding of NEAM distribution. The model spans the northeast Atlantic and Nordic Seas and includes the full life cycle of mackerel. The IBM applies an energy budget framework, driven by satellite-derived sea surface temperature and chlorophyll-a concentration, to generate emergent stock-level outputs such as spawning stock biomass and weight-at-age. Feeding and spawning behaviour is fully emergent allowing exploration of the processes shaping spatial and temporal patterns. Ongoing work focuses on adding connectivity matrices from particle tracking models to represent drift of eggs and larvae from spawning grounds to nursery areas. The model eventually aims to provide a tool to inform management under current/future environmental and management conditions and it is hoped that similar models can be developed for other relevant species in the northeast Atlantic such as blue whiting (*Micromesistius poutassou*) and Atlanto-Scandian herring (*Clupea harengus*).

S01, Oral, AbstractID=18898

The sudden, irreversible collapse of chub mackerel driven by overexploitation and climate change

Shota **Nishijima**[1,2] and Stephan Munch[2]

[1]Japan Fisheries Research and Education Agency, Yokohama, Kanagawa, Japan.
E-mail: nishijima_shota02@fra.go.jp
[2]Department of Applied Mathematics, University of California, Santa Cruz, CA, U.S.A.

Population dynamics models used for fisheries stock assessments often ignore nonlinear responses to fishing pressure and environmental influences, which can lead to poor predictive performance and underestimation of risks, particularly for short-lived species. In this study, we applied Gaussian Process Empirical Dynamic Modeling (GP-EDM), an equation-free nonlinear time-series analysis, to the chub mackerel (*Scomber japonicus*) in the northwestern Pacific to improve future projection accuracy and to understand greatly fluctuating dynamics. Using leave-future-out cross-validation, we found that GP-EDM predictions based solely on the time series of spawning stock biomass (SSB) outperformed conventional stock assessment approaches based on life-cycle models linking SSB and recruitment. Including sea surface temperature as a covariate further improved prediction skill and revealed the emergence of alternative stable states, where both high and low SSB regimes coexisted under warm conditions. Our results suggest that the recent collapse of chub mackerel population was driven by increased fishing pressure, and that recovery is unlikely as long as elevated temperatures persist, even if fishing pressure is substantially reduced. These findings highlight that under global warming, small changes in fishing pressure may trigger sudden and irreversible stock collapses. The approach developed here contributes to forecasting and sustainable management of small pelagic fish exhibiting complex dynamics under environmental variability.

S01, Oral, AbstractID=18915, (ECOP)

Using species distribution models to develop movement scenarios for management strategy evaluation: A Pacific sardine case study

Stephanie **Hopkins**[1], Robert Wildermuth[2], Isaac Kaplan[3], Alexander Jensen[2], Caitlin Allen Akselrud[2], Barbara Muhling[1] and Desiree Tommasi[1]

[1]University of California, Santa Cruz, Seattle, WA, U.S.A. E-mail: shopkin1@ucsc.edu
[2]Fisheries Resources Division, Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, 8901 La Jolla Shores Dr., La Jolla, California 92037, U.S.A.
[3]Conservation Biology Division, Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, Washington, U.S.A.

Present day management of Pacific sardine (*Sardinops sagax*) assumes there are three subpopulations (cold, temperate, and warm), with the U.S. only considering the northern (cold) subpopulation in its management. The current U.S. coastal pelagic species survey method therefore assigns individual sardine observations to the northern (cold) subpopulation depending on the habitat suitability (SST and CHL-a concentration) at the sample's location. Ocean conditions are changing, and in recent years, there have been fewer northern (cold) subpopulation sardines in U.S. waters. This raises questions around the performance of the current harvest control rule under future spatial distribution scenarios and different stock structure hypotheses. To understand the directional response of sardine distribution to environmental variability, we leveraged existing survey data with species distribution models (SDMs) that integrate downscaled regional oceanographic model data. We show how outputs of these SDMs were used to develop different movement scenarios for novel spatial operating models (OMs) built in Stock Synthesis. These spatial OMs will be used in research-track closed-loop simulations similar to a management strategy evaluation to assess management performance under alternative movement scenarios as well as different hypotheses around stock structure.

S01, Oral, AbstractID=18919

Contribution of a DEB-IBM to the understanding of the drivers of change in life history traits of small pelagic fish and to ecosystem-based management

Martin **Huret**[1*], Clara Menu[2], Denis Gourves[3] and Matthieu Caillaud[4]

[1]DECOD, Institut Agro, IFREMER, INRAE, Brest, France. E-mail: martin.huret@ifremer.fr
[2]IFREMER, DYNECO/PELAGOS, Brest, France
[3]SHOM, Brest, France
[4]IFREMER, DYNECO/DHYSED, Brest, France

Small pelagic fish exhibit variability in abundance and life history traits over seasonal to inter-annual time scales. In particular, evidence is accumulating on the decline of their size and condition across more and more ecosystems. However, understanding the processes driving variability in growth, reproduction, or survival remains challenging, as they may be shaped by both external environmental factors and internal mechanisms, such as density dependence. A bioenergetic model, here the Dynamic Energy Budget (DEB), forced by a coupled physical-biogeochemical model, provides a mechanistic representation of the environmental forcing (currents, temperature, plankton) on the transport and physiology of individuals. Responses at the population level can then be up-scaled by integrating the bioenergetics into an individual-based model (IBM). Through the case study of anchovy and sardine in the Bay of Biscay and a scenario-based approach, we will illustrate how the DEB-IBM can shed light on the drivers of variability in biological traits and population abundance. The model highlights the importance of seasonality in growth, building of reserves and survival under environmental constraints, while long term decline in fish size seems to be related to the decline in zooplankton size. A comparison of a 0-D vs. a 3-D version of the model highlights how the spatial exploration of the habitat can be profitable for the fitness of the populations. Identifying the drivers of population dynamics, as well as quantifying the variability in vital rates and connectivity patterns, should ultimately feed the ecosystem-based management willing to integrate non-stationarity in growth and recruitment.

S01, Oral, AbstractID=18970 (CANCELLED)

Model-based indices of abundance from hydro-acoustic surveys improve biomass estimates of South Africa's small pelagic fish species

Dawit **Yemane**[1], Janet C Coetzee[1,2], Dagmar Merkle[1] and Nandipha Mhlongo[1]

[1]Department of Forestry, Fisheries and the Environment (DFFE), Cape Town, South Africa.
E-mail: dawityemane@gmail.com
[2]Department of Biodiversity and Conservation Biology, University of the Western Cape, Cape Town, South Africa

The assessment and management of South Africa's small pelagic fish species, anchovy, sardine, and round herring, critically depend on biomass estimates derived from biannual hydro-acoustic surveys. Based on stratified, random transect design theory, these surveys produce estimates with known precision because variance is objectively calculated from between-transect variability, without requiring assumptions about the underlying spatial distribution. However, these biomass estimates often have large coefficients of variation (CVs), which has implications for stock assessments and the setting of Total allowable catches (TACs) and Total allowable bycatches (TABs). Model-based indices of abundance are typically associated with lower CVs and can account for multiple covariates, while offering additional benefits. These include the ability to generate indices for the full survey area when surveys are interrupted or incomplete, enabling extrapolation from surveyed to un-surveyed regions. Model-based methods may also lend support to short-term projections from population dynamics models, by predicting abundance using recent trends and environmental covariates. Given these advantages, the value of using spatio-temporal Generalized Additive Models (GAMs) to generate indices of abundance for small pelagic fish species was explored. Initial results indicated that the indices produced were comparable to those derived from the design-based approach and exhibited similar CVs. The subsequent use of a higher-resolution mesh lead to relatively lower CV. By explicitly incorporating spatial information and underlying spatial processes at relevant scales, model-based indices can provide more comprehensive insights into distribution and abundance patterns. Moreover, their ability to derive reliable estimates for unsampled regions of incomplete surveys is of paramount importance given frequent survey disruptions and budgetary constraints.

S01, Oral, AbstractID=19003 (CANCELLED)

Is it worth using a complicated model when the fishery biomass is very variable?

Margarita **Rincon Hidalgo**[1], Danai Mantoupoulou[1] and Ernesto Jardim[2]

[1]JRC European Commision, Ispra, Italy. E-mail: margarita.rincon-hidalgo@ec.europa.eu
[2]Portuguese Institute for sea and Atmosphere (IPMA), Lisbon, Portugal

Stock assessment is crucial in fisheries management as it provides the essential scientific basis for setting sustainable harvest levels, thereby safeguarding fish populations from overexploitation and potential collapse. Usually this assessment is performed by using complex mathematical models when enough data is available but when small pelagic fish (SPF) are involved, this task has an added value of complexity. Their short life expectancy, characteristic aggregative behaviour, rapid response to climate and environmental signals and large and variable natural mortality make them less tractable through traditional population dynamic models and assumptions and, their assessment particularly difficult and uncertain.

In this case, perhaps a trade off between a complex mathematical model and management precision (e.g. MSY), and a mathematical rule based on the recruitment estimation from a survey performed in the recruitment season that assures reasonable exploitation levels and low risks of collapse, is more effective than trying to tame all uncertainty associated with higher modelling complexity. Different scenarios will be tested for the European anchovy using the same data input as the one used for scientific advice against using only a recruitment index from a recruitment survey in a MSE simulation framework. This can set a methodological framework giving evidence on when adding complexity could not be the best option for stock assessment and could be easily applied for other small pelagics.

S01, Oral, AbstractID=19009, (ECOP)

Competition shapes the responses of small pelagic resources to SSP scenarios in the northern Humboldt Current System

Mariana **Hill**[1], Ivy Frenger[1], Renato Salvatteci[2] and Mathias Zeller [1]

[1]GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel, Germany.
E-mail: mhill-cruz@geomar.de
[2]Center for Ocean and Society (CeOS), Kiel University, Kiel, Germany

The northern Humboldt Current System (NHCS) is the most productive marine ecosystem in the planet in terms of fish landings and hosts the world's largest single-species fishery. However, its ecosystem is susceptible to strong environmental variability, which has previously induced regime shifts in the pelagic resources. Consequently, changes in the ecosystem that might arise from climate change and future management strategies will have major implications for the Peruvian fishing sector, local communities, and the entire global food security. The IPCC Shared Socioeconomic Pathways (SSPs) describe potential socioeconomic and environmental futures, ranging from cooperation- and sustainability-oriented scenarios (SSP1) to high-emission, inequality driven scenarios (SSP3 and SSP5). In this study, we used the multispecies model OSMOSE to simulate the marine ecosystem of the NHCS. We simulated different SSPs by applying plankton anomalies derived from an Earth System Model. For each SSP, we also developed plausible fisheries management strategies, ranging from reduced fishing pressure (SSP1) to intensified exploitation of existing and emerging fisheries (e.g., SSP3). The simulations revealed an inverse relationship between Peruvian anchovy and red squad lobster in scenarios SSP1 and SSP3, reflecting competition for resources and overlapping ecological niches. Our simulations also show a decline in anchovy biomass of more than 50% under SSP3, while strong fishing pressure on anchovy in this scenario led to a relative increase in mesopelagic fish abundance. Overall, our results show the importance of adopting an ecosystem-based fisheries management approach that accounts for species interactions and ecosystem dynamics when designing adaptation strategies to future climate change.

S01, Oral, AbstractID=19019

Mechanistic ensemble population models to evaluate environmental drivers and climate change impacts in forage fish populations

Stefan **Koenigstein**[1,2] and Desiree Tommasi[2]

[1]Coastal Resources Programme Area, Leibniz Institute for Tropical Marine Research, Bremen, Germany. E-mail: stefan.koenigstein@leibniz-zmt.de
[2]Institute of Marine Science, University of California Santa Cruz, Santa Cruz CA, U.S.A.

Forage fish play key ecological roles as prey for other fish, seabirds and marine mammals, while representing some of the world's most important and most variable fisheries resources, challenging sustainable management and adaptation. In the California Current, contrary to expectations after recent warm ocean conditions, Pacific sardine (*Sardinops sagax*) remains at low biomass, while Northern anchovy (*Engraulis mordax*) has recently appeared to recover.

We present an integrative modelling approach based on mechanistic, age-structured MICE models (Models of Intermediate Complexity for Ecosystem assessments), to improve understanding of sardine and anchovy variability, and assess the cumulative impacts of the environment, predators and fisheries. Early life stage survival and offshore transport, food availability for larvae and adults, migration, consumption and egg production are explicitly modelled driven by regional ocean-biogeochemical models. An ensemble model configuration is derived from global sensitivity analysis and calibrated to stock assessment, fisheries, predator and physiological data, to quantify uncertainty in driving processes.

The models reproduce the last boom-and-bust and lack of recent recovery of sardine, and the resurgence of anchovy. Ensemble projections of population abundance, catch and spatial distribution for the 21st century under three downscaled earth system models show a likely sardine recovery to early 2000's abundance and catch by mid-century, and concurrent decreases in anchovy, driven by changes in recruitment success under warming temperatures and changing food availability.

These models support the development of ecosystem-based management and climate change adaptation strategies, that are robust to uncertainties in environmental, biological and socio-economic factors.

S01, Oral, AbstractID=19088

One for all, all for one: Using an ensemble of climate-informed ecological models to characterize climate and ecosystem-driven uncertainty in the California Current

Pierre-Yves Hernvann[1,2], Robert P. **Wildermuth**[1,3], Desiree **Tommasi**[1,3], Daniele Bianchi[4], Steven J. Bograd[5], Jerome Fiechter[1], Dylan Gomes[6,7], Jerome Guiet[4], Elliott L. Hazen[5], Charlie Hinchliffe[8], Michael G. Jacox[5,9], Isaac C. Kaplan[2], Stefan Koenigstein[1,10], Nerea Lezama-Ochoa[1], Colleen M. Petrik[11], Jim Ruzicka[12], James A. Smith[13], Michael A. Spence[14], Andrew R. Thompson[3] and Kelly Vasbinder[1]

Presented by Desiree Tommasi

[1]University of California Santa Cruz, San Diego, CA, U.S.A. 95060
[2]NOAA Fisheries Northwest Fisheries Science Center, Seattle, WA, U.S.A.
[3]NOAA Fisheries Southwest Fisheries Science Center, La Jolla, CA, U.S.A.
E-mail: robert.wildermuth@noaa.gov
[4]University of California Los Angeles, Los Angeles, CA, U.S.A.
[5]NOAA Fisheries Southwest Fisheries Science Center, Monterey, CA, U.S.A.
[6]NOAA Fisheries Northwest Fisheries Science Center, Newport, OR, U.S.A.
[7]Marine Reserves, Oregon Department of Fish and Wildlife, Newport, OR, U.S.A.
[8]Centre for Freshwater Ecosystems, La Trobe University, Wodonga, VIC, Australia
[9]NOAA Physical Sciences Laboratory, Boulder, CO, U.S.A.
[10]Leibniz Centre for Tropical Marine Research, Bremen, Germany
[11]Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA U.S.A.
[12]NOAA Fisheries Pacific Islands Fisheries Science Center, Honolulu, HI, U.S.A.
[13]Port Stephens Fisheries Institute, New South Wales Department of Primary Industries and Regional Development, Nelson Bay, NSW, Australia
[14]Centre for Fisheries and Aquaculture Science, Lowestoft, Suffolk, United Kingdom

Model ensembles present a promising approach for informing fisheries management. Instead of relying on a single 'best' model, they aggregate predictions and diagnostics across multiple models to better capture uncertainty and provide robust scientific advice. Ensemble modeling approaches are especially useful for comparing models that estimate common variables with varying biological resolution, as they reveal how differences in integrated biological and ecological processes affect system dynamics and help quantify structural uncertainty. This framework can also identify agreement among the models, offering high levels of confidence for management relevance. An ensemble modeling framework that highlights concordance among model outputs would build confidence in multiple model projections. We apply an ensemble modeling framework to a set of models developed for assessing climate change and fishing impacts on small pelagic forage species (SPF) in the California Current. Our analysis demonstrates that ecosystem model structure has a dominant influence on estimated outcomes for California Current SPF, relative to climate model structure, resulting in discordant estimates of dynamics among ensemble members through the end of the century. We discuss lessons learned and highlight important avenues for improving the applicability of ensemble modeling approaches to strategic ecosystem-based fisheries management.

S01, Pre-Recorded Invited, AbstractID=18838

Adaptive management of the Peruvian anchoveta fishery in the context of a highly variable ecosystem

Erich **Diaz**

Instituto del Mar del Peru, Callao, Peru. E-mail: ediaz@imarpe.gob.pe

The Peruvian anchoveta (*Engraulis ringens*) is a small, fast-growing, short-lived, and highly abundant pelagic fish that inhabits the cold, nutrient-rich waters of the Peru Current Ecosystem. Within this system, anchoveta plays key ecological, economic, social, and food security roles. An additional aspect that must always be considered when describing this species is that both the resource and its fishery are situated within a highly environmentally variable ecosystem. This variability, occurring across multiple time scales, affects the ecosystem's structure and functioning, as well as the species' population dynamics and fishery performance. Nevertheless, over seventy-five years of experience have shaped an adaptive management approach designed to cope with such variability. This approach is based on four main pillars: 1) a stock assessment methodology grounded in direct and highly frequent observations, which also incorporates the most probable environmental scenarios into projections; 2) comprehensive monitoring of the resource, the fishery, and the ecosystem; 3) flexible decision-making and legal frameworks that enable the implementation of responsive measures based on the most recent observations; and 4) fluent institutional communication that ensures science is promptly conveyed to managers, policymakers, and stakeholders. This framework has enabled the continuity of this important fishing activity without compromising the biological sustainability of the resource, even under environmental disturbances, such as heatwaves or El Niño events. It also provides a foundation for adapting fishery management to broader environmental changes, including new ecosystem regimes and climate change.

SESSION 1

Bridging the Gap: From Ecological Data and Models to Fisheries Decision-Making

Poster Presentations

S01, Poster, AbstractID=18815, PosterID: S01-P1, (ECOP) (CANCELLED)

Improving small pelagic species forecasting by accounting for features in time series data

Caitlin I. Allen **Akselrud**, Andre E. Punt, Trevor A. Branch and Eric J. Ward

Presented by Robert Wildermuth on behalf of Caitlin I. Allen Akselrud

NOAA, La Jolla, CA, U.S.A. E-mail: caitlin.allen_akselrud@noaa.gov

Managers need reliable forecasts to set catch limits for small pelagic species, but the boom-bust nature of these stocks makes forecasting notoriously difficult. There is a tendency to believe that complex new methods, such as machine learning, will solve this problem. In some cases, simple machine learning tools can improve forecasting in fisheries. However, even methods that have been around for decades, such as Random Forests, need attention to detail in relation to the input covariates and model parameterization and configuration. By default, random forest and other machine learning techniques may not account for the temporal structure in fisheries datasets, and ignoring this may yield poor or biased predictions. We show that accounting for trends and patterns in covariate data can improve predictive skill for methods such as random forests. For instance, there is a tendency to over-fit training data and lose predictive power when applying to testing data if autocorrelation in model structure and design is ignored when analyzing time-series data. The key lesson is that the most significant gains in the ability to forecast these challenging stocks will come from a renewed focus on the fundamentals: understanding the data, identifying the key drivers, and thoughtfully constructing models.

S01, Poster, AbstractID=18950, PosterID: S01-P2 (CANCELLED)

Seasonal resilience of temperate estuarine fish in response to climate change

Zhaopeng Zhang[1,2,3], Cui **Liang**[1,2,4*], Lei Zheng[1,2,3] and Weiwei Xian[1,2,4]

[1]Institute of Oceanology Chinese Academy of Sciences, Qingdao, Shandong, China, PR.
E-mail: liangc@qdio.ac.cn
[2]Laboratory for Marine Ecology and Environmental Science, Qingdao National Laboratory for Marine Science and Technology, Qingdao, China, PR
[3]University of Chinese Academy of Sciences, Beijing, China, PR
[4]Center for Ocean Mega-Science, Chinese Academy of Sciences, Qingdao, China, PR

To date, the intricacies and efficacy of how periodic seasonal environmental fluctuations affect fish populations in biogeography in the context of profound climate change remain to be elucidated. Collected monitoring data on fish resources in the Temperature Estuary provide an excellent opportunity to assess the effects of seasonal environmental fluctuations on populations and functional assemblages under climate change. We first developed a framework for predicting habitat suitability under different climate change scenarios (SSP1-2.6 and SSP5-8.5) for 12 fish populations in the Yangtze estuary by examining the seasonal environmental affinities of temperate estuarine fishes. We then summarized the multidimensional habitat suitability responses (HSRs) of populations and functional assemblages and discussed the possible drivers and mechanisms underlying these changes. The results suggest that the acidity of the Yangtze estuary may decline in the future as the climate warms, endangering the ecosystem that many fish species depend on. Prospective climate change may have an impact on fish population HSRs through redistribution, area changes, and centroid migration of suitable habitats; nevertheless, affinity for environmental factors may be limited to distinguishing patterns of population response in the spring. Fish (5 populations) and functional assemblages (11 assemblages) may exhibit robust adaptations or non-adaptations to climate change when seasons change, given their suitable habitat area. Furthermore, projections indicate that the majority of fish habitat centroids exhibit seasonal responses, migrating northeast in the spring and southeast in the autumn. By decentralizing climate risk to seasonal scales, seasonal resilience in the multidimensional HSRs of several fish populations (5/12) and their functional assemblages (11/16) is revealed for the first time. Efforts to mitigate climate risks and safeguard resources should take these seasonal forecasts and indicative information into account.

S01, Poster, AbstractID=18957, PosterID: S01-P3 (CANCELLED)

Long-term trophic shifts and energy flow changes in China's major estuaries under climate change and anthropogenic activities

Hui **Zhang** and Bo Hu

Laboratory of Marine Ecology and Environmental Sciences, Institute of Oceanology, Chinese Academy of Sciences, Qingdao, China, PR. E-mail: zhanghui@qdio.ac.cn

Estuarine ecosystems connect terrestrial and marine environments and are strongly influenced by both climate variability and human activities. In China, the Yellow River, Yangtze River, and Pearl River estuaries have experienced rapid ecological and socio-economic changes over recent decades, yet their long-term trophic dynamics remain insufficiently quantified. We applied the Ecopath with Ecosim (EwE) modeling framework to historical ecological and fisheries datasets to investigate changes in food-web structure and energy flow over the past 20–40 years. Time-series data on biomass, catch, and trophic linkages were integrated to identify key species, functional groups, and dominant drivers. Results revealed pronounced shifts in trophic composition and energy pathways. Phytoplankton and zooplankton biomass increased, while most fish and shrimp species declined, indicating intensified interspecific competition and reduced transfer efficiency. Grazing food chains became increasingly dominant relative to detritus-based pathways. These dynamics were jointly driven by climate change, fishing pressure, and major policy or restoration events. Our findings highlight how combined climatic and anthropogenic forces have reshaped the structure and productivity of estuarine ecosystems. The study illustrates the value of ecosystem modeling in linking environmental change to management outcomes, providing a quantitative foundation for adaptive, ecosystem-based fisheries management under future climate scenarios.

S01, Poster, AbstractID=18985, PosterID: S01-P4

Effect of wind variability on the recruitment of anchovy *Engraulis ringens* in the southern Humboldt upwelling ecosystem

Marcos **Arteaga**[1,2], Sebastián, I. Vásquez[1,3], Sergio Neira[2,4] and Luis Cubillos [2,4]

[1]Fisheries Research Institute, Talcahuano, Chile. E-mail: marteaga@inpesca.cl
[2]Programa de Doctorado en Ciencias con mención en Manejo de Recursos Acuáticos Renovables, Universidad de Concepción, Concepción, Chile
[3]Programa de Doctorado en Oceanografía, Universidad de Concepción, Concepción, Chile
[4]Programa COPAS COASTAL ANID FB210021, Departamento de Oceanografía, Universidad de Concepción, Concepción, Chile

Recruitment is a critical process in the dynamics of fish populations since it represents the abundance of new fish that enter a population each year. In Ekman-type upwelling ecosystems, wind is a critical factor for small pelagic fish recruitment, as it controls food availability and physical constraints such as turbulence and offshore advection. In this study, we evaluate the effect of wind, chlorophyll-a, and spawning biomass as independent variables on anchovy recruitment. Using generalized additive models (GAMs), we tested (i) the significance of each factor, (ii) the shape of the relationship between recruitment and predictors variables, (iii) recruitment regimes in the series, and (iv) whether extended windy events are associated with low recruitment levels potentially related to offshore transport of early life stages. The study period spanned from 1990 to 2021, focusing on the austral spring in south-central Chile (35–40°S) when both upwelling and anchovy spawning are maximized. GAMs revealed a parabolic relationship between the velocity of upwelling-favorable winds and anchovy recruitment. Maximized recruitment occurred at wind speeds around 6 ms^{-1} but decreased with winds above 7 ms^{-1} and below 5 ms^{-1}, and during periods of extended windy events (i.e., those lasting more than 15 days). Chlorophyll-a showed no significance on anchovy recruitment, suggesting that phytoplankton were not a limiting factor for anchovy early survival. We also found that anchovy recruitment regimes were associated with specific wind intensities. We discussed the pertinence of incorporating a recruitment index based on wind in the fishery management of the anchovy in south-central Chile.

S01, Poster, AbstractID=18995, PosterID: S01-P5

Performance of harvest control rules based on static and dynamic reference biomass B_{MSY} under recruitment regime shifts: The case of anchovy in the southern Humboldt ecosystem

Marcos **Arteaga** [1,2], Cristian M. Canales [3] and Sergio Neira [2,4]

[1]Fisheries Research Institute, Talcahuano, Chile. E-mail: marteaga@inpesca.cl
[2]Programa de Doctorado en Ciencias con mención en Manejo de Recursos Acuáticos Renovables (MaReA), Departamento de Oceanografía, Universidad de Concepción, Concepción, Chile.
[3]Escuela de Ciencias del Mar, Pontificia Universidad Católica de Valparaíso, Lab. DIMARE, Valparaíso, Chile
[4]Programa COPAS COASTAL ANID FB210021, Departamento de Oceanografía, Universidad de Concepción, Concepción, Chile

Reference biomass related to MSY (B_{MSY}) has been traditionally used both to diagnose the status of a fishery and to establish catch limits by using a Harvest Control Rule (HCR). These B_{MSY} can be either fixed or dynamic depending on the management agreement and fishery particularities. In most fisheries worldwide, B_{MSY} has been considered time-invariant; however, several studies have reported strong variations due to changes in recruitment scale or regime shifts. In this manner, the use of fixed or dynamic B_{MSY} could affect decision-making and fishery sustainability. Considering the anchovy fishery of the southern zone of the Humboldt ecosystem as a case study and given the evidence of regime shifts in its recruitment, we evaluated the performance of HCRs and management performance conditioned on static and dynamic B_{MSY} under regime shift scenarios. Our results show that the performance of the HCRs varies depending on the B_{MSY} criterion applied, and that the effectiveness of the status indicator is influenced by both the control rule and the productivity scenario. Stock management using an HCR adapted to a dynamic indicator improved fishing performance without compromising population sustainability. However, the dynamic index produced slightly lower average biomass compared to the static index, especially under low anchovy productivity scenarios. We conclude that using a dynamic B_{MSY} through a ramp-type HCR could improve the performance of the fishery without compromising the sustainability of the population. Nevertheless, under conditions of low anchovy productivity, the static approach proves to be more appropriate for effective fishery management.

S01, Poster, AbstractID=19036, PosterID: S01-P6, (ECOP)

From data-limited to management-ready: A regional assessment framework for Mediterranean dolphinfish

John G. **Ramirez**[1], Antonio Palermino[2], Lucia Rueda[3], Imane Haddi[1], Kelly Camilleri[4], Amina Besbes[5] and Elisabetta Morello[1]

[1]FAO, Rome, Italy. E-mail: john.ramireztellez@fao.org
[2]Consiglio Nazionale delle Ricerche, Messina, Italy
[3]Instituto Español de Oceanografia, Malaga, Spain
[4]Aquatic Resources, Malta
[5]Institut National des Sciences et Technologie de la Mer (INSTM). Centre of Monastir, Monastir, Tunisia

Dolphinfish (*Coryphaena hippurus*) is a key regional species across the Mediterranean Sea, managed by the General Fisheries Commission for the Mediterranean (FAO-GFCM). It is exploited seasonally (August-December) by several countries using Fish Aggregation Devices (FADs) and is also caught incidentally in longline fisheries throughout the year. Given its high growth rate, the FADs fishery predominantly targets age zero fish (35-70 cm). In the absence of survey-designed indices, this study developed standardized, fishery-dependent CPUE indices. Longline bycatch data (Italy and Spain) and targeted longline fishery data (Malta) were used for quarters 3 and 4 (Q3Q4), periods holding comparable sizes to the FADs fishery. These indices showed a consistent increasing trend from 2011 onwards. A Seasonal Surplus Production model (SPiCT) was then implemented to assess the fraction of the stock removed by FADs. The SPiCT model indicated that the stock is being exploited sustainably. Short-term forecasts further suggest a potential to increase fishing mortality. These results constitute the necessary initial step to evaluate requests from several countries to expand the dolphinfish fishery, which will require a comprehensive management strategy evaluation that considers new development plans.

SESSION 2

New Approaches for Assessment of Human Impacts Beyond Fisheries

Oral Presentations

S02, Invited, AbstractID=18871

On the impact of offshore wind farms on coastal marine ecosystems

Ute **Daewel**[1], Nils Christiansen[1], Déborah Benkort[2] and Corinna Schrum[1]

[1]Helmholtz-Zentrum Hereon, Geesthacht, Germany. E-mail: ute.daewel@hereon.de
[2]Université du Québec à Rimouski UQAR, Rimouski, Canada

Offshore renewable energy remains one of the key human interventions currently structuring coastal marine landscapes. In the Ostend declaration in 2023 the North Seas were declared Europe's green power plant with plans for 300 GW installed capacity for offshore renewable energy by 2050. In the last two decades several studies have been published to shed more light on the potential impacts of offshore wind farms on the environment they are situated in, including atmosphere, ocean physics and the biosphere. Still, understanding large scale effects on lower trophic level ecosystem productivity and how it effects food web processes and ultimately fish production and population dynamics is still limited. By integrating knowledge from recent modelling studies and observations, we explore how several OWF related impacts cumulatively effect marine ecosystem productivity and how this might translate into effects relevant for the fish community. Thereby, we also discuss the importance of time and space scales and why what happens in an offshore wind farm does not stay in an offshore wind farm. This has consequences not only for ecosystem components but needs to be discussed together with potential changes in fishing distribution and other potential co-uses to raise awareness for the expected scales of human interventions and the connectivity of the marine systems.

S02, Oral, AbstractID=18790

Effects of noise on Pacific sand lance *Ammodytes personatus* with implications for their avian predators

Nora V Carlson[1], Meredith Anne Vaillancourt White[1], Jose Tavera[2], Patrick D O'Hara[1,3], Matthew R Baker[4,5], Douglas F Bertram[3], Adam Summers[5], David A Fifield[6] and Francis **Juanes**[1]

[1]University of Victoria, Victoria, British Columbia, Canada. E-mail: nora.v.carlson@gmail.com
[2]Universidad del Valle, Ciudad Universitaria Meléndez, Valle del Cauca, Colombia
[3]Environment and Climate Change Canada, Integrated Marine Spatial Ecology Lab, Institute of Ocean Sciences, Sidney, British Columbia, Canada
[4]NOAA Alaska Fisheries Science Center, Anchorage, Alaska, U.S.A.
[5]University of Washington, Friday Harbor Laboratories, Friday Harbor, WA, U.S.A.
[6]Wildlife Research Division, Science and Technology Branch, Environment and Climate Change Canada, Mount Pearl, Newfoundland, Canada

As anthropogenic noise continues to grow throughout the world's oceans, its effects on fish have increasingly become an area of concern, as they are both economically and ecologically important. Forage fish, as they often play a central role in transferring energy from lower to higher trophic levels in the marine food web, are a critical resource for many predatory species. However, although noise is known to have negative effects on many fish species, information about how noise affects forage fish condition and behavior remains scarce. Research suggests that noise may affect both the behavior (availability) and condition (quality) of forage fish like Pacific sand lance, *Ammodytes personatus*. Pacific sand lance are unique as they bury in the sand both short-term (hours in summer) and long-term (months in winter) making them inaccessible to predators. To understand how noise affects Pacific sand lance quality and availability as prey in summer, and if winter dormancy buffers them against potential effects, we captured Pacific sand lance and exposed them to anthropogenic noise in summer and winter. We found that fish in control conditions were higher quality and that fish in all treatments varied in their accessibility compared to controls in summer. During winter dormancy fish showed fewer negative effects of noise on quality, though some differences still remained. These results suggest that noise may indirectly affect the seabirds that rely on these fish by lowering Pacific sand lance quality and altering their availability in the summer when they are most important to breeding seabirds.

S02, Oral, AbstractID=18808, (ECOP)

What can otolith chemistry reveal about capelin migrations?

Romaric **Jac**[1,2], Elisabeth van Beveren[3], Lola Coussau[3], Mathieu Boudreau[3], Olivier Le Pape[2], Pascal Sirois[4], Dominique Robert[1] and Pablo Brosset[2]

[1]Institut des sciences de la mer de Rimouski, L'institut agro Rennes-Angers, Rimouski, Québec, Canada. E-mail: romaric.jac@uqar.ca
[2]UMR DECOD (Ecosystem Dynamics and Sustainability), Ifremer, INRAE, L'Institut Agro, Rennes, France
[3]Fisheries and Oceans Canada, Institut Maurice-Lamontagne, Mont-Joli, QC, Canada
[4]Département des Sciences Fondamentales, Université du Québec à Chicoutimi, Chicoutimi, QC, Canada

Capelin (*Mallotus villosus*) is a keystone forage fish in the Gulf of St. Lawrence (GSL), linking trophic levels and sustaining many predators. Despite its ecological importance, major gaps remain in our understanding of its spatial dynamics, particularly movements across life stages and the location of spawning habitats. Addressing these gaps is important for both effective stock management and for understanding the impacts of rapid environmental changes in the GSL ecosystem. This presentation synthesizes findings from using otolith chemistry as a natural tracer to reconstruct capelin movements and habitat use. Capelin were collected from multiple regions of the GSL, and their otolith elemental profiles were analyzed to identify migration pathways and regional connectivity. Results indicate that while capelin exhibit strong regional fidelity, they also maintain substantial intra-GSL connectivity. Individuals displayed diverse movement strategies and spawned in distinct locations, highlighting a complex spatial structure. These findings demonstrate the capacity of otolith chemistry to reveal movement patterns in small pelagic fishes that are otherwise difficult to track. By clarifying uncertainties in distribution and connectivity, this work contributes to a more predictive understanding of capelin population dynamics under changing ocean conditions. The results also offer guidance for developing spatially informed management and conservation strategies for this critical forage species.

S02, Oral, AbstractID=18866, (ECOP)

Temporal stability of otolith chemistry in the embryonic region of recently hatched larval capelin (*Mallotus villosus*) in Newfoundland, Canada

Ashley **Tripp** and Gail K. Davoren

University of Manitoba, Brantford, ON, Canada. E-mail: ashleymariatripp@gmail.com

Capelin (*Mallotus villosus*) is an ecologically, economically and culturally important forage fish that plays a critical role transferring energy to many upper trophic level predators throughout their circumpolar distribution. In Newfoundland, Canada capelin migrate inshore during July-August to spawn in coastal embayments at multiple sites in both intertidal and subtidal habitats upon reaching maturity at age-2+. As larvae emerge from multiple sites, habitats and bays throughout coastal Newfoundland, productivity at each spatial scale remains unknown, impacting monitoring and management efforts. Previous work indicated that chemical signatures in the embryonic region of larval capelin otoliths can be used to successfully classify larvae to their natal site. However, most studies have collected one larval sample per site within a year and it is unknown whether all larvae originating from a site have the same otolith chemical signature regardless of hatch date and year, a key assumption underlying using otolith chemistry to identify natal origins of adult fish. To investigate site-specific temporal stability of embryonic otolith chemistry, recently emerged larval capelin were collected throughout a protracted hatching period at two sites across three years in Notre Dame Bay, Newfoundland. Variation in otolith chemistry was highest between spawning habitats however years with more protracted spawning did show higher rates of misclassification to the correct spawning timing, especially at subtidal sites. As Newfoundland capelin have been collapsed for the past 30 years, long-term annual monitoring of bay-specific otolith chemistry could be used to inform bay-specific productivity and connectivity among bays, which are currently unknown.

S02, Oral, AbstractID=18968

Ocean alkalinity enhancement as a carbon dioxide removal strategy: Implications for small pelagic fish

Marta **Moyano**[1,2], Silvan Urs Goldenberg[3], Daniel Brüggemann[3], Gregor Börner[3,4], Michael Sswat[3], Arild Folkvord[5,6], Maria Couret[7], Synne Spjelkavik[8], Nicolás Sánchez[3], Cornelia Jaspers[8] and Ulf Riebesell[3]

[1]Norwegian Institute for Water Research, Oslo, Norway. E-mail: marta.moyano@niva.no
[2]Centre for Coastal Research, University of Agder, Kristiansand, Norway
[3]Biological Oceanography, GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel, Germany
[4]Institute of Marine Ecosystem and Fishery Science, University of Hamburg, Hamburg, Germany
[5]Department of Biological Sciences, University of Bergen, Bergen, Norway
[6]Institute of Marine Research, Bergen, Norway
[7]Instituto de Oceanografía y Cambio Global, IOCAG, Universidad de Las Palmas de Gran Canaria, Unidad Asociada ULPGC-CSIC, Campus de Taliarte, Gran Canaria, Canary Islands, Spain
[8]Centre for Gelatinous Plankton Ecology & Evolution, Technical University of Denmark, DTU Aqua, Kongens Lyngby, Denmark

Ocean alkalinity enhancement (OAE) stands as a promising marine carbon dioxide removal (mCDR) technology. It is based on the acceleration of natural rock weathering, which increases the buffer capacity of seawater to take up CO_2. While the field is developing fast, there is still little understanding of the impacts of OAE deployment on higher trophic levels, such as fish. Here, we investigated the direct and indirect effects of OAE on larvae of commercially important fish species. First, we studied early life stages of fish in a mesocosm setting with natural plankton communities under different alkalinity addition scenarios. Larvae and young juveniles of temperate coastal species, including Atlantic herring (*Clupea harengus*) and cod (*Gadus morhua*), were exposed to direct physiological and indirect food-web-mediated effects of OAE for 49 days. We found no impairment of fish growth or survival over either the short or long term; in fact, fish biomass increased under elevated alkalinity. Similarly, egg production rate and metabolism of the most abundant copepods in the mesocosms (*Calanus* spp. and *Temora* spp) did not seem to be affected by OAE. Second, a parallel laboratory experiment was conducted to explore the direct effects of OAE on herring larvae metabolism, behavior and growth. While no effects of OAE were observed for the tested parameters, issues with the maintenance of OAE levels throughout the experiment prevented us from further analyzing these data. Altogether our results suggest that the tested fish species and their prey tolerate moderate OAE interventions. Further research is needed to evaluate the potential vulnerability of other life stages and species before implementing this technology. We will close this talk by summarizing currently considered OAE mineral sources and application methods and discuss how these may affect small pelagic fish across different life stages to support future assessments.

S02, Oral, AbstractID=18987, (ECOP)

Tracking pelagic forage fishes with acoustic telemetry: Our experience and future directions

Robert J. Lennox[1], Romaric Jac[2], Caliyena Brown[1], Ava Sergio[1], Marin Marsala[1], Levi Denny[1,3], Skylar Jeddore[3], Shae Denny[3], Shelley Denny[3], Hugo Flavio[1], Elisabeth Van Beveren[4], Jena Edwards[1] and Morgan **Piczak**[1,5]

[1]Dalhousie University, Halifax, Canada, B3H 4R2, E-mail: lennox@dal.ca
[2]Institut des sciences de la mer de Rimouski, Université du Québec à Rimouski, Rimouski, QC, Canada
[3]Unama'ki Institute of Natural Resources, 4102 Shore Rd, Eskasoni, NS B1W 1M4
[4]Department of Fisheries and Oceans Canada, 850, route de la Mer, P.O. Box 1000, Mont-Joli, Quebec G5H 3Z4
[5]University of British Columbia , Vancouver, BC, Canada. E-mail: morganpiczak@gmail.com

Forage fishes are critical to marine ecosystems and make outsized contributions to food webs and ecosystem stability. Despite their relatively small size, forage fishes are highly mobile and can move long distances in the ocean, making their movement ecology important to their life history and stock dynamics. However, movement ecology of many forage fish species is poorly understood despite several methods being available for this research. In Atlantic Canada, we have worked with Indigenous partners and management agencies to undertake studies of several forage fish species movement ecology at sea using acoustic telemetry. This talk will provide an overview of forage fish movement ecology research in Canada, methodological developments that unlock the ability to understand the spatiotemporal dynamics of forage fishes at sea and discuss case studies of Atlantic mackerel (*Scomber scombrus*) and alewife (*Alosa pseudoharengus*) using acoustic telemetry to understand how these species move at daily and seasonal scales.

S02, Pre-recorded Oral, AbstractID=19031

Within reach: Microplastic bioavailability to lanternfish (Myctophidae) larvae in a southwestern Atlantic basin

Tulio Silva[1], Silvia **Schwamborn**[2], Dieter Fisher[3], Robin Lenz[3], Melinda Arnold[3], Julia Lötsch[3], Christina Enders[3], Felipe Kessler[4] and Pedro Melo[1]

[1]Departamento de Oceanografia, Recife, Brazil
[2]UFPE, Vitória de Santo Antão, Pernambuco, Brazil. E-mail: silvia.schwamborn@ufpe.br
[3]Leibniz Institute of Polymer Research Dresden (IPF), Dresden, Germany
[4]Universidade Federal de Rio Grande, Rio Grande, Brazil

This study investigates the presence and bioavailability of microplastics (MP) in the Sergipe–Alagoas Basin (SEAL), Southwestern Atlantic, focusing on the vulnerability of Myctophidae larvae to ingestion. The sampling grid encompassed two regions under fluvial influence—associated with the São Francisco River (transect A) and the Sergipe River (transect B)—with stations located at the 25, 400, 1000, and 1900 m isobaths, sampled at the surface (1 m) and at the Chlorophyll Maximum Depth (60–122 m). A total of 28 samples were analyzed, yielding 823 MP particles, mainly fibers (50%) and fragments (30%), predominantly polyethylene terephthalate (PET). Average MP abundance was significantly higher during the dry season (8.7 ± 9.8 part./100 m³) than in the rainy season (3.0 ± 1.5 part./100 m³), with peaks in coastal surface waters and at the chlorophyll maximum layer in oceanic areas. Hydrodynamic processes, such as coastal currents and riverine inputs, influence MP distribution and its bioavailability to Myctophidae larvae. A distinctive feature of this study was the assessment of potential MP bioavailability based on the maximum mouth gape (MMG) of Myctophidae larvae, ranging from 0.1 to 5 mm. About 20% of translucent PET fibers and 27% of polyamide fragments fell within the ingestion range compatible with larval mouth size, indicating a real risk of consumption. The MP:larvae ratio (~1.5 particles per larva) reinforces this susceptibility, particularly during the dry season. The potential ingestion of MPs may impair larval growth and survival, with cascading effects on trophic dynamics.

S02, Oral, AbstractID=19049

Differentiating between the impacts of ship-channel dredging and seasonal-to-interannual variation in the abundance and diversity of larval forage fishes

Rebecca G. **Asch,** Naomi Jainarine, Lulea Adams, Abigail Alford, Brian Bartlett, Christine Chan, Elise Easterling, Esra Gokturk, Peyton Jackson, Taniya Johnson, Caitlin McGarigal, Quentin Nichols, Brianna Salazar, Jalen Walker, Zachary Reece Warfel, Ceilia Wood and Mae Wright

East Carolina University, Greenville, NC, U.S.A. E-mail: aschr16@ecu.edu

Ship-channel dredging can be necessary for maintaining navigable waterways, but it can negatively impact fishes through release of suspended sediments, mobilization of pollutants, noise pollution, habitat destruction, and mortality due to direct entrainment. Many waterways have been regularly dredged for years, often without baseline data on community composition prior to the onset of this disturbance. A change in the season when ship-channel dredging is permitted in the Albemarle-Pamlico Sound Estuarine System (the second largest estuary in the United States) has allowed us to differentiate between dredging and typical seasonal-to-interannual variability in larval fish abundance and diversity. Using data from Beaufort Inlet Ichthyoplankton Sampling Program (BIISP), we contrast patterns in 2017-2019 prior to the initiation of summertime dredging and 2020-2021 when dredging occurred in June-July. Across all years, 34 taxa of forage fishes were identified, constituting 28% of larval fish species richness and 77% of abundance. Species richness and Shannon-Wiener diversity declined during dredging with little-to-no recovery later in the summer after dredging ceased. This contrasts with seasonal patterns during baseline years prior to dredging when no statistically significant seasonality was detected in biodiversity metrics. Preliminary results indicate that three of the four most abundant forage taxa (Blenniidae, Engraulidae, and other Clupeiformes) experienced declining abundance coincident with dredging, while Gobiidae abundance was stable throughout years with dredging. However, the declines in Engraulidae and Blenniidae matched seasonal patterns from baseline years, indicating that such baseline data were truly needed to differentiate between dredging impacts and natural variability. In contrast, the impact of dredging on Gobiidae was only apparent when considering baseline years, since this group typically undergoes a seasonal increase in larval abundance, which was not observed in years with dredging. Since taxa in similar guilds reacted distinctly, this emphasizes that patterns extrapolated based on species traits alone may be inadequate for detecting anthropogenic impacts. Continued summer dredging could have implications for the reproductive success of forage fishes and other commercially and recreationally important species.

S02, Oral, AbstractID=19085, (ECOP)

Summer dredging effects on estuarine zooplankton near Cape Fear, North Carolina

Naomi **Jainarine** and Rebecca Asch

East Carolina University, Greenville, North Carolina, U.S.A.
E-mail: jainarinen20@students.ecu.edu

Historically, dredging in North Carolina was restricted to a winter "environmental window" to minimize harm to sensitive marine life. From 2020 to 2023, year-round hopper dredging was temporarily permitted to reduce costs and avoid operational challenges during winter, contingent on environmental monitoring. This study investigates the ecological effects of summer dredging on estuarine zooplankton near the mouth of the Cape Fear River. Zooplankton serve as key biological indicators due to their short life cycles and role as prey for larval and juvenile fish, including small pelagic species. Mid-water bongo net tows were conducted across multiple sites before, during, and after dredging. Samples were processed using a Zooscan imaging system and classified via Ecotaxa, a machine-learning platform for plankton identification. Sites were categorized by dredging period and proximity to the dredging path. Preliminary results suggest that spatial factors, particularly distance from dredging, had a stronger influence on total zooplankton abundance ($p = 0.05$, $F = 4.16$) and copepod density ($p = 0.04$, $F = 4.56$) than time period did. Ongoing analysis will compare diversity and abundance across dredging phases and spatial gradients, with a focus on taxa-specific responses. These findings will contribute to broader assessments of summer dredging impacts, prey availability for early life stages of coastal fish, and zooplankton responses to environmental factors.

SESSION 3

Life History Variation Across Space, Time, and Ontogeny: Implications for Populations, Ecosystems, and Fisheries

Oral Presentations

S03, Invited, AbstractID=18817

Understanding growth and survival declines in small pelagic fish: A multi-approach study in the Bay of Biscay and Gulf of Lions

Pablo **Brosset**

Institut Agro Rennes-Angers, Rennes, France. E-mail: pablo.brosset@agrocampus-ouest.fr

Small pelagic fish populations are experiencing widespread shifts in life-history traits, particularly reduced growth, body condition, and survival, yet the mechanisms underlying these changes remain poorly understood. These alterations are of major concern because they not only disrupt the ecological functioning of marine ecosystems, where small pelagics play a pivotal role as forage species, but also directly threaten the economic sustainability of fisheries that depend on them. In this presentation, I will examine case studies from the Bay of Biscay and the Gulf of Lions, where declines in growth, condition, and size-selective mortality have been observed despite no clear evidence of overfishing. Adopting an ecophysiological perspective, I will explore how environmental variability (i.e., bottom-up drivers) and physiological constraints interact to shape these life-history changes. Particular attention will be given to the effects of reduced prey size and quality, as well as rising sea surface temperatures, in driving energetic trade-offs between growth, maintenance, and reproduction, with consequences for population resilience. Finally, I will address the broader implications of these biological shifts, including reductions in fishing fleet capacity, disruptions to processing industries such as canneries, and changes in international market flows. I will also outline future research directions, with a focus on other life-history traits such as reproduction.

S03, Oral, AbstractID=18800, (ECOP)

A dual habitat spawning strategy in spring-spawning Atlantic herring: Evidence from the southern Gulf of St. Lawrence

Jacob **Burbank**[1], Benjamin Grégoire[2], Andrew Darcy[1], François-Étienne Sylvain[1] and Laurie Maynard[1]

[1]Gulf Fisheries Centre, Fisheries and Oceans Canada, Moncton, Canada.
E-mail: jacob.burbank@dfo-mpo.gc.ca
[2]Institut Maurice Lamontagne, Pêches et Océans Canada, Mont-Joli, Canada

Spawning and hatching are critical components of fish life history, and variation in spawning habitat can have important implications for hatching success, early life survival, recruitment, and population dynamics. However, spawning habitats are often overlooked in small pelagic fishes that spawn demersal eggs, such as Atlantic herring (*Clupea harengus*). Here, we examine variation in the spawning habitat of spring-spawning Atlantic herring in the southern Gulf of St. Lawrence to identify key habitats and trade-offs in spawn site selection. We document two distinct habitat types utilized by spring-spawners: conventional shallow subtidal sites with vegetation cover (~1–6 meters depth) and novel intertidal sites, where eggs exposed to air at low tide while adhered to vegetation and rocks. We compare habitat quality across sites and assess the influence of habitat type and quality on egg diameter and spawning success. Our findings reveal how spatial variation in spawning habitats shapes early life outcomes in this ecologically, economically, and culturally important population of Atlantic herring.

S03, Oral, AbstractID=18842 (CANCELLED)

Early life history traits of a dominant mesopelagic fish and hydrographic conditions in the South Humboldt Current Ecosystem

Alexandra Camilla-Vivar[1], Claudia Morales-Garrido[2,7], Manuel I. Castillo[2,3], Fernanda S. Orrego[1,8], Hugo A. Benítez[4], Guido Plaza[5], Cláudia Namiki[6] and Mauricio F. **Landaeta**[1,3,7*]

[1]Laboratorio de Ictiología e Interacciones Biofísicas (LABITI), Instituto de Biología, Facultad de Ciencias, Universidad de Valparaíso, Valparaíso, Chile. E-mail: mauricio.landaeta@uv.cl
[2]Laboratorio de Oceanografía Física y Satelital (LOFISAT), Escuela de Biología Marina, Facultad de Ciencias del Mar y de Recursos Naturales, Universidad de Valparaíso, Viña del Mar, Chile.
[3]Centro de Observación y Análisis del Océano Costero (COSTA-R), Universidad de Valparaíso, Viña del Mar, Chile.
[4]Laboratorio de Ecología y Morfometría Evolutiva, Instituto One Health, Facultad de Ciencias de la Vida, Universidad Andrés Bello, Santiago, Chile
[5]Laboratorio de Esclerocronología, Escuela de Ciencias del Mar, Pontificia Universidad Católica de Valparaíso, Valparaíso, Chile.
[6]Laboratório de Ecologia das Fases Iniciais dos Peixes, Instituto Oceanográfico, Universidade de São Paulo, São Paulo, Brazil.
[7]Millenium Nucleus for Ecology and Conservation of Temperate Mesophotic Reef Ecosystem (NUTME), Valparaíso, Chile.
[8]Programa Doctorado en Oceanografía, Universidad de Concepción, Concepción, Chile.

Hydrographic conditions experienced during early life stages of marine fish are relevant for larval growth and survival, and the temporal variation of the environment may differentially affect consecutive cohorts. Taking advantage of two cruises carried out in the Southeastern Pacific Ocean during June-July 2022 (austral winter) and September-October 2023 (spring), we studied the cohort variability of the abundance, distribution, and early life history traits of the lanternfish *Hygophum bruuni* (Myctophidae) off northern-central Chile, and their relationship with hydrography. Larvae showed similar abundances in 2022 and 2023, but they were more aggregated in the open ocean, between the Chilean coast and oceanic islands. Larval size was smaller in 2022 (2.77 to 8.40 mm SL) than in 2023 (2.90 to 14.51 mm SL). The size of the otoliths increased exponentially with larval length, without differences between cohorts when compared in a similar size range (3-9 mm SL). The estimated size at hatch (3.05 and 2.88 mm) and larval growth rates (0.205 and 0.227 mm day^{-1}) were similar between 2022 and 2023, as well as the instantaneous mortality rate (Z) and the daily losses of larvae, varying from Z = -0.11 day^{-1} and 10.42% (winter 2022), to Z = -0.07 day^{-1} and 6.67% (spring 2023). The hatching events occurred between the first quarter and the full moon in 2022, and around the new moon in 2023, with differences in the temporal patterns between cohorts. Larval cohorts exhibited similar recent growth index patterns three days before capture (ROGI), indicating that the recent condition of larval *H. bruuni* did not vary at the cohort level. Finally, there were no significant effects of hydrographic conditions on ELHT; however, GLM indicates that specimens found in the open ocean showed better condition than those from near the coast and oceanic islands. These results suggest that lanternfish may develop a "loophole" strategy to reduce predation risks in coastal and insular zones.

S03, Oral, AbstractID=18845, (ECOP)

Can physiological biomarkers provide new insights to understand growth variations in the European sardine?

Raphaëlle **Huard**[1], Emma Gousset[1,2], Karine Salin[2], Pablo Brosset[3], Fany Sardenne[2], Maxime Olmos[1], Philippe Soudant[2] and Christophe Lebigre[1]

[1]DECOD (Ecosystem Dynamics and Sustainability), Ifremer, INRAE, Institut Agro, Plouzané, France. E-mail: raphaelle.huard.baudry@gmail.com
[2]LEMAR (Laboratory of Environmental Marine Sciences), University of Brest, CNRS, IRD, Ifremer, Plouzané, France
[3]DECOD (Ecosystem Dynamics and Sustainability), Ifremer, INRAE, Institut Agro, Rennes, France

Over past decades, individual body size in several small pelagic fish stocks has declined. Sardines (*Sardina pilchardus*) in the Bay of Biscay are no exception, experiencing a decrease in size and weight-at-age since the mid-2000s (1-year-old sardines' weight halved). These phenotypic patterns may arise from intrinsic physiological mechanisms. Our objective is to determine whether different physiological biomarkers are associated with sardines' declining size. We measured oxidative stress markers, mitochondrial aerobic metabolism and membrane fatty acid composition from muscle samples of wild sardines caught during scientific surveys across the Bay of Biscay. We found that large 1-year-old sardines had greater oxidative damage to proteins, but not lipids, compared to smaller individuals, suggesting that their past growth may have led to an oxidative cost. While oxidative stress mainly results from the production of reactive oxygen species (ROS) in mitochondria, we surprisingly found that larger sardines produced less mitochondrial ROS. An explanation for this discrepancy might lie in the fact that antioxidant mechanisms and environmental variability can influence the relationship between growth and oxidative stress. Mitochondrial metabolism strongly depends on membrane fatty acid composition, itself dependent upon food. We found strong relationships between membrane fatty acid composition and sardine size. Larger 1-year-old sardines had higher EPA and lower DHA proportions than their smaller conspecifics. This relationship weakened for age-2 sardines, suggesting an age-specific link between fatty acid composition and growth. Finally, we discuss the potential environmental covariates underlying changes in our physiological biomarkers and how they can be incorporated into physiology-based habitat models.

S03, Oral, AbstractID=18850

Persistent regional growth differences indicate limited connectivity in subpopulations of Pacific Sardine

Juan Pablo **Zwolinski**[1] and Concepción Enciso-Enciso[2]

[1]Institute of Marine Sciences, University of California Santa Cruz, Santa Cruz, CA, U.S.A.
E-mail: jzwolins@ucsc.edu
[2]Centro Regional de Investigación Pesquera – Ensenada, Baja California, Mexico

In 2015, the biomass of the northern subpopulation (NSP) of Pacific Sardine fell below the threshold required to support a commercial fishery off the U.S. West Coast. In contrast, both sardine catches off the Pacific coast of Baja California and nearshore biomass off Southern California, all attributed to the southern subpopulation (SSP), have increased. The implied rise of SSP biomass, however, was not accompanied by an increase in spawning in U.S. waters, suggesting that the SSP completes its life cycle predominantly to the south. To qualitatively assess the level of connectivity between the two subpopulations, we examined multigenerational differences in growth rates. Between 2005 and 2014, sardines captured in Mexico and classified as SSP were significantly smaller at most ages when compared to those caught on California spawning grounds and in U.S. fisheries, which were classified as NSP. These observations reaffirm a nearly century-old pattern of differential growth among sardines inhabiting distinct geographic and environmental spaces. The findings indicates that once sardines recruit to a particular oceanographic habitat, they tend to remain there. Occasional spillover may occur during periods of subpopulation expansion, and some mixing is likely to occur in the Southern California Bight. However, the persistence of distinct phenotypic traits implies that post-recruitment mixing is limited, which is coherent with the divergent biomass trends observed between the subpopulations of the larger Pacific Sardine metapopulation.

S03, Oral, AbstractID=18860, (ECOP)

Life history trait variation among Atlantic herring (*Clupea harengus*) populations

Florian **Berg**[1], Violaine Dolfo[1], Dorte Bekkevold[2], Valerio Bartolino[3], Thassya C. dos Santos Schmidt[4], Christophe Pampoulie[4], Guðmundur J. Óskarsson[4], Stefanie Haase[5], Léo Le Gall[5], Michael O'Malley[6], Cormac Nolan[6], Edward Farrell[7], Steven O'connell[8], Cecilie Kvamme[1], Aril Slotte[1] and Arild Folkvord[1,9]

[1]Institute of Marine Research, Bergen, Norway. E-mail: florian.berg@hi.no
[2]National Institute of Aquatic Resources, Technical University of Denmark, Silkeborg, Denmark
[3]Institute of Marine Research, Swedish University of Agricultural Sciences, Lysekil, Sweden
[4]Marine and Freshwater Research Institute, Hafnarfjörður, Iceland
[5]Thünen Institute of Baltic Sea Fisheries, Rostock, Germany
[6]Marine Institute, Galway, Ireland
[7]Killybegs Fishermen's Organisation, Donegal, Ireland
[8]Marine Directorate Scotland, Aberdeen, Scotland, United Kingdom
[9]Department of Biological Sciences, University of Bergen, Bergen, Norway

Understanding variation in life-history traits among wild populations is essential for effective fisheries management and conservation, which influences population resilience and productivity. The Atlantic herring (*Clupea harengus*) is an ideal model species for studying this variation due to its pronounced phenotypic plasticity and local adaptations. Here, we examine phenotypic differences among multiple genetically distinct herring populations across the Northeast Atlantic, with all individuals genetically assigned to their population of origin prior to analyses. In total, >25,000 herring individuals assigned to 12 genetic populations were analyzed. We compared maturity ogives, mean vertebral counts, growth trajectories, and condition indices among these populations. The northernmost population exhibited the highest growth estimated by length-at-age, whereas Baltic Sea populations showed the lowest. No major within-population growth differences were detected among herring caught in different spatial regions, and length–weight relationships were generally consistent across populations. Maturity ogives, both based on age and length, varied among populations but showed no clear latitudinal or ecological (e.g. autumn vs. spring spawners) pattern. These findings enhance our understanding of how life-history variability is structured among genetically distinct populations within managed and harvested stocks. This improved understanding supports interpretation of phenotypic diversity in mixed samples, especially when genetic data are lacking, and ultimately informs a more accurate assessment, effective management, and conservation of herring populations and in turn marine biodiversity.

S03, Oral, AbstractID=18861, (ECOP)

Understanding the underlying mechanisms affecting growth of small pelagic fish: An experimental meta-analytical approach

Florian **Berg**[1,2], Marta Moyano[3,4], Jennifer Boldt[5], Quentin Queiros[6], Tómas Árnason[7], Claudia Ofelio[8], Myron A. Peck[9], Susana Garrido[10], Edward Houde[11], Martin Lindegren[12] and Arild Folkvord[1,2]

[1]Institute of Marine Research, Bergen, Norway. E-mail: florian.berg@hi.no
[2]Department of Biological Sciences, University of Bergen, Norway
[3]Norwegian Institute for Water Research, Oslo, Norway
[4]Center for Coastal Research, University of Agder, Norway
[5]Fisheries and Oceans Canada, Pacific Biological Station, Nanaimo, Canada
[6]MARBEC, University of Montpellier, CNRS, Ifremer, IRD, Sète, France
[7]Marine and Freshwater Research Institute, Grindavík, Iceland
[8]Valencian International University - VIU, Valencia, Spain
[9]Royal Netherlands Institute for Sea Research, Texel, Netherlands
[10]Portuguese Institute for Sea and Atmosphere, Lisbon, Portugal
[11]University of Maryland Center for Environmental Science, Solomons, U.S.A.
[12]Centre for Ocean Life, National Institute of Aquatic Resources (DTU Aqua), Technical University of Denmark, Lyngby, Denmark

Understanding the mechanisms influencing growth is essential for accurately assessing and modeling the dynamics of small pelagic fish stocks worldwide. Controlled laboratory and mesocosm studies provide powerful tools to isolate and quantify the effects of individual factors on growth at specific life stages. However, evaluating how multiple drivers interact, e.g. such as temperature and food availability, or comparing their effects across species and regions, remains challenging. Here, we compiled and compared experimental growth data from more than 50 studies on eight small pelagic fish species, spanning a wide range of biotic and abiotic conditions across the North Atlantic and the Peruvian coast. Atlantic herring (*Clupea harengus*) was the most extensively studied species. This joint dataset provides a comprehensive overview of experimental growth responses across all life stages, from larvae to adults. To enable direct comparisons among studies, we standardized growth rates (% per day) relative to key environmental factors such as temperature, feeding level, light condition, or salinity. Growth rates varied substantially both among species and within species across environmental gradients, with temperature and rearing density emerging as the primary factors influencing growth. This meta-analysis provides new insight into the mechanisms shaping growth dynamics of small pelagic fishes across regions and taxa, offering a valuable empirical foundation for improving parameterization of individual-based models and other mechanistic approaches to predict responses of small pelagic fishes to environmental drivers.

S03, Oral, AbstractID=18868, (ECOP)

Linkages between dynamic environmental conditions and northern anchovy recruitment

Luke A. **Bobay**, Robert K. Cowen, Toby D. Auth, Richard D. Brodeur and Su Sponaugle

Hatfield Marine Science Center Oregon State University, Corvallis, OR, U.S.A.
E-mail: bobayl@oregonstate.edu

Climate change will affect fish abundance by altering recruitment to adult populations. Therefore, being able to predict recruitment from environmental conditions would aid fisheries management under future climate scenarios. While effects of many environmental influences on early life-history characteristics of fishes have been identified, most attempts to predict recruitment from environmental conditions have been unsuccessful. This may be because such efforts rarely account for the spatially explicit effects of environmental conditions on individuals across the range of a population. Toward predicting recruitment to the northern subpopulation of northern anchovy (NSNA) while accounting for environmental variability on the scales that influence individual larval success, we collected NSNA larvae on research cruises during summers 2018, 2019, 2022, and 2023. Otolith microstructure analysis was used to estimate the hatch size and daily growth rates of these larvae. In addition, the National Oceanic and Atmospheric Administration (NOAA) maintains a time series (biweekly–monthly, 1996–present) of NSNA larval abundance off Newport, Oregon. We used outputs from physical and biogeochemical regional ocean models to explain variability in NSNA larval abundance, hatch size, and daily growth. We then generated spatially (1/12° horizontal resolution) and temporally (daily timestep) explicit hindcasts of NSNA larval abundance, hatch size, and growth rates for 2014–2024, which were aggregated annually and related to observed variation in age-1 NSNA abundance. Results from this analysis will be presented to demonstrate how environmental conditions are linked to recruitment through effects on early life-history characteristics and how spatially explicit modeling can inform climate-resilient fisheries management.

S03, Oral, AbstractID=18899

A cross-system comparison of internal and external forcing regulating growth of small pelagic fish throughout ontogeny

Martin Lindegren[1*], Martin **Huret**[2], Florian Berg[3], Marta Albo-Puigserver[4,] Caitlin Allen Akselrud[5], Jennifer Boldt[6], Jacob Burbank[7], Ali Cemal Gucu[8], Jaclyn Cleary[6], Pieter Daniel van Denderen[1], Mathieu Doray[9], Tarek Hattab[10], Nis Sand Jacobsen[1], Jeroen van der Kooij[11], Peter Kuriyama[5,] Fernando Ramos[12], Margarita M. Rincón[12], Isabel Riveiro[13], Stelios Somarakis[14], Motomitsu Takahashi[15], Akinori Takasuka[16], Sebastián I. Vásquez[17] and Laura Wise[18]

[1]National Institute of Aquatic Resources, Technical University of Denmark, Kgs. Lyngby, Denmark. E-mail: mli@aqua.dtu.dk
[2]DECOD, Institut Agro, IFREMER, INRAE, Brest, France. E-mail: martin.huret@ifremer.fr
[3]Institute of Marine Research, Bergen, Norway
[4]IEO-CSIC, Oceanographic Center of Baleares, Palma de Majorca, Spain
[5]NOAA Southwest Fisheries Science Center, La Jolla, CA, U.S.A.
[6]Fisheries and Oceans Canada, Pacific Biological Station, Nanaimo, BC, Canada
[7]Fisheries and Oceans Canada, Gulf Fisheries Center, Moncton, NB, Canada
[8]Middle East Technical University, Institute of Marine Sciences, Mersin, Turkiye
[9]DECOD, Institut Agro, IFREMER, INRAE, Lorient, France
[10]Ifremer, Univ Montpellier, CNRS, IRD, MARBEC, Sète, France.
[11]Centre for Environment, Fisheries and Aquaculture Science, Lowestoft, United Kingdom
[12]Centro Oceanográfico de Cádiz (COCAD-IEO), Instituto Español de Oceanografía (IEO-CSIC), Cádiz, Spain
[13]Centro Oceanográfico de Vigo (COV-IEO), CSIC, Spain
[14]Hellenic Centre for Marine Research, Heraklion, Greece
[15]Fisheries Resources Institute, Japan Fisheries Research and Education Agency, Nagasaki, Japan
[16]Graduate School of Agricultural and Life Sciences, The University of Tokyo, Tokyo, Japan
[17]Instituto de Investigación Pesquera, Talcahuano, Chile
[18]Instituto Português do Mar e da Atmosfera (IPMA), Lisbon, Portugal.

The underlying factors affecting growth of small pelagic fish (SPF) throughout ontogeny remain poorly understood and are often overlooked in formal stock assessments and fisheries management at large. Since growth of SPF is highly variable and has direct effects on the stock status and yield derived from a stock, it is of paramount ecological and commercial interest to better understand and be able to predict changes in growth, especially under ongoing global changes. In this study, we performed a cross-system comparison and assessment of internal and external forcing factors regulating the highly variable growth of sardine, anchovy and herring stocks throughout their ontogeny, by compiling and analyzing long-term time series of weight-, length- and numbers-at-age from available surveys and stock assessments worldwide. Using a multi-model approach, including both non-linear regression models and machine learning, our results demonstrate a negative relationship between total abundance and weight, as well as a significant, yet stock-dependent effect of environmental conditions acting on weight throughout ontogeny. The derived responses and predictive accuracy of weights based on observations not used during model fitting (i.e., cross-validation routine) demonstrated consistent and robust patterns and results across methods. To that end, our findings, demonstrating clear signs of

density-dependent regulation and environmental forcing acting on growth across species and stocks, provide a stronger scientific basis for management advice to ensure the sustainability and profitability of fisheries. This is especially important for commercially valuable small pelagic fish species characterized by fast and highly variable growth.

Key words: population dynamics, growth, survey, stock assessment, short-term forecasts, fisheries management

S03, Oral, AbstractID=18908, (ECOP)

From fine-scale spatial growth to regional perspective: Understanding small pelagic fish dynamics in the NW Mediterranean

Joan **Mir-Arguimbau**[1,2], Mireia Silvestre[1,2], Paloma Martin[1], Marc Balcells[1,2], Núria Raventós[3], Jordi Salat [1], M. Mar Flexas[4], Vanesa Raya[1], Marta Carreton[1,2] and Ana Sabatés[1]

[1]Institut de ciències del Mar- CSIC, Barcelona, Barcelona, Spain. E-mail: joanmir@icm.csic.es
[2]Institut Català de Recerca per a la Governança del Mar (ICATMAR), Barcelona, Spain
[3]Centre d'Estudis Avançats de Blanes (CEAB-CSIC), Blanes, Girona, Spain
[4]California Institute of Technology, Pasadena, CA, U.S.A.

In the NW Mediterranean, small pelagic fish populations have experienced a marked biomass decline over the past two decades, related to reduced individual growth— especially in the Gulf of Lions, with significant socioeconomic impacts. While several hypotheses have been proposed, bottom-up control has emerged as a likely mechanism, though direct evidence is still lacking.

Fish growth is influenced by extrinsic factors (e.g., temperature, food availability) and intrinsic traits (e.g., energy allocation throughout the life-cycle). This study investigates the growth performance of sardine (*Sardina pilchardus*) and anchovy (*Engraulis encrasicolus*) in two close areas (~200 km apart) under similar fisheries management but with differing environmental conditions. From a fine-scale spatial approach, we assess the role of sea surface temperature (SST) and chlorophyll-a (proxy for primary production), and species-biological traits (age at first maturity, spawning period, body condition) to understand local growth variability. We also analyzed SST and chorophyll-a trends to gain insight into the ongoing crisis.

Results reveal faster juvenile growth and larger size-at-age in the southern area, likely linked to higher SST. Biological traits were similar between areas, suggesting environmental factors as the main drivers. Long-term SST trends (1974–2022) show a regime shift around 2007, coinciding with the onset of growth decline, particularly in sardine. Chorophyll-a trends (2002-2022) show earlier onset of oligotrophic conditions throughout the year in the north, potentially reducing food availability during key periods. These changes may have triggered earlier maturity in the north since 2007, reducing growth performance, with species-specific implications for their population dynamics.

S03, Oral, AbstractID=18910, (ECOP)

Decline in muscle fat content of northeast Atlantic mackerel (*Scomber scombrus*) on traditional feeding grounds between 2004 and 2021

Susan **Kenyon**[1,2], Martin Pastoors[3], Steven Mackinson[4] and C. Tara Marshall[2]

[1]Centre for Environment, Fisheries & Aquaculture Science, Lowestoft, United Kingdom.
E-mail: susan.kenyon@cefas.gov.uk
[2]School of Biological Sciences, University of Aberdeen, Aberdeen, United Kingdom
[3]Martin Pastoors Fish & Fisheries, Wijster, The Netherlands
[4]Scottish Pelagic Fishermen's Association, Fraserburgh, United Kingdom

Atlantic mackerel (*Scomber scombrus*) is a widely distributed and highly migratory pelagic fish of high economic importance. During the 2000's, the feeding distribution of the northeast Atlantic mackerel stock expanded from the Norwegian Sea into waters around Svalbard and Iceland. Over the same period, spawning stock biomass more than doubled while individual growth rates and weight-at-length declined. This study resolved spatio-temporal trends in mackerel fat content during this period of dramatic change in stock dynamics. We analysed processing factory data to estimate the trend in muscle fat content across weight grades between 2004 and 2021. For the first time, the seasonal pattern in fat content was also estimated. Additionally, this study determined both intra- and interannual spatial variability in fat content from the southern Norwegian Sea to the Bay of Biscay between 2008 and 2021. A continual decline in mackerel fat content of 4.5% in the traditional feeding area occurred between 2010 and 2021 across all weight grades. Mackerel weighing < 250 g exhibited the fastest rate of decline compared to larger mackerel. Additionally, the intra-annual spatial and temporal variation in fat content was consistent with patterns expected during the annual reproductive cycle, thus confirming the validity of the data for this species. It is hypothesised that the decline in fat reserves was largely driven by increased intra-specific, density-dependent competition for limited food resources. Given that the magnitude of fat reserves has implications for individual fecundity, a continual decline in fat content may affect future stock recruitment.

S03, Oral, AbstractID=18911, (ECOP)

Environment-driven shifts in life history traits and vital rates of chub mackerel under the prolonged Kuroshio large meander (2017–2024): An individual-based bioenergetics–movement–population framework

Ziqin **Wang**[1] and Shin-ichi Ito[2]

[1]Graduate School of Agriculture and Life Science, the University of Tokyo, Tokyo, Japan
E-mail: zqwang@g.ecc.u-tokyo.ac.jp
[2]Atomosphere and Oceanography Research Institute, the University of Tokyo, Chiba, Japan

Life history trait and vital rate shifts in small pelagic fish can alter population productivity, size structure, and energy transfer to higher trophic levels. Leveraging the prolonged Kuroshio large meander (LM) as a natural experiment, we evaluated LM's impacts on chub mackerel (*Scomber japonicus*) growth, size-at-age, biomass distribution, and cohort survival rate. We built an individual-based framework linking bioenergetics, horizontal movement, and population dynamics, and ran scenario experiments with and without LM forcing to isolate the roles of temperature, prey, and currents. Diagnostics include growth trajectories, recruitment per egg (RPE), surviving biomass, and spatial shifts, benchmarked against observations, with discussion of trophic and fishing sector implications (e.g., reduced size/condition). Our results reproduced typical growth and distribution in NLM years. During LM, May–June cohorts, which correspond to the main spawning months, showed the largest reductions in RPE and surviving biomass, indicating strong month-specific sensitivity. Sensitivity experiments showed sea surface temperature during LM2017 contributed to increase abundance, whereas anomalies in food availability and the current field drove declines. This framework advanced understanding of environment–fishery linkages in the Northwest Pacific and supports adaptive management under Kuroshio variability. Collectively, the results revealed regime-driven constraints on key life-history traits and vital rates, with cohort-specific bottlenecks that matter for resilience, stock assessment, and adaptation in fisheries and supply chains.

S03, Oral, AbstractID=18926, (ECOP)

Energetics of "the savior fish": The phenology of Eulachon (*Thaleichthys pacificus*) energy reserves and potential survival bottlenecks in British Columbia marine and freshwater systems

Karlee A. **Orvis**[1], Alejandro D. Buren[2,3], Steve Sharron[4] and J. Mark Shrimpton[1]

[1]University of Northern British Columbia, Pitt Meadows, BC, Canada. E-mail: orvis@unbc.ca
[2]Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Buenos Aires, Argentina
[3]Instituto Antártico Argentino, Buenos Aires, Argentina
[4]Ecofish Research, Vancouver, BC, Canada

Understanding how energy is distributed within a fish at various life stages is crucial to understanding influential factors, or "bottlenecks", to their survival and success. This is particularly important for forage fish species such as the Eulachon (*Thaleichthys pacificus*) that are energy dense and serve as a critical food source across marine, freshwater, and terrestrial ecosystems throughout their anadromous life history. Eulachon have also experienced declines in abundance in recent years. The purpose of this study was to describe the phenology of Eulachon energy reserves throughout their life history and compare measurement methodologies. Body composition was characterized using proximate composition analyses, and energy density was quantified both directly using bomb calorimetry and indirectly using an established model for salmonids. Length, weight and relative condition relationships were also determined. Findings aligned with previous studies and supported that Eulachon are extremely energy rich. Mature spawning fish were found to have mean lipid contents ranging from 11 to 14% and mean wet energy densities from 7.1 to 8.1 kJ/g, with female fish having the highest lipid and energy density values, whilst immature fish were found to have a mean lipid content of 19% and mean wet energy density of 9.5 kJ/g. Eulachon were found to have a higher overall lipid content and energy density during their immature, marine life history stage compared to their spawning life history stage in freshwater. Decline in lipid content during spawning has also been previously observed for another Osmerid, Capelin (*Mallotus villosus*), although interestingly, Eulachon were found to have lipid content values nearly three times higher during spawning than Capelin (3%) despite having relatively similar lipid content values during other life history stages. This research aids in describing energy allocation and usage in an understudied, but important forage fish species in the Northeast Pacific Ocean. Our work also provides energetic values and relationships amongst measurement methodologies that can be used in further work related to Indigenous nutrition, trophic relationships, and identifying survival bottlenecks for Eulachon.

S03, Oral, AbstractID=18929, (ECOP) (Pre-recorded)

A review of spawning frequency estimates across *Trachurus* species worldwide: Regional patterns and methodological variation

Katerina **Charitonidou** and Tim Ward

Institute for Marine and Antarctic Studies, University of Tasmania, Taroona, Tasmania, Australia.
E-mail: charitonidouk@hotmail.com

Spawning frequency is a key parameter in spawning stock biomass estimation, essential for fisheries management. The most common method for assessing spawning frequency is through the spawning fraction using the postovulatory follicle (POF) method, based on the presence and duration of POFs in the ovary. Alternative methods, including the Migratory Nucleus (MN) and hydrated oocytes, have also been applied across *Trachurus* species. This study presents a global review of spawning fraction estimation methods applied to five commercially important small pelagic species, *T. trachurus*, *T. mediterraneus*, *T. murphyi*, *T. symmetricus*, *T. declivis*, selected for their commercial value and broad geographic distribution. *T. trachurus* was the most studied species, followed by *T. murphyi*, with fewer estimates for the other species. Meta-analysis showed no significant differences in average spawning fraction across species, with values ranging from 0.044 (*T. declivis*) to 0.187 (*T. symmetricus*), corresponding to spawning intervals of 22.7 to 5.4 days. Method comparisons revealed no significant differences, though MN estimates were slightly lower for *T. mediterraneus* and *T. symmetricus*. Within the POF method, a 2-day duration was most common, with no significant difference between *T. declivis* and *T. trachurus*, though the latter showed greater variability. Hierarchical clustering revealed that Northern Hemisphere species (*T. trachurus*, *T. symmetricus*) were closer to each other, as were Southern Hemisphere species (*T. declivis*, *T. murphyi*), suggesting regional patterns. Notably, *T. trachurus* stocks from the Northeast Atlantic and Gulf of Saronikos showed significantly higher spawning fractions. This study supports method selection and highlights global spawning fraction patterns in *Trachurus* spp.

S03, Oral, AbstractID=18939

Testing the growth-mortality hypothesis in the anchoveta (*Engraulis ringens*) in the Humboldt Current system using otolith microstructure analysis

Francisco **Cerna**[1] and Guido **Plaza**[2]

Presented by Guido Plaza on behalf of Francisco Cerna

[1]Instituto de Fomento Pesquero, Valparaíso, Chile. E-mail: francisco.cerna@ifop.cl
[2]Pontificia Universidad Católica de Valparaíso, Valparaíso, Chile.

The growth-mortality hypothesis was tested in spring cohorts of anchoveta (*Engraulis ringens*) in four different years (2014, 2019, 2020 and 2021) in Northern Chile (18-24°S) in the Humboldt Current system (HCS). Linear mixed-effect models (LMMs) were used to compare the variation of otolith radii-at-age (RAI) and increment width (IW), as proxy of fish size and growth rate of survivors (pre-recruit and recruits) with an initial population of larvae hatched in spring. Spline smoothed profiles of RAI and IW showed an increasing pattern from a common origin, after which a clear divergent tendency appeared, where survivors always showed larger and wider RAI and IWs for the first 20 days, when comparing with larvae, for the two cohorts evaluated (2014 and 2019). LMMs showed that both RAI and IW were significant bigger and higher for recruits than larvae, irrespective of years. Overall results showed evidence that survivors were bigger and grew faster than members of the original population, giving support for the growth–mortality hypothesis for this small pelagic fish in the HCS. In addition, other distinctive finding was that older juvenile (recruits), were larger and grew faster than young juveniles (pre-recruits), when were larvae and transforming juveniles.

S03, Oral, AbstractID=18961

Dynamics of growth–feeding linkage in Japanese anchovy larvae: Insights from field studies and laboratory feeding experiments

Shota **Tanaka**[1], Shizuna Togoshi[1], Daichi Murayama[1], Etienne Germain[2], Naotaka Yasue[3], Masahiro Nakamura[4], Michio Yoneda[5], Dominique Robert[2] and Akinori **Takasuka**[1]

Presented by Akinori Takasuka

[1]Graduate School of Agricultural and Life Sciences, The University of Tokyo, Tokyo, Japan. E-mail: shotana0326@gmail.com
[2]Institut des Sciences de la Mer, Université du Québec à Rimouski, Rimouski, QC, Canada
[3]Wakayama Prefectural Fisheries Experimental Station, Wakayama, Japan
[4]Fisheries Technology Institute, Kamiura Field Station, Japan Fisheries Research and Education Agency, Kamiura, Japan
[5]Fisheries Technology Institute, Miyako Field Station, Japan Fisheries Research and Education Agency, Miyako, Japan

The linkage between growth rate and feeding success in fish larvae has been widely recognized as a potential indicator of future growth and survival. However, as increasing evidence suggests high variability in the growth–survival relationships, the growth–feeding linkage could also exhibit variable dynamics. In the present study, we examined the dynamics and mechanisms driving the growth–feeding linkage in Japanese anchovy *Engraulis japonicus* larvae through field studies and laboratory feeding experiments. First, we tested three hypothesized growth–feeding mechanisms, which focus on the potential advantages of larger somatic size, higher growth rate, and earlier morphological development, respectively, using multiple cohort-level samples collected by commercial trawls. All three growth–feeding mechanisms were supported in a certain number of cohorts, but none of them were universally applicable. Thus, the growth–feeding linkage changed across different environmental conditions. Second, we tested the growth–feeding mechanisms through 5-minute controlled laboratory feeding experiments. Somatic size and morphological development had positive effects on the prey number and prey size consumed. In contrast, growth rate had negative effects on the prey size consumed at a given somatic size. This finding was consistent with a morphological trend that slower-growing individuals had relatively larger mouth at a given somatic size. Overall, the dynamics of the growth–feeding linkage seem to be primarily driven by fluctuations in environmental factors that could change the relative feeding advantages of individuals with different growth rates. Such dynamics of growth–feeding linkage would partly explain the dynamics of the growth–survival relationship.

S03, Oral, AbstractID=18978

Bioenergetic modeling of anchovy larval responses to temperature and food availability in Korean waters under future climate scenarios

Dongwha **Sohn**[1], Heeseok Jung[2], Minkyoung Bang[2], Hwan-Sung Ji[3], Sukyung Kang[3], Chan Joo Jang[2] and Sangil Kim[1]

[1]Pusan National University, Busan, Korea, R. E-mail: sohndongwha@pusan.ac.kr
[2]Korea Institute of Ocean Science and Technology, Busan, Korea, R
[3]National Institute of Fisheries Science, Busan, Korea, R

Marine ecosystems are rapidly changing due to climate warming, influencing the distribution, growth, and survival of marine species. Quantifying the combined effects of temperature and food availability on early life stages is essential for predicting climate-driven changes in fisheries productivity. Anchovy (*Engraulis japonicus*), one of the most ecologically and commercially important species in Korean waters, is highly sensitive to environmental variability during its larval stage. We developed a bioenergetically coupled individual-based model (IBM) integrating a Dynamic Energy Budget module to simulate larval growth and survival in response to temperature and food supply. The model was forced by physical and biogeochemical outputs from the Korea Regional Ocean Climate Model for a historical period (2010–2020) and future projections for the 2050s under CMIP6-based climate scenarios (SSP1–2.6 and SSP5–8.5). Each simulation tracked individual larvae from the egg stage for 30 days, with energy allocation dynamically regulated by temperature-dependent metabolism and food ingestion. Model results indicated reduced larval growth and survival under warming and food-limitation conditions, particularly during summer (June–September), when metabolic demands exceeded food availability. Slight improvements in growth were projected in spring (April–May) under moderate warming and sufficient prey. These findings suggest that warming-induced metabolic stress combined with reduced food supply increases early life-stage vulnerability of anchovy populations. The study highlights the importance of incorporating temperature- and food-dependent bioenergetic processes into predictive IBMs to improve understanding of recruitment success and to support climate-adaptive fisheries management in Korean waters.

S03, Oral, AbstractID=18984, (ECOP)

Linking Atlantic herring larval growth variability to recruitment strength in eastern Canada over the last four decades

Etienne **Germain**[1], Pierre Lavoie[1], Jacob Burbank[2] and Dominique Robert[1]

[1]Institut des sciences de la mer, Université du Québec à Rimouski, Rimouski, QC, Canada
E-mail: etienne.germain@uqar.ca
[2]Gulf Fisheries Centre, Fisheries and Oceans Canada, Moncton, NB, Canada

Atlantic herring (*Clupea harengus*) is one of the most important pelagic species in eastern Canada fisheries. Among the 12 recognized stocks in the Northwest Atlantic, the two that are located in the southern Gulf of St. Lawrence – differentiated by their spawning period (spring or fall) – have been experiencing low recruitment over the past three decades. More specifically, the spring spawning stock has been in a critical state since the beginning of the 2000s, leading to a fishery closure in effect since 2022. To better understand this decline, we adopted a comparative approach, aimed at reconstructing and contrasting the growth trajectories during the larval stage of one-year-old individuals from year-classes that experienced high and low recruitment strength. Using an extensive otolith archive collected between 1982 and 2011, we compared the mean larval growth trajectories among three strong and four weak year-classes over a period spanning nearly three decades. We observed that strong year-classes were characterized by a faster growth trajectory during the first 40 days of life relative to individuals issued from weak recruitment, a signal that was undetectable when we observed the cumulative growth over the entire first year of life. This study provides empirical evidence of the key role of early growth performance in driving the survival and recruitment success of spring-spawning herring in the southern Gulf of St. Lawrence. These findings also offer a valuable framework for interpreting recent recruitment failure and supporting conservation efforts for the sustainable management of this critically declining stock.

S03, Oral, AbstractID=18990, (ECOP)

Integrating physiology, environment, and adaptation in anchovy (*Engraulis ringens*): Insights from a Dynamic Energy Budget model in the southern Humboldt ecosystem

Sebastián I. **Vásquez**[1,2], Cristian Salas[1], Leonardo Castro[3], Eline Le Moan[4], Jorge Flores-Valiente[5], Timothèe Brochier[6], Christophe Lett[7], Nicolas Barrier[7] and Laure Pecquerie[4]

[1]Instituto de Investigación Pesquera, Talcahuano, Bío Bío, Chile. E-mail: svasquez@inpesca.cl
[2]Programa de Doctorado en Oceanografía, Universidad de Concepción, Concepción, Chile
[3]Departamento de Oceanografía and Copas Coastal Center, Universidad de Concepción, Concepción, Chile
[4]LEMAR, Institut de Rechercher pour le D´eveloppement (IRD), UBO/IRD/CNRS/Ifremer, IUEM, Plouzanè, France
[5]Instituto del Mar del Perú, Callao, Peru
[6]Institut de Recherche pour le Développement, IRD, Sorbonne Université, SU, Université Cheikh Anta Diop, UCAD, UMMISCO, Bondy, France
[7]MARBEC, Institut de Recherche pour le D´eveloppement (IRD), Univ Montpellier/IRD/CNRS/Ifremer, Sète, France

The Dynamic Energy Budget (DEB) model provides a mechanistic framework for describing how organisms acquire and use energy, linking assimilation, maintenance, growth, development, and reproduction to environmental drivers such as temperature and food availability. Here, we developed a DEB model for the anchovy (*Engraulis ringens*) in the southern Humboldt ecosystem, where this neritic species sustains a major fishery and plays a central ecological role. The model was calibrated using experimental and long-term biological monitoring data from central-southern Chile to estimate key parameters and quantify the effects of environmental variability on growth and reproduction. Simulations reproduced correctly observed adult size and weight dynamics under local temperature and feeding conditions, confirming the model's ability to capture regional life-history patterns. Results revealed slower larval growth rates at lower temperatures and differences in reproductive timing compared with populations from the northern Humboldt, suggesting potential local physiological adaptation. Beyond reproducing observed patterns, the model provides a quantitative basis to explore how environmental change affects anchovy performance and recruitment. Furthermore, we demonstrate its integration with a Lagrangian larval drift model, enabling spatially explicit simulations of early-life survival under variable temperature and food regimes. This framework strengthens the mechanistic understanding of how climate variability influences anchovy population dynamics and supports the development of adaptive, ecosystem-based fisheries management within the Humboldt Current System.

S03, Oral, AbstractID=18996, (ECOP)

Environmental forcing and phenological shifts in the spawning dynamics of anchoveta *(Engraulis ringens*) in Northern Chile

Carola **Hernández-Santoro**[1,2*], Fabian J. Tapia[3], Mauricio F. Landaeta[4,5], Guido Plaza[6], Eduardo Diaz[1] and José María Bellido[7]

[1]Instituto de Fomento Pesquero (IFOP), Valparaíso, Chile. E-mail: carola.hernandez@ifop.cl
[2]Programa de Doctorado en Ciencias del Mar y Biología Aplicada, Universidad de Alicante, Alicante, España. Orcid.org/0000-0003-1973-5595
[3]Centro de Investigación Oceanográfica COPAS Coastal & Departamento de Oceanografía, Facultad de Ciencias Naturales y Oceanográficas, Universidad de Concepción, Concepción, Chile
[4]Laboratorio de Ictiología e Interacciones Biofísicas (LABITI), Instituto de Biología, Facultad de Ciencias, Universidad de Valparaíso, Valparaíso, Chile. ORCID ID: 0000-0002-5199-5103
[5]Centro de Observación y Análisis del Océano Costero (COSTA-R), Universidad de Valparaíso, Valparaíso, Chile
[6]Escuela de Ciencias del Mar, Pontificia Universidad Católica de Valparaíso, Valparaíso, Chile. Orcid.org/0000-0002-3980-3340
[7]Instituto Español de Oceanografía, Consejo Superior de Investigaciones Científicas (IEO, CSIC), Centro Oceanográfico de Murcia, Murcia, España. Orcid-ID: 0000-0002-6887-4391

In recent decades, marked declines in biomass and landings of anchoveta (*Engraulis ringens*) have been recorded, together with shifts in size structure, particularly in northern Chile. This study retrospectively analyzed changes in reproductive phenology using a 22-year time series of the spawning index, coastal upwelling indicators (standardized Ekman index, transport, and pumping), temperature, chlorophyll-a, and female body condition (Kn), weight, and length. Seasonal and long-term environmental trends were examined through time-series decomposition and breakpoint analysis to compare distinct temporal periods. Results revealed: (i) strong interannual and seasonal variation in fertilization levels; (ii) a shift from a single winter–spring spawning peak before 2015 to a bimodal pattern thereafter, with a new summer peak; (iii) weakening of the winter–spring upwelling signal over time, linked to warmer sea surface temperatures (SST) and lower chlorophyll-a, whereas the summer peak coincided with stronger upwelling and cooler SST; and (iv) a general decline in reproductive intensity despite increased summer spawning. Both spawning periods occurred independently of female size, with individuals larger than 13 cm contributing to both. The generalized additive model (GAM) explained 52% of the variability in the spawning index, with season (50%), period (18%), SST (28%), and the standardized Ekman index (6%) as key predictors. Overall, the results suggest a shift in anchoveta reproductive strategies driven by changes in upwelling dynamics, with potential implications for ecosystem functioning and fisheries management in the Humboldt Current system.

S03, Oral, AbstractID=18998, (ECOP)

Timing Matters: The influence of sardine hatch timing on growth, survival and recruitment in a changing upwelling system

Andreia V. **Silva**[1,4], Íris Quinta[2,3], Ana C. Brito[2,3], Cristina Nunes[1], Alexandra A. Silva[1,2], Alexandra Teodósio[4,5] and Susana Garrido [1,2]

[1]Portuguese Institute for Sea and Atemosphere, Lisboa, Algés, Portugal.
E-mail: avsilva@ipma.pt
[2]Marine and Environmental Sciences Centre (MARE), Faculty of Sciences, University of Lisbon, Lisbon, Portugal
[3]Sciences Faculty, University of Lisbon, Lisbon, Portugal
[4]Faculty of Sciences and Technology, Algarve University, Faro, Portugal
[5]Centre of Marine Sciences (CCMAR), Algarve University, Faro, Portugal

Fluctuations in sardine (*Sardina pilchardus*) recruitment along the Iberian coast are strongly influenced by environmental and parental factors affecting larval and early juvenile survival. Although multiple studies correlate recruitment with environmental variables, the mechanisms that determine survival, especially in the juvenile stage, remain poorly understood. This study investigates the periods during the protracted spawning season contribute to successful recruitment and explores how maternal condition and environmental variability affect sardine growth and survival. Using otolith microstructure to obtain hatch date distributions during years of contrasting recruitment strength (2007, 2008, 2013, and 2024), we identified cohorts corresponding to distinct spawning seasons and compared their growth trajectories along early stages. Early growth patterns were examined to test for size-selective mortality and to assess whether individuals that hatched larger maintained higher growth rates throughout development. Generalized additive models (GAMs) were applied to evaluate the influence of sea surface temperature (SST), chlorophyll-a concentration, upwelling intensity, and parental indicators such as adult condition factor (Wr) on larval growth and survival. Results suggest that interannual variability in temperature and food availability shapes recruitment success both directly, through larval growth conditions, and indirectly, via maternal effects on egg quality. High growth rates during early ontogeny were associated with increased survival, but extreme summer temperatures may have imposed strong selective pressure favouring only highly fit individuals. Understanding the combined effects of parental and environmental drivers provides new insights into the mechanisms behind sardine recruitment variability in the Iberian upwelling system.

S03, Poster, AbstractID=18999, (ECOP)

Climate effects in biomineralization of Brazilian sardine *sagittae*: A five-decade interval

Carolina **Siliprandi** and June Ferraz Dias

University of São Paulo, São Paulo, Brasil. E-mail: carolina.siliprandi@gmail.com

The abundance of small pelagic fish, including sardines, is closely linked to oceanographic and meteorological processes; thus, understanding how these organisms respond to global climate change remains a major scientific challenge. The Brazilian sardine (*Sardinella brasiliensis*) plays a key ecological role in marine ecosystems and represents the most important fishery resource in Brazil. Despite its economic relevance, the stock is heavily exploited and poorly managed. Biomass is not assessed annually, and fishing mortality is not monitored, increasing the risk of depletion. To evaluate decadal changes in sardine otolith morphology, 258 left *sagittae* (200–249 mm total length) collected in the 1970s and 2020s were analyzed. The macular face was examined using Wavelet Transform (WT) analysis, and otolith weight was determined on a precision scale. Contours were processed with the AFORO image system to quantify and locate specific irregularities. Principal Component Analysis (PCA) and Multivariate Linear Models were applied to WT5 specimens. The first 38 components explained 99% of contour variance. Appropriate Discriminant Analysis achieved a 75.6% classification success rate (Jackknife validation). The first axis (64.7%) reflected rostrum elongation; the second (10.6%) distinguished rounded versus oblique posterior regions. A two-way PERMANOVA revealed significant differences between decades ($F = 2.3525$; $p = 0.0004$). These morphological differences indicate long-term shifts in otolith growth patterns, likely driven by environmental variability and fishing pressure. The results underscore the potential of otolith-based indicators as sensitive tools for detecting climate-related changes and guiding adaptive management of small pelagic fisheries in a warming ocean.

S03, Oral, AbstractID=19007

Spatio-temporal variations of biological traits of anchovy (*Engraulis ringens*) and common sardine (*Strangomera bentincki*) in central-zone Chile, as a response to environmental drivers: Bases for a sustainable fisheries management

Nazareth Sánchez and Cristian M. **Canales**

Pontificia Universidad Católica de Valparaíso, Valparaíso, Valparaíso, Chile.
E-mail: cristian.canales.r@pucv.cl

The sustainability of pelagic fish stocks is a priority objective in fisheries management due to their high ecological and socioeconomic importance. A constant challenge in their management is the influence of environmental variability, as these species are particularly sensitive to changes in ecosystem conditions, which introduces significant uncertainty into management strategies. With the aim of providing technical input to strengthen management under an ecosystem approach that explicitly integrates the environmental component into decision-making, this study analyzed the variability of the biological traits of anchovy (*Engraulis ringens*) and common sardine (*Strangomera bentincki*) in south-central Chile (32°10'S to 43°00'S). Using Generalized Linear Mixed Models (GLMM), biological samples of anchovy and sardine collected from the fishery and acoustic surveys between 2001 and 2023 are analyzed, along with the main environmental variables obtained by telemetry. The results show significant spatiotemporal differences in biological traits. Sardines exhibit greater variability than anchovies, likely related to sensitivity to environmental conditions. Sexual maturity in sardines showed notable spatial heterogeneity, as did the average size and weight of gonads in both species. A yield per-recruit analysis shows the fisheries management implications that this spatial heterogeneity has. Significant orthogonal relationships with the annual effects of environmental variables are identified, highlighting relationships that should be considered in the management of these spatially heterogeneous and environment-dependent resources.

S03, Oral, AbstractID=19016

New insights into lanternfish larvae distribution patterns in the Southwest Atlantic

Gabriel **Vilanova**, June Ferraz Dias, Maria de Lourdes Zani-Teixeira, Mario Katsuragawa, João Pedro Mancio de Amorim, Ilson Carlos Almeida da Silveira and Cláudia **Namiki**

Presented by Cláudia Namiki on behalf of Gabriel Vilanova

University of São Paulo, São Paulo, Brazil. E-mail: gabriel.vilanova@usp.br, namiki@usp.br

Lanternfish (Myctophidae) larvae are dominant in oceanic ichthyoplankton assemblages, although information on their vertical distribution and association with mesoscale features along the Brazilian coast remains limited. In this sense, this study aims to expand knowledge on lanternfish larvae, through samplings down to 2,300 m depth in the South Brazil Bight during two contrasting periods (2019 austral winter-spring and 2021-2022 austral summer). Ichthyoplankton was collected using a Multinet with 500 µm mesh through oblique tows in up to eight depth layers. Larvae were identified to the lowest possible taxonomic level, and abundance and frequency of occurrence were calculated. Horizontal and vertical distributions were analyzed, along with the association with local oceanographic features. A total of 3,325 specimens were identified, representing 15 genera and 26 species/morphotypes. Larvae were mainly recorded over the outer shelf and slope, with higher abundances during summer, reflecting increased reproductive activity and spawning synchronized with periods of higher biological productivity. Vertically, larvae were broadly distributed, but higher densities occurred from the surface to 150 m. Larvae were associated with warmer, saltier waters, and the Brazil Current flow area appears to be a preferred spawning ground, likely due to proximity to adult habitats and transport by mesoscale features. This study provides novel insights into the vertical distribution of fish larvae in Brazilian waters and underscores the importance of deep-water ichthyoplankton sampling. It also reveals aspects of the lanternfish life cycle, including occurrence below 100 m and association with the Brazil Current in early life stages.

S03, Oral, AbstractID=19020 **CANCELLED**

Changing phenology of small pelagic fishes in the Gulf of Alaska

Lauren A. **Rogers**[1], Kelia Axler[1] and Jennifer S. Bigman[2]

[1]NOAA Alaska Fisheries Science Center, Seattle, WA, U.S.A. E-mail: lauren.rogers@noaa.gov
[2]School of Marine Science and Policy, University of Delaware, Lewes, DE, U.S.A.

Changes in the timing of fish spawning and early life stage development can affect the temporal match or mismatch of larvae with production of preferred prey as well as their availability to predators, with potential consequences for recruitment success, food-web dynamics, and fisheries. Using observations from over four decades of spring ichthyoplankton surveys in the Gulf of Alaska, we investigated long-term changes in the phenology of 28 fish species, including small pelagic species such as Pacific herring and sand lance. Larval size on a standardized date (size-at-date) was used as a proxy for larval developmental timing in spring, and reflects a combination of hatch timing (larval age) and growth. Spatiotemporal generalized linear mixed models were used to account for variable sampling effort in space and time in order to isolate long-term trends and thermal effects on larval size. For a majority of species, including Pacific herring and sand lance, interannual variation in mean size-at-date was significantly and positively related to temperature, demonstrating widespread effects of temperature on phenology of fish early life stages. Despite the wide diversity of life history traits exhibited by the species examined, patterns in size-at-date over time were similar across most species, reflecting the common effect of temperature on phenology. While temperature affected size-at-date, there was little evidence of long-term linear trends, likely due to the lack of a long-term trend in winter-spring temperatures observed in recent decades in this region. We demonstrate a novel analytical method to assess changes in phenology from larval size observations sampled at variable locations and times, and detect phenological shifts that were not necessarily identifiable from larval abundance data alone. Our results suggest that earlier spring phenology due to warming will be a common response among fishes to projected future climate change in high-latitude ecosystems.

S03, Oral, AbstractID=19033

Nutritional stress in *Myctophum affine* (Myctophidae) larvae in the Southeastern Brazilian Bight

Claudia **Namiki**[1], June F. Dias[1], Maria L. Zani-Teixeira[1], Helcy L. N. Silbiger[1], Ulisses C. dos Santos[1], Mario Katsuragawa[1] and Mauricio F. Landaeta[2]

[1]Instituto Oceanográfico, Universidade de São Paulo, São Paulo, Brasil. E-mail: namiki@usp.br
[2]Instituto de Biología, Facultad de Ciencias, Universidad de Valparaíso, Valparaíso, Chile.

In the Southeast Brazilian Bight (SBB) the larvae of mesopelagic *Myctophum affine* are one of the most abundant species in the oceanic ichthyoplankton assemblages. It is associated with the Tropical Water (TW), an oligotrophic water mass that occupies the uppermost layer of the Brazil Current. Since TW shows relatively low levels of nutrient, productivity and biomass, it is expected to have poor nutritional conditions of larvae in this water mass. However, *M. affine* larvae are also widely distributed on the continental shelf where they may take advantage of high phyto- and zooplankton production and biomass. In this study we use the liver as a nutritional biomarker to evaluate the nutritional stress of *M. affine* larvae collected on the continental shelf and slope of the SBB. Fish larvae were collected through oblique tows using a 505 μm mesh-sized bongo net during a cruise in January 2002. A total of 44 individuals of different stages of development were randomly selected for histological study. The liver was the target organ and two approaches were used: the hepatocyte morphology and the glycogen content. Glycogen level in the liver was high in 41% of larvae, moderate in 27% and absent in 32%, with no difference between shelf and slope ($p= 0.237$). However, the levels of glycogen were significantly different between day and night ($p = 0.023$), indicating that it could be related to the daily diet cycle. The hepatocyte condition of *M. affine* larvae was classified as healthy (61.4%), average (27.3%) and degraded (11.4%). The percentage of healthy condition was higher on the shelf (77%) than on the slope (39%), with significant difference between regions ($p = 0.031$), indicating that *M. affine* larvae would find a more appropriate environment condition on the shelf when compared with the slope.

S03, Oral, AbstractID=19093

Age and growth of Pacific sardine (*Sardinops sagax*) in United States waters during the recent period of low abundance, 2012-2021

Kelsey C. **James**[1], Jon M. Walker[2], Brittany D. Schwartzkopf[1], Emmanis Dorval[3] and Brad E. **Erisman**[1]

Presented by Brad Erisman on behalf of Kelsey C. James

[1]Fisheries Resources Division, Southwest Fisheries Science Center, NOAA, National Marine Fisheries Service, La Jolla, CA, U.S.A.E-mail: brad.erisman@noaa.gov, kelsey.james@noaa.gov
[2]Walker Environmental, San Diego, CA, U.S.A.
[3]Lynker Technologies, LLC Under Contract with Southwest Fisheries Science Center, Leesburg, VA, U.S.A.

Pacific sardine (*Sardinops sagax*) is an economically important forage fish in the Northeast Pacific Ocean that undergoes large changes in abundance over decadal timescales and exhibits high individual variation in somatic growth. Past studies have suggested that Pacific sardine may display density-dependent growth and regional differences in growth patterns. We analyzed somatic growth in Pacific sardine off the U.S. Pacific coast during the recent period of low abundance (2012-2021) and compared the results to those of previous studies to evaluate whether growth patterns vary across studies and in response to changes in population abundance. Sampled fish (n = 3228) ranged in length from 30 to 291 mm SL and in age from 0 to 9 years. Age-at-length data were best explained by the von Bertalanffy growth model and sample distribution simulations showed the dataset to be robust and unbiased. Estimated growth parameters (L_∞ = 243, K = 0.795, t_0 = -0.638) were consistent with an opportunistic life history strategy characterized by rapid growth, early maturation, and a short lifespan. While the estimated growth rate (K) was higher than a previous study and indicate that growth may be density dependent, the parameter estimates from the previous study were influenced by sample distribution bias. Estimated growth parameters also varied among studies conducted in different regions but were inconsistent with ecological theory on the relationship between growth and ocean temperature. Differences in aging methods, sample distributions, and other factors precluded any definitive conclusions on the influence of environmental conditions on growth.

SESSION 03

Life History Variation Across Space, Time, and Ontogeny: Implications for Populations, Ecosystems, and Fisheries

Poster Presentations

S03, Poster, AbstractID=18804, PosterID: S03-P1

A comprehensive analysis of physical, biological, and fishery-related drivers shaping pacific herring population dynamics

Caihong Fu[1], Jennifer L. **Boldt**[1], Christopher N. Rooper[1], Jaclyn S. Cleary[1], Thomas Doniol-Valcroze[1], Roy A. S. Hourston[2], Christie J. McMillan[1], Akash R. Sastri[2] and Strahan Tucker[1]

[1]Fisheries and Oceans Canada, Pacific Biological Station, Nanaimo, BC, Canada.
E-mail: Jennifer.Boldt@dfo-mpo.gc.ca
[2]Fisheries and Oceans Canada, Institute of Ocean Sciences, Sidney, BC, Canada.

Pacific herring (*Clupea pallasii*) stocks in British Columbia (BC) have exhibited pronounced fluctuations in abundance and body condition over the past century, likely driven by a complex interplay of physical, biological, and fishery-related factors. To better understand the mechanisms underpinning these dynamics, we employed a novel randomized Dynamic Structural Equation Modeling (DSEM) framework to assess the influence of 30 drivers on recruitment, age-3 weight, spawning biomass, and female body condition across five major herring stocks (Haida Gwaii, Prince Rupert District, Central Coast, West Coast of Vancouver Island, and Strait of Georgia) from 1990 to 2024. Unlike previous studies that examined a fixed set of drivers, our approach systematically explored thousands of driver combinations to identify emergent patterns. Biological drivers such as spring bloom date, boreal copepod biomass, combined predatory fish biomass, and harbor seal biomass consistently outperformed commonly used physical drivers such as the Arctic Oscillation Index, upwelling, downwelling, and North Pacific Gyre Oscillation. Strong and consistent intrinsic effects were also observed, particularly the pathways of 1) age-3 weight to spawning biomass and 2) recruitment to spawning biomass. Feedback mechanisms played a central role: improved female body condition enhanced recruitment, while prior spawning biomass positively influenced future body condition. These results highlight the dominant role of biological and intrinsic dynamics in regulating herring populations and demonstrate the power of the randomized DSEM framework in identifying robust, ecologically meaningful relationships. Our findings support a more nuanced, ecosystem-based approaches to fisheries management under changing climatic conditions.

S03, Poster, AbstractID=18805, PosterID: S03-P2

Are Argentine anchovies' sizes shrinking? Results from twenty-five-year analysis of landings and research survey data

Paula Orlando[1], M. Cecilia Spath[1], A. David Garciarena[1], Germán E. Buratti[1], Manuela **Parietti**[1] and Claudio C. Buratti[1,2]

[1]Instituto Nacional de Investigación y Desarrollo Pesquero, Mar del Plata, Buenos Aires, Argentina. E-mail: mparietti@inidep.edu.ar
[2]Facultad de Ciencias Exactas y Naturales (FCEyN), Universidad Nacional de Mar del Plata, Mar del Plata, Argentina.

The Argentine anchovy is, in terms of biomass, the most important fishery resource in the Southwest Atlantic. Small pelagic fish are short-lived and fast-growing, so their populations respond quickly to fluctuations in the environment, constituting excellent indicators of climatic changes. The aim of this work is to analyze the evolution of body condition and sizes of anchovy from two sources of data: landings in the ports of Necochea and Mar del Plata between 2001-2023 and research surveys conducted by the National Institute of Fisheries Research and Development (INIDEP) between 2001 and 2021 in the total area of distribution of the species. Significant differences were found in the correlation between the volumes landed in Mar del Plata and Necochea with the mean length, with the particularity that landings in Mar del Plata have a positive relationship with the mean length of anchovies, while those in Necochea do not seem to contribute significantly. The results showed that landings of anchovy have tended to have a greater presence of specimens of smaller length and weight. These changes in the structure of landings of the commercial fleet affect the activity of the canning and salting industry, since the market price of the matured product is related to the size of the specimens. The sequential analysis of lengths and average weights allowed us to identify a change of regime in these variables, with a recent period characterized by smaller anchovies. We found that reduction in size of anchovies is related to the areas of operation of fishing vessels since the high cost of fuel price limit search time investment of fish shoals conducting to concentrate the activity in fishing zones closer to the landing ports. From 2014, a concentration of activity was observed in areas close to Mar del Plata and Necochea. The stability observed in the condition factor of Argentine anchovy, regardless of the origin of the samples, would indicate the absence of effects of the variables that affect it, such as food availability, dense-dependence and competition, physical factors and physiology, among others.

S03, Poster, AbstractID=18806, PosterID: S03-P3

Have growth parameters of Argentine anchovy Engraulis anchoita changed over thirty years of study?

M. Cecilia Spath[1], Manuela **Parietti**[1], Paula Orlando[1], Germán E. Buratti[1], Brenda Temperoni[1,2] and Claudio C. Buratti[1,3]

[1]Instituto Nacional de Investigación y Desarrollo Pesquero, Mar del Plata, Buenos Aires, Argentina. E-mail: mparietti@inidep.edu.ar
[2]Instituto de Investigaciones Marinas y Costeras (IIMyC, UNMdP-CONICET), Mar del Plata, Argentina
[3]Departamento de Ciencias Marinas, Facultad de Ciencias Exactas y Naturales, Universidad Nacional de Mar del Plata, Mar del Plata, Argentina

The Argentine anchovy (*Engraulis anchoita*) is a keystone species in the Southwest Atlantic marine ecosystem, fulfilling a pivotal role in the food web as a primary prey item for a diverse assemblage of fish, seabirds, and marine mammals. Beyond its ecological importance, E. anchoita is of substantial socioeconomic importance since the landings are destined for the salting and canning industry, which places its products in both the domestic and foreign markets. In the northern stock (34° - 41° S), in recent years, a decline in the average size of anchovies landed by commercial fleets has been documented. Such observations may reflect a population-level response to fishing pressure and/or environmental variability influencing individual growth rates. However, it is important to note that fishing pressure on this stock has historically been low relative to its estimated exploitation potential, with assessments consistently categorizing the stock as underexploited. To investigate potential changes in population dynamics, a comprehensive analysis of 30 years of landing data from the northern anchovy stock was conducted, focusing on the estimation of growth parameters using robust modeling approaches. The results indicate no significant temporal changes in growth parameters over the study period, suggesting a stable population dynamic despite observed size reductions. This stability underscores the resilience of the stock and highlights the need to consider environmental factors alongside fishing pressure when interpreting biological trends.

S03, Poster, AbstractID=18837, PosterID: S03-P4, (ECOP)

Use of advanced vitellogenic oocytes as a proxy for egg quality in sardine

Xènia **Frigola-Tepe**[1], Júlia Rotger-Triay[1], Judith Ollé-Vilanova[2], Jordi Viñas[2] and Marta **Muñoz**[1]

Presented by Marta Muñoz on behalf of Xènia Frigola-Tepe

[1]Institute of Aquatic Ecology, Universitat de Girona, Girona, Spain.
E-mail: xenia.frigola@udg.edu
[2]Laboratori d'Ictiologia Genètica (LIG), Department of Biology, Universitat de Girona, Girona, Spain

Egg quality is the feasibility of an egg to be fertilized and develop into a healthy embryo. In commercially important marine fish species, a common technique to assess egg quality is to measure the mean dry mass of hydrated oocytes obtained from the ovary. In European sardines (*Sardina pilchardus*), actively spawning females separate from the rest of the population accompanied by a proportion of males, forming short-term spawning aggregations at greater depths. Spawning peaks occur between 6 and 7 p.m., which implies that sardines must begin hydrating their eggs approximately nine hours earlier. Since purse seines operate closer to the surface and at night, they are unlikely to capture hydrated females. The aim of this study was to evaluate whether oocytes in advanced vitellogenesis are suitable for estimating egg quality, by comparing the dry mass of different replicates of oocyte cohorts (previously identified through size frequency distribution plots). Replicates consisted of 50 oocytes from the most advanced cohort (either hydrated or in advanced vitellogenesis), along with 150 oocytes from the less advanced cohort. The results indicated that advanced vitellogenic oocytes no longer accumulate additional nutrients, and their dry mass does not differ significantly from that of hydrated oocytes. Only oocytes with a diameter of at least 500 μm should be used, since dry mass differs between early–mid and advanced vitellogenic stages. This study provides new insights into the use of advanced vitellogenic oocytes as a proxy for egg quality, an important step for fisheries management.

Keywords: *Sardina pichardus*, egg quality, vitellogenesis, spawning, oocytes

S03, Poster, AbstractID=18873, PosterID: S03-P5, (ECOP)

An indirect approach to estimate the seasonal pattern of the daily spawning fraction in two small pelagic fish from Chile

Luis A. Cubillos and Eveling **Monsalve**

Universidad de Concepción, Concepción, Concepción, Chile.
E-mail: evelingmonsalve@udec.cl

The daily spawning fraction (S) is a key parameter for assessing the spawning biomass of species with undetermined fecundity. Traditionally, S is estimated through histological analyses of aging postovulatory follicles, which is a costly and temporally limited method. In contrast, routine fisheries monitoring of biological data offers the potential for an indirect approach, with the advantages of being low-cost and applicable to longer time series. In this study, we estimated the spawning fraction over an annual cycle for common sardine (*Strangomera bentincki*) and anchovy (*Engraulis ringens*) in central-southern Chile, using monitoring data from the Instituto de Fomento Pesquero. A logistic regression model based on macroscopic maturity stages and gonadosomatic index (GSI) thresholds was applied, and the results were compared with a method relating GSI to hydrated oocyte diameter. For anchovy, S showed high values from August to October and a second peak in December, whereas values during the first half of the year were approximately three times lower. For the common sardine, S increased sharply between July and September, reaching values approximately six times higher than those observed during the rest of the year. The interannual variation in the daily spawning fraction reflects adaptive strategies in response to environmental variability. Although seasonal patterns were similar between the methods, the magnitude of S estimates requires calibration using histological techniques. We discuss sampling design considerations for applying GSI-based thresholds as a practical tool for defining timely temporal closures during periods of peak reproductive activity.

S03, Poster, AbstractID=18901, PosterID: S03-P6

Proximate composition and water to derive condition state and energy density of small pelagic fish

Aurélien Favreau[1], Jérôme Spitz[2], Mathieu Doray[3], Sophie Le Mestre[1] and Martin **Huret**[1*]

[1]DECOD, Institut Agro, IFREMER, INRAE, Brest, France. E-mail: martin.huret@ifremer.fr
[2]Observatoire Pelagis, UAR 3462, La Rochelle Université/CNRS, La Rochelle, France
[3]DECOD, Institut Agro, IFREMER, INRAE, Lorient, France

Evidence of a decline in body condition of small pelagic fish (SPF) is accumulating across various ecosystems, likely under climate change through bottom-up processes, calling for its widespread monitoring. While morphometric condition indices, such as the le Cren index, are increasingly used because they only require measurements of length and weight, they lack some assessment of their intrinsic quality with regard to estimating energy density. The latter is considered the best indicator of fish health, but remains time-consuming and expensive to obtain. Our study aimed to identify the best indicator of energy density with respect to measurement accuracy and cost-efficiency. We compiled a unique dataset on the proximate composition and energy density of 976 sardines and 503 anchovies sampled from the Bay of Biscay to the English Channel. Energy density is weakly correlated with morphometric indices, but strongly relates to lipid and protein contents, and indirectly to water content. We identified three distinct condition states by detecting breakpoints in the linear relationships between proximate composition and water content. The pattern is interestingly similar for both species, characterized by a preferential use of lipids, complemented by proteins when lipid reserves are depleted. Overall, water content is the best estimator of energy content, and accounting for the three condition states improved the accuracy of energy predictions. Monitoring water content is relatively easy, and should contribute to better understanding the drivers and consequences of the decline in condition of SPF for their populations, their predators and the fishing sector.

S03, Poster, AbstractID=18909, PosterID: S03-P7, (ECOP)

Temporal variability in life-history parameters and body condition of sardine (*Sardina pilchardus*) in the English Channel

Susan **Kenyon**, Jeroen van der Kooij and Rosana Ourens

Centre for Environment, Fisheries and Aquaculture Science, Lowestoft, United Kingdom.
E-mail: susan.kenyon@cefas.gov.uk

Changes in individual-level productivity can impact population success via effects on reproductive output. These effects may be more acutely realised in populations at the environmental limits of their species range. Declines in individual weight-at-age and –length have been found in several stocks of small pelagic fish distributed along the northwest European continental shelf (e.g. anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*) in the Bay of Biscay). These declines in productivity are reflected in decreasing stock biomass and have been attributed to bottom-up processes, such as changes in zooplankton abundance and quality. Sardine in the English Channel and Celtic Seas are at the northernmost limit of their range and, while there appears to be relatively high genetic connectivity with the Bay of Biscay population, individuals are larger in these northern compared to southern areas. This latitudinal gradient in growth rate is thought to be related to sea temperature and oxygen levels. However, long-term variability in the life-history traits of sardine at the northern limits of their distribution have not been estimated. This study analyses a combination of survey and fishery self-sampling data to determine temporal variability in growth, maturity, and body condition of sardine in the English Channel. Results can be linked with the biomass index time-series and sea temperature to identify potential drivers of variability in these traits as well as provide input data for future improvements to the current data-limited assessment.

S03, Poster, AbstractID=18913, PosterID: S03-P8

Vertical distribution of cephalopod paralarvae across the Eastern Tropical North Pacific Oxygen Minimum Zone

Laura **Sánchez-Velasco**[1], Erick D. Ruvalcaba-Aroche[2], Juan Gerardo Gutiérrez Bravo[3], Rosabel Camacho-Gastélum[4], Laura A. Shirasago-Sánchez, S. Patricia A. Jiménez-Rosenberg[1] and Mark Altabet[5]

[1]Instituto Politécnico Nacional, La Paz, BCS, México E-mail: lsvelasc@gmail.com
[2]SECIHTI-CICESE' Estación La Paz, BCS, México
[3]Oregon State University, Corvallis, OR, U.S.A.
[4]SECIHTI-CICIMAR-IPN, La Paz, BCS, México
[5]University of Massachusetts, Dartmouth, New Bedford, Massachusetts, U.S.A.

Forage species of cephalopods are pivotal for world food sustenance and marine food webs. In the Eastern Tropical North Pacific, low dissolved oxygen (DO) concentrations cause hypoxic stress that limits larval distributions. This study reports taxon-specific cephalopod paralarvae distributions along five oxygen levels: Oxic, 200 µmol/kg; Hypoxic, 100 µmol/kg; Suboxic, 10 µmol/kg; Anoxic, <1 µmol/kg; and Deep, 10 µmol/kg at ~1000 m depth. Samples were collected using vertically stratified tows with a MOCNESS (333 um mesh size and CTD-DO sensors) at 8 stations from Costa Rica to California. A midwater anoxic core was recorded, expanding from Costa Rica (350 to 600 m depth) to off-central Mexico (between 100 and 800 m depth) and then shrinking along Baja California (between 500 and 600 m depth). Highest paralarvae abundances were detected in stations associated with an anticyclonic eddy off Mexico, showing the anticyclone as a favorable habitat for paralarvae development. Taxa were differentially distributed with respect to vertical DO structure: Ommastrephidae (SD complex) and Ancistrocheiridae were collected exclusively in the Oxic level. Cranchliidae and Enoploteuthidae were recorded mainly at the Oxic level, but with presence at the hypoxic level. Argonautidae and Onychoteuthidae were mostly at the hypoxic level, and Bolitaenidae were only at the Suboxic level. No paralarvae were collected in the anoxic core. Chiroteuthidae was exclusively found at the Deep level below the core. These distribution patterns suggest that cephalopod paralarvae are highly sensitive to changes in the vertical distribution of dissolved oxygen, modulated by mesoscale activity.

S03, Poster, AbstractID=18931, PosterID: S03-P9

Small pelagic fish vulnerability to climate change – growth rate potential of juvenile Pacific herring in the Strait of Georgia, British Columbia

Jennifer L. **Boldt**[1], Christopher N. Rooper[1], Hilari Dennis-Bohm[1], Angelica Pena[2] and Jaclyn Cleary[1]

[1]Fisheries and Oceans Canada, Pacific Biological Station, Nanaimo, BC, Canada.
E-mail: Jennifer.Boldt@dfo-mpo.gc.ca
[2]Fisheries and Oceans Canada, Institute of Ocean Sciences, Sidney, BC, Canada

Small pelagic fish populations, such as Pacific herring, undergo large fluctuations in abundance in large part due to the highly variable number of recruits joining the population each year, making it difficult to forecast population dynamics and sustainably manage these species. Variability in recruit abundance is often attributed to growth and mortality during the early life stages of fish. Understanding how growth will be affected by climate change and the implications for recruitment is essential for management. The objectives of this study were to fit bioenergetics models to growth rates of herring during their first year of life and apply the model to assess potential impacts of climate change on juvenile herring growth. Data from Fisheries and Oceans Canada's juvenile herring survey, age-1 samples collected during spawning, environmental monitoring, and regional ocean model hindcasts were used to construct a bioenergetics model in the Strait of Georgia, British Columbia. Initial results indicate that the model can reproduce herring growth successfully. Growth projections under RCP 4.5 and 8.5 emissions scenarios were examined to project the impact of changing temperature on future herring growth. The implications for these changes in herring survival and recruitment will be discussed and used to propose potential climate impacts for herring populations in the Strait of Georgia.

S03, Poster, AbstractID=18937, PosterID: S03-P10, (ECOP)

Influence of the Biobío River discharge on the early life stages of anchovy (*Engraulis ringens*) and common sardine (*Strangomera bentincki*) in the Gulf of Arauco, Chile

Samuel **Soto-Mendoza**[1,2], Odette Vergara[1], Vincent Echevin[3] and Leonardo **Castro**[1,4]

Presented by Leonardo Castro

[1]Centro de Investigación Oceanográfica COPAS COASTAL, Universidad de Concepción, Concepción, Chile. E-mail: sasoto@udec.cl
[2]Programa Doctorado en Ciencias con mención en Manejo de Recursos Acuáticos Renovables (MaReA), Universidad de Concepción, Concepción, Chile.
[3]Laboratoire d'Océanographie et de Climatologie: Expérimentation et Analyse Numérique (LOCEAN), Institut Pierre-Simon Laplace (IPSL), IRD/CNRS/UPMC/MNHN, Paris, France.
[4]Departamento de Oceanografía, Facultad de Ciencias Naturales y Oceanográficas, Universidad de Concepción, Concepción, Chile.

The Gulf of Arauco (GA) is an important spawning and nursery location for some of the Humboldt Current System's primary pelagic resources. The Biobío River's freshwater input is a major contributor to the area's hydrographic fluctuation. However, the impact of freshwater discharge on the early stages of fishing resources has received little attention in Chile. To study how the Biobío River affects the anchovy and sardine early stages in the GA, we used an interannual biophysical simulation (2014-2018; 1.5 km resolution) and in situ biological and hydrographic data (2007-2019). The model started with the egg distributions of both species in September and October. The findings revealed that the temporal variability of spawning influences the survival of eggs and larvae from both species. Early life stage transport was predominantly south-to-north. Both species' egg abundances were highest near and south of the Biobío River mouth, linking with brackish waters. The Biobío River plume has a significant linear association with the river's average monthly discharge and egg abundance (in situ and modeled data; 2014-2018). Between 2007 and 2019, anchovy and common sardine egg abundance showed a significant polynomial relationship with the plume-influenced area, indicating an optimal threshold range (anchovy: 338–357 km²; common sardine: 306–372 km²); above these ranges, abundance decreased dramatically. In conclusion, the area impacted by the Biobío River plume, which is in turn determined by the river's discharge, regulates the anchovy and common sardine abundance early life stages in the GA.

S03, Poster, AbstractID=18940, PosterID: S03-P11

Changes in the anchoveta growth in northern Chile over the last thirty years and their relationship to environmental drivers and the potential impact of fishing

Francisco **Cerna**[1], Guido **Plaza**[2], Carola Hernández-Santoro[1], Jessica Bonicelli[1], Juan Saavedra-Nievas[1], Erika López[1], Claudeth Asencio[2] and Osneider Palomino[2]

Presented by Guido Plaza on behalf of Francisco Cerna

[1]Instituto de Fomento Pesquero, Valparaíso, Chile. E-mail: francisco.cerna@ifop.cl
[2]Pontificia Universidad Católica de Valparaíso, Valparaíso, Chile

The growth of Anchoveta (*Engraulis ringens*) of the coast off northern Chile (18°00'S to 24°00'S) between 1973 and 2022 was studied through otolith microstructure analysis. Chronological analysis of daily increment widths in otoliths, as a proxy of the growth rate, modeled using a generalized additive model (GAM), detected significant differences in the mean increment width between cohorts, with a decreasing trend over time, that suggesting a decrease in the growth rate after 2009. In this same sense, the mean length at age of the fish observed at the time of capture modeled with a GLM, showed significant differences between cohorts, with coefficients that consistently decrease from the first cohort analyzed (1972-1973) to the most recent (2022-2023). The mean lengths predicted from the model show an interannual decrease, that is, at the same age, juvenile anchovy fish between 50 and 129 days old were smaller, which can range from 2.6 to 5.8 cm less in total length than recorded at least 15 years ago. This finding is consistent with the decrease in anchovy growth rate recorded through the Laird-Gompertz growth model, as well as the result of the absolute growth rate for each cohort. In summary, all methodologies employed show a decrease in somatic growth independent of life stage (pre-recruit, recruit, and adult) in anchovy off the coast of northern Chile. The origin of these changes is discussed in relation to environmental variables, food availability, and the effect of fishing as the main drivers.

S03, Poster, AbstractID=18945, PosterID: S03-P12

Shifting reproductive phenology of the European sardine Sardina pilchardus off the Iberia

Susana **Garrido**[2], Laura Wise[1], Daniela da Silva[1,3], Ana Machado[4,5] and Cristina Nunes[1]

[1]Instituto Português do Mar e da Atmosfera - IPMA, Lisboa, Portugal.
E-mail: susana.garrido@ipma.pt
[2]Centro de Ciências do Mar e do Ambiente (MARE), Évora, Portugal
[3]University of Minho, Centre of Mathematics (CMAT), Braga, Portugal
[4]Faculdade de Ciências da Universidade de Lisboa (FCUL), Lisboa, Portugal
[5]Instituto Dom Luiz (IDL), Lisboa, Portugal

Global warming has a significant impact on the vital parameters of marine organisms, altering their spatial distribution and/or the phenology of vital processes, namely reproduction. The survival of early developmental stages of pelagic fish is strongly influenced by environmental conditions, therefore shifts in reproductive phenology associated with climate change may have a pronounced effect on the recruitment strength and sustainability of this species. This study analyses the spatial and temporal trends of the spawning phenology of European sardine in the northern limit of the Canary upwelling system, and the impact of environmental factors (SST, Chl-a) on such trends. Analysis of more than 170000 sardines collected between 1987 and 2024 revealed distinct reproductive phenologies across Iberian regions, with spawning activity generally increasing with age and clustering into three geographically structured groups. In the western regions, significant shifts in spawning seasonality were detected, with peaks occurring earlier in the year after the 2000s, while no changepoints were identified for southern Iberia. Environmental factors, particularly SST and body condition, were the main drivers of reproductive phenology, with optimal spawning activity occurring within specific ranges for both variables, underscoring the combined role of extrinsic and intrinsic factors in shaping sardine reproductive timing. A better understanding of the drivers of reproductive phenology is essential to anticipate shifts in spawning and improve management under climate change.

S03, Poster, AbstractID=18969, PosterID: S03-P13 (CANCELLED)

Bioenergetics modelling for the understanding of the variability in growth across European anchovy and sardine stocks

Martin **Huret**[1*], Martin Lindegren[2], Marta Albo-Puigserver[3], Ali Cemal Gucu[4], Mathieu Doray[5], Tarek Hattab[6], Jeroen van der Kooij[7], Fernando Ramos[8], Margarita M. Rincón[9], Isabel Riveiro[10], Stelios Somarakis[11] and Laura Wise[12]

[1]DECOD, Institut Agro, IFREMER, INRAE, Brest, France. E-mail: martin.huret@ifremer.fr.
[2]National Institute of Aquatic Resources, Technical University of Denmark, Kemitorvet, Lyngby, Denmark
[3]IEO-CSIC, Oceanographic Center of Baleares, Palma de Majorca, Spain
[4]Middle East Technical University, Institute of Marine Sciences, Mersin, Turkiye
[5]DECOD, Institut Agro, IFREMER, INRAE, Lorient, France
[6]Ifremer, Univ Montpellier, CNRS, IRD, MARBEC, Sète, France
[7]Centre for Environment, Fisheries and Aquaculture Science, Lowestoft, United Kingdom
[8]Centro Oceanográfico de Cádiz (COCAD-IEO), Instituto Español de Oceanografía (IEO-CSIC), Cádiz, Spain
[9]European Commission, Joint Research Centre, Ispra, Italy
[10]Centro Oceanográfico de Vigo (COV-IEO), Instituto Español de Oceanografía (IEO-CSIC), Vigo, Spain
[11]Hellenic Centre for Marine Research, Heraklion, Greece
[12]Instituto Português do Mar e da Atmosfera (IPMA), Lisbon, Portugal

Small pelagic fish exhibit variability in their life history traits across stocks and over time. In particular, evidence is accumulating on the decline of their size and condition across more and more populations. However, understanding the processes driving variability in growth, reproduction or survival remains challenging, as they may be shaped by both external environmental factors and internal mechanisms such as density dependence. Our activity within the ICES/PICES WGSPF aims to describe and explore the mechanisms explaining the spatial and temporal variability in these traits, with a particular focus on growth. After gathering a large dataset on size, weight and abundance on 17 European sardine and anchovy stocks over the period 2000-2024, we used the Dynamic Energy Budget (DEB) model, forced by temperature and zooplankton from two different lower trophic level models, to explore the role of the environment and density-dependence in explaining the observed variability in growth. The latitudinal gradient in size- and weight-at-age was best explained by the gradient in zooplankton concentration. Adding density-dependence through limitation of the food availability in the Holling Type II functional response contributed to the fit between model and data when exploring the inter-annual variability. However, inability of the model to capture the trend in growth over time calls for change in food quality rather than just quantity. Remaining unexplained variability is supposed to arise from genetic differences between stocks that the DEB model should eventually integrates through variability in its parameters.

S03, Poster, AbstractID=18980, PosterID: S03-P14, (ECOP) (CANCELLED)

Chub mackerel (*Scomber colias*) body condition in relation to growth and reproductive activity and environment off the Atlantic Iberian coast

Cristina Nunes[1], Diana Feijó[2,3], Alberto Rocha[2], Corina Chaves[1] and Andreia V. **Silva**[1]

[1]Instituto Português do Mar e Atmosfera, Lisboa, Portugal.
E-mail: cnunes@ipma.pt, avsilva@ipma.pt
[2]Instituto Português do Mar e Atmosfera, Matosinhos, Portugal.
[3]Universidade de Vigo, Campus de Vigo, Spain

In Atlantic-Iberian waters, together with sardine (*Sardina pilchardus*), anchovy (*Engraulis encrasicolus*), and horse-mackerel (*Trachurus trachurus*), chub-mackerel (*Scomber colias*), a medium-size pelagic temperate-tropical fish, play a key role in the pelagic ecosystem where it links lower and upper trophic level species. Moreover, it is socioeconomically important in fisheries activity, representing e.g., in Portuguese waters, 1/4 to 1/3 of total fish landings. In several European areas, Small Pelagic Fish (SPF) condition has been showing a decreasing trend, but the influence of this poorer condition in growth and reproductive patterns, and hence in population dynamics, in connection to the environment, is poorly understood. Based on historical series of biological data of chub mackerel (from market and surveys), this work thus intended to 1) investigate the evolution of condition (Kr, fat content), growth (length-at-age) and reproductive dynamics (GSI, spawning season duration) at different time-scales (seasonal and inter-annual) and 2) in relation to environmental variables, evaluate which could potentially explain the variations of condition observed. Several morphometric indices were calculated (condition factor, gonadosomatic index, fat content). Growth was estimated based on mean length-at-age. Reproductive activity is determined as the duration of reproductive season. The environmental variables considered are SST and Chl-a. These morphometric indices were modelled against the environmental variables using Generalized Additive Models (GAMs) to assess which variables (environmental, and/or biological indices) could explain most of the variance of the condition (Kr, mean fat content). The analysis could contribute to shed light on the processes behind population fitness and fluctuations observed in chub mackerel, information important for the assessment of these fisheries.

Keywords: Chub mackerel, condition, phenology, environment

S03, Poster, AbstractID=19074, PosterID: S03-P15, (ECOP)

Population size structure and length-weight relationships of main small pelagic fishes from the Gambian waters (West Africa)

Momodou **Sidibeh**[1], Bocar Sabaly **Baldé**[2]*, Momodou Jallow[1] and Patrice Brehmer[3,4]

*Presented by Bocar Sabaly **Baldé***

[1]Fisheries Department, 6 Marina Parade, Banjul, The Gambia. E-mail: mbailo85@hotmail.com
[2]Institut Sénégalais de Recherche Agricole (ISRA), Centre de Recherche Océanographique de Dakar-Thiaroye (CRODT), Dakar, Sénégal. E-mail: bocarbalde2005@hotmail.com
[3]IRD, Univ Brest, CNRS, Ifremer, Lemar, Dakar, Sénégal
[4]Sub-Regional Fisheries Commission (SRFC/CSRP), Secrétariat Permanent, Dakar, Sénégal

The population size structure and length–weight relationships are fundamental tools in fisheries science, offering insights into fish stock health, population dynamics, and management. This study assessed the main small pelagic species exploited in the Gambian waters—*Ethmalosa fimbriata*, *Sardinella aurita*, *S. maderensis*, and *Trachurus trecae*—based on samples collected between November 2020 and October 2021 using surface and bottom gillnets. The modal lengths were 20 cm for *E. fimbriata*, 21 cm for *S. aurita*, 22 cm for *S. maderensis*, and 30 cm for T. trecae. The parameter b values ranged from 1.6831 to 2.9461, with correlation coefficients (r^2) between 0.81 and 0.95, indicating strong and significant length–weight relationships for all species ($p < 0.001$). Variations in b values reflect species-specific growth strategies, environmental conditions, and fishing pressure. The results provide essential baseline information for updating management measures of shared pelagic stocks in The Gambia and the wider West African subregion. In the context of data-poor fisheries, this study demonstrates the importance of strengthening long-term national monitoring and research capacity to support ecosystem-based fisheries management.

Keywords: Clupeidae, Carangidae, growth, small pelagics, fisheries management, West Africa

S03, Poster, AbstractID=19007, PosterID: S03-P16

Spatio-temporal variations of biological traits of anchovy (*Engraulis ringens*) and common sardine (*Strangomera bentincki*) in central-zone Chile, as a response to environmental drivers: Bases for a sustainable fisheries management

Nazareth Sánchez and Cristian M. **Canales**

Pontificia Universidad Católica de Valparaíso, Valparaíso, Valparaíso, Chile.
E-mail: cristian.canales.r@pucv.cl

The sustainability of pelagic fish stocks is a priority objective in fisheries management due to their high ecological and socioeconomic importance. A constant challenge in their management is the influence of environmental variability, as these species are particularly sensitive to changes in ecosystem conditions, which introduces significant uncertainty into management strategies. With the aim of providing technical input to strengthen management under an ecosystem approach that explicitly integrates the environmental component into decision-making, this study analyzed the variability of the biological traits of anchovy (*Engraulis ringens*) and common sardine (*Strangomera bentincki*) in south-central Chile (32°10'S to 43°00'S). Using Generalized Linear Mixed Models (GLMM), biological samples of anchovy and sardine collected from the fishery and acoustic surveys between 2001 and 2023 are analyzed, along with the main environmental variables obtained by telemetry. The results show significant spatiotemporal differences in biological traits. Sardines exhibit greater variability than anchovies, likely related to sensitivity to environmental conditions. Sexual maturity in sardines showed notable spatial heterogeneity, as did the average size and weight of gonads in both species. A yield per-recruit analysis shows the fisheries management implications that this spatial heterogeneity has. Significant orthogonal relationships with the annual effects of environmental variables are identified, highlighting relationships that should be considered in the management of these spatially heterogeneous and environment-dependent resources.

SESSION 4

Forage Fish and Food Webs: Trophic Dynamics of Small Pelagic Fish, from Freshwater to the Open Ocean

Oral Presentations

S04, Invited, AbstractID=19002, (ECOP)

Use of trait-based approaches to reveal the complexity of trophic ecology in deep-pelagic fishes

Liz **Loutrage**[1], Jérôme Spitz[2,3], Anik Brind'Amour[4], Tiphaine Chouvelon[3,5], Anaïs Médieu[6] and C. Anela Choy[1]

[1]Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA, U.S.A.E-mail: lloutrage@uscd.edu
[2]Centre d'Études Biologiques de Chizé (CEBC), UMR 7372, La Rochelle Université - CNRS, Villiers-en-Bois, France
[3]Observatoire Pelagis, UAR 3462, La Rochelle Université - CNRS, La Rochelle, France
[4]DECOD (Ecosystem Dynamics and Sustainability), Institut Agro, Ifremer, INRAE, Nantes, France
[5]Ifremer, CCEM Contamination Chimique des Écosystèmes Marins, Nantes, France
[6]IRD, Univ Brest, CNRS, Ifremer, LEMAR, IUEM, F-29280, Plouzané, France

Understanding the functioning of the deep-pelagic food web is challenging due to the wide diversity of animals inhabiting this ecosystem and the difficulty of observations. Deep-pelagic fish species display various feeding strategies modulated by individual size, depth, and vertical migration patterns. We applied a trait-based approach at multiple ecological scales to identify the main drivers of trophic variability among species. Fish species were sampled at night in the Bay of Biscay (NE Atlantic) between 20 and 2,000 m depth with a large pelagic trawl. At the intraspecific level, analyses of ontogenetic shifts in the depth distribution and trophic ecology of 12 fish species revealed distinct trade-offs. Some species exhibited ontogenetic changes in relation to size, while others not. At the community level, measurements of 27 morphological traits related to foraging function in 42 species revealed marked differences between surface-dwelling and bathypelagic species. Surface-dwelling species were characterized by larger eyes, suggesting a prey-tracking strategy, whereas bathypelagic species exhibited larger mouth opening and teeth, as well as luminescent appendages, traits consistent with an ambush hunting strategy. Within an active IMBeR CLIOTOP task team focused on synthesizing the trophic ecology of global micronekton species, we are working to extend this trait-based framework across distinct oceanographic regions. Our team compiled a global micronekton database of stable isotope and mercury concentrations, and are currently examining large-scale patterns in the trophic structure and functional diversity of mesopelagic communities.

S04, Oral, AbstractID=18807 (Pre-recorded)

Status of ecotrophic studies on pelagic fishes in the South West Atlantic Ocean: Goals and challenges

Brenda Temperoni[1,2], Luciano Padovani[1], Aylén Fernández Abud[1,2], Victoria Rodríguez Zanchín[1,2], Manuela **Parietti**[1], M. Cecilia Spath[1], Germán E. Buratti[1], Paula Orlando[1] and Claudio C. Buratti[1,3]

[1]Instituto Nacional de Investigación y Desarrollo Pesquero, Mar del Plata, Buenos Aires, Argentina. E-mail: mparietti@inidep.edu.ar
[2]Instituto de Investigaciones Marinas y Costeras (IIMyC, UNMdP-CONICET), Mar del Plata, Argentina
[3]Facultad de Ciencias Exactas y Naturales (FCEyN), Universidad Nacional de Mar del Plata, Mar del Plata, Argentina.

Small and medium-sized pelagic fishes are crucial to marine food webs, making up to 50% of marine landings and supporting food security. Small pelagic fishes dominate intermediate trophic levels and serve as key prey for many predators, while medium pelagic fishes act both as predators of small pelagics and as prey for higher trophic levels. In this regard, knowledge on their trophic ecology is relevant for a further understanding of the energy flow in the pelagic food webs and its role in the ecosystem. In the South West Atlantic Ocean (SWAO), ecotrophic studies on pelagic fish have been ongoing since 1960's. Most of the focus was placed on species with commercial interest, such as Argentine anchovy *Engraulis anchoita* and Atlantic chub mackerel *Scomber colias*. However, in recent decades, other species have emerged in terms of abundance, with a relevant ecological role, such as rough scad *Trachurus lathami*, Atlantic sabretooth anchovy *Lycengraulis grossidens*, bluefish *Pomatomus saltatrix*, white snake mackerel *Thyrsitops lepidopoides*, and mesopelagic fishes. This work summarizes results gathered from 1960 to the present, regarding diet information of these pelagic species in different areas in the SWAO from 34º to 45ºS. In this regard, high quality analyses of stomach contents, and the relation with the oceanographic conditions of the area, have been essential for food web understanding, providing a high level of taxonomic context to predator–prey relationships not yet duplicated by other methods. Notwithstanding, ongoing goals featuring methodologies such as stable isotope analysis and energy density determinations are presented, highlighting their current challenges and opening the door to global collaboration with related pelagic fish working groups.

S04, Oral, AbstractID=18812, (ECOP) (CANCELLED)

Fishing pressure effects on trophic dynamics and biodiversity patterns in the Moroccan Mediterranean over time

Salma **Aboussalam**, Karima Khalil and Khalid Elkalay

Essaouira school of technology, Cadi Ayyad University, Essaouira, Marrakech-Safi, Morocco.
E-mail: salmaaboussalam@gmail.com

An ecosystem model of the Moroccan Mediterranean Sea was developed using data from 2000 to 2019 to assess the combined effects of trophic interactions, fishing pressure, and environmental drivers on marine resources. The model is driven by fishing effort and mortality rates and compares predicted outputs with observed biomasses and catches. Model outputs closely align with observed trends for key species: sardine, anchovy, and deep-water rose shrimp showed marked declines, while common octopus, bluefin tuna, and blackspot seabream exhibited biomass increases. These contrasting patterns are expected to influence ecosystem structure through direct and indirect trophic interactions. In particular, increases in non-commercial species at lower trophic levels (e.g., benthic invertebrates) and species with high turnover rates (e.g., cephalopods, benthopelagic fish) suggest the occurrence of trophic cascades, potentially driven by predator and competitor release following the depletion of top predators and small pelagic fish. Ecological indicators reveal a dynamic trajectory over time: the mean trophic level of the community (mTLco, excluding primary producers and detritus), Kempton's biodiversity index (Q), and the Fishing-in-Balance (FIB) index all increased, while the mean trophic level of the catch (mTLc) and Shannon diversity index declined. Moreover, the rising demersal-to-pelagic biomass ratio indicates a relative shift in community composition, with demersal species gaining prominence as small pelagic fish become less abundant.

S04, Oral, AbstractID=18849, (ECOP)

Fueling the Gulf of Maine food web: Forage fish energetics to support ecosystem-based fisheries management

Abrielle E. **Remick**[1], Michelle D. Staudinger[1], Walter J. Golet[1] and Matthew Cieri[2]

[1]University of Maine, Walpole, ME, U.S.A. E-mail: abrielle.remick@maine.edu
[2]Maine Department of Marine Resources, Boothbay, ME, U.S.A.

The nutritional quality of forage fish strongly influences the population dynamics of commercially and ecologically important marine predators. Many forage species in the Northwest Atlantic (NWA) serve as key energetic links between trophic levels and sustain valuable commercial fisheries, underscoring the need for continuous monitoring of their condition. Although prior regional studies have documented energetic content (EC) for some forage species, substantial data gaps remain. This study provides current nutritional profiles of forage species from estuarine and inshore habitats in the Gulf of Maine (GOM), a highly productive yet rapidly changing ecosystem. Focal species were chosen based on their prevalence in regional diet studies and include multiple clupeids, Atlantic mackerel (*Scomber scombrus*), sand lance (*Ammodytes sp.*), and longfin squid (*Doryteuthis pealeii*). Bomb calorimetry was used to quantify seasonal and size-based shifts in EC (kJ/g) during 2024-2025. Preliminary analyses revealed interspecific differences across six forage species. Mean energy density (± SD) was highest in Atlantic menhaden (*Brevoortia tyrannus;* 22.6 ± 2.5 kJ/g, n = 10) and lowest in sand lance (20.6 ± 3.7 kJ/g, n = 2). In Atlantic mackerel, EC increased significantly with total length ($p < 0.001$, $R^2 = 0.60$), suggesting that larger individuals may provide higher energetic returns to predators. This ongoing research identifies optimal size-based foraging windows for regional predators while providing species and season-specific EC values. Such information can help fisheries managers understand how changes in forage fish condition influence predator dynamics, supporting a more holistic ecosystem-based management framework.

S04, Oral, AbstractID=18853

A new method for identifying key prey using ecosystem-specific thresholds and predator-prey preferences

Marjoleine M.H. **Roos**[1], Rachel Zuercher[2], Santi Roberts[2], Sam Wilding[2] and Éva E. **Plagányi**[3]

*Presented by **Andre Boustany***

[1]Independent scientist, Coolum Beach, QLD, Australia. E-mail: marjoleineroos@gmail.com
[2]Monterey Bay Aquarium, Monterey, CA, U.S.A.
[3]CSIRO Environment, St Lucia, QLD, Australia. E-mail: Eva.Plaganyi-lloyd@csiro.au

Knowledge on how species interact within food webs is essential for advancing ecosystem-based fisheries management and ensuring both ecosystem health and the sustainability of fisheries. A critical step toward this goal is identifying prey species that underpin ecosystem structure and functioning, regardless of their abundance. Existing indices for identifying these "key" prey species rely on thresholds that are fixed across ecosystems and diet composition data, which can misrepresent actual predator–prey preferences and the true trophic role of prey. To overcome these limitations, we developed a new method that integrates ecosystem-specific thresholds combined with an extended index, the SUpportive Role to Fishery ecosystems – Integrated Diagnostic (SURF ID) index, incorporating predator–prey preferences. We applied this method to food web data from four ecosystem states of the Southern Benguela Current, known for pronounced shifts in forage species biomass, plus 30 other ecosystems worldwide. Our analysis demonstrates that ecosystem-specific thresholds provide a more adaptive and reliable means of identifying key prey species and that accounting for predator–prey preferences allows SURF ID to better capture true trophic importance despite biomass fluctuations. Most prey species identified as key using the new method integrating ecosystem-specific thresholds combined with the extended index were established forage species, with at least one key species present in most ecosystems tested. Overall, this approach improves the identification of ecologically critical prey species and strengthens the foundations of ecosystem-based fisheries management.

S04, Oral, AbstractID=18858

Forage fish niche partitioning on the Newfoundland and Labrador shelves

Hannah M. **Murphy**, Mariano Koen-Alonso, Paula Lundrigan, and Frances Mowbray

Northwest Atlantic Fisheries Centre, Fisheries and Oceans Canada, St. John's, NL, Canada.
E-mail: Hannah.Murphy@dfo-mpo.gc.ca

Three forage fish species occupy the middle trophic position on the Newfoundland and Labrador shelves and Grand Banks (Northwest Atlantic Fisheries Organization Divisions 2HJ3KLNOP): Arctic cod (*Boreogadus saida*), capelin (*Mallotus villosus*), and sand lance (*Ammodytes* spp.). It is unknown if these three forage fish are sharing the same resources. In the autumn bottom trawl survey, all three forage fish were sampled for the years 2008 – 2016 and their diets were analyzed. In the spring bottom trawl survey, capelin and sand lance were sampled for the years 2013 – 2016 and their diets were analyzed. Arctic cod's centre of gravity was in the northwest (52 – 58 °N latitude), resulting in reduced overlap with capelin and sand lance's centre of gravities, which were further south (46 – 53 °N latitude). Based on frequency of occurrence, the most frequent prey item in Arctic cod stomachs was hyperiid amphipods, while copepods were the most frequent prey item in capelin and sand lance stomachs in both seasons. A diet overlap index found that in both seasons the majority of species/division/size-class combinations showed statistically similar diets, but there was spatial or ontogenetic diet niche partitioning in certain circumstances. Using ordinations, in the autumn there was a clear separation of Arctic cod diet from sand lance and capelin diets, which overlapped; while in the spring, capelin and sand lance diets showed moderate separation. The borealization of the Arctic could increase diet overlap between Arctic cod and other forage fish, while capelin and sand lance are currently sharing resources.

S04, Oral, AbstractID=18869, (ECOP)

Feeding responses to seasonal and latitudinal variations in environmental conditions revealed by stable isotopes in anchovy and common sardine in the central and south Humboldt Current System

Bastián **Garrido**[1,2], Leonardo R. Castro[2], Sebastián I. Vásquez[3,4] and Gabriel Claramunt[5]

[1]Programa de Magíster en Ciencias con Mención en Pesquerías, Universidad de Concepción, Concepción, Chile. E-mail: bastian.egarrido@gmail.com
[2]COPAS COASTAL Center and Departamento de Oceanografía, Facultad de Ciencias Naturales y Oceanográficas, Universidad de Concepción, Concepción, Chile
[3]Departamento de Pesquerías, Instituto de Investigación Pesquera, Talcahuano, Chile
[4]Programa de Doctorado en Oceanografía, Universidad de Concepción, Concepción, Chile
[5]Universidad Arturo Prat, Iquique, Chile.

Key aspects of the trophic ecology of small pelagic fish are not fully understood along the Humboldt Current. In this study, we examined the trophic seasonal dynamics, their relationships with oceanographic conditions, and interactions among cohabiting species (anchovy and common sardine) at the central (20°S) and southern (36°S) Humboldt Current System, using stable isotopes ($\delta^{13}C$, $\delta^{15}N$) measured at different levels of the food web (POM, copepods, and fish). Anchovies at both zones showed narrow $\delta^{13}C$ seasonal variations but marked differences between zones. A wider inter-seasonal range in $\delta^{15}N$ values, and a wider trophic amplitude (size of the isotopic niche) were observed in anchovies from the central HCS zone. In the south HCS, the trophic positions (TP) of both species showed slight variation during the year (TP anchovy: 3.15 - 3.43, TP common sardine: 3.08-3.28), with those of common sardine slightly lower than those of anchovy. However, the isotopic niche size in both species changed seasonally, as did the trophic overlap between them. Winter was when the lowest trophic overlap occurred between species, suggesting a trophic partitioning mechanism to overcome periods of reduced food availability. Overall, the seasonal variations of stable isotopes in the components of the food web seem closely associated with large-scale atmospheric and oceanographic processes (coastal upwelling) that affect both areas but with different intensity and duration during the year. Local geographic differences between zones also influence the input of organic carbon and nitrogen from certain sources, and interactions between species become significant during specific seasons.

S04, Oral, AbstractID=18895

Terrestrial organic matter entering the coastal zone in rainy seasons: Does it ingress to the pelagic trophic web up to small pelagic fishes (SPF) and their spawned eggs?

Leonardo **Castro**[1], Valeria González[1], Patricio Cabrera[1], Samuel Soto[1], Pamela Barrientos[1], Gabriel Claramunt[2], Sebastián Vásquez[3] and Jorge Castillo[4].

[1]Departamento de Oceanografía and Copas Coastal Center. Universidad de Concepción. Concepción, Chile. E-mail: lecastro@oceanografia.udec.cl
[2]Universidad Arturo Prat. Iquique, Chile.
[3]Doctorado en Oceanografía at Universidad de Concepción, and Instituto de Investigaciones Pesqueras de Talcahuano. Talcahuano, Chile.
[4]Instituto de Fomento Pesquero. Valparaíso, Chile.

In the SPF spawning zone of central Chile, scarce information exists on the entry of terrestrial organic carbon (TOC) to the coastal zone, its incorporation into the trophic web, and its transfer from fish to their eggs. Because the main SPF spawning season starts in winter, when primary production is low, and rainfall is maximum, the incorporation of TOC might constitute a surplus carbon input to eggs that should be visualized differently in years of contrasting rainfall. To test this hypothesis, we utilized $\delta^{13}C$ as an indicator of TOC entering the coastal zone, and assessed its presence in particulate organic matter, copepods, anchovy and common sardine tissues, and spawned eggs of both species. The studies were conducted in years of contrasting rainfall: monthly samplings during the spawning season (2016-2017), and early spring cruises (2014, 2015, 2016, 2018). Results from the first study revealed a $\delta^{13}C$ seasonal variation, primarily driven by large-scale upwelling along the Chilean coast, in all components of the food web, including anchoveta eggs and larvae. In the year with higher river discharges (2017), eggs and larvae showed decreased $\delta^{13}C$ values, revealing the influence of terrestrial carbon. In the second study, copepods, anchoveta, and common sardine eggs showed low $\delta^{13}C$ values in years of increased river discharge (2014, 2017). Further south, in the rainy Patagonian zone, copepods and anchovies tend to present even lower $\delta^{13}C$ values. In summary, TOC entering the coastal food web, up to SPF offspring, seems to be a common feature during increased rainfall seasons.

S04, Oral, AbstractID=18914, (ECOP)

Predator-prey size relationships of small pelagic fish: A global overview

Wesley **Greentree**[1], Alejandro Schmill[2], Eneko Bachiller[3], Richard Brodeur[4], Elizabeth Daly[5], Joshua Egan[6], Todd Miller[7], Justin Suca[8] and Francis Juanes[1]

[1]Department of Biology, University of Victoria, Victoria, BC, Canada.
E-mail: wgreentree@outlook.com
[2]Institute for the Oceans and Fisheries, University of British Columbia, Vancouver, BC, Canada
[3]AZTI, Integrated Marine Data Management (ItsasData), Basque Research and Technology Alliance (BRTA), Sukarrieta, Bizkaia, Spain
[4]Hatfield Marine Science Center, Oregon State University, Newport, OR, U.S.A.
[5]Cooperative Institute for Marine Ecosystem and Resource Studies, Oregon State University, Newport, OR, U.S.A.
[6]Great Lakes Fishery Commission, Ann Arbor, MI, U.S.A.
[7]Auke Bay Laboratories, Alaska Fisheries Science Center, National Oceanic and Atmospheric Administration, Juneau, AK, U.S.A.
[8]Department of Oceanography, University of Hawai‘i, Mānoa, HI, U.S.A.

Small pelagic fishes (SPF) play a key role in marine ecosystems, linking lower and upper trophic levels. Highly abundant SPF can compete with and feed on the larval stages of their fish predators. Intra-guild predation on early life stages of other SPF species is hypothesized to regulate population dynamics, through the role of SPF as both competitors and predators is not well resolved. Within this context, variation in the prey sizes that SPF consume is a key aspect of their trophic ecology that remains poorly studied. Accordingly, we compiled available data from 29 SPF species to identify size-based ontogenetic changes in their feeding ecology. We tested how minimum, mean, and maximum prey lengths changed with increasing SPF length. Absolute and relative predator-prey size relationships varied widely. Strong differences among closely related species (e.g., Atlantic and Pacific herring) and within one species (Atlantic mackerel populations from each side of the north Atlantic Ocean) suggested that these relationships may be driven by extrinsic factors that influence available prey sizes, rather than feeding morphology or tactics. We also did not find evidence for a shared relationship between SPF length and size-based trophic niche breadth. Expanded data collection on predator-prey size relationships between SPF and their prey will help resolve the complex roles that SPF play as prey, competitors, and predators in marine ecosystems.

S04, Oral, AbstractID=18941, (ECOP)

Living apart together: Spatial and isotopic niche differentiation between the pelagic fish species in the Gulf of Cadiz

Juan José **Ortiz García**[1], José Antonio Canseco[2], Fernando Ramos[2], Izaskun Preciado[1], María Ángeles Torres[2], Jorge Tornero[2] and Lucía López[1]

[1]Spanish Institute of Oceanography (IEO-CSIC), C.O. Santander, Cantabria, Spain.
E-mail: juanjose.ortiz@ieo.csic.es
[2]Spanish Institute of Oceanography (IEO-CSIC), C.O. Cádiz, Andalucía, Spain

Understanding what drives marine species' spatial distribution and resource use within a community is a crucial step for quantifying energy flows and assessing competition. Hutchinson's concept of the ecological niche as an n-dimensional hypervolume has been explored through various approaches, but few studies have integrated spatial and resource-use dimensions simultaneously. In this study, we aim to investigate the pelagic community of the Gulf of Cádiz, composed of small (anchovy and sardine) and mid-sized fishes (chub and horse mackerels), hypothesizing that species reduce competition by differentiating their spatial and isotopic niches. To test this, we quantified these niches using geostatistical models and Bayesian isotope ellipses based on hydroacoustic and stable isotope (carbon and nitrogen) data from the *ECOCADIZ-RECLUTAS* 2024 survey, allowing us to assess and map spatial and isotopic overlap among species. Results showed that anchovy and sardine exhibited the highest spatial overlap (Ov = 4.0), followed by chub and horse mackerel (Ov = 3.8), and lowest overlap occurred between anchovy and Mediterranean horse mackerel (Ov = 0.8). Contrary to our expectations, the highest isotopic overlaps were found between Mediterranean and Atlantic horse mackerels (44%), followed by Mediterranean horse mackerel and sardine (38%), chub mackerel and anchovy (36%), and anchovy and sardine (32%). Overall, the results obtained partially support our hypothesis since small pelagic fish showed a higher degree of spatial overlap and resource use, suggesting potential competition between them in the Gulf of Cádiz. On the other hand, lower interspecific overlap between mid-sized pelagic fish and small pelagic fish highlights the differences between them in their respective resource origin and use.

Keywords: Pelagic fish, community, spatial models, isotopic niche, distribution.

S04, Oral, AbstractID=18946

Trophic ecology of micronekton communities in the Northeast Atlantic revealed by stable isotopic analysis

Susana **Garrido**[1], Joana Cruz[2], Eva García-Seoane[3,4], Astrid Fredriksen[3], Tom J. Langbehn[5] and Webjørn Melle[3]

[1]Instituto Português do Mar e da Atmosfera - IPMA, Lisboa, Portugal.
E-mail: susana.garrido@ipma.pt
[2]Centre of Marine Sciences (CCMAR), Universidade do Algarve, Faro, Portugal
[3]Institute of Marine Research (IMR), Bergen, Norway
[4]Møreforsking AS, Ålesund, Norway
[5]Department of Biological Sciences, University of Bergen, Bergen, Norway

Mesopelagic fish play an important role as forage species in marine food webs, mediating energy transfer from plankton to higher trophic levels, yet much remains to be understood about their ecological role. Bulk stable carbon (δ13C) and nitrogen (δ15N) isotopic composition was determined for zooplankton, crustaceans and mesopelagic fish in a wide geographic area of the Northeast Atlantic during spring 2019. We compared the isotopic composition, trophic position, breath and niche between mesopelagic species collected in the same geographical areas. We also compared the same species collected in several areas, from Northwestern Africa waters to deep waters off the Bay of Biscay. There was a large overlap of trophic niche between mesopelagic species collected in the same area, revealing a high potential for competition. There is also a high overlap of isotopic niche for species collected from distant areas across Northern Atlantic, confirming the specialized feeding behaviour observed for most myctophid species investigated previously through gut content analysis. Isotopic values vary significantly with mesopelagic fish size irrespective of species. These findings highlight the consistency of mesopelagic trophic strategies across broad spatial scales, underscoring their specialized and stable role in oceanic food webs and providing novel insights into their functional importance in the transfer of energy within open-ocean ecosystems.

S04, Oral, AbstractID=18953, (ECOP)

Linking predator-prey size ratios with forage fish consumption by juvenile Chinook and coho salmon in the Strait of Georgia, British Columbia, Canada

Madeleine G. **Thomson**[1], Will Duguid[1,2], Katie Innes[2], Jessica Qualley[1,2], Wesley Greentree[1], Bridget Maher[1], Nathanael Tabert[1] and Francis Juanes[1]

[1]University of Victoria, Victoria, BC, Canada. E-mail: maddy.thoms@gmail.com
[2]Pacific Salmon Foundation, Vancouver, BC, Canada

Predator-prey size ratios play a critical role in shaping trophic interactions within marine ecosystems. In the Strait of Georgia (British Columbia, Canada), Pacific herring are the dominant forage fish, serving as important prey for many marine predators including Chinook and coho salmon. While Strait of Georgia herring spawning stock biomass remains near historical highs, the spatial and temporal distribution of spawning has contracted over recent decades. Work from the past two decades also suggests that age-0 herring may be less available to salmon than before the 1990s in some areas, coinciding with regional declines in Chinook and coho survival. With the loss of late and satellite herring spawning events, we hypothesize that Chinook salmon may at times be constrained in their transition to piscivory by their size relative to age-0 herring. We sampled diet contents of juvenile Chinook and coho salmon throughout their first ocean summer in the Strait of Georgia. The size of digested forage fish in diets was reconstructed from otolith measurements using an otolith-body size relationship. We compare the frequency of herring occurrence in salmon diets by region and time of year and investigate the relationship between salmon body size and herring consumption. We also assess the dietary importance of other forage fish with different reproductive phenologies, including Pacific sand lance and Northern anchovy. Understanding the factors controlling juvenile salmon access to Pacific herring is likely crucial to understanding changes in salmon population productivity and how shifts in forage fish population dynamics may restructure marine food webs.

S04, Oral, AbstractID=18956, (ECOP)

Chinook salmon diets reveal historical trends in forage fish distribution and availability

Nathanael **Tabert**[1], Wesley Greentree[1], Will Duguid[2] and Francis Juanes[1]

[1]University of Victoria, Victoria, Canada. E-mail: uvicsalmondiet@gmail.com
[2]Pacific Salmon Foundation, Vancouver, Canada

Forage fish play a critical role in marine food webs as the primary prey of a variety of predators. Consequently, understanding shifts in forage fish communities that are likely to occur in response to changing environmental conditions is essential for characterizing marine food webs. However, many forage fish are not exploited commercially, and fishery-independent surveys are resource intensive, meaning these populations are often not monitored. Predator diets provide an alternative method for sampling forage fish. In British Columbia, Canada, Chinook salmon are a marine predator that feed primarily on forage fish, but the most recently published data on adult Chinook salmon diets are from the 1960s. In 2017, the Adult Salmon Diet Program was created to address knowledge gaps in salmon diets and monitor forage fish populations; nearly 7000 Chinook salmon digestive tracts have been analyzed to date. We used Chinook salmon diets to characterize recent trends in the distribution and availability of forage fish in southern British Columbia. We compared our data to historical datasets, highlighting major trends over the past century. Herring have been consistently important in Chinook salmon diets across years in most regions and seasons. Sand lance have been important across years in certain regions and seasons. Anchovy are currently important in small regions but historically were not observed. Sardine were important in the early 1940s but have been rare in diets since. This research provides novel insights into Chinook salmon diets and forage fish community dynamics providing an indicator for monitoring changing pelagic food webs.

S04, Oral, AbstractID=18966

Global micronekton (small pelagic fish and invertebrates) nutritional quality and its spatial-temporal variability

Brian P.V. **Hunt**[1,2]

[1]Institute for the Oceans and Fisheries, University of British Columbia, Vancouver, BC, Canada. E-mail: b.hunt@oceans.ubc.ca
[2]Department of Earth, Ocean and Atmospheric Sciences, University of British Columbia, Vancouver, BC, Canada

Micronekton, including small pelagic fish and invertebrates, occupy a pivotal position in marine pelagic food webs, connecting lower trophic levels to top predators. Within marine food webs, prey nutritional quality is increasingly recognized for its importance to individual and population level health, development, reproduction and survival, while also having implications for overall food web production. A wide array of metrics are available to measure the nutritional quality of micronekton prey available to top predators, including energy density, proximate composition, fatty acids, and micronutrients. Recently, efforts have been made to synthesize data on micronekton prey quality at regional scales. However, applying these data at ocean basin and climate change scales requires deeper understanding of intra and inter-specific variability in micronekton nutritional traits and its environmental drivers. The ICES-PICES SPF Working Group Activity 2 task team is undertaking a systematic review of the published literature with the aim to address this knowledge gap. Specifically, we aim to synthesize and compare data on spatial and temporal variability of micronekton nutrition, drawing on case studies to address nutritional response to ocean warming. This presentation will provide an overview of the review framework, preliminary case study results, and introduce emerging issues of concern.

S04, Oral, AbstractID=18972, (ECOP)

The importance of incorporating ontogenetic Diet Shifts for forage fish and main predators in Ecosystem models

Pedro **Fonseca**, Dorota **Szalaj** and Susana Garrido

Presented by Dorota Szalaj on behalf of Pedro Fonseca

Instituto Português do Mar e da Atmosfera (IPMA), Lisboa, Portugal.
E-mail: pedro.fonseca@ipma.pt

The majority of fish species that prey on planktivorous forage fish, such as hake or mackerels, transition from being planktivorous during the juvenile stage to piscivory, while adults, thereby shifting their trophic level and altering their ecological role in the food web. , Using the Ecopath with Ecosim (EwE) framework and previously parametrised model l for the Portuguese Continental Shelf Ecosystem (PCSE), this study presents an improved multi-stanza Ecopath model designed to incorporate the ontogenetic dietary shifts of the main predators and prey in the ecosystem.

The new model explicitly separates in different stanza the most important fish species in the ecosystem—namely sardine (*Sardina pilchardus*), anchovy (*Engraulis encrasicolus*), blue whiting (*Micromesistius poutassou*), hake (*Merluccius merluccius*), horse mackerel (*Trachurus trachurus*), blue jack mackerel (*Trachurus picturatus*), chub mackerel (*Scomber colias*) and Atlantic mackerel (*Scomber scombrus*)— following observed ontogenetic transitions in diet composition and habitat use. Results were compared with those from the previous model, which provided the first comprehensive description of the PCSE trophic structure.

By integrating these life-stage divisions, the model enhances realism in estimating trophic flow, energy transfer, and predation pressure, improving the predictive power of EwE simulations in constantly changing environmental and fishing scenarios. From an ecosystem-based management perspective, the multi-stanza structure allows assessment of stage-specific vulnerabilities to exploitation and climate change, providing more accurate insights into recruitment, stock productivity, and predator–prey coupling.

Overall, this model represents an important step toward applying the Ecosystem Approach to Fisheries Management, offering a clearer picture of how life-stage dynamics of dominant pelagic species influence ecosystem balance and the sustainability of national fisheries.

S04, Oral, AbstractID=18991, (ECOP)

Species and life stage variability in thiamine (vitamin B1) and thiaminase concentrations of forage fish confers nutritional tradeoffs for predators in the northeast Pacific

Anna K. **McLaskey**[1], Jacob E. Lerner[1] and Brian P.V. Hunt[1,2]

[1]University of British Columbia, Vancouver, BC, Canada. E-mail: a.mclaskey@oceans.ubc.ca
[2]Earth, Ocean, and Atmospheric Sciences, University of British Columbia, Vancouver, Canada

Forage fish are critical components of marine food webs as abundant, high-energy prey that also provide consumers with essential fatty acids and vitamins. Thiamine (vitamin B1) deficiency has long been observed in Baltic Sea and Great Lakes (North America) salmonids but has recently emerged in the Pacific affecting Chinook, coho, and steelhead. Despite their importance as prey**,** some forage fish (particularly northern anchovy) have been implicated in thiamine deficiency of predators because they produce the enzyme thiaminase, which breaks down thiamine and prevents its absorption. This study investigated three important forage fish species – northern anchovy, Pacific herring, and Pacific sand lance – as potential drivers of thiamine deficiency in predators, by characterizing multiple aspects of nutrition and foraging history: thiamine concentration, thiaminase activity, lipid content, fatty acids, and stable isotopes. Thiaminase was detected in all species, with the highest enzyme activities in northern anchovy. Across species, thiamine concentrations were higher in juveniles than adults. Corresponding with this ontogenetic change, percent lipid was negatively correlated with thiamine. Additionally, thiamine in herring and anchovy was correlated with fatty acid composition, indicating that diet influences their vitamin concentrations. Fatty acids differed among species, suggesting markers to trace predator consumption of these prey. Shifting prey communities likely drive expanding thiamine deficiency in the Pacific. This study reveals the complexity of this issue, demonstrating both species and life stage differences in thiamine / thiaminase. Simultaneously, we show that lipids and fatty acids can improve understanding of physiological and dietary drivers of prey and predator thiamine concentrations.

S04, Oral, AbstractID=19004

Modeling trophic dynamics and climate-driven shifts in the Northern Humboldt Current Ecosystem

Stefan **Koenigstein**[1], Giovanni Romagnoni[1,2], Jorge Tam[3], Adolfo Chamorro[5], Dante Espinoza-Morriberón[3], Marc Taylor[4] and Hauke Reuter[1]

[1]Leibniz Centre for Tropical Marine Ecology (ZMT), Bremen, Germany.
E-mail: stefan.koenigstein@leibniz-zmt.de
[2]Center for Ocean and Society & Department of Agricultural Economics, University of Kiel, Germany
[3]Instituto del Mar del Perú (IMARPE), Callao, Peru
[4]Thünen Institute of Sea Fisheries, Bremerhaven, Germany
[5]Pontificia Universidad Católica del Perú (PUCP), Lima, Peru

The Northern Humboldt Current (NHC) off Peru is one of the most productive upwelling systems, dominated by Peruvian anchoveta (Engraulis ringens), a keystone forage species that mediates energy flow from plankton to higher trophic levels. Environmental fluctuations such as the El Niño–Southern Oscillation (ENSO) have pronounced impacts on anchoveta, the food-web and fisheries in the NHC, and climate change is anticipated to impact this system via poleward distribution shifts of important fish stocks, advancing tropicalization, and potential shifts in ecosystem functioning.

We developed the first spatially explicit food-web model for the NHC in the Ecopath with Ecosim and Ecospace (EwE) framework, coupled to a regional ocean-biogeochemical model (CROCO-PISCES) and fitted to historical time series of biomass, catch, and fishing effort. The modeling framework captures key environmental drivers such as productivity in phyto- and zooplankton groups, ocean temperature, and dissolved oxygen, allowing spatially explicit simulations of trophic interactions, species distribution, and emerging ecosystem responses to climate variability. Using future projections of downscaled earth system models under different scenarios (shared socioeconomic pathways), we assess how climate trends may reshape trophic dynamics, ecosystem structure and productivity, and impact fisheries yields through 2100.

The coupled model supports the identification of emerging governance challenges (e.g., conflicts among user groups), and the identification of robust and fair adaptation strategies to future ecosystem shifts under climate change, for sustaining forage fish resources, ecosystem functioning, and the dependent human fishing communities.

S04, Oral, AbstractID=19012, (ECOP)

Foraging traits reveal climate-driven variability in albacore tuna resources in the NE Pacific

Miram R. **Gleiber**[1], Natasha A. Hardy[1], Catherine F. Nickels[2,3], Barbara A. Muhling[3], Brian K. Wells[2,4], Toby D. Auth[5], Jarrod A. Santora[4,6], Ric Brodeur[7], Elliott L. Hazen[8], Michael G. Jacox[8], Steven J. Bograd[8], Larry B. Crowder[9] and Stephanie J. Green[1]

[1]Department of Biological Sciences, University of Alberta, Edmonton, AB, Canada.
E-mail: miramgleiber@gmail.com
[2]Fish Ecology Division, Northwest Fisheries Science Center, NOAA, Seattle, WA, U.S.A.
[3]Institute of Marine Sciences, University of California, Santa Cruz, Santa Cruz, CA, U.S.A.
[4]Fisheries Ecology Division, Southwest Fisheries Science Center, NOAA, Santa Cruz, CA, U.S.A.
[5]Pacific States Marine Fisheries Commission, Newport, OR, U.S.A.
[6]Department of Applied Mathematics, University of California, Santa Cruz, CA, U.S.A.
[7]Hatfield Marine Science Center, Oregon State University, Newport, OR, U.S.A.
[8]Environmental Research Division, Southwest Fisheries Science Center, NOAA, Monterey, CA, U.S.A.
[9]Hopkins Marine Station of Stanford University, Pacific Grove, CA, U.S.A.

Understanding how predators respond to variations in prey assemblages is critical to forecasting future population dynamics and food-web functioning. Prey traits (habitat, behavior, morphology, nutrition) are emerging as important factors driving predator consumption and predator-prey dynamics. Trait-based frameworks can help simplify complex foraging dynamics, highlighting recurring characteristics across diverse taxa consumed by predators across ocean basins. We used such a framework to understand resource use by and availability for albacore tuna (*Thunnus alalunga*), a species targeted by pelagic fisheries globally that has undergone recent shifts in distribution with climate in the NE Pacific. Applying traits to historical juvenile albacore diet and prey community composition revealed that consistent trait forms are selected across time and space in the California Current System (CCS). We use these trait-based insights as a tool to facilitate short-term predictions and future projections of prey availability for albacore in the CCS under climate change. We first compiled these key traits across all taxa (n = 182) in 20 years of forage community composition using a trait imputation framework to fill data gaps. Applying such traits to community abundances enables aggregation of taxa across shared functional roles relevant to the predation process. We then identify hotspots of prey with desirable traits for albacore and relationships with environmental conditions to develop early-season forecasts of prey distributions. We ultimately explore the utility of a traits-distribution model representing prey, coupled with thermal constraints to provide insights into the unpredictable albacore distributions in the CCS. This enhanced understanding of albacore prey will help anticipate the impact of changes in prey assemblages on predator productivity and distribution as pelagic communities are altered by climate change.

S04, Oral, AbstractID=19025

Trophic shifts and energetic responses in small pelagic fishes during variable oceanographic conditions in the Northern California Current

Richard D. **Brodeur**[1], Elizabeth A. Daly[2], Mary E. Hunsicker[3], Kaitlyn Osborne[4], Yi Gong[5], Todd W. Miller[6] and Olivia Burnip[7]

[1]Hatfield Marine Science Center, Oregon State University, Newport, OR, U.S.A.
E-mail: ricbrodeur1@gmail.com
[2]Cooperative Institute for Marine Resources Studies, Oregon State University, Newport, OR, U.S.A.
[3]NOAA, Northwest Fisheries Science Center, Newport, OR, U.S.A.
[4]School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA, U.S.A.
[5]College of Marine Sciences, Shanghai Ocean University, Shanghai, China, PR.
[6]NOAA, Alaska Fisheries Science Center, Auke Bay, AK, U.S.A.
[7]University of Plymouth, Plymouth, England, UNITED KINGDOM

The U.S. west coast marine ecosystem has recently experienced unprecedented ocean warming due to anomalous marine heatwaves (MHWs) lasting several years. The MHWs led to profound changes in species composition, spatial distribution, and food web structure throughout the California Current ecosystem (CCE). A key unknown that warrants attention is how MHWs may impact marine food web interactions, and particularly the trophic interactions of small pelagic fishes (SPF). Previous diet studies indicated that crustaceans were the dominant prey item of SPF in cool or normal oceanographic conditions, but gelatinous species were the dominant prey during the MHW. Our goal is to use stable isotope signatures in SPF muscle tissue combined with a Bayesian mixing model to determine if we detect similar changes in their feeding during warm ocean conditions. We measured the stable isotopic signatures ($\delta^{13}C$, $\delta^{15}N$) of SPF and their invertebrate prey during 11 oceanographically variable years (2000,2002, 2015-2023) including several anomalous MHWs. Most species fed on a narrower diet and had a higher trophic position during the MHW, and the proportion of gelatinous material in the diet increased during the heatwave compared to non-heatwave ocean conditions. We also found higher energy content of both the SPF and their prey during MHW conditions. Overall, our results corroborate the findings from stomach content analyses, providing further support for a shift in SPF feeding habits from a crustacean to a gelatinous dominated diet in the CCE during warm ocean conditions.

S04, Oral, AbstractID=19044

Trait-Based Insights into Pelagic Food Webs under Climate Change

Stephanie J. **Green**[1], Miram R. Gleiber[1], Zackary Tandy[1], Alana Krug-Macleod[1], Elizabeth A Daly[2], Elan J. Portner[3], C. Anela Choy[3], Natasha A. Hardy[1], Zachary Roote[1], Caitlin J. Morganson[1], Iris George[1], Cindy Matuch[1], Cole B. Brookson[1], Barbara A. Muhling[4,5], Owyn Snodgrass[5], Travis Richards[4,5] and Larry B. Crowder[6]

[1]University of Alberta, Edmonton, Alberta, Canada. E-mail: sgreen1@ualberta.ca
[2]Cooperative Institute for Marine Ecosystem and Resources Studies, Oregon State University, Newport, OR, U.S.A.
[3]Scripps Institution of Oceanography, University of California San Diego, La Jolla, CA, U.S.A.
[4]Institute of Marine Sciences, University of California, Santa Cruz, CA, U.S.A.
[5]Fisheries Resources Division, Southwest Fisheries Science Center, NOAA, La Jolla, CA, U.S.A.
[6]Hopkins Marine Station of Stanford University, Pacific Grove, California, U.S.A.

Trait-based frameworks are increasingly useful for predicting how ecological communities respond to ongoing global climate change. As range shifts result in encounters between new predator and prey pairs, identifying prey 'guilds', based on suites of shared traits that confer vulnerability to predators, can assist with predicting future food web dynamics. The Pelagic Species Trait Database is a comprehensive resource developed to advance trait-based understanding of ecological interactions in pelagic systems. The database provides functional trait information for over 500 fish and invertebrate species related to 1) habitat use and behavior, 2) morphology and morphometrics, 3) nutritional quality, and 4) population status in a single, open-source repository. With a focus on the NE Pacific Ocean, this resource is facilitating novel analyses of changes in pelagic community functional diversity and composition, and estimates of prey quality for top predators across the NE Pacific in relation to changing environmental regimes. It also highlights key gaps in trait information to guide data collection and monitoring efforts by the scientific community. In particular, nutritional metrics– key indicators of ecological processes in pelagic systems– are particularly data-poor, with information on lipid or energy content available for only 40-45% of species, and limited information on variation with ontogeny and across environmental conditions. Both short-term research and long-term monitoring initiatives can play a key role in filling key trait information gaps to inform analysis of change in pelagic communities and the fisheries they support.

S04, Oral, AbstractID=19050, (ECOP)

Cryptic but critical: Role of copepods in trophic pathways to fish in the St. Lawrence Estuary

Luis **Avila**[1], Pascal Sirois and Gesche Winkler[2]

[1]Institute of Marine Sciences of Rimouski (ISMER), University of Québec at Rimouski, Rimouski, QC, Canada. E-mail: luis.avilaromero@uqar.ca
[2]Research Chair in Exploited Aquatic Species, University of Québec at Chicoutimi, Chicoutimi, QC, Canada

In the St. Lawrence Estuary, the Maximum Turbidity Zone (MTZ) is a highly heterogeneous and productive environment. Hydrodynamic retention promotes the accumulation of suspended matter, phytoplankton, zooplankton, and nekton, making this area a key nursery and feeding habitat for the early life stages of several fish species. Zooplancton is the main prey, and particularly in the MTZ, the copepod *Eurytemora affinis* dominates the trophic transfer to higher trophic levels. However, in the St. Lawrence, two genetically divergent clades of this cryptic species complex coexist: the North Atlantic clade (*E. affinis*) and the Atlantic clade (*E. carolleeae*). This study investigates the trophic role of these cryptic species in supporting two ecologically and socioeconomically important fish species, the rainbow smelt (*Osmerus mordax*) and the Atlantic tomcod (*Microgadus tomcod*). A multimarker approach combining stable isotope analysis (as a proxy for trophic niche differentiation) and qPCR-based stomach content analysis (SYBR Green assay) was applied to identify copepod consumption by fish larvae in 2021 and 2025. Preliminary results indicate marked trophic plasticity within the *Eurytemora* complex along the estuarine salinity gradient, suggesting differential contributions to food web dynamics. In 2021, the North Atlantic clade appeared to dominate trophic transfer within the core nursery areas of rainbow smelt and tomcod, whereas *E. carolleeae* may help sustain fish populations across broader spatial and temporal scales. Ongoing analyses of isotopic mixing models (2021) and qPCR analyses (2025) will refine our understanding of interannual variability in *Eurytemora* consumption and the ecological significance of cryptic diversity in estuarine food web.

S04, Oral, AbstractID=19073, (ECOP) (CANCELLED)

Comparing the trophic ecologies of mesopelagic fish assemblages in the northern Benguela and the Southeast Atlantic regions

Lourenço **Zacarias**[1,2*], Carl D van der Lingen[1,3] and Mark J Gibbons[1]

[1]Department of Biodiversity and Conservation Biology, University of the Western Cape, Cape Town, South Africa
[2]Instituto Oceanografico de Mocambique, Maputo, Maputo Province, Mozambique.
E-mail: loumucambe@gmail.com
[3]Department of Forestry, Fisheries and the Environment, Cape Town, South Africa

Although mesopelagic fishes can be abundant in oceanic waters across the globe, where they play a critical role in linking lower to upper trophic levels, trophic interactions among and between regional species remain partially elucidated. To better understand these interactions, we investigated the trophic morphology and the $\delta^{13}C$ and $\delta^{15}N$ stable isotope ratios of twelve species of mesopelagic fishes from the northern Benguela and ten from the more oceanic SE Atlantic, with seven species occurring in both regions. Our approach combined the data to investigate feeding behavior, source production and relative trophic level of each species in each region, and compared the trophic structure of the mesopelagic fish assemblages from the two regions. While the trophic structure of each assemblage was broadly similar across regions, both morphometric and stable isotope datasets from the oceanic SE Atlantic showed higher variability than those from the northern Benguela. Four species *Maurolicus* sp.*, Diretmus argenteus, Diaphus hudsoni,* and *Symbolophrous boops* showed notable regional differences, with a clear separation between species from the northern Benguela, and SE Atlantic regions. Three species *Chauliodus sloani, Electrona risso,* and *Diaphus ostenfeldi* exhibited less pronounced regional variation, indicating more consistent ecological or isotopic traits across regions. It is critical to recognize, however, that the sampling effort varied considerably across these regions. Therefore, while our data point towards species-specific regional adaptations in resource utilization, the observed patterns should be considered as indicative rather than definitive, warranting future studies with a more equitable sampling distribution to ascertain their robustness.

S04, Oral, AbstractID=19087, (ECOP)

Interannual variability in Northern Anchovy and Myctophid consumption by Pacific Bluefin Tuna in the Southern California Bight

Travis M. **Richards**[1], Antonella Preti[1], Owyn Snodgrass[2] and Barbara Muhling[1]

[1]Institute of Marine Sciences, University of California Santa Cruz, Santa Cruz, CA, U.S.A.
E-mail: trichar3@ucsc.edu
[2]Fisheries Resources Division, Southwest Fisheries Science Center, National Marine Fisheries Service, La Jolla, CA, U.S.A.

Understanding the factors that influence predation on forage fish by pelagic predators is critical for predicting food web responses to environmental change in dynamic marine ecosystems. We examined Pacific Bluefin Tuna (PBF; *Thunnus orientalis*) diets in the Southern California Bight over 17 years (2008-2024) to characterize temporal variability in forage fish consumption and identify the environmental and biological drivers underlying consumption of key small pelagic fishes.

Across our time series, PBF diets exhibited pronounced temporal shifts in the type of prey consumed. Midwater cephalopods and crustaceans were prevalent in PBF diets during the first half of the study, while small pelagic fishes dominated diets from 2017-2024. Within this fish-dominated period, Northern Anchovy (*Engraulis mordax*) was the primary prey from 2017-2022, while myctophids were the primary prey from 2023-2024. To identify environmental and biological drivers of small pelagic fish consumption, we used Generalized Additive Models to examine relationships between the proportional abundance of Northern Anchovy and myctophids in PBF diets and environmental conditions (temperature, water column stratification, chlorophyll, climate indices), prey biomass estimates, and spatiotemporal factors using a subset of our dataset (2020-2024). Our results show the importance of diverse predictors such as sea surface temperature anomalies, water column stratification, and prey biomass in driving consumption of epipelagic and mesopelagic forage fish by PBF. As highly mobile predators, PBF are capable of foraging on prey across a range of vertical and horizontal habitats. We show that environmental and biological factors could potentially be used to predict the relative consumption of small pelagic fishes by pelagic predators, and contribute to understanding of ecosystem responses to environmental change.

S04, Oral, AbstractID=19095

Modeling vertical exchange processes in oceanic ecosystems to understand forage and predator dynamics

Jim **Ruzicka**

NOAA Pacific Islands Fisheries Science Center, Honolulu, HI, U.S.A.
E-mail: james.ruzicka@noaa.gov

Open ocean ecosystems support some of the most commercially valuable fisheries in the world, tuna and billfish, yet our ability to understand their spatiotemporal dynamics is limited by a poor understanding of their forage base. Studying oceanic micronekton presents unique hurdles: vast spatial scales, rarity of time-series observations, and the importance of diel vertical migration (DVM) across extreme thermal gradients as an ecosystem structuring element. To help address these challenges, I present the development of a ROMS-coupled, vertically-resolved ecosystem model of the oceanic central North Pacific (*CNP-EcoTran*). By explicitly incorporating the DVM of forage species, the model resolves critical pathways of vertical connectivity between epipelagic, mesopelagic, and bathypelagic zones and the consequences of their wide thermal environment. The model is here used to characterize the importance of critical knowledge gaps in open oceanic forage dynamics — community composition, food-web structure, thermal physiologies, and regional variations in DVM behavior — on forage and higher trophic level species. Such mechanistic modeling platforms are essential for the strategic forecasting of oceanic fish (and fishery) production in the face of natural environment variability and anthropogenic change.

S04, Oral, AbstractID= 19106 (CANCELLED)

Observing life in the California Current using environmental DNA (eDNA)

Francisco **Chavez**, Kathleen Pitz, Jacoby Baker, Kobun Truelove and Marguerite Blum

Monterey Bay Aquarium Research Institute, Moss Landing, California USA 93950
E-mail: chfr@mbari.org

Starting in 2014, with support from the US Marine Biodiversity Observation Network (MBON) program, our lab started collecting samples for eDNA in collaboration with a series of sampling programs that broadly cover the California Current from the California-Oregon border to the US-Mexico border. In Monterey Bay samples collected for other purposes and frozen in liquid nitrogen allowed us to assemble a monthly time series from 2008 to the present. Our partners include the NOAA Rockfish Recruitment and Ecosystem Assessment Survey (RREAS), the Applied California Current Ecosystem Studies (ACCES), Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO), and the Trinidad Head Line (THL). Here we present products from this collaboration showing time and space variations in marine biodiversity in the California Current from microbes to whales, related to the seasonal cycle and interannual to multidecadal variability.

SESSION 4

Forage Fish and Food Webs: Trophic Dynamics of Small Pelagic Fish, from Freshwater to the Open Ocean

Poster Presentations

S04, Poster, AbstractID=18826, PosterID: S04-P1, (ECOP)

Study of the trophic behavior of sardine and anchovy in the central Atlantic of Morocco

Soukaina **Ragmane**, Hicham Masski and Meryame Elmediouni

Presented by Sarah Bouasse on behalf of Soukaina Ragmane

National Fisheries Research Institute, Casablanca, Morocco.
E-mail: soukaina.ragmane@gmail.com

Small pelagic fish are central to marine food webs, linking zooplankton to higher predators and supporting regional fisheries. In the Moroccan upwelling system, the European anchovy (*Engraulis encrasicolus*) is an important forage species, while the sardine (*Sardina pilchardus*), which feeds on a wide range of prey sizes using a filter-feeding strategy, occupies the lowest trophic position among fish. This study examined the diet of anchovy and sardine on the central Atlantic continental shelf of Morocco, between Cape Ghir (31°N) and Cape Boujdour (26°N), using 150 individuals anchovy and 359 individuals sardine collected during a hydroacoustic survey conducted during November 2022. Anchovy stomach content analysis revealed a predominantly zooplanktivorous diet, with copepods identified as the primary prey, based on the percentage of occurrence (93%), amphipods (33%) ,euphausiids (38%) ,mysids (23%), and small fish (42%) were consumed less frequently and considered secondary prey, and the sardine diet in this study area is unbalanced, given the dominance of copepods as prey, in this study area showed a preference for small prey in large numbers, which qualifies them as filter feeders. Statistical analysis showed that the diet depended mainly on the prey composition of each site, the trophic conditions of each site and an affinity between certain prey. These results indicate that copepods are the main prey of anchovy and sardine serving as its primary trophic resource in the Moroccan upwelling system, and also emphasize methodological constraints associated with differential prey digestion rates.

S04, Poster, AbstractID=18930, PosterID: S04-P2

Intra-and interspecific competition for prey organisms among sardine, anchovy, and mackerel

Yuji **Okazaki**[1], Kazuaki Tadokoro[1] and Kiyotaka Hidaka[2]

[1]Fisheries Resources Institute, Japan Fisheries Research and Education Agency, Shiogama, Japan. E-mail: okazaki_yuji37@fra.go.jp
[2]Fisheries Resources Institute, Japan Fisheries Research and Education Agency, Yokohama, Japan

Understanding the mechanisms behind fluctuations in the recruitment of small pelagic fish in waters surrounding Japan requires insight into environmental factors (temperature and food availability) affecting the survival of larvae and juveniles from the Kuroshio Extension to the Mixed water region. However, few studies have examined the feeding habits of larvae and juveniles, leaving details of their food utilization unclear. Furthermore, in recent years, declining body condition in chub mackerel has become a concern. It has become clear that reduced body condition affects egg quality and larval survival through maternal effects. Consequently, intra- and interspecific competition for prey, which influences body condition, has also been paid attention to, necessitating feeding studies from new perspectives. This study, therefore, demonstrates the actual state of prey utilization and competition by reviewing the feeding habits of sardine (*Sardinops melanostictus*), anchovy (*Engraulis japonicus*), and mackerel (*Scomber* spp.) primarily in the Kuroshio Extension and the Mixed water region. Comparing the size composition of prey consumed by three small pelagic fish species according to their body size revealed that sardine and anchovy consumed prey of similar sizes from the larval stage through adulthood. In contrast, mackerel consumed larger prey as they grew. However, mackerel species under 40 mm in body length consumed prey of similar size to sardine and anchovy, suggesting that sardine and anchovy could potentially compete with mackerel species during specific life stages.

S04, Poster, AbstractID=18934, PosterID: S04-P3, (ECOP)

Diet of the Atlantic Mackerel (*Scomber colias*) along the Moroccan Atlantic Coast between Cape Ghir and Cape Boujdor

Meriem **Elmediouni**, Hicham Masski and Soukaina Ragmane.

Presented by Sarah Bouasse on behalf of Meriem Elmediouni

National Fisheries Research Institute,Casablanca,Morocco. E-mail : contact@inrh.ma

In Morocco, small pelagic fish account for nearly 80% of total fishery landings, with the Atlantic mackerel (Scomber colias) representing approximately 10%. Analysis of the diet of this species provides essential information for understanding its ecology and life history strategies, and supporting the sustainable management of marine resources.

The dietary variability of Scomber colias was examined based on stomach content analysis of 347 individuals collected between Cape Ghir (30°37'N) and Cape Boujdor (26°07'N). Copepods were the dominant prey, occurring in 100% of stomachs and indicating their role as preferential food items. Fish, euphausiids, and mysids also showed high occurrence frequencies (>50%). Amphipods and polychaetes exhibited moderate occurrence (20%). In contrast, branchiopods, crabs, tunicates, and decapods were less frequent, while bivalves, chaetognaths, other crustaceans, and stomatopods occurred very rarely (<10%), suggesting they are accidental prey.

The Atlantic mackerel thus exhibits a piscivorous and opportunistic feeding behavior, combined with marked trophic flexibility. This plasticity allows the species to adapt its diet to spatio-temporal fluctuations in the species composition of the zooplankton, dominated by copepods in the upwelling zones along the Moroccan Atlantic coast. These findings provide valuable insights into the ecological role of Scomber colias and improve our understanding of the trophic dynamics of exploited small pelagic fish in Morocco.

S04, Poster, AbstractID=19051, PosterID: S04-P4, (ECOP)

Trophic coupling of zooplankton and forage fishes on the Northeast U.S. Shelf revealed by stable isotopes

Alexandra C. **Cabanelas**

Woods Hole Oceanographic Institution, Woods Hole, MA, U.S.A.E-mail: acabanelas@whoi.edu

Forage fishes form a critical trophic link between plankton production and higher predators, yet how seasonal and interannual variability in baseline carbon and nitrogen sources influences their feeding dynamics on the Northeast U.S. Shelf (NES) remains poorly understood. Shifts in isotopic composition and prey availability may alter forage fish trophic position and niche overlap, reflecting changes in food web connectivity and efficiency. We analyzed bulk stable isotope values ($\delta^{13}C$ and $\delta^{15}N$) of size-fractionated zooplankton and dominant forage fishes to characterize spatial and temporal variation in trophic structure and resource use. Zooplankton samples were collected during seasonal Northeast U.S. Shelf–Long Term Ecological Research (NES–LTER) cruises, while forage fishes were obtained from NOAA Northeast Fisheries Science Center Bottom Trawl Surveys conducted in spring and fall. By integrating isotope data with forage fish diet and zooplankton abundance data, we assessed how changes in prey composition influence trophic coupling along a shelf gradient. Preliminary results reveal inshore–offshore gradients in $\delta^{15}N$, size-dependent enrichment across zooplankton size fractions, and seasonal isotopic shifts consistent with changes in zooplankton community structure and primary production. As a next step, we will apply compound-specific isotope analyses of amino acids (CSIA-AA) to disentangle baseline and trophic effects and quantify trophic position and niche differentiation among co-occurring forage fish species in the NES. This work advances our understanding of how environmental variability and lower-trophic processes shape forage fish communities across the NES and other continental shelf regions.

SESSION 5

Spatiotemporal Dynamics of Small Pelagic Fishes in a Changing Ocean

Oral Presentations

S05, Invited, AbstractID=18843, (ECOP)

Chromosomal inversions and selection shape the population structure of Pacific herring

Eleni L. **Petrou**[1,2], Kyle Rosendale[3], Todd Sandell[4], Jeff Feldpausch[3], Dayv Lowry[4,5], Madonna Moss[6] and Lorenz Hauser[1]

[1]School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA, U.S.A.
[2]U.S. Geological Survey, Alaska Science Center, Anchorage, AK, U.S.A.
E-mail: elpetrou@gmail.com
[3]Sitka Tribe of Alaska, Sitka, AK, U.S.A.
[4]Washington Department of Fish and Wildlife, Mill Creek, WA, U.S.A.
[5]Present address: NOAA Fisheries, Lacey, WA, U.S.A.
[6]University of Oregon, Eugene, OR, U.S.A.

The processes that shape phenotypic and genetic diversity in wild populations are critical for conservation and management planning. Such diversity underpins the evolutionary potential of populations to adapt to changing environmental conditions and can contribute to asynchronous population dynamics, which help stabilize the overall abundance of harvested species. This is particularly important for forage fish such as Pacific herring (*Clupea pallasii*), which are foundational to coastal food webs and fisheries. Their environment and life history would suggest high connectivity and extensive dispersal, yet in some cases there is considerable population structure on relatively small geographic scales. The mechanisms creating and maintaining this structure are relatively unknown and may include external factors, such as dispersal barriers and environmental variation, as well as internal factors, such as genome structure, genomic incompatibility and population history. In this study, we examined genome-wide patterns of divergence among sympatric herring populations that differ in spawn timing (i.e., winter, spring, and late-spring spawners), using low-coverage whole genome sequencing of 556 spawning individuals from the Pacific Northwest coast. Our results reveal that large chromosomal inversions are major drivers of genetic differentiation. These inversions were relatively rare in spring-spawners, which represent most of the spawning biomass. In contrast, winter and late-spring spawners shared similar inversion frequencies but diverged at narrow genomic regions, suggesting localized selection. Together, our results indicate that both large structural variants and selection at specific loci contribute to genetic differentiation among spawning phenotypes, highlighting the complex genomic architecture underlying life-history variation in this ecologically and economically important species.

S05, Oral, AbstractID=18791, (ECOP) (CANCELLED)

Climate-induced changes in habitat suitability for artisanal stocks in the inland sea of northern Chilean Patagonia.

Nicolás **Muñoz-Aroca**[1,2,3], Sergio Neira[2,3], Luis A. Cubillos[2,3], Reinaldo Rivera[4], Ana Arriagada[1,2] and Diego Narváez[2,3]

[1]Programa de Doctorado en Ciencias con Mención en Manejo de Recursos Acuáticos Renovables (MaReA), Facultad de Ciencias Naturales y Oceanográficas, Universidad de Concepción, Concepción, Chile.
[2]Center COPAS Coastal, Universidad de Concepción, Chile.
[3]Instituto de Fomento Pesquero, Valparaíso, Chile. E-mail: nicolas.munoz@ifop.cl
[4]Instituto Milenio de Oceanografía, Concepción, Chile.

Climate change (CC) affects the conditions of marine habitats and the distribution of the species that inhabit them. In the inland marine ecosystem of northern Chilean Patagonia (41°28.6 S–45°30' S), CC is expected to cause less precipitation and higher temperatures, which could affect the spatial distribution of valuable fish artisanal stocks, such as the forage Falkland spratt (*Sprattus fuegensis*) and three demersal predators, such as the Patagonian grenadier (*Macruronus magellanicus*), the southern hake (*Merluccius gayi*), and the pink ling (*Genypterus blacodes*). Since 2014, the fishing grounds of the artisanal pelagic fleet targeting Falkland spratt have been shifting towards the southern Gulf of Ancud, which could indicate a distribution shift towards more suitable habitats. This change could affect the availability of Falkland spratt for both the fleet and predators. In this study, the MAXENT modeling approach was used to evaluate the effect of three Shared Socioeconomic Pathways (SSP) scenarios (SSP 2, 3, and 5) on habitat suitability for the main fish species in the inland sea of northern Chilean Patagonia. Results indicated functional responses for temperature and salinity within the ranges found in previous studies. Temperature was the variable that contributed the highest percentage to the model for the southern sardine, while dissolved oxygen contributed the most to the model for demersal species. Currently, the most suitable habitats for the Falkland spratt are mainly distributed in the Gulf of Ancud and the Gulf of Corcovado. Projected suitable habitats for demersal species were found in the inner and outer margins of the study area. A contraction of the suitable area for Falkland spratt will be observed, with the remaining presence in the Gulf of Ancud and surrounding fjords, and a displacement of suitable habitat for demersal and pelagic species between 0.11 and 0.19° in the S, SE, and NW directions. These changes in suitable habitat for demersal species appear to be associated with low dissolved oxygen concentrations, which is consistent with the deoxygenated conditions present in the inland sea. In the case of Falkland spratt, changes in the extent of suitable habitat would be associated with warm waters and narrow salinity ranges in the fjords and channels of the inland marine ecosystem of northern Patagonia. Projected changes in suitable areas could affect future production and increase the vulnerability of the main resources caught by the artisanal fleet in the inland sea to CC.

S05, Oral, AbstractID=18802 (Pre-recorded)

Spatiotemporal dynamics of Argentine anchovy (*Engraulis anchoita*) stocks south of 34°S

Manuela **Parietti**[1], Paula Orlando[1], Brenda Temperoni[1,2], M. Cecilia Spath[1], Germán E. Buratti[1] and Claudio C. Buratti[1,3]

[1]Instituto Nacional de Investigación y Desarrollo Pesquero, Mar del Plata, Buenos Aires, Argentina. E-mail: mparietti@inidep.edu.ar
[2]Instituto de Investigaciones Marinas y Costeras (IIMyC, UNMdP-CONICET), Mar del Plata, Argentina
[3]Facultad de Ciencias Exactas y Naturales (FCEyN), Universidad Nacional de Mar del Plata, Mar del Plata, Argentina.

The Argentine anchovy (*Engraulis anchoita*) is distributed across the Argentine Shelf in the Southwest Atlantic Ocean between 34° and 47°30′S, and is managed as two distinct stocks separated at 41°S. This species, the most abundant fish resource in the southwestern Atlantic Ocean, is exploited well below its potential. Argentine anchovy plays a key ecological role as a primary food source for numerous fish, seabirds, and marine mammals. Understanding its spatial and seasonal abundance dynamics provides valuable insights into ecosystem functioning. Using acoustic and *in situ* oceanographic data, we analyzed the influence of environmental variables on the acoustic abundance (nautical area scattering coefficient *sA*; m^2 nmi^{-2}) of *E. anchoita* over a 10-year period for the southern stock (Parietti et al. 2025) and over a 30-year period for the northern stock, across both warm and cold seasons. Additionally, a localized assemblage within a semi-enclosed deep gulf (San Matías Gulf) was examined during the spring. Our results reveal a mixed influence of oceanographic variables on seasonal abundance, as well as a contraction–expansion distribution pattern in both stocks. In the cold season, the southern stock contracts northward to lower latitudes (~45°30′S) and then expands southward to 47°30′S during the warm season. Conversely, the northern stock contracts to around 39.5°S and 200 m depth in the cold season, expanding northward to 41°S in the warm season, but remaining in shallower, more coastal waters (~100 m depth). The seasonal expansions differ in function: feeding in the southern stock and reproduction in the northern. In SMG, *E. anchoita* occurred mostly nearshore in spring season, influenced by bottom temperature and salinity, and providing novel information for understanding their role in the Gulf's food web and their link to higher trophic levels. Understanding the spatial and seasonal distribution of small pelagic species like *E. anchoita* is crucial for sustainable resource management within an ecosystem-based approach.

S05, Oral, AbstractID=18811

Changing distribution of juvenile Pacific herring in an expanding population in the Strait of Georgia, British Columbia

Chris **Rooper**[1], Jennifer L. Boldt[1], Matthew Thompson[1], Chrys Neville[1] and Stéphane Gauthier[2]

[1]Pacific Biological Station, Fisheries and Oceans Canada, Nanaimo, BC, Canada.
E-mail: chris.rooper@dfo-mpo.gc.ca
[2]Institute of Ocean Sciences, Fisheries and Oceans Canada, Sidney, British Columbia, Canada

The volatility in forage species productivity has led to substantial interest in both predicting recruitment of forage species and in determining the relationships between environmental factors and recruitment, mortality and distribution. Strait of Georgia Pacific herring (*Clupea pallasi*) are a species that are a prey for bird, marine mammal, salmonids and groundfish species, while also supporting a commercial, recreational and First Nations fisheries. This study combined multiple pre-recruit surveys with multiple gear types in a spatial-temporal modeling framework to predict the distribution and abundance of juvenile (Ages 0 and 1) herring. Modeling showed that in most years herring were present in all regions of the Strait of Georgia in June and September, but there was a distributional shift in the center of biomass to the south over the last three decades. These changes were related to sea surface temperature and salinity, but the primary driver of juvenile herring distribution was the physical features of the habitat, such as depth and geologic setting. This resulted in the model predicting consistent hotspots in the distribution of both Age 0 and Age 1 herring with higher biomass closer to shore and near the Gulf Islands regions, compared to the open basin of the Strait of Georgia. This pattern was consistent except in years of very high abundance when herring were more broadly and evenly distributed. The annual index of abundance of both year-classes from the model was less variable than the design-based index and about 22% of the variability in the annual recruitment of Pacific herring was explained by the abundance of age 0+ herring. Over the last three decades the spawning biomass of herring in the Strait of Georgia has generally increased and the pre-recruit surveys have been useful in capturing both the changes in the ecology of the Strait of Georgia forage community as well as in explaining some of the high variability in recruitment.

S05, Oral, AbstractID=18832

Deep learning classification of otoliths for spatiotemporal detection of mixing dynamics in Baltic herring stock components

Szymon **Smoliński**, Krzysztof Świtek and Mariia Tiurina

National Marine Fisheries Research Institute, Gdynia, Poland. E-mail: smolinski@mir.gdynia.pl

Understanding the spatial mixing of fish stock components is essential for adaptive fisheries management, particularly in dynamic systems like the Baltic Sea. Baltic herring (*Clupea harengus*) consists of genetically and ecologically distinct components that overlap seasonally and regionally, complicating efforts to quantify migration, connectivity, and productivity. We propose an operational framework that uses deep neural networks to detect spatial patterns of stock mixing from otolith morphology. Digital otolith images collected during scientific surveys (2021–2024) were classified using a ResNet-50 model trained to distinguish between the northern and southern components of the central Baltic stock. Unlike traditional applications of AI-based otolith classification that focus solely on automation, we use prediction probabilities as indicators of mixing intensity across space and time. Emerging patterns, such as pre-spawning aggregations of one component in specific areas or spatial shifts in dominance likely linked to environmental conditions, suggest that AI-derived predictions can improve our understanding of fish distribution processes. Model interpretability was investigated through Grad-CAM visualizations, which confirmed that predictions are driven by biologically meaningful otolith features. When coupled with growth and age structure differences between components, these predictions provide insight into both movement dynamics and their demographic consequences. This study demonstrates how AI can move beyond static classification toward real-time spatial monitoring. By embedding machine learning outputs into survey-based spatial frameworks, we offer a scalable tool for detecting distribution shifts, migration fronts, and connectivity hotspots, contributing to more dynamic stock-based management in a changing Baltic Sea.

S05, Oral, AbstractID=18836

Insights in the European sardine genome: Unraveling population structure and somatic condition

Marta Caballero Huertas[1,2*], Judith Ollé-Vilanova[3*], Xènia Frigola-Tepe[1], Marta Muñoz[1] and Jordi **Viñas**[3]

[1]Institute of Aquatic Ecology, Universitat de Girona, Girona, Spain.
[2]AquaDivE team. Institut des Sciences de l'Évolution de Montpellier. Université de Montpellier.
[3]Laboratori d'Ictiologia Genètica (LIG), Department of Biology, Universitat de Girona, Girona, Spain. E-mail: jordi.vinas@udg.edu
[*]Equally contributed

In recent years, the European sardines have exhibited a marked decline in both somatic condition and body size, prompting concerns about the long-term viability of their populations. Despite its importance, the population structure and adaptive variability of this species remain insufficiently understood. In this study, we employed a genomic approach (ddRADseq) to investigate population structure and explore the associations between genetic markers and somatic condition from six locations across the Atlantic and Mediterranean. Using 5,506 high-quality SNPs, we identified four genetically distinct populations: (1) Atlantic-Alboran, (2) Northwestern Mediterranean (Catalan coast), (3) Adriatic, and (4) Aegean. The Almeria-Oran Front was confirmed as a strong biogeographical barrier, limiting gene flow between Atlantic and Mediterranean populations. The Adriatic population showed evidence of genetic admixture, suggesting its role as a transitional zone between the western and eastern Mediterranean basins. Moreover, estimates of effective population size (Ne) decreased from west to east, reaching their lowest value in the Aegean population. While population differentiation was evident using both neutral and selected loci, the outlier SNPs (2.3% of total) contributed disproportionately to genetic divergence (F_{ST} = 0.242), highlighting the role of local adaptation. Moreover, 19 SNPs were significantly associated with somatic condition (Kn), although none overlapped with those contributing to population structure, suggesting distinct genetic mechanisms underlying adaptation and condition variability. These findings provide novel insights into the genetic structure and adaptive potential of the European sardine, offering the first genomic evidence of genetic loci associated with somatic condition. Our results emphasize the importance of integrating genomic and phenotypic data to develop conservation and management strategies for this declining species.

Keywords: ddRADSeq, Fish health, Fisheries, Le Cren, Sardina pilchardus

S05, Oral, AbstractID=18846, (ECOP)

Characterizing the spatio-temporal variability and interaction in anchovy spawning grounds: A case study in the North Aegean Sea (eastern Mediterranean)

Eleni **Servou**[1,2], Maxime Olmos[3], Martin Huret[3], Pierre Petitgas[4], Eudoxia Schismenou[1] and Stylianos Somarakis[1]

[1]Institute of Marine Biological Resources and Inland Waters, Hellenic Centre for Marine Research, Heraklion, Crete, Greece. E-mail: e.servou@hcmr.gr
[2]Biology Department, University of Crete, Heraklion, Crete, Greece
[3]DECOD (Ecosystem Dynamics and Sustainability), L'Institut Agro, IFREMER, INRAE, Brest, France
[4]IFREMER, RBE, Nantes, France

Understanding the underlying mechanisms driving marine species distribution is required in population ecology. In particular, it is critical understand the distribution of eggs as a characterization of spawning habitats, which i) represent the initial conditions of the life cycle driving recruitment, ii) are the location where DEPM surveys should focus, and iii) may evolve under the impact of climate change. However, characterizing their spatiotemporal distribution is challenging as it is driven by population intrinsic (such as SSB or density dependence processes) and extrinsic (such as environmental) factors. Using anchovy egg density data from the North Aegean Sea, eastern Mediterranean, collected from 2003 to 2022, this study aims at understanding the mechanisms underlying spatiotemporal changes in egg distribution. The Aegean Sea is characterized by strong hydrological and biological variability driven by the inflow of low-salinity and nutrient-rich waters, and its anchovy population is highly variable. Using geostatistical generalized linear mixed effect models (GLMM), we investigated whether spatiotemporal changes in egg distribution are driven by density dependence and/or by environmental variables. Our approach allowed us to partition the spatiotemporal variability into a temporal term (average temporal trend), a spatial term (expected spatial distribution on average over time), density and environmental effects, and spatiotemporal - residual variability (unexplained by covariates, unmeasured environmental conditions). Results revealed a consistent spatial pattern, with lower egg densities in areas beyond the continental shelf. Depth and sea surface salinity were key drivers of the spatial and spatial-temporal variability while spawning stock biomass or the total number of eggs explained most of the temporal variability. Density-dependent spatial dynamics were also detected. Our results appear to corroborate the basin model theory, with an increased spawning biomass leading to a local increase in egg density while promoting expansion offshore into saltier waters.

S05, Oral, AbstractID=18847

Effects of climate variability in the Gulf of California on two marine resources using satellite and fisheries data

Raúl **Aguirre-Gómez**

National Autonomous University of Mexico (UNAM), Coyoacan, CD. DE MEXICO, México.
E-mail: raguirre@geografia.unam.mx

The Gulf of California supports important fisheries nationwide, particularly that of sardines and shrimp. The present work aims to analyze the effect of climate variability on the capture of these two species. The analysis was carried out by considering live weight catch data and satellite-measured environmental variables: Sea Surface Temperature (SST) for sardines; Nightly Sea Surface Temperature (NSST) for shrimp; and Chlorophyll_ concentration [Chl_a] for both species. Satellite information was obtained through MODIS imagery, in the period 2011-2024. Seven fisheries zones were delimited on biological, geographical and political grounds: three for sardines and four for shrimp. Results indicate that [Chl_a] was higher in the coastal and large islands regions, reaching its highest peak in March and its lowest in August. SST varies from south to north, being January the month with the lowest SST and August the warmest. Sardine has a significant positive relationship with [Chl_a] (r = 0.659) and a negative one with SST (r = -0.582). Shrimp showed a high significant relationship with NSST (r = 0.857), and a no-significant statistical relationship with [Chl_a] (r = 0.114). The coast of Sonora and Sinaloa Mexican states are the regions with the highest [Chl_a], promoting sardine capture. Even though shrimp species did not show a good relationship with [Chl_a], it fairly grows in Sinaloa´s coast, the region with the largest [Chl_a], due to the presence of important lagoon systems, where shrimp are cultivated.

S05, Oral, AbstractID=18852, (ECOP)

Forage fish exhibit varied response to future ocean conditions: Implications for divergent predator-prey redistribution

Hunter M. **Milles**[1,2], Jerald McDermott[1], Nima Farchadi[1,3], Laura H. McDonnell[3], Justin J. Suca[4], Camrin D. Braun[3] and Rebecca L. Lewison[1]

[1]San Diego State University, San Diego, U.S.A. E-mail: hmilles@sdsu.edu
[2]Graduate Group in Ecology, University of California, Davis, Davis, CA, U.S.A.
[3]Woods Hole Oceanographic Institution, Woods Hole, MA, U.S.A.
[4]University of Hawai‘i at Mānoa, Honolulu, HI, U.S.A.

It is largely thought that distributions of marine top predators are mediated by a mixture of local prey availability and oceanographic conditions. Yet, quantifications of potential redistributions in key prey populations under changing ocean conditions, including forage fish, are poorly understood. Here, we leverage the U.S. Northeast Fisheries Science Center bottom trawl survey data, developing spatially explicit general linear mixed effect models for four species (*Clupea harengus, Ammodytes spp., Prepilus triacanthus, Alosa pseudoharengus*) for each trawl season, Spring and Fall, and compare model outputs to Atlantic bluefin tuna (*Thunnus thynnus*). Using downscaled global climate models, outputs revealed responses in forage fish suitable habitat that varied by species, season, and direction of redistribution. Overall, predicted spatial redistributions of forage fish were mismatched with redistributions of Atlantic bluefin tuna. For example, while Atlantic bluefin tuna were predicted to gain suitable habitat in the Gulf of Maine, all forage fish apart from butterfish were predicted to lose suitable habitat. Declines in suitable habitat were largely shared among predator and prey species in the Mid-Atlantic Bight and Georges Bank, although the magnitude of predicted loss in suitable habitat was markedly higher for forage fish in the spring season. Together, these mismatches in the future dynamics of forage fish prey and highly migratory predator distributions underscore broad unresolved ecosystem impacts as the effects of ocean change continue to accumulate. Illuminating divergent dynamics between economically important marine top predator species and prey energy sources is essential for supporting climate-ready management of fisheries.

S05, Oral, AbstractID=18867, (ECOP)

Distinguishing natal origins of larval Atlantic herring (*Clupea harengus*) in coastal Newfoundland using otolith microchemistry

Carolyn **Currie**[1], Ashley Tripp[1], Hannah Murphy[2] and Gail Davoren[1]

[1]University of Manitoba, Winnipeg, MB, Canada. E-mail: curriec1@myumanitoba.ca
[2]Fisheries and Oceans Canada, St. John's, NL, Canada

For marine fish, larval exchange among regions determines whether depleted populations can be replenished from other areas. Therefore, tracking larval dispersal, or ecological connectivity, among fish populations is crucial for stock management. Herring (*Clupea* spp.) are key forage fish throughout the Pacific and Atlantic, supporting commercial fisheries and transferring energy to higher trophic levels. In coastal Newfoundland, the current management structure for Atlantic herring (*Clupea harengus*) is based on tagging studies from the 1980s that show adults return annually to the same spawning grounds. Due to challenges tracking larval dispersal, however, it is unknown whether larvae are retained and whether adults spawn in their natal bay. Otolith chemistry provides a natural record of environmental conditions experienced by fish, offering a potential tool for assessing natal origins and larval dispersal. To determine the suitability of otolith chemistry for studying connectivity in Newfoundland Atlantic herring, we first examined the influence of ambient water chemistry on the pre-hatch otolith chemistry by experimentally increasing concentrations of non-essential trace elements during embryo incubation in the lab (1x, 2x, 3x, 4x, 5x ambient Strontium, Barium, and Strontium + Barium). Second, we sampled larvae from five bays in coastal Newfoundland to investigate bay-specific otolith chemical signatures. Trace element concentrations were quantified (n=20/bay or treatment) via laser ablation inductively coupled-plasma mass spectrometry. Findings will determine whether distinct bay-specific chemical signatures exist, indicating whether otolith chemistry is a suitable tool for assessing larval herring dispersal, allowing continued monitoring of dispersal dynamics and stock structure under predicted climate change scenarios.

S05, Oral, AbstractID=18883, (ECOP)

Spawning grounds, nursery grounds, and adult distributions of ecologically and economically important pelagic fishes in the NE Atlantic

Aaron **Brazier**

Centre for Environment, Fisheries, and Aquaculture Science (Cefas), Lowestoft, United Kingdom. E-mail: aaron.brazier@cefas.gov.uk

Identifying spawning grounds, nursery areas and describing the distribution of adults is vital for both fisheries and environmental management. Spawning and nursery grounds are subject to continual revision in line with changing behaviours of individual species. Updated spatial distributions of these important areas are presented for herring (*Clupea harengus*), sprat (*Sprattus sprattus*), sardine (*Sardina pilchardus*), anchovy (*Engraulis encrasicolus*), blue whiting (*Micromesistius poutassou*), horse mackerel (*Trachurus trachurus*), mackerel (*Scomber scombrus*), boarfish *(Capros aper),* and bogue (*Boops boops*). Accurate descriptions of adult distributions are especially important for fishers and managers, both on a temporal and spatial scale, to provide suitable catch advice. Internationally co-ordinated survey data collecting larvae were standardised to provide insights into spawning ground locations with juvenile abundance, standardised to adjust for survey and gear variation, indicating nursery areas. Mature adults (defined by length at maturity) showcase adult distributions.

S05, Oral, AbstractID=18886

The changing distributions of herring and sardine on the northwestern European Shelf, consequences for fisheries management

Richard D.M. **Nash**, Aaron Brazier, Rosana Ourens and Susan Kenyon

Centre for Environment, Fisheries & Aquaculture Science, Lowestoft Laboratory, United Kingdom. E-mail: richard.nash@cefas.gov.uk

Changes in the distribution of small pelagic fish populations over time is not a new concept. A classic example is the switch in dominance between herring (*Clupea harengus*) and sardine (*Sardina pilchardus*) in the western Channel, to the southwest of the British Isles. In more recent decades climate change has seen relatively rapid warming of annual temperatures on the northern European shelf, and this has consequences on the distributions of species which have warmer or cooler thermal niches. The two examples are, herring in the Celtic Sea and Channel area, which are at the southern extreme of their thermal distribution and sardine which are at the northern end of their thermal niche. Over the western European Shelf both species are exploited and are identified as distinct stocks with their own management and harvest regulations. In the Celtic Sea, the herring stock size is extremely low and does not appear to be rebuilding and there is evidence that Celtic Sea herring may be occurring in the Irish Sea more often and at older ages. Here, management has to deal with one stock below biologically safe limits (Celtic) and another where 'mixing' may be a consideration (Irish). In the case of sardine in the same area, population/stock abundance is increasing along with the productivity. For herring, management is having to adapt to lower sustainable harvest levels, and, in the case of sardine, management is having to consider introducing sustainable harvest levels as these populations increase in size and widen their distribution northward.

S05, Oral, AbstractID=18887, (ECOP)

Spatio-temporal modeling of juvenile sardine: Integrating fisheries data and environment

Daniela **Silva**[1,2], Raquel Menezes[3], Gonçalo Araújo[4,5], Ana Machado[6], Renato Rosa[7], Ana Moreno[1], Alexandra Silva[1] and Susana Garrido[1]

[1]Portuguese Institute for the Sea and Atmosphere (IPMA), Algés, Portugal.
E-mail: daniela.dasilva@ipma.pt
[2]Centre of Mathematics (CMAT), University of Minho, Braga, Portugal
[3]Centre of Mathematics (CMAT), University of Minho, Guimarães, Portugal
[4]NOVA University Lisbon, Lisboa, Portugal
[5]University of Algarve, Faro, Portugal
[6]University of Lisbon, Lisboa, Portugal
[7]Centre for Business and Economics Research, Coimbra University, Coimbra, Portugal

The European sardine (*Sardina pilchardus*) is the most important small pelagic fish (SPF) species in the northern Canary Upwelling Ecosystem (NCUE), with population dynamics strongly shaped by environmental variability and fishing pressure. While most distribution studies focus on the adults, understanding the spatial ecology of juveniles is essential for identifying nursery grounds, recruitment dynamics, and long-term stock resilience.

We applied a joint hierarchical spatio-temporal model integrating fishery-independent (FID) and fishery-dependent (FDD) data to investigate juvenile sardine distribution along the western and southern Iberian shelf, in the NCUE. The framework leverages the complementary strengths of both sources - mitigating survey limitations, reducing preferential sampling bias in FDD, and improving spatial and temporal resolution. Ecological and environmental variables (SST, chlorophyll-a, currents) are incorporated to explain juvenile spatio-temporal dynamics, providing a mechanistic understanding of habitat use.

This study introduces three advances compared with earlier application to adults: (i) explicit focus on juveniles, enabling identification of nursery grounds and early life-stage drivers; (ii) extension of vessel-specific catchability effects to both survey and commercial fleets, harmonizing heterogeneous observations; and (iii) inclusion of external conditions (e.g., bathymetry) to explain the spatial point process of fishing activity and improve ecological interpretation.

By combining diverse data streams with explicit environmental drivers, this study extends species distribution modelling to a critical life stage of sardine - advancing ecosystem-based fisheries management and supporting the PICES–ICES WG53 objectives on climate-resilient, cross-disciplinary science. This methodology can be applied to study forage fish spatial dynamics across different ecosystems.

S05, Oral, AbstractID=18905

Climate change impacts on small pelagic fish distribution in Northwest Africa: Trends, shifts, and risk for food security /Regional initiatives to tackle the impacts?

Abdoulaye **Sarre**[1], Hervé Demarcq[2], Noel Keenlyside[3], Jens-Otto Krakstad[4], Salaheddine El Ayoubi[5], Ahmed Mohamed Jeyid[6], Saliou Faye[1], Adama Mbaye[1], Momodou Sidibeh[7] and Patrice Brehmer[1,8]

[1]ISRA/CRODT, Dakar, Sénegal. E-mail: ablaysarrey@yahoo.fr
[2]MARBEC, IRD, Ifremer, CNRS, University Montpellier, Sète cedex, France
[3]Geophysical Institute, University of Bergen and Bjerknes Centre for Climate Research, Bergen, Norway
[4]Institute of Marine Research, Bergen, Norway
[5]INRH, Institut National de Recherche Halieutique, Casablanca, Maroc
[6]Institut Mauritanien de Recherche Océanographique et des Pêches, Nouadhibou, Mauritanie.
[7]Fisheries Department, FD, Marina Parade, Banjul, The Gambia
[8]IRD, University Brest, CNRS, Ifremer, LEMAR, SRFC, CSRP, Dakar, Senegal

Climate change is recognised to lead to spatial shifts in the distribution of small pelagic fish, likely by altering their environmental optima. Fish supply along the Northwest African coast is significant at both socio-economic and cultural levels. Evaluating the impacts of climatic change on small pelagic fish is a challenge and of serious concern in the context of shared stock management. Evaluating the impact of climate change on the distribution of small pelagic fish, a trend analysis was conducted using data from 2363 trawl samplings and 170,000 km of acoustics sea surveys. Strong warming is reported across the Southern Canary Current Large Marine Ecosystem (CCLME), extending from Morocco to Senegal. Over 34 years, several trends emerged, with the southern CCLME experiencing increases in both wind speed and upwelling intensity, particularly where the coastal upwelling was already the strongest. Despite upwelling-induced cooling mechanisms, sea surface temperature (SST) increased in most areas, indicating the complex interplay of climatic-related stressors in shaping the marine ecosystem. Concomitant northward shifts in the distribution of small pelagic species were attributed to long-term warming trends in SST and a decrease in marine productivity in the south. The abundance of Sardinella aurita, the most abundant species along the coast, has increased in the subtropics and fallen in the intertropical region. Spatial shifts in biomass were observed for other exploited small pelagic species, similar to those recorded for surface isotherms. An intensification in upwelling intensity within the northern and central regions of the system is documented without a change in marine primary productivity. In contrast, upwelling intensity is stable in the southern region, while there is a decline in primary productivity. These environmental differences affected several small pelagic species across national boundaries. This adds a new threat to these recently overexploited fish stocks, making sustainable management more difficult. Such changes must motivate common regional policy considerations for food security and sovereignty in all West African countries sharing the same stocks.

S05, Oral, AbstractID=18923, (ECOP) (CANCELLED)

Modelling individual movement decisions of forage fish: A mapping review

Deepanjali **Prasad**[1], Alethea Barbaro[1] and Samuel Subbey[2]

[1]Delft University of Technology, Delft, The Netherlands. E-mail: dpprasad@tudelft.nl
[2]Institute of Marine Research, Bergen, Norway

Forage fish are typically small, schooling fish that integrate energy across lower and higher trophic levels. They are ecologically pivotal and commercially valuable. Their management depends on reliable predictions of their spatio-temporal distributions and migratory routes, which is an increasing challenge under climate change. A widely used approach to study these processes are individual-based or agent-based models (IBMs or ABMs), which define movement rules at the level of individuals while incorporating intra-specific variation and energy budgets.

Many forage fish species undertake migrations that range from tens to hundreds of kilometers, associated with key life-history stages such as foraging, spawning, and overwintering. These stages are closely tied to bioenergetic processes. Energetic gains or costs act as drivers and constraints of movement. By linking movement decisions to underlying metabolic activity we retain individual-specific responses to changing environmental conditions. In this review, we map the literature on forage fish movement, focusing on IBMs that incorporate energetics. We describe the mathematical models used and the commonly represented abiotic and biotic stimuli. By synthesizing common concerns across studies, we identify recurring gaps in current modelling approaches and make suggestions for improving the representation of biotic interactions. Further, we highlight the need for the incorporation of individual-based energetics to capture the intrinsic link between physiology, movement and distribution.

S05, Oral, AbstractID=18925, (ECOP)

Multiple chromosomal inversions reveal the evolutionary history of lineage divergence and admixture in the European sardine

Marina **Puebla-Aparicio**[1], Alice Manuzzi[1], Pierre-Alexandre Gagnaire[2], Natalia Díaz-Arce[1], Kenza Mokhtar-Jamaï[3] and Naiara Rodriguez-Ezpeleta[1]

[1]AZTI, Marine Research, Basque Research and Technology Alliance (BRTA), Sukarrieta, Spain. E-mail: mpuebla@azti.es
[2]ISEM, Univ Montpellier, CNRS, EPHE, IRD, Montpellier, France
[3]Institut National de Recherche Halieutique (INRH), Centre Régional d'Agadir, Laboratoire de Génétique des Populations Halieutiques, Agadir, Morocco

Chromosomal inversions are increasingly recognized as key drivers of evolutionary processes, shaping adaptive and deleterious variation and population divergence. Inversions are therefore particularly relevant when assessing adaptive capacity under environmental changes, yet their ecological and evolutionary significance is poorly understood and overlooked in fisheries management. Multiple polymorphic inversions have been identified in the European sardine (*Sardina pilchardus*), a highly valuable small pelagic fish (SPF) in the Northeast Atlantic and the Mediterranean. Here, we investigate the contribution of these inversions to sardine population structure, connectivity, and evolutionary history across its distribution. Using ~6 million SNP markers from low-coverage whole-genome sequencing of 345 individuals across 44 locations, we identified 24 chromosomal inversions, a notably high number compared to other clupeid species. Ancestral inference suggests that half of the identified chromosomal inversions originated in the Mediterranean, and the remaining half in the southeastern North Atlantic, during a period of divergence. These two lineages subsequently admixed in the Northeast Atlantic, forming a wide contact zone with a high level of inversion polymorphism. Rather than contributing to ecotype differentiation as in other species, our findings suggest that inversions have contributed to maintaining partial reproductive isolation between geographical lineages following secondary contact, despite the wide admixture zone observed today. While their adaptive significance remains unclear, understanding the geographic distribution of inversions provides a valuable framework for studying population structure and connectivity. It also offers novel insights into the mechanisms driving SPF spatial dynamics, with implications for understanding past events, forecasting future changes, and informing fisheries management.

S05, Oral, AbstractID=18927

Climate driven shifts in larval and juvenile small pelagic fish and salmon prey dynamics in the northern California Current

Elizabeth A. **Daly**[1], Toby D. Auth[2], Cheryl A. Morgan[1], Catherine Nickels[3] and Brian J. Burke[3]

[1]Cooperative Institute for Marine Ecosystem and Resources Studies, Oregon State University, Newport, OR, U.S.A.E-mail: Elizabeth.Daly@oregonstate.edu
[2]Pacific States Marine Fisheries Commission, Newport, OR, U.S.A.
[3]NOAA, Northwest Fisheries Science Center, Seattle, WA, U.S.A.

The structure and seasonality of small pelagic fish assemblages in the Northern California Current have shifted in response to evolving ocean conditions. Long-term observations show that the assemblage of trophically-similar, slender, near-surface small pelagic fish larvae has changed from being dominated by smelts in winter and northern anchovy in spring-summer, to sardines and smelts from winter through summer. This suggests a potential shift in forage fish assemblages likely driven by changing ocean temperature, currents, or possible competition. Most notably, since 2015, larval sardines have been observed in the northern California Current early in the year (winter-spring) and in nearshore coastal waters, in deviation from our time-series dating back to 1998. These larvae have survived to the juvenile stage in large numbers in May 2021, 2023, and especially 2024, where they were consumed as a novel prey by Columbia River spring Chinook salmon when they first out-migrated into the ocean. However, juvenile spring Chinooks salmon's dependence on YOY sardines appears to fluctuate with total prey biomass. In 2024, approximately 30% of the juvenile spring Chinook salmon consumed juvenile sardines, when there was a low biomass of other small pelagic fish prey taxa in the environment. However, in 2023, the salmon consumed few sardines, when the total prey field biomass was approximately four times higher. Continued monitoring will be critical for understanding how emerging small pelagic fish assemblages alter energy flow and recruitment success in this dynamic coastal ecosystem.

S05, Oral, AbstractID=18936, (ECOP)

Revisiting the otolith stable oxygen isotope−temperature model of Pacific sardine

Daisaku **Suda**[1], Alexanra Bagarinao Regalado[1*], Emmanis Dorval[2], Tatsuya Sakamoto[3], Toyoho Ishimura[3], Brad Erisman[4] and Shinichi Ito[1]

[1]AORI, The University of Tokyo, Kashiwa, Chiba, Japan. E-mail: daifish@g.ecc.u-tokyo.ac.jp
[2]Ocean Associates Inc., under contract with Southwest Fisheries Science Center (SWFSC), La Jolla, CA, U.S.A.
[3]Kyoto University, Kyoto, Japan
[4]NOAA Southwest Fisheries Science Center, Fisheries Research Division, La Jolla, CA, U.S.A.
[*]Equivalent lead author

Pacific sardine and Japanese sardine are ecologically and commercially important in the California and Kuroshio Current Ecosystems, respectively. Pacific sardine is managed assuming two subpopulations (northern and southern), although recent genomic studies showed the existence of one homogeneous population. Ratios of subpopulations in catches are derived from habitat models, assuming the northern subpopulation inhabits waters of ≤ 17°C. Whether there are temperature-based spatial segregations of Pacific sardine have yet to be validated. [$\delta^{18}O_{otolith}$] is commonly used to reconstruct water temperatures experienced by fish over their lifespan. [$\delta^{18}O_{otolith}-\delta^{18}O_{water}$] decreased linearly with water temperature, but this relationship may be species-specific. Previous models of Pacific sardine and Japanese sardine differed significantly, but differences in experimental designs and analytical methods were identified as potential factors influencing their intercept and slope. We re-examined the Pacific sardine model (PSM), using similar methods to those of Japanese sardine. Juvenile fish, injected with oxytetracycline (OTC) to mark their otoliths, were reared over ~12 months in 2014-2015. Fish were randomly assigned to tanks maintained at constant temperatures (13°C, 15°C, 17°C, and 21°C). Otoliths (n=14-15/tank) were micro-milled to collect $CaCO_3$ powder from the OTC mark to the margin. Powder samples were analyzed for $\delta^{18}O_{otolith}$ using a microgram-scale calcite auto-measurement line (MICAL3c). $\delta^{18}O_{water}$ was estimated from seawater collected at the SIO Pier in 2014-2015. We derived a new PSM whose parameters were statistically similar to those of Japanese sardine. This PSM could help study fine spatial structures in the distribution of Pacific sardine, while providing a better framework for apportioning catches.

S05, Oral, AbstractID=18947 (CANCELLED)

Pelagic resources dynamics in the Cape Blanc transition zone at 21°00′n: Between the latitudinal shift paradigm and climate warming

Najib **Charouki**[1], Kamal Mamza[1], Abdelmajid Dridi[1], Mohamed A. Jeyid[2] and Nikolioudakis, Nikolaos[3]

[1]Institut National de Recherche Halieutique (INRH), Casablanca, Morocco.
E-mail: charouki@inrh.ma
[2]Institut Mauritanien de Recherches Océanographiques et des Pêches (IMROP), Nouakchott, Mauritania
[3]Institute Of Marine Research (IMR), Bergen, Norway

The poleward shift of marine species under ocean warming is a widely recognized pattern in global change biology. Within the Canary Current Large Marine Ecosystem (CCLME), this paradigm would suggest that tropical-affinity fishes expand northward as sea temperatures rise. However, the Cap Blanc region (21°00'N) represents a complex transition zone where this pattern may not necessarily hold. This study draws on long-term data from extensive scientific assessment surveys conducted by both *Dr. Fridtjof Nansen* and local research vessels along the CCLME, complemented by fisheries landing data. These datasets were analyzed to assess abundance trends in key small pelagic species, including *Sardina pilchardus* and *Sardinella aurita*. Contrary to prevailing assumptions, preliminary results reveal inconsistent or even opposing trends: some tropical-associated species have declined in northern areas over time, despite warming conditions, whereas temperate-affinity species, such as sardine, have become more abundant south of Cap Blanc. These observations indicate that ocean warming alone cannot fully account for the dynamics of these resources. We highlight that local oceanographic variability, tropho-dynamic interactions, and fishing pressure may modulate species responses in this ecologically critical zone. By emphasizing these nonlinear and region-specific patterns, the study underscores the complexity of small pelagic dynamics under climate change. Further analyses are planned to better understand the drivers behind these distributional shifts and to provide insights into the ecological processes shaping shared pelagic resources across the CCLME region.

S05, Oral, AbstractID=18954, (ECOP)

From tropics to temperate: Latitudinal variation in life-history traits and connectivity in range-expanding *Sardinella lemuru* populations

Alexanra A. **Bagarinao-Regalado**[1,2,5], Daisaku Suda[1,2], Toyoho Ishimura[3], Wilfredo L. Campos[5], Kaito Inoue[4], Koki Matsuda[4] and Shin-ichi Ito[2]

[1]Department of Aquatic Bioscience, Graduate School of Agricultural and Life Sciences, The University of Tokyo, Tokyo, Japan. E-mail: regaladoab@aori.u-tokyo.ac.jp
[2]Atmosphere and Ocean Research Institute, The University of Tokyo, Chiba, Japan
[3]Graduate School of Human and Environmental Studies, Kyoto University, Kyoto, Japan
[4]Miyazaki Prefectural Fisheries Research Institute, Miyazaki, Japan
[5]OceanBio Lab, Division of Biological Sciences, College of Arts and Sciences, University of the Philippines Visayas, Miagao, Philippines

Spatial disequilibrium drives fish populations to shift through space, leading to expansions or contractions in their distribution ranges and consequent changes in life-history traits among populations. The Bali sardinella (*Sardinella lemuru*) is one of the most abundant sardine species in the tropical western Pacific but in recent years its distribution has extended northward into the temperate waters off Japan. Based on reproductive traits and otolith microstructure analyses, contrasting life-history traits have been observed between tropical and temperate populations: the tropical population exhibits faster early life growth (0.5 – 1.3 mm d-1), smaller size (~17 cm SL), younger (smaller) age (size)-at-maturity (< 1 year), longer spawning duration (6 – 9 mos.), lower fecundity (mean: 20,858), and smaller to medium-sized eggs (mean: 303 µm). In contrast, the temperate population displays slower early life growth (0.25 – 0.6 mm d-1), larger size (~23 cm SL), older (bigger) age (size) -at-maturity, higher fecundity (mean: 50,971) and bigger eggs (mean: 533 µm). The results suggest a trade-off and differing energy allocation strategies between these populations. Moreover, high-resolution otolith stable oxygen isotopes analysis indicate that the temperate population is likely composed of both locally hatched individuals while others are likely transported from warm waters in the south (e.g. Taiwan and Philippines). This appears to be consistent with the study that these regions share a genetic degree of similarity. While the drivers of this expansion remain unclear, the results of this study provide valuable insights into how populations respond to environmental changes, highlighting potential adaptation and survival strategies in the context of climate change.

S05, Oral, AbstractID=18960 (CANCELLED)

Evolution of sardinella abundance and distribution patterns in relation to climatic variability in Angolan waters, 1994-2024

Filomena Vaz **Velho**[1], Marek Ostrowski[2], Virgilio Estevão[1] and Miguel André[1]

[1]National Fishery and Marine Research Institute, Luanda, Angola.
E-mail: filomena.velho@minpermar.gov.ao
[2]Institute of Marine Research, 5817 Bergen, Norway. E-mail: marek@hi.no

In the southeastern tropical Atlantic, the reproduction of small pelagic fishes occurs under a distinct regime in which remotely forced coastally trapped waves, rather than local winds, drive coastal upwelling. This environment is highly sensitive to long-term ocean warming and interannual warm and cold events, resulting in pronounced year-to-year variation in the extent, quality, and seasonal persistence of the reproductive habitat of sardinella. The two dominant species, *Sardinella aurita* and *S. maderensis*, exhibit contrasting habitat preferences, leading to variable impacts of this environmental variability depending on their relative proportions within the population. We examined how climate variability from 1994 to 2024 influenced changes in the structure and distribution of the Angolan sardinella population. Five major periods were identified: 1994–2004 — a stable phase dominated by *S. maderensis*, when population size and distribution patterns were largely insensitive to climatic variability, except for short-term shifts during extreme events; 2005–2010 — a transition phase marked by a rising share of *S. aurita* and a southward range expansion, coinciding with progressive coastal warming; 2011–2012 — a boom period producing a strong 2012 year class under favourable climatic conditions; 2012–2015 — an exploitation phase during which fisheries expanded, relying heavily on the 2012 cohort; and 2016 onward — an overfishing phase, when fishing pressure persisted while the reproductive habitat was affected by an unprecedented series of marine heatwaves linked to long-term warming and intensified extremes, leading to severe socio-economic consequences for Angola's fishery sector.

S05, Oral, AbstractID=18971 (CANCELLED)

Long-term trend in realised habitat for three small pelagic fishes off South Africa

Dawit **Yemane**[1], Nandi Mhlongo[1], Janet C Coetzee[1,2] and Dagmar Merkle[1]

[1]Fisheries Management, Cape Town, South Africa. E-mail: dawityemane@gmail.com
[2]Department of Biodiversity and Conservation Biology, University of the Western Cape, Cape Town, South Africa

Small pelagic fishes are key prey for many predators and support a small pelagic purse-seine fishery and related economic activity off South Africa. Understanding how changing environmental conditions impact their biomass and shape their distribution is important for sustainable management and optimal harvesting. This study assessed long-term patterns in the distribution and realised habitat of anchovy, sardine, and round herring and examined how the availability of suitable habitat relates to annual biomass estimates. Environmental conditions were defined as both short-term variability and systematic long-term and large-scale variability. Whereas previous studies have investigated the influence of environmental conditions on the distribution of these three species, this study applied a spatio-temporal Generalized Additive Mixed Model (GAMM) to provide new insights. Hydro-acoustic survey-derived density data between 1984 and 2024 were converted to presence/absence data, while sea surface temperature and its gradient as well as Chl *a* were used as proxies for environmental factors. The best-supported models were used to generate predicted habitat suitability maps, which were transformed into binary presence/absence maps using an optimal probability threshold that maximised correct categorisation. Results show a strong association between suitable habitat availability and annual biomass estimates for anchovy and round herring, but a weaker relationship for sardine. These results can be incorporated into both tactical (short-term) and strategic (long-term) fishery management frameworks. For example, targeting survey effort towards areas that have a higher predicted habitat suitability may improve biomass estimation precision and reduce survey costs, whereas including habitat suitability indices as covariates in stock assessment models may enhance future biomass projections and contribute to sustainable management. Furthermore, understanding how distributions may shift under changing climate scenarios can inform adjustments to management plans and harvest strategies enabling targeted management actions.

S05, Oral, AbstractID=18974

Region-specific niches and responses of SPF to climate variability and change

Martin **Lindegren**[1], Marta **Moyano**[2,3], Florian Berg[4], Maria Manuel Angelico[5], Guillermo Boyra[6], Pablo Carrera[7], Mathieu Doray[8], Fernando Ramos[9] and Jeroen van der Kooij[10]

Presented by Marta Moyano on behalf of Martin Lindegren

[1]Centre for Ocean Life, National Institute of Aquatic Resources (DTU Aqua), Technical University of Denmark, Lyngby, Denmark. E-mail: mli@aqua.dtu.dk
[2]Norwegian Institute for Water Research, Oslo, Norway
[3]Center for Coastal Research, University of Agder, Norway
[4]Institute of Marine Research, Bergen, Norway.
[5]Portuguese Institute for Sea and Atmosphere (IPMA), Lisbon, Portugal
[6]AZTI Marine Research, Basque Research and Technology Alliance (BRTA), Pasaia, Spain
[7]Instituto Español de Oceanografía (IEO-CSIC), Centro Oceanográfico de Vigo (COV-IEO), Vigo, Spain
[8]DECOD (Ecosystem Dynamics and Sustainability), IFREMER, INRAE, Nantes, France
[9]Instituto Español de Oceanografía (IEO, CSIC). Centro Oceanográfico de Cádiz, Spain
[10]Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Lowestoft, U.K.

Marine fish species are shifting their ranges in response to climate change. However, most species consist of genetically distinct populations that are morphologically and physiologically adapted to environmental conditions in their respective areas. This study investigates whether small pelagic fish (SPF) respond similarly to climate variability and change across their distribution range, or if their responses are region-specific. A compilation of scientific, standardized trawl-survey data across the North Atlantic for sardine, anchovy, herring and sprat was done. Key environmental drivers (i.e. temperature, salinity, phytoplankton biomass, and depth) were derived from model reanalysis. Species distribution models (SDMs) were then developed and trained for each species with season and with/without ecoregion to represent the overall vs region-specific responses to the environment (i.e., niches). Model performance was acceptable for all species in both setups (AUC > 0.7), with slightly improved accuracy when ecoregion was included. Temperature emerged as the most influential predictor across species, followed by salinity and phytoplankton biomass. Response curves revealed dome-shaped relationships with temperature, contrasting salinity effects, and species-specific affinities to primary production. Variability in the derived responses and environmental niches across ecoregions was pronounced for all tested species, particularly for herring which had a larger number of ecoregions represented. These results were later compared to those obtained using detailed acoustic data from fisheries-independent surveys for the NE Atlantic. Our findings suggest that SPF populations exhibit region-specific environmental responses, likely reflecting local adaptations and tolerance to environmental conditions. Consequently, climate change impacts may not be uniform across a species' distribution, with implications for fisheries management and conservation under future climate scenarios.

S05, Oral, AbstractID=18979

Spawning habitat and alternating dominance of anchovy and sardine in the Bay of Biscay

Leire **Ibaibarriaga**, Leire Citores, Naroa Aldanondo, Elorri Arevalo, Guillem Chust and Maria Santos

AZTI, Sukarrieta, Bizkaia, Spain. E-mail: libaibarriaga@azti.es

Anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*) are two commercially important small pelagic species inhabiting the Bay of Biscay. Many studies have identified long-term regimes favoring one species over the other in different parts of the world. In this study, we first tested for the existence of such anchovy-sardine cycles in the Bay of Biscay. Then, we assessed the environmental conditions at spawning for the two species. For that, we compiled anchovy and sardine egg presence/absence data collected during the BIOMAN spring surveys. Associated environmental variables at each sampling location were obtained from physical and biogeochemical models from the Copernicus Marine Environment Monitoring Service (CMEMS). The spawning habitat of each species was characterized using shape-constrained generalized additive models (SC-GAMs), which impose biologically realistic constraints on species–environment response curves. The similarities and differences between both species were captured through the fitted response curves to environmental gradients. The resulting habitat suitability maps revealed distinct spatio-temporal patterns for anchovy and sardine. These patterns may differentially affect the reproductive success of each species and were discussed in the context of their potential contribution to the observed alternation in dominance.

S05, Oral, AbstractID=18988, (ECOP)

Linking ENSO-driven coastal ocean dynamics to larval retention and early survival of anchovy (*Engraulis ringens*) in the southern Humboldt Current

Sebastián I. **Vásquez**[1,2], Cristian Salas[1], Andrés Ospina-Álvarez[3], Ignacio Catalán[3] and Leonardo Castro[4]

[1]Instituto de Investigación Pesquera, Talcahuano, Chile. E-mail: svasquez@inpesca.cl
[2]Programa de Doctorado en Oceanografía, Universidad de Concepción, Concepción, Chile
[3]Mediterranean Institute for Advanced Studies (IMEDEA-CSIC/UIB), Balearic Islands, Spain
[4]Departamento de Oceanografia and Copas Coastal Center, Universidad de Concepción, Concepción, Chile

The anchovy (*Engraulis ringens*) accounts for nearly one-third of pelagic landings in the southern Humboldt ecosystem, where productivity strongly depends on annual recruitment. However, recruitment shows pronounced interannual variability linked to environment-driven early life survival, the mechanisms of which remain poorly understood. Here, we developed a Spatially Explicit Individual-Based Model (SEIBM) to investigate the main drivers of variability in egg and larval dispersal and survival in the southern Humboldt Current System, focusing on changes associated with the El Niño–Southern Oscillation (ENSO) during 1994–2023. For each spawning season, individuals were released from multiple spawning areas along the coast of central-southern Chile and tracked until they reached 20 mm in length (planktonic phase). Individuals remaining within coastal areas were considered successfully recruited. Model simulations highlighted the importance of the southern spawning zone (38°–40°S), where weaker wind stress, a broader continental shelf, and riverine discharge enhance coastal retention. Larval trajectories varied markedly among years, responding to ENSO-related shifts in wind-driven transport—showing enhanced northward dispersal during La Niña and stronger retention near spawning sites during El Niño. The probability of larval recruitment increased by 5–15% during El Niño events but declined by 0.4–3% during La Niña. These results emphasize the role of ENSO in modulating offshore transport and coastal retention processes, thereby shaping anchovy recruitment variability in central-southern Chile. The strong coherence between model outputs and independent recruitment proxies supports the SEIBM as a valuable tool for understanding climate–recruitment linkages and advancing ecosystem-based fisheries management.

S05, Oral, AbstractID=18997, (ECOP)

Modelling the seasonal spatial distribution of European anchovy (*Engraulis encrasicolus*) using fishery-dependent data in two regions of the Mediterranean Sea

Domenico **Ciorciaro**, Marco Barra, Gabriella Lo Cicero, Rosalia Ferreri, Ignazio Fontana, Giovanni Giacalone and Gualtiero Basilone.

CNR - ISMAR , Naples, Italy. E-mail: domenico.ciorciaro@ias.cnr.it

The European Anchovy is widespread throughout the Mediterranean Sea and tolerates a wide range of environmental variability. However, the geographic space occupied by its populations may vary depending on the geomorphological, oceanographic and seasonal variability features of each distinct region of the basin.

This study aimed to explore the influence of local-scale oceanographic processes on anchovies habitat suitability in two distinct fishing regions along the Italian coast.

Generalized Additive Models were used to investigate the spatio-temporal variability of anchovy presence as a function of environmental covariates, considering both additive and interaction effects. Fisheries Dependent Information derived from the processing of e-logbook and Vessel Monitoring System over the period 2020 - 2023, were used as input georeferenced presence data, thus allowing to evaluate seasonal changes in anchovy spatial distribution. Pseudo-absences were generated applying the “reverse niche approach” taking into account the extension of the species’ ecological space.

The results show that higher probability of presence (probability > 0.6) is linked to coastal areas characterized by environmental conditions satisfying the “ocean triad”. However, distinct oceanographic processes in the two regions contribute to generating these conditions, each with its own temporal and spatial variability at local scale.

A seasonal expansion of habitat is observed, mainly during the peak of the spawning period (summer), likely driven by the interaction between the species' reproductive strategy and the extent of optimal environmental conditions that support this life-trait. Spatio-temporal prediction maps reveal that suitable anchovy habitats are confined to specific zones and provide valuable insight for spatially based management approaches along the study regions.

These results represent a step forward in understanding how environmental and seasonal variability influences anchovy distribution at finer spatial scale, an aspect often overlooked in species distribution models.

Furthermore, incorporate local-scale aspects in species distribution models can improve their usefulness for assessing the effects of a changing climate on anchovy populations, especially in the Mediterranean.

S05, Oral, AbstractID=19015

The rise and fall of Pacific Sardine off the West Coast of the US

Juan Pablo **Zwolinski**

Institute of Marine Sciences, University of California Santa Cruz, Santa Cruz, CA, U.S.A. E-mail: jzwolins@ucsc.edu

Between the 1920s and 1940s, the Pacific sardine (*Sardinops sagax*) fishery was the largest single-species fishery along the U.S. West Coast but oceanographic changes and overfishing eventually led to the population's collapse and the fishery's closure. In the 1990s, sardine rebounded, allowing fishing to resume operations across its historical range, from Baja California to Canada. By 2013, however, roughly two decades into this new exploitation cycle, sardines failed to return to Vancouver Island—a warning sign of an impending decline. In response to the biomass falling below the management cutoff, the U.S. closed its directed sardine fishery in 2015. In a comprehensive review combining published research and novel analyses, I will examine: (1) the trajectory of the northern subpopulation of Pacific sardine (NSP) as depicted by integrated stock assessment models alongside an independent larval density index used as a proxy for NSP spawning stock biomass; (2) the dynamic geographic distribution of the NSP, shaped by oceanographic forces and fish behavior; (3) the maintenance of the NSP's temporal and spatial integrity throughout its period of low abundance; and (4) indicators of recovery.

S05, Oral, AbstractID=19032

Incoherent dimensionality between the population and stock structure of Pacific sardine (*Sardinops sagax*)

Brad **Erisman** and Matthew Craig

NOAA Fisheries, Southwest Fisheries Science Center, La Jolla, CA, U.S.A.
E-mail: brad.erisman@noaa.gov

Best practices for defining the spatial boundaries and structure in stock assessment should consider biological reality, theoretical assumptions, and practical solutions for meeting fishery management objectives. Ideally, stock (i.e., management unit) boundaries should align with the most plausible population (i.e., biological unit) boundaries to ensure that stock assessments consider spatial and temporal aspects in population structure at scales relevant to the entire life history of the species under consideration. Management of the Pacific Sardine (*Sardinops sagax*) in the U.S. has seemingly strived to follow this approach─by recognizing two separate subpopulations along the Pacific coast based on the hypothesized existence of genetically distinct groups with distinct migratory and spawning patterns and life history traits. The subpopulation hypothesis was formally proposed in the late 1950s and remained untested for decades, yet it has evolved into a paradigm backed by affirmational studies that shape the design of annual, fishery-independent surveys and stock assessments for Pacific Sardine. Recently, several systematic reviews have found no evidence in support of subpopulations, and emerging research using whole genome sequencing shows a single, panmictic population of Pacific Sardine along the entire Pacific coast that is congruent with its life history traits associated with reproduction, growth, movement, and ontogeny. The current stock definition and management structure of Pacific Sardine is biologically implausible, lacking both empirical and theoretical support. The consequences of the incoherent dimensionality that exists between the management unit and the biological unit include inaccurate estimates of stock biomass and biased metrics that generate misconceptions about stock status, reduced fishing opportunities, and the effects of climate on future fisheries production.

S05, Oral, AbstractID=19041, (ECOP)

Spatiotemporal variation of sardine, *Sardina Pilchardus*, recruitment in the Northeast Atlantic and Western Mediterranean Sea

Inês **Pereira**[1,2], Ana Teles-Machado[1,8], Jilali Bensbai[3], Pablo Carrera[4], Leire Citores[5], Erwan Duhamel[6], Leire Ibaibarriaga[5], Magdalena Iglesias[7], Ana Moreno[1], Richard Nash[9], Lionel Pawlowski[6], Isabel Riveiro[4], Fernando Ramos[10], Rosana Ourens[9], Andres Uriarte[11], Jeroen Van der Kooij[8], Fabio Campanella[8], Pedro Torres[12], Ana Ventero[7], Laura Wise[1], Susana Garrido[1,2], Renato Rosa[13], Isabel Domingos[2,14] and Alexandra A. Silva[1,2]

[1]IPMA - Instituto Português do Mar e da Atmosfera, Lisboa, Portugal.
E-mail: inesoki31799@gmail.com
[2]MARE − Marine and Environmental Sciences Centre, Lisboa, Portugal
[3]INRH - National Institute of Fisheries Research, Morocco
[4]Centro Oceanográfico de Vigo, Instituto Español de Oceanografía, Vigo, Spain
[5]AZTI, Bizkaia, Spain
[6]IFREMER, Lorient, France
[7]Centro Oceanográfico de Baleares, Instituto Español de Oceanografía, Palma, Spain
[8]IDL - Instituto Dom Luiz, Lisboa, Portugal
[9]CEFAS - Centre for Environment Fisheries and Aquaculture Science, Lowestoft, United Kingdom
[10]Centro Oceanográfico de Cádiz, Instituto Español de Oceanografía, Cádiz, Spain
[11]AZTI, Pasaia-Bizkaia, Spain
[12]Centro Oceanográfico de Málaga, Instituto Español de Oceanografía, Fuengirola, Spain
[13]Faculdade de Economia da Universidade de Coimbra, Coimbra, Portugal
[14]Faculdade de Ciências da Universidade de Lisboa, Lisboa, Portugal

The European sardine (*Sardina pilchardus*) shows a wide distribution throughout the northeast Atlantic Ocean and the Mediterranean Sea. There is evidence that sardine has a complex population structure, although its constitution, distribution limits, and connectivity patterns are still a matter of debate.

To investigate putative populations and assess the degree of connectivity between them, data of recruitment and adult biomass was compiled by age group for 11 areas in the Northeast Atlantic and two regions of the Mediterranean Sea. The work studied the recruitment synchrony, potential migration of recruits to adjacent areas and identification of common trends between recruitment time series.

A cross-correlation analysis was performed between recruitment time series and recruitment and adult biomass.

The main results showed, in general, that there might be a possible connection between the three northern Atlantic areas (English Channel, Bay of Biscay and Cantabrian Sea), which is still a matter of debate. The Western Mediterranean (Catalonia and Alboran) was mostly correlated with itself, and Catalonia's recruitment was negatively correlated with its neighbour's recruitment, Cadiz, suggesting a possible separation from the Atlantic.

Dynamic Function Analysis was used to identify common trends between recruitment. Recruitment decreased from 1996 to 2014 and increased thereafter in the North and Southwest Portugal, and in the Cadiz Gulf. The Bay of Biscay recruitment showed a contrasting trend, increasing until 2010, and decreasing afterwards.

The analysis conducted in this study helped understand the current connectivity and dynamic patterns of this species, in light of the present definition of its stocks.

S05, Oral, AbstractID=19042

Advances in revealing population connectivity in small pelagic fishes of the Humboldt Current System using otolith-based ecological markers

Edwin Niklitschek[1], Guido **Plaza**[2], Pamela Toledo[1] and Franciso Cerna[3]

[1]Universidad de los Lagos, Puerto Montt, Chile
[2]Pontificia Universidad Católica de Valparaíso, Valparaíso, Chile. E-mail: guido.plaza@pucv.cl
[3]Instituto de Fomento Pesquero, Valparaíso, Chile

In the current research, the main findings on population connectivity are presented for the anchoveta (*Engraulis ringens*) and the common sardine (*Strangomera bentincki*) off Chilean waters. For E. ringens, $\delta^{13}C$ and $\delta^{18}O$ isotopes, elemental concentrations, and otolith microstructural features were analyzed in juvenile and adult samples from the 2012 and 2015 cohorts across three population units (North: 18–25°S; Central: 25–32°S; and South: 32–42°S). These analyses were complemented with Fourier elliptical descriptors from sagittal otoliths of adults from the three geographic zones. Significant differences among zones were detected for all otolith-based markers, indicating complete spatial segregation between the extreme zones, and partial mixing levels between the northern–transition and transition–southern zones, respectively. The chemical and structural analyses of *S. bentincki* otoliths from the 2018 cohort revealed marked spatial and ontogenetic variability, with isotopic signatures confirming two distinct origins: an estuarine one (Calbuco) and an oceanic one (Corral and Talcahuano). Microstructural analysis allowed estimation of daily growth during the first 40–50 days of life, showing significant differences in increment width and radius-at-age among zones, with higher growth rates in oceanic areas. Overall, results for both species demonstrate high levels of spatial segregation throughout their distributional range, within an ecosystem characterized by high biological productivity.

S05, Oral, AbstractID=19056

Nearshore observations reveal more forage fish biomasses and an increasing presence of southern subpopulation sardine in US waters

David A. **Demer**[1], Kevin L. Stierhoff[2], Josiah S. Renfree[2] and Juan P. Zwolinski[3]

[1]NOAA Fisheries, Office of Science and Technology, Silver Spring MD, U.S.A.
E-mail: david.demer@noaa.gov
[2]NOAA Fisheries, SWFSC Fisheries Resources Division, La Jolla, CA, U.S.A.
[3]University of California, Santa Cruz, The Cooperative Institute for Marine, Earth and Atmospheric Systems, Santa Cruz, CA, U.S.A.

Since 2006, NOAA Fisheries has conducted annual or biannual acoustic-trawl (AT) surveys of small pelagic fishes (SPF) in the California Current Ecosystem (CCE). These surveys, originally focused on the northern subpopulation of Pacific Sardine (NSPS), provide information on the biomasses, distributions, and demographics of eight subpopulations of six SPF. In the mid-2000s, the CCE transitioned into a cold period, during which the NSPS exhibited decreased production and seasonal migration, experienced increased exploitation, and then, in 2014, collapsed. Following the closure of the NSPS fishery in 2015, the AT surveys documented a resurgence of the central subpopulation of Northern Anchovy. Meanwhile, industry observed sardine closer to shore than the fisheries survey vessel (FSV) could sample and advocated for estimations of the SPF biomasses in unsampled nearshore areas. Beginning in 2015, measurements made by the FSV were extrapolated into the nearshore regions. Then, in 2019, echosounder and purse-seine sampling from two chartered fishing vessels was added to directly measure the nearshore SPF biomasses. We present an overview of the nearshore surveys, the methods and results, compare extrapolations and measures, and highlight unanticipated ecological insights. Although the proportion of the NSPS biomass observed nearshore was typically 1-5% of the total subpopulation biomass, it has recently increased. Still, the total NSPS biomass has remained north of its historic spawning grounds off southern California, and an insufficient amount for managers to change the overfished status and restart exploitation. Also, unexpectedly, the nearshore sampling uniquely elucidated the increasing and persistent presence of southern subpopulation Pacific Sardine in US waters, tracking changes in the distribution of its potential oceanographic habitat.

SESSION 05

Spatiotemporal Dynamics of Small Pelagic Fishes in a Changing Ocean

Poster Presentations

S05, QR-Poster, AbstractID=18810, PosterID: S05-P1

Seasonal and long-term changes in distribution and relative abundance of common small mesopelagic predators in the northwestern Pacific

Alexei M. **Orlov** and Igor V. Volvenko

Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow, Russia.
E-mail: orlov.am@ocean.ru

Pelagic predators play an important role in marine ecosystems. Among them, more attention is paid to large aquatic animals (e.g., sharks, tunas, billfishes, marine mammals, etc.), while the much more abundant small mesopelagic predatory fishes are much less studied. We analyzed seasonal and long-term changes in the spatial distribution, range boundaries, and catch rates of six of the most abundant fish species, i.e. spotted barracudina *Arctozenus risso*, northern pearleye *Benthalbella dentata*, Pacific viperfish *Chauliodus maouni*, slender barracuda *Lestidiops ringens*, scaly paperbone *Scopelosaurus harryi*, and Adler's waryfish *S. adleri* in Russian waters of the Northwest Pacific based on the results of midwater trawl surveys. For most of these species, there were no significant seasonal changes in the northern boundaries of the ranges, which was approximately 60°N during the year. The exception was *L. ringens*, whose northern distribution limits were significantly south in the spring compared to the rest of the year. Of the six species considered, only four (*A. risso*, *L. ringens*, *S. harryi*, and *C. macouni*) were observed in the study area throughout the study period, while *B. dentata* was not recorded in the 2020s, and *S. adleri* in the 2010s-2020s. At the same time, a significant shift of the northern distribution boundary to the south was observed in *A. risso* in the 2010s-2020s, in *B. dentata* in the 2010s, and in *C. macouni* in the 2020s. The maximum occurrence in catches of *A. risso*, *S. adleri* and *C. macouni* was in winter, of *L. ringens* and *S. harryi* in summer, and of *B. dentata* in autumn. The occurrence of the vast majority of the species considered was maximal in the 1990s. Only *L. ringens* was most frequently observed in the study area in the 2000s. The relative abundance of *B.* dentata, S. *harryi*, and *L. ringens* in the study area was maximal in summer, while that of *A. risso* in winter, *S. adleri* in autumn, and *C. macouni* in spring. The highest catches of *A. risso*, *B. dentata*, and *C. macouni* were recorded in the 1990s, while those of *L. ringens*, *S. adleri*, and *S. harryi* in the 2000s. Changes in the seasonal and long-term spatial distribution, occurrence and abundance of these species are most likely due to changes in environmental conditions.

S05, Poster, AbstractID=18813, PosterID: S05-P2, (ECOP)

Seasonal characterization of the effects of climate change on the habitat of Peruvian anchovy (*Enrgaulis ringens*) off Peru

Álvaro **Recoba**[1,2], Daniel Grados[1], Jorge Tam[1] and Giannina Passuni[3]

[1]Instituto del Mar del Perú, Callao, Perú
[2]Universidad Peruana Cayetano Heredia, Lima, Perú. E-mail: alvaro.recoba@upch.pe
[3]University of Hamburg, Hamburg, Germany

Engraulis ringens is a keystone of the Humboldt Current ecosystem, supporting the region's largest fishery and the world's second-largest single-species fishery. Its distribution varies with the regional ocean–atmosphere processes that now carry the increasingly evident climate-change signal, expected to alter the seasonal cycle of oceanographic variables such as sea-surface temperature. In this study, we quantify how climate change may impact the potential habitat of juvenile and adult Peruvian anchovy during spring and summer under RCP 2.6 and RCP 8.5 through the rest of the XXI century. We trained life-stage-specific species distribution models using Conditional Inference Random Forest with data obtained during IMARPE's hydroacoustic surveys through the 2010's, paired with environmental variables sourced from Mercator Ocean GLORYS12 global reanalysis. In our reference period, adult habitat area during spring was ~26% larger than during the summer, while juvenile habitat in spring was located ~1° farther north than during the summer. Ontogenetically, we found that juvenile habitat showed greater area losses by the end of the century in comparison to adult habitat, regardless of season or scenario. Seasonally, we found that summer habitat is projected to decline with greater magnitude and/or an earlier onset (depending on life stage and scenario), whereas spring responses are more uncertain: habitat expands for both stages under RCP 2.6 but contracts starting 2070-2080 under RCP 8.5. Area losses are accompanied by tendencies to a coastal compression so, given the trade-off between greater stock accessibility and potential biomass reduction, the effects these changes may have on the anchovy industrial fishery remains unclear. Nonetheless, we found that the summer habitat between Piura and Lambayeque seems to be most affected, as it experiences the loss of persistent coastal habitat as early as 2030–2040 in both scenarios, thus likely affect the small-scale fleet operating there during the first fishing season of the year. In contrast, a narrow belt of persistent habitat between Pisco Bay and Ático remains through mid-century across seasons, stages, and scenarios, suggesting a potential climate refuge for the Peruvian anchovy.

S05, Poster, AbstractID=18824, PosterID: S05-P3

Satellite remote sensing and eDNA metabarcoding for adaptive management of small pelagic fish in the Humboldt Current: A Korea–Peru Initiative

Jun-Ho **Lee**[1,2], Sung Kim[2], Won-Kyung Baek[2] and Aníbal Aliaga Rosales[1,3]

[1]Korea-Perú Joint Research Center on Ocean Science & Technology for Latin America, Lima, Peru. E-mail: leejh@kiost.ac.kr
[2]Korea Institute of Ocean Science & Technology, Busan, Korea, R.
[3]Instituto del Mar del Perú, Lima, Peru

Small pelagic fish (SPF), particularly anchoveta (*Engraulis ringens*), form the basis of Peru's globally significant fishery but exhibit extreme sensitivity to El Niño–Southern Oscillation (ENSO) events. Biomass reductions exceeding (up to ~70-80 %) have been documented during strong El Niño phases, linked to weakened upwelling and suppressed primary productivity. Anticipating such variability is crucial for sustainable management in the face of accelerating climate change. This study, developed through the KOPELAR (Korea–Peru Joint Research Center on Ocean Science and Technology for Latin America), proposes an integrated monitoring framework that combines satellite remote sensing of SST, Chl-*a*, and upwelling indices, as well as eDNA metabarcoding, for high-resolution biodiversity assessment. By aligning these datasets with long-term observations from the Instituto del Mar del Perú (IMARPE) and NOAA, we aim to quantify climate-driven habitat shifts and refine early-warning indicators for anchoveta distribution and resilience. Our approach enhances ecosystem-based fisheries management (EBFM) in the Humboldt Current by advancing predictive capabilities and fostering cross-regional collaboration. The Korea–Peru framework offers a transferable model for climate-adaptive fisheries policy and long-term marine ecosystem sustainability.

S05, Poster, AbstractID=18851, PosterID: S05-P4

Effects of climate change on habitats suitable for pelagic resources in Chile*

Eleuterio **Yáñez**, Claudio Silva, María Angela Barbieri, Felipe Sánchez** and María Eugenia Garrido

Pontificia Universidad Católica de Valparaíso, Valparaíso, Chile.
E-mail: eleuterio.yanez@pucv.cl

The distribution of eggs, landing, fishing effort and CPUE abundance index, and sea surface temperature, chlorophyll concentration, winds and sea height are analyzed. The conceptual models are elaborated and predictive models associated with regionalized climate change are developed. For jack mackerel (*Trachurus murphyi*), a Maxent model was developed that shows losses in the area of the most suitable habitat in summer and gains during the rest of the year, around 2055. Neural networks estimate an increase in landings by 2056-2065, which would be due more to a change in availability than to greater abundance, while there would be a notable loss of the area of the suitable habitat for their eggs. Swordfish (*Xiphias gladius*) would move further the coast as climate change develops. For anchovy (*Engraulis ringens*) the model shows a very important loss of the area of the most egg suitable habitat, particularly in august and september, by 2055; and a notable loss of suitable habitat for adults until that year, as would be the case for common sardine (*Strangomera bentinki*). It is necessary to refine the regionalization of climate change, consider its effect on the entire life cycle of the species and develop a regional transdisciplinary research program.

Key words: climate change, pelagic resources, Chile, habitats, projections.

*Project FIP 2014-25, Chile
**Currently works at the Fisheries Development Institute, Chile.

S05, Poster, AbstractID=18906, PosterID: S05-P5, (ECOP)

Modeling the population dynamics of Pacific saury considering migration

Rentaro **Mitsuyu** and Toshihide Kitakado

Tokyo University of Marine Science and Technology, Tokyo, Japan.
E-mail: m257021@edu.kaiyodai.ac.jp

The Pacific saury (*Cololabis saira*) is a small pelagic species widely distributed across the North Pacific Ocean and managed by the North Pacific Fisheries Commission (NPFC). Stock assessments by the NPFC have reported a decline in abundance in recent years. In addition, previous studies have documented substantial changes in migratory patterns associated with changing oceanographic conditions. To properly understand the current state of the stock, it is essential to quantitatively capture its spatio-temporal distribution. The migratory behavior of Pacific saury is known to be strongly influenced by sea surface temperature (SST). Building on this understanding, this study proposes a modeling approach that can better represent migration patterns shaped by local SST fronts without relying on autocorrelation structures used in conventional spatio-temporal modeling. A state-space model was developed to explicitly incorporate the relationship between oceanic environmental variables and migratory processes. The estimation performance was evaluated through simulation experiments, where virtual migratory dynamics of Pacific saury were generated based on SST data, from which catch and CPUE datasets were simulated. The generated data were then applied to the proposed model to validate its performance. As a result, the model demonstrated satisfactory performance in estimating the parameters associated with the assumed migratory dynamics when sufficient data were available. It should be noted that this approach can be applied to other species whose movements are driven by environmental factors. Moreover, it provides a framework capable of representing changes in fish stock distributions under varying oceanic conditions and is expected to be applicable in the future to management strategy evaluation (MSE) focusing on spatio-temporal management measures such as seasonal and area closures.

S05, Poster, AbstractID=18916, PosterID: S05-P6

Distribution of Spawning Grounds of Japanese Sardine and Chub Mackerel During the Prolonged Kuroshio Large Meander Period

Mikio **Watai**

Fisheries Resources Institute, Japan Fisheries Research and Education Agency, Yokohama, Japan. E-mail: watai_mikio40@fra.go.jp

Monthly egg and larval surveys have been conducted along the Pacific coast of Japan since 1978, targeting small pelagic fishes within the 200-nautical-mile EEZ. These surveys provide a globally unique, fishery-independent dataset for estimating spawning biomass and monitoring distribution patterns, covering nearly all spawning seasons and grounds of major species.

The Kuroshio Large Meander, which began in summer 2017, persisted until May 2025, making it the longest event on record. Since 2022, the Kuroshio Extension has shown a pronounced and prolonged northward shift, while the southern limit of the Oyashio First Branch has remained unusually far north, indicating a weakened Oyashio influence. Such simultaneous occurrences have not been observed since 1960 and are likely manifestations of decadal-scale oceanographic variability driven by climate change.

This study investigates how these oceanographic anomalies have affected the spawning ground distribution of Japanese sardine *Sardinops melanosticta* and chub mackerel *Scomber japonicus*. Using multi-stage egg and larval occurrence data, we analyzed spatial patterns and co-occurrence indices to identify emerging spawning hotspots.

Our results show increased occurrences of eggs and larvae around the seamounts near the Izu Islands and upstream shelf areas along the meander path, particularly during and after the onset of the meander in 2018. Early-stage eggs were especially concentrated near the Izu seamounts, suggesting a shift in core spawning grounds. These findings are supported by particle tracking experiments and fishing ground data.

This study highlights the ecological significance of recent oceanographic changes and underscores the importance of long-term monitoring in detecting rapid shifts in the spawning ecology of small pelagic fishes.

S05, Poster, AbstractID=18938, PosterID: S05-P7, (ECOP) (QR-Poster)

Influence of sea surface temperature on the spatiotemporal dynamics and fishing efficiency of small pelagic species in the Western Mediterranean Sea (Algerian basin)

Yousra **Zaoui**[1], Imène Nouali[2] and Mohamed Kache[1]

[1]National School of Marine Science and coastal Management (ENSSMAL), Algiers, Tunisia.
E-mail: yousra.zaoui@enssmal.edu.dz
[2]University of Mostaganem Abdel-Hamid Ibn Badis

Small pelagic fish such as sardine (*Sardina pilchardus*), round sardinella (*Sardinella aurita*), and anchovy (*Engraulis encrasicolus*) dominate Mediterranean fisheries and play a key role in the productivity and stability of marine ecosystems. Their abundance, distribution, and catchability are closely linked to environmental variability, particularly sea surface temperature (SST), which affects spawning, feeding, and aggregation patterns.

This study investigates the influence of SST on the spatiotemporal dynamics and fishing efficiency of small pelagic species along the Algerian coast of the western Mediterranean. A dataset of 357 daily purse-seine landings (2015–2016) was analyzed alongside satellite-derived SST data. Catch per unit effort (CPUE) was estimated for each fishing day, and the Kruskal–Wallis test was applied to compare catch efficiency under different thermal conditions. SST diffusion patterns were classified into four typologies (ABS, CCC, CCPDZI, and DDDZI) to describe the spatial distribution of favorable temperature ranges for fishing activities.

Results show that optimal fishing efficiency occurs when SST ranges between 19 °C and 21 °C, corresponding to the seasonal aggregation of sardine and anchovy near the coast. Beyond this range, a decline in catch rates and fleet profitability was observed.

These findings highlight the critical role of temperature variability in shaping small pelagic fisheries and emphasize the need to integrate environmental indicators into fisheries monitoring and adaptive management frameworks to support sustainability in a changing Mediterranean ecosystem.

Keywords: small pelagic fish; sea surface temperature; CPUE; Mediterranean Sea; spatiotemporal dynamics; climate variability; sustainable fisheries

S05, Poster, AbstractID=18952, PosterID: S05-P8

Different migration patterns of European anchovy and sardine around Iberian Peninsula revealed by eye lens isotopes

Tatsuya **Sakamoto**[1,2] and Susana **Garrido**[1]

Presented by Susana Garrido on behalf of Tatsuya Sakamoto

[1]Instituto Português do Mar e da Atmosfera (IPMA), Lisboa, Lisboa, Portugal.
E-mail: susana.garrido@ipma.pt
[2]The Hakubi Center for Advanced Research, Kyoto University, Kyoto, Japan.
E-mail: sakamoto.tatsuya.3p@kyoto-u.ac.jp

Small pelagic fish are key components of productive coastal ecosystems, yet their migration ecology remains poorly understood, causing challenges for their management. We applied stable carbon and nitrogen isotope (δ^{13}C and δ^{15}N) analyses of eye lenses to investigate movements of European anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*) around the Iberian Peninsula. Muscle isotopes showed strong spatial heterogeneity, largely consistent between species and reflecting differences in baseline values. Eye lens centres of small anchovy, and to a lesser extent sardine, also showed clear geographic variation: higher δ^{15}N off the Atlantic south coast, lowest δ^{15}N in the Alboran Sea, and lower δ^{13}C off the west coast. These patterns persisted across years and fish sizes in anchovy, with only minor outliers, suggesting limited cross regional migration. An exception was the overlap between west coast and Cantabrian Sea values, consistent with connectivity supported by cohort tracking. In contrast, sardine isotopes from the west and south coasts converged into a unimodal distribution with growth, indicating frequent exchange between these regions. These findings support recent stock revisions that separate south and west coast anchovy and maintain a single Iberian sardine stock, but they question the current assumption of separation between west and north coast anchovy stocks. Eye lens isotopes provide a powerful complementary tool to resolve nursery origin and connectivity, offering new opportunities for fisheries management in shorter time scales than molecular techniques, which is paramount to be able to cope with rapid changes of fish distribution due to climate change and for spatially explicit management.

S05, Poster, AbstractID=18955, PosterID: S05-P9, (ECOP)

Spatiotemporal structure of small pelagic fish acoustic density in the Northern Patagonia estuarine zone of Chile incorporating physical barriers

Juan **Antón-Heredia**[1] and Luis A. Cubillos[2]

[1]Doctoral Program in Sciences with a specialization in Manejo de Recursos Acuáticos Renovables, Faculty of Natural and Oceanographic Sciences, University of Concepción, Concepción, Chile. E-mail: janton@udec.cl
[2]COPAS Coastal, Department of Oceanography, Faculty of Natural and Oceanographic Sciences, University of Concepción, Concepción, Chile.

The austral sardine (*Sprattus fuegensis*), common sardine (*Strangomera bentincki*), and anchoveta (*Engraulis ringens*) are key components of artisanal fisheries and marine ecosystems in the Northern Patagonia Estuarine Zone (NPEZ) of Chile. The complex coastal geography of this region, dominated by islands, fjords, and channels, suggests that physical barriers strongly influence the spatiotemporal distribution of these small pelagic species.

This study evaluated the spatiotemporal structure of acoustic density for these species, explicitly considering the effect of geographic barriers. Hydroacoustic data collected between 2015 and 2022 during assessment surveys conducted between the Los Lagos and Aysén regions were analyzed. Three modeling approaches were compared using R-INLA: a strictly spatial model, an opportunistic model (with independent temporal effects), and a progressive model (dynamic spatiotemporal). In all three approaches, physical barriers were incorporated to avoid unrealistic interpolations in geographically discontinuous areas.

The progressive model showed the best performance, allowing a more accurate representation of the spatial distribution of resources. S. *fuegensis, S. bentincki*, and *E. ringens* exhibited similar aggregation patterns, concentrating in fjords, inner channels, and areas adjacent to Chiloé and Aysén. Although occurrence remained relatively stable during the study period, density and biomass exhibited interannual fluctuations.

These results highlight relevant evidence on the role of physical barriers in complex estuarine systems, providing valuable information to identify priority areas and strengthen spatially explicit management and conservation strategies.

S05, Poster, AbstractID=18967, PosterID: S05-P10 (CANCELLED)

Spatio-temporal modelling of data-poor small pelagic fish populations: Assessing abundance variations and distribution shifts

Wayne Rostant, Steven Wallbridge, Eva **Garnacho** and Richard D. M. Nash

Centre for Environment, Fisheries & Aquaculture Science, Lowestoft Laboratory, United Kingdom. E-mail: steven.wallbridge@cefas.gov.uk, eva.garnacho@cefas.gov.uk

Small migratory pelagic fish can be important forage species exhibiting a relative short lifespan influenced by environmental conditions and difficult to assess due to data limitations. We use spatio-temporal generalised linear mixed models to estimate variation in European sprat (*Sprattus sprattus*) abundance in the North Sea and adjacent Skagerrak. We assess the relationship of abundance and environmental covariates to address data gaps and understand distribution dynamics. Recent research addressing questions in fisheries has shown that such models can provide useful input to st19040ock, ecosystem, habitat, and climate assessments. In this case study, we use standardized fishery independent data and static and time-dependent environmental covariate data from 2012 to 2022 and model seasonal variations in juvenile and adults. We generate and validate standardized indices and investigate seasonal and interannual distributional shifts. We explore this modelling framework to consider how climate driven changes in the environment might affect the distribution of the population in future.

S05, Poster, AbstractID=19008, PosterID: S05-P11, (ECOP)

Exploring the out-migration and oceanic movements of alewife and blueback herring

Marin **Marsala**, Jena E. Edwards, Shelley K. Denny and Robert J. Lennox

Dalhousie University, Halifax, NS, Canada. E-mail: marin.marsala@dal.ca

Alewife (*Alosa pseaudoharengus*) and blueback herring (*Alosa aestivalis*) are two species of anadromous fish collectively known as gaspereau or river herring, due to their indistinguishable appearance. Anadromous fishes such as the gaspereau, which hold cultural, ecological, and economic significance are declining drastically. Their main threats include overfishing, offshore bycatch, and loss of spawning habitat. Despite numerous attempts to prevent these declines, no method has proven effective in recovering gaspereau stocks. Additionally, little is known about the out-migration and oceanic movements of gaspereau, hindering the development of effective management and recovery strategies. This study aims to address the knowledge gaps in gaspereau movement ecology by using acoustic telemetry to identify the out-migration routes and oceanic movement patterns of post-spawning gaspereau in Bras d'Or Lake, Nova Scotia, Canada. A total of ninety-eight gaspereau were captured using dip-nets during their upstream migration into four different spawning locations in the Bras d'Or Lake. Acoustic transmitters were surgically implanted into each individual, and tracked using existing receiver arrays positioned along several channels linking the Bras d'Or Lake to the Atlantic Ocean. These results will offer new insights into the movement ecology of gaspereau and support the development of effective management strategies for their recovery.

S05, Poster, AbstractID=19040, PosterID: S05-P12, (ECOP) (CANCELLED)

Climate-driven distributional shifts of larval chub mackerel (*Scomber japonicus*) projected by a bio-physical coupled individual-based model

Seonggil **Go**, Sun Kyeong Choi and Young Baek Son

Korea Institute of Ocean Science & Technology (KIOST) Jeju Research Institute, Jeju, Korea, R.
E-mail: sggo117@kiost.ac.kr

Small pelagic fishes are highly sensitive to ocean warming, making early-life stage dynamics critical to understanding future stock productivity under climate change. We developed a high-resolution bio-physical individual-based model (IBM) coupled with a regional ocean circulation model to quantify the spatiotemporal shifts in the abundance and biomass distribution of chub mackerel (*Scomber japonicus*) eggs and larvae in the western North Pacific. The model successfully reproduced the present-day distribution pattern driven by the Tsushima Warm Current, spanning from the spawning grounds in the southern East China Sea to the Korea Strait and the Japan/East Sea. Simulations for the 2010s indicated a distinct seasonal peak in larval biomass in May, concentrated in the East China Sea. For the 2050s, our results revealed a marked increase in larval biomass accompanied by a northward expansion of nurseries toward the Yellow Sea and the Japan/East Sea, suggesting a potential redistribution of spawning and recruitment habitats. These changes highlight climate-driven shifts in habitat suitability and connectivity of small pelagic fish populations. Our findings provide mechanistic insights into how warming oceans may alter the spatiotemporal dynamics of small pelagic fishes and underscore the importance of coordinated regional surveys and data sharing to improve predictive capacity and support adaptive fisheries management in a changing ocean.

Acknowledgment: This research was supported by the Korea Institute of Marine Science and Technology (KIMST) funded by the Ministry of Oceans and Fisheries (RS-2024-00406249 and RS-2025-02304432).

S05, Poster, AbstractID=19043, PosterID: S05-P13, (ECOP)

ENSO modulation on larval fish connectivity in a Tropical Marine Reserve: Trophic implications around Cabo Pulmo National Park

Diana C. **Gutiérrez-Moreno**[1], Laura Sánchez-Velasco[1], Jorge M. Montes[2], Jaime Gómez-Gutiérrez[1] and Silvia Patricia Jiménez-Rosenberg[1]

[1]Instituto Politécnico Nacional-Centro Interdisciplinario de Ciencias Marinas, La Paz, México. E-mail: dgutierrezm2200@alumno.ipn.mx
[2]Universidad de Guadalajara- Centro Universitario de Ciencias Exactas e Ingenierías, Guadalajara, México

Understanding forage community dynamics requires integrating early pelagic stages of fish with the physical processes that govern their transport, retention, and export. This study quantifies El Niño–Southern Oscillation (ENSO)-modulated larval connectivity in Cabo Pulmo National Park (CPNP), a tropical reef system at the southern entrance of the Gulf of California that supports diverse small pelagic and mesopelagic assemblages.

A reproducible Lagrangian particle-tracking framework, driven by GLORYS12 ocean currents (~1/12° resolution) and ERA5 wind, was used to conduct ten 10-day simulations during four seasonal windows (January, April, July, October), spanning three phases: Neutral (2014), El Niño (2015–2016), and La Niña (2022). Particles were released from three sites in the park and tracked to evaluate retention, nearshore export, and offshore dispersal.

Results indicate that CPNP consistently acts as a coastal larval source, with nearshore export—defined as dispersal outside the park and ≤15 km of the coastline—dominating across all phases (~75–90%). This pathway prevailed across, particularly in the northern area under cold conditions (~90%). Oceanic leakage was minor, with export to a southwestern peninsular pathway ranging from ~10–16%, primarily from the central sector. Exports toward the Gulf entrance remained weak (≤7%). Transport speed and dispersal distance varied with ENSO, with faster, directional flows during La Niña and more diffuse, retentive patterns during El Niño.

These shifts modulate larval connectivity between reef and adjacent habitats, shaping trophic linkages around the Baja California Sur peninsula. The findings offer insights into conservation and adaptive management in tropical marine protected areas.

S05, Poster, AbstractID=19046, PosterID: S05-P14, (ECOP)

Reproductive Biology of *Sardina pilchardus* (Walbaum, 1792) and *Sardinella aurita* (Valenciennes, 1847) in the West Mediterranean, Morocco

Sarah **Bouasse**[1,2,3], Moulay Hachem Idrissi[2], Hounaida Farah Idrissi[3], Omar Ettahiri[3], Douaa Slimani[3], Nassir Kaddouri[2,4], Mohamed Fadili[2], Najib El Ouamari[2], and Aarab Saïda[1]

[1]Laboratory of Research and Development in Engineering Sciences, Faculty of Sciences and Techniques of Al Hoceima,Morocco. E-mail: sarah.bouasse@etu.uae.ac.ma
[2]Fisheries Laboratory, Regional Center of INRH, Nador, Morocco
[3]Regional Center of INRH, Casablanca, Morocco
[4]Laboratory of Biodiversity, Ecology and Genomics, Faculty of Sciences, Mohammed V University in Rabat, 4 Avenue Ibn Battouta, B.P. 1014 RP, Rabat, Morocco

In recent years, a decline in sardine (Sardina pilchardus) abundance has been observed, while round sardinella (Sardinella aurita) has shown an increase in the Moroccan Mediterranean Sea. In the present study, a comparative analysis of the reproductive biology of these two species was conducted to better understand their reproductive strategies. Between January 2024 and March 2025, a total of 1,139 individuals were sampled (752 S. pilchardus and 387 S. aurita), with total lengths (TL) ranging from 81 to 204 mm for sardine and from 114 to 316 mm for round sardinella, with females significantly predominant (58% in S. pilchardus and 54% in S. aurita). Sardina pilchardus exhibits a winter spawning peak; nearly 100% of individuals were at stage 4 in January, while more than 90% were at stage 1 in August. Peaks of the gonadosomatic index (GSI) were recorded in December, January, and February, and the highest hepatosomatic index (HSI) values were observed in July. For Sardinella aurita, reproductive activity reaches its maximum in summer, with the GSI peaking in July and 100% of individuals reaching maturity stage 4 in June; the HSI peak occurred in June. These findings highlight two contrasting reproductive strategies: Sardina pilchardus shows higher RHS values during winter spawning, whereas Sardinella aurita exhibits an increase in RHS prior to summer reproduction, followed by a decrease during the spawning period. Such differences reflect a seasonal adaptation that promotes the coexistence of both species within the same environment while reducing competition for resources. Keywords: Sardina pilchardus, Sardinella aurita, GSI, HSI, reproduction, energy, Moroccan Mediterranean Sea.

S05, Poster, AbstractID=19055, PosterID: S05-P15, (ECOP)

Low mitochondrial genetic diversity of *Engraulis ringens* compared to its congeners from coastal upwelling systems

Deivis Cueva[1], María Inés Trucco[2], Claudio Buratti[2] and Giovanna **Sotil**[1,3]

[1]Instituto del Mar del Peru (IMARPE), Callao, Peru. E-mail: dcueva@imarpe.gob.pe
[2]Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP), Mar del Plata, Argentina
[3]Facultad de Ciencias Biológicas, Universidad Nacional Mayor de San Marcos (UNMSM), Lima, Perú

The southeastern Pacific Ocean is characterized by high variability in its environmental conditions, exhibiting oceanic features that challenge its marine inhabitants. Marked fluctuations in the abundance of *Engraulis ringens*, in response to both natural and anthropogenic pressures, suggest a high adaptive capacity of the species. We aimed to compare the genetic diversity of this species with that of its congeners from similar coastal upwelling ecosystems, using mitochondrial markers, and interpret these patterns in light of the demographic characteristics of each species and their respective habitats. A total of 236 individuals were sequenced for two mitochondrial regions (gene *Cyt*b and the control region). Both *E. ringens* and *E. anchoita* (from Brazil-Argentina) exhibited notably lower genetic diversity compared to anchovy species *E. mordax* (from USA), *E. japonicus* (Japan), and *E. encrasicolus* (Europe). The haplotype genealogy of *E. ringens* revealed mitochondrial lineages with little divergence among them, in sharp contrast to *E. encrasicolus*, whose genetic diversity reflects a biocomplexity encompassing genetically differentiated populations and ecotypes. Neutrality tests yielded significantly negative values, consistent with two possible scenarios: past demographic changes or the direct/indirect effects of selection on mitochondrial genes. More complex demographic dynamics than a single recent population expansion have been proposed for Peruvian anchoveta, including recurrent population collapses and recoveries, a scenario consistent with the demographic fluctuations typical of small clupeids. Alternatively, the reduction in mitochondrial diversity may reflect the predominant influence of natural selection, driven by the large population size of *E. ringens* and the environmental pressures resulting from the highly variable nature of its habitat.

S05, Poster, AbstractID=19058, PosterID: S05-P16, (ECOP)

Behavioral and bioenergetic trade-offs set temperature and oxygen limits for pelagic fishes

Jonathan E. **Falciani**[1], Colleen M. Petrik[1] and Ken H. Andersen[2]

[1]Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA, U.S.A.E-mail: jfalciani@ucsd.edu
[2]National Institute of Aquatic Resources, Technical University of Denmark, Kongens Lyngby, Denmark

Forecasting climate vulnerability in small pelagic fishes (SPF) requires a size-explicit framework that links food acquisition, temperature, oxygen supply, and behavior. We develop a behavioral bioenergetics model that couples temperature and oxygen to consumption, basal metabolism, active metabolism, and optimal cruising speed across body sizes typical of pelagic forage taxa.

Two limitation regimes emerge. First, food (carbon) limitation is primarily temperature-driven: as feeding level declines, the temperature of peak available energy shifts cooler and sensitivity to warming increases—most strongly in smaller fish. Second, oxygen limitation is primarily size-driven: larger fish, operating with tighter metabolic budgets, encounter oxygen ceilings sooner, and warming further compresses aerobic scope and oxygen habitat. Crucially, cruising-speed plasticity modulates exposure to both regimes. Reducing speed lowers active costs and can buffer hypoxia for metabolic demand-side resilience, whereas increasing speed can partially offset low feeding but risks exceeding oxygen limits, particularly for large fish and at higher temperatures. These dynamics provide testable, size-structured predictions for distributional shifts, cohort bottlenecks, and habitat compression in SPF, and offer behavioral and physiological indicators that can be paired with surveys to anticipate regional management needs.

S05, Poster, AbstractID=19092, PosterID: S05-P17, (ECOP) (CANCELLED)

Mesopelagic fish vertical distribution patterns in the Northwestern Pacific Ocean from multi-frequency echosounders and their potential carbon sequestration effects

Jianchao **Li**, Hailing Wang, Zhaohui Chen, Honghai Zhang, Lingyun Nie, Yang Liu, Peng Sun, Zhenjiang Ye and Yongjun Tian

Ocean University of China, Qingdao, Shandong, China, PR. E-mail: sunpeng@ouc.edu.cn

The vertical distribution of the mesopelagic fish in Northwest Pacific (NWP) is remarkably impacted by regional ocean dynamical structure, however, traditional sampling methods can't reflect the rapid and complicated response pattern, especially for the less explored mesopelagic water. Therefore, we carried out this research utilizing high-resolution multi-frequency EK80 acoustic data in a meridional cruise of NWP (a meridional section from 13°N to 40°N), aiming at illustrating the specific distribution pattern of mesopelagic fish and biodetritus in the euphotic and mesopelagic layers. Firstly, a latitude-dependent three-layer vertical structure in sound scattering layers (SSLs) was revealed, dividing the SSLs into five ecologically distinct regions. Secondly, within the North Pacific Subtropical Gyre region, there exists a subsurface aggregation layer primarily abundant with organisms and particles as indicated by the SSLs. Thirdly, hydrographical condition, eddies and Kuroshio front are identified as key factors influencing the ecological conditions. Strong correlations are observed between temperature, dissolved oxygen, and density with SSLs depth. It is likely that biological and convergent oceanic processes play a significant role in shaping subsurface aggregation layers, revealing a potentially crucial role of mesopelagic NPSG region in the marine carbon cycle.

S05, Poster, AbstractID=18977, PosterID: S05-P18

Drivers of spatial variability in Iberian sardine spawning habitats

Ana **Moreno**[1], Daniela Silva[1,2], Maria Manuel **Angélico**[1], Pablo Carrera[3], Sílvia Rodriguez-Climent[3], Anxo Conde[1], Diana Feijó[1], Elisabete Henriques[1], Hugo Mendes[1], Cristina Nunes[1], Dina Silva[1] and Susana Garrido[1,4]

Presented by Maria Manuel Angélico on behalf of Ana Moreno

[1]Portuguese Institute for the Ocean and Atmosphere (IPMA), Lisboa, Portugal.
E-mail: amoreno@ipma.pt
[2]Centre of Mathematics, University of Minho, Braga, Portugal.
[3]Centro Oceanográfico de Vigo, Instituto Español de Oceanografia - IEO-CSIC, Spain
[4]Marine and Environmental Sciences Centre (MARE), Faculty of Sciences, University of Lisbon, Lisbon, Portugal

The spawning habitats of small pelagic fish varies according to the abundance and demographic structure of the adult population and is influenced by oceanographic conditions. Although the general boundaries of the main spawning area of the Iberian sardine population are well known, variability of the fine-scale distribution of spawning aggregations from year to year has never been described. The location of spawning grounds is crucial, as it influences larval survival by determining the dispersal of eggs and larvae driven by local hydrodynamics. Understanding the spatial variability of spawning areas is essential for parameterizing hydrodynamic models that enable more accurate assessments of early life-stage dispersal pathways and the variability of Iberian sardine recruitment. In this study, acoustic survey data and ichthyoplankton samples collected using a Continuous Underway Fish Egg Sampler (CUFES) during spring acoustic surveys off the Atlantic Spanish and Portuguese continental shelves were analyzed to investigate the fine-scale distribution of sardine (*Sardina pilchardus*) spawning aggregations and relate it to oceanographic variables. Biological sampling of fish was used in combination with the acoustic assessment to obtain a fine-scale spatial distribution of spawning females. A geostatistical framework based on hierarchical Bayesian species distribution models was implemented to quantify the influence of environmental variability on spawning habitat selection, providing a detailed characterization of the spatial dynamics of Iberian sardine reproduction. Portuguese and Spanish acoustic surveys conducted in 2022, 2023, and 2024 during the spawning season were selected for this analysis, a period marked by highly variable recruitment strength, a significant decline in abundance and a spatial contraction in sardine distribution.

S05, Poster, AbstractID=19048, PosterID: S05-P19, (ECOP)

Critical points of natural and anthropogenic pressures and responses in the state of the north–central anchovy stock in the pelagic system of the Peruvian sea

Elmer **Quispe-Salazar** and Jorge Tam

Instituto del Mar del Perú (IMARPE), Callao, Perú. E-mail: oquispe@imarpe.gob.pe

The pelagic system off Peru is one of the most productive and dynamic marine ecosystems, where natural and anthropogenic forcings interact to regulate the structure, productivity, and stability of small pelagic fish populations. Within this context, the north–central stock of anchovy (*Engraulis ringens*), a key component of the trophic network and the basis of one of the largest fisheries worldwide, exhibits nonlinear and discontinuous responses in population magnitude, size structure, somatic condition, reproductive activity, and spatial distribution. These responses indicate the presence of critical points in natural and anthropogenic pressures that affect the state and functional resilience of the stock. Using information from pelagic resource assessment surveys and fishery monitoring between 1996 and 2024, this study identifies critical points in environmental pressures (temperature, oxygen, upwelling, productivity) and anthropogenic pressures (catch, effort, and size selectivity). A multiscale analytical framework was applied, combining structural change detection tests (Rodionov regime shift test, STARS, and Pettitt non-parametric test) with functional response analyses using Boosted Regression Trees (BRT) and Generalized Additive Models (GAMs). This framework characterizes temporal trajectories, identifies nonlinear response zones, and estimates the relative importance of pressures on biological indicators. In addition, a functional resilience analysis quantifies recovery amplitude and duration after disturbances (e.g., El Niño events). The approach provides an early diagnostic of state transitions, establishes stock-based critical points, and explicitly incorporates resilience into adaptive and ecosystem-based management of small pelagic fisheries in the southeastern Pacific.

Keywords: anchovy, critical points, functional resilience, adaptive management, Humboldt Current.

SESSION 6

Managing Small-Pelagic Fisheries within an Ecosystem Approach: Lessons, Challenges, and Outlook

Oral Presentations

S06, Invited, AbstractID=18933

Black Sea small pelagic dynamics: Two key stocks

Ali Cemal **Gücü**

Middle East Technical University, Institute of Marine Sciences, Mersin, Turkey.
E-mail: gucu@ims.metu.edu.tr

The Black Sea represents one of the youngest and most hydrographically distinctive marine basins, shaped by repeated transitions between lacustrine and marine conditions. Following its reconnection with the Mediterranean roughly 10 000 years ago, a unique faunal assemblage evolved, combining elements of both temperate and boreal origin. Among small pelagic fishes, two species — the warm-affinity European anchovy (*Engraulis encrasicolus*) and the cold-adapted European sprat (*Sprattus sprattus*) — dominate ecosystem dynamics and regional fisheries.

The basin's strong stratification, with permanent anoxia below ~100 m and a pronounced thermocline that splits the oxygenated layer into a warm surface and a colder intermediate water mass, exerts a fundamental control on habitat structure and species distribution. Anchovy productivity is closely linked to nutrient inputs, retention within anticyclonic eddies, and seasonal circulation patterns such as the basin-wide Rim Current that facilitates spawning and migration. In contrast, sprat depend on a narrow niche bounded by the above and the anoxic layer below, where oxygen supply is maintained only through winter convection and Cold Intermediate Layer renewal.

Recent decades have seen growing evidence that climate-driven warming, weakened northerly winds, and eutrophication have altered these long-standing physical–biological linkages. The upward expansion of suboxic waters, deepening of the thermocline, and reduced winter ventilation collectively degrade habitat quality for sprat, while changes in wind forcing and current strength disrupt anchovy overwintering migrations and recruitment success. These changes coincide with apparent inconsistencies between model-based stock assessments and field observations, suggesting that conventional age-structured approaches may underestimate climate sensitivity.

This contribution reviews current understanding of these coupled processes and argues that establishing quantitative links between large-scale climatic drivers (e.g. the Arctic Oscillation) and recruitment dynamics is essential for developing more robust, environmentally grounded stock–recruit relationships in future assessments. Such an approach would provide a mechanistic basis for interpreting stock fluctuations and support adaptive management under continued environmental change.

S06, Oral, AbstractID=18798

A need for ecosystem-based management of Western Baltic herring under climate change and altered natural mortality rates

Rüdiger **Voss**, Martin F. Quaas and Nis S. Jacobsen

Kiel University, Kiel, Germany. E-mail: voss@economics.uni-kiel.de

Western Baltic herring fisheries are under distress. Stock size has decreased drastically, caused by a combination of overfishing and climate change. Currently, zero catch quota is scientifically advised. The Western Baltic Sea, and the Western Baltic herring stock as one of the economically most important stocks in the area, are key examples for the need of implementing ecosystem-based (fisheries) management. Scientific advice needs to take modifications in stock productivity into account to safeguard healthy stocks, and to secure viable fisheries, which provide economic and social benefits.

Here, we include (i) temperature-dependent stock-recruitment relationships and (ii) changes in natural mortality rates into an ecological-economic multispecies optimization model for Western Baltic herring fisheries. The model includes the interaction between herring and its historically most important predator, i.e. cod.

Climate-driven temperature increase negatively impacts stock productivity of herring and cod. We combine three climate change scenarios (RCP4.5, RCP8.5, constant climate) with different management scenarios, to explore the potential development of ecological and economic key fisheries indicators. Under ecosystem-based fisheries management, Western Baltic herring shows potential for stock recovery, but only if allowed for an initial stock rebuilding moratorium. Still, future commercial exploitation critically needs to include climate change as well as changes in natural mortality rates in order to avoid a repetition of too optimistic advice, and resulting overfishing. Future catch opportunities for cod are less optimistic, and will stay below 5.000 tons (historically >40.000 tons), even under optimal EBFM.

Under climate change, Multispecies Maximum Economic Yield (MMEY) management might be superior to Multispecies Maximum Sustainable Yield (MMSY) management in terms of stock size, catch, and total economic surplus, and would result in lower fishing mortality.

S06, Oral, AbstractID=18921, (ECOP)

Incorporating time-varying natural mortality into MSE framework for the EBFM of the Iberian sardine

Inês R. **Martins**, Dorota Szalaj, Laura Wise, Susana Garrido and Alexandra A. Silva

IPMA - Instituto Português do Mar e da Atmosfera, Algés, Portugal.
E-mail: ines.rebolo.martins@ipma.pt

The Iberian sardine (*Sardina pilchardus*) is a key low-trophic-level (LTL) species supporting not only major fisheries in Portugal and Spain, but also needs of multiple predators in the ecosystem. Therefore, it's recommended that its management account for ecological interactions and variability in ecosystem drivers. Developing ecosystem-based fisheries management requires incorporating ecological information into management procedures and testing their robustness under uncertainty.

Here, we integrate ecosystem-derived information from ecosystem model into a Management Strategy Evaluation (MSE) framework to test the robustness of harvest strategies for the sustainable management of the Iberian sardine fishery.

In this approach predator-prey interactions and ecosystem feedback derived from Ecopath with Ecosim (EwE), in the form of natural mortality (M) is implemented in the MSE process. To account for the uncertainty in the empirical methods to derive M, multiple initial values of M are calculated based on equations from Pauly, (1986), Gislason, (2010) and Lorenzen, (1996) and then incorporated into EwE. Consequently, simulations of time-varying M estimated from EwE are integrated into the operating model and assessment model testing the robustness of harvest control rules (HCRs) against ecosystem objectives. Furthermore, in addition to Blim ($SSB < Blim \leq 5\%$) reference point recommended by ICES, new, ecosystem-based reference point 75% B_0 recommended by the Marine Stewardship Council for key LTL species is used to set HCR to account for ecological variability.

This approach enables quantitative assessment of trade-offs among yield, stock stability, and ecosystem objectives, providing a robust, transparent basis for adaptive management of the Iberian sardine.

S06, Oral, AbstractID=18924 - CANCELLED

Incorporating seasonal and spatial dynamics into ecological reference points for Atlantic Menhaden

David **Chagaris**[1], Andre Buchheister[2], Katie Drew[3], Jainita Patel[3], Amy Schueller[4] and Alexei Sharov[5]

[1]University of Florida, Gainesville, FL, U.S.A. E-mail: dchagaris@ufl.edu
[2]Cal Poly Humboldt, Arcata, CA, U.S.A.
[3]Atlantic States Marine Fisheries Commission, Arlington, VA, U.S.A.
[4]NOAA Fisheries, Beaufort, NC, U.S.A.
[5]Maryland Department of Natural Resources, Annapolis, MD, U.S.A.

Atlantic menhaden (*Brevoortia tyrannus*) are a small pelagic fish that support the largest commercial fishery on the U.S. east coast, where approximately 145,000 mt are landed each year valued over $40 million USD. They are also important prey for many marine predators, including resident and migratory fishes, marine mammals, and birds. In 2020, ecological reference points (ERPs) were adopted by the Atlantic States Marine Fisheries Commission (ASMFC) with the objective of sustaining both menhaden and their predators. The ERPs were developed using an ecosystem model of the Northwest Atlantic Continental Shelf (NWACS) and a modeled tradeoff relationship between menhaden harvest and the biomass of a key predator, striped bass (*Morone saxatilis*). Those ASMFC ERPs were used by the ASMFC to set the coastwide total allowable catch, representing the first formal interdependent multispecies reference points ever adopted in the U.S. In 2025, the NWACS model was updated to resolve seasonal and spatial dynamics between predators and prey and the revised model and ERPs were again approved for management. This talk will provide an overview of menhaden ERPs, how seasonal and spatial dynamics were incorporated in the models, and future research needs to ensure the ERPs remain viable in the future and continue to address the evolving needs of managers.

S06, Oral, AbstractID=18942, (ECOP)

Aligning the management of small pelagic fish with ecosystem needs - A global review of progress, limitations, and future roadmap

Dorota **Szalaj**[1], Ines Martins[1], Laura Wise[1], Susana Garrido[1], Laurence T. Kell[2], Jacob W Bentley[3], Valerio Bartolino[4], Salvador E. Lluch-Cota[5], Concepción Enciso-Enciso[6], Warsha Singh[7], Maartje Oostdijk[8], Jaclyn Cleary[9], David Chagaris[10], Leire Ibaibarriaga[11], Leire Citores[11] and Peng Sun[12]

[1]Portuguese Institute of Sea and Atmosphere, Algés, Portugal. E-mail: dorota.szalaj@ipma.pt
[2]Centre for Environment Policy, Imperial College London, London, United Kingdom
[3]Natural England, London, United Kingdom
[4]Swedish University of Agricultural Sciences (SLU), Institute of Marine Research, Lysekil, Sweden
[5]Fisheries Ecology Program, Northwest Biological Research Center (CIBNOR), La Paz, Mexico
[6]Instituto Mexicano de Investigación en Pesca y Acuacultura Sustentable (IMIPAS), México
[7]Marine and Freshwater Research Institute, Fornubúðir 5, IS-220 Hafnarfjördur, Iceland
[8]Environment and Natural Resources Economics, Wageningen University, Wageningen, Netherlands
[9]Fisheries and Oceans Canada (DFO-MPO), Nanaimo, BC, Canada
[10]University of Florida, IFAS Nature Coast Biological Station, Cedar Key, FL, U.S.A.
[11]Marine and Food Research Center, AZTI, Basque Research and Technology Alliance (BRTA), Sukarrieta, Bizkaia, Spain
[12]College of Fisheries, Ocean University of China, Qingdao, China, PR.

Small pelagic fish (SPF) play a crucial role in marine food webs and global fisheries, and there is a growing consensus that their sustainable management depends on the implementation of ecosystem-based fisheries management (EBFM). This presentation reviews global SPF case studies to evaluate the extent of EBFM integration, highlight key challenges, and outline a roadmap for improving implementation worldwide. Ten SPF fisheries across the globe were selected based on relevance, geographic coverage, and data availability. Each case was analysed using a structured framework built on pre-defined criteria designed to assess the degree of EBFM integration across SPF stocks. These criteria were informed by previously identified challenges and key factors that enable effective EBFM. The assessment covered management practices, EBFM integration, incentives, availability of expertise and knowledge, stakeholder involvement, institutional and legal support, and main challenges. Through the application of this framework, we assessed the level and maturity of EBFM in SPF across regions, identified common barriers, and derived recommendations to advance its operationalization. This analysis provides an overview of the current global state of EBFM in SPF fisheries and helps guide future efforts to overcome challenges and strengthen sustainable management.

S06, Oral, AbstractID=18949 (CANCELLED)

OSMOSE as a Model of Intermediate Complexity (MICE) for climate-aware, tactical management of the shared small pelagic fisheries in Southern Peru and Northern Chile

Ricardo **Oliveros-Ramos**[1], Dante Espinoza-Morriberón[2], Jorge Tam[2] and Camilo Torres[3]

[1]MARBEC, University of Montpellier, IRD, CNRS, Ifremer, Montpellier, France.
E-mail: ricardo.oliveros@ird.fr
[2]Instituto del Mar del Perú, Callao, Perú
[3]Instituto de Fomento Pesquero, Valparaiso, Chile

Small pelagic fisheries are among the world's most productive and socioeconomically critical marine resources, yet their shared nature across national boundaries poses major management challenges. The Humboldt Current System sustains one of the world's most productive small pelagic fisheries, dominated by anchoveta (*Engraulis ringens*). In its central region, the stock is shared by Peru and Chile, making coordinated, ecosystem-based management essential to ensure both sustainability and resilience under environmental variability.

To address this challenge, we developed OSMOSE-SPNC, a binational ecosystem model designed to provide a harmonised framework supporting transboundary fisheries management. Built on OSMOSE, an individual-based, spatially explicit model simulating size-structured trophic and fishing dynamics, OSMOSE-SPNC has been adapted as a Model of Intermediate Complexity for Ecosystem assessments (MICE). The model is interannually calibrated with multi-source data from both countries for the period 1994-2024, including fishery-dependent and -independent observations, alongside environmental forcing from NEMO–PISCES biogeochemical simulations.

OSMOSE-SPNC bridges the gap between single-species assessments and full end-to-end models, enabling exploration of ecological, economic, and governance dimensions under scenarios of environmental change. It represents 19 species or functional groups, with explicit focus on anchoveta, sardine (*Sardinops sagax*), and red lobster (*Pleuroncodes monodon*), including both industrial and artisanal fisheries from Chile and Peru. This allows detailed investigation of food-web interactions and ecosystem-scale responses to fishing.

This binational initiative demonstrates the feasibility and value of OSMOSE as a flexible, climate-aware modelling platform, capable of supporting tactical, adaptive applications for transboundary small pelagic fisheries. Through this flexibility, OSMOSE-SPNC provides a robust framework to explore short- and medium-term management scenarios, assess ecosystem responses to fishing and environmental variability, and guide sustainable, transboundary forage fish management.

S06, Oral, AbstractID=18959, (ECOP)

Assessing the *lilang* fishery of Miagao, Iloilo, Philippines: Ecosystem-based insights on catch dynamics and sustainable fisheries management

Tiffany C. Xu and Jerry Ian L. **Leonida**

Institute of Marine Fisheries and Oceanology, CFOS, UP Visayas, Philippines.
E-mail: jlleonida@up.edu.ph

The *lilang* fishing gear is an artisanal modified pushnet targeting small pelagic species in the coastal waters of Miagao, Iloilo, Philippines. This study provides the first molecular-based species confirmation of *maragbas* and *gurayan*, the target catch of *lilang* and other fine-meshed fishing gears in the region. DNA barcoding identified the said target catch as the respective larval and juvenile stages of two anchovies species, *Encrasicholina heteroloba* and *E. punctifer*. This resolves the longstanding taxonomic misconception for these culturally important small pelagic resources, often thought of by locals as adult individuals. Through catch monitoring and semi-structured interviews with 55 fishers across 12 coastal barangays, we documented catch composition, fishing effort, and socioeconomic factors affecting fisher participation and compliance with regulations. The lilang fishery exhibited high species selectivity (98% anchovies) and minimal bycatch, but exhibited high catch variability (0.41–6.21 kg/trip monthly average) and low economic return. Reported net income revealed that 31.8% of fishers participating in the *lilang* fishery earned only at most PhP 5,000 (~USD 90) over the entire 6-month open season, with about one-third experiencing net losses, which forces them to engage in 1-6 alternative livelihoods. Key factors identified to affect catch and livelihood include climate change, commercial fishing encroachment, and high fuel costs. Hence, we propose an ecosystem approach to fisheries management by integrating ecological sustainability, strong social protection mechanisms such as alternative livelihoods, and participatory governance to achieve long-term management success for *lilang* and other small pelagic fisheries facing environmental and overfishing crises.

S06, Oral, AbstractID=18976, (ECOP)

Distal drivers of fishing pressure in small pelagic fisheries

Beth **Woodhead**[1], Christina Hicks[1], Ife Okafor-Yarwood[2], Gareth Williams[3] and James Robinson[1]

[1]Lancaster University, Lancaster, County, United Kingdom.
E-mail: b.woodhead@lancaster.ac.uk
[2]University of St Andrews, St Andrews, United Kingdom
[3]Bangor University, Menai Bridge, United Kingdom

Small pelagic fish (SPF) are disproportionately important for food security in low- and middle-income countries, yet an increasing number of SPF stocks are overexploited or collapsing due to high fishing effort. Distal drivers are underlying social processes which influence proximate drivers present in the focal system. Impacts of overfishing are often studied using proximate drivers, such as fishing effort, rather than the underlying distal drivers such as market demand, demographic change or governance. SPF fisheries are complex, meaning they are exposed to a variety of interacting drivers. We therefore lack holistic understanding of how distal drivers affect fishing effort on SPF. Here, we conduct a systematic review to assess the influence of five categories of distal driver (policy and governance, economics, demographics, culture and technology) on fishing pressure in SPF fisheries. We analysed 16 papers, focusing on fisheries across Europe, Asia, North America and Africa. These papers consider seven species, and 50% of studies focused on herring species. The most prevalent single drivers were technological advances relating to fishing gear and boats, whereas demographic change, traditions and compliance were least frequently identified. Across driver categories, economic drivers and policy and governance drivers appeared most often. 72% of studies only identified one distal driver of fishing pressure, whereas studies of multiple distal drivers identified technological plus policy and governance drivers as the most common combination. By examining distal drivers of fishing effort, this study expands our understanding of the factors driving fishing pressure on SPF. Sustainable SPF management should look to incorporate understanding of distal drivers to ensure that SPF fisheries can continue to support coastal communities.

S06, Oral, AbstractID=19013, (ECOP)

Evaluating climate-responsive management strategies for Gulf menhaden using an end-to-end ecosystem framework

Hallie C. **Repeta** and Cameron H. Ainsworth

University of South Florida, St. Petersburg, U.S.A. E-mail: hallierepeta@usf.edu

Gulf menhaden (*Brevoortia patronus*) are among the most abundant small-pelagic forage fish in the northern Gulf of Mexico, supporting a wide range of predator species and sustaining the region's largest fishery by volume and the second-largest by weight in the United States. Climate change is influencing the northern Gulf through rising sea levels, warming waters, and shifts in precipitation patterns that alter freshwater and nutrient discharge from the Mississippi River. These environmental changes can affect estuarine and nearshore productivity, habitat availability, and plankton dynamics, all of which are essential for menhaden across different life stages in the region. Seasonal and spatial shifts in plume dynamics and nutrient loading further contribute to ecosystem uncertainty, underscoring the need to better understand how changing environmental conditions may affect Gulf menhaden populations and ecosystem resilience. This study applies the Gulf Atlantis ecosystem model—a spatially explicit, end-to-end framework—to evaluate a suite of harvest control rules, including ecosystem-based and climate-responsive strategies, using a management strategy evaluation framework approach. The model integrates trophic and biophysical dynamics and simulates varying nutrient inputs from the Mississippi River to represent climate-driven changes in productivity and ecosystem variability. Scenario-based simulations will evaluate the range of harvest control rules under varying environmental conditions, with performance assessed across multiple ecological and fishery indicators. We hypothesize that static harvest control rules perform less effectively under climate-driven variability, leading to greater fluctuations in forage fish biomass and reduced predator resilience. Results will inform adaptive, ecosystem-based management strategies to support forage fish productivity and ecosystem resilience under future environmental change.

S06, Oral, AbstractID=19021

Applying the ecosystem approach to small pelagic fisheries management

Marcelo **Vasconcellos**

Fisheries and Aquaculture Division, Food and Agriculture Organization (FAO), Rome, Italy.
E-mail: marcelo.vasconcellos@fao.org

The ecosystem approach to fisheries (EAF) has been widely promoted and applied as a framework for managing the risks to the sustainable development of fisheries. Its implementation typically involves integrating scientific data and local knowledge to evaluate ecological, social, economic, and institutional dimensions of a fishery. Risk assessment is then used to prioritize key issues for inclusion in comprehensive, multi-annual management plans. Throughout this process, management objectives are defined, management interventions proposed, and indicators selected to monitor performance. This presentation reviews experiences with the application of the EAF in selected small pelagic fisheries across developing countries. It aims to identify lessons and common management priorities emerging from these cases and to discuss how such priorities can guide research agendas to strengthen the effectiveness of small pelagic fisheries management.

S06, Oral, AbstractID=19039

Modelling predator-prey dynamics to evaluate management tradeoffs for a rebuilding Pacific herring population

Ashleen Benson[1], Jaclyn **Cleary**[2], Sean Cox[1], Samuel Johnson[1], Jim Lane[3] and Beau Doherty[1]

[1]Landmark Fisheries Research, Port Moody, BC Canada.
[2]Fisheries and Oceans Canada, Nanaimo, BC, Canada. E-mail: Jaclyn.Cleary@dfo-mpo.gc.ca
[3]Uu-a-thluk Fisheries, Port Alberni, BC, Canada

Pacific herring (*Clupea pallasi*) on the west coast of Vancouvser Island (WCVI) declined to historically low biomass levels in 2006, and experienced persistent low biomass and low productivity states from 2006 through 2012 despite concurrent fishery closures. Recent annual stock assessments estimate a modest increase in biomass, but persistent and high rates of adult natural mortality. Both western and Indigenous science confirm significant increases in herring predator populations in recent decades, and suggest an ecosystem-based mechanism for the continued low productivity of herring in this stock area. These dynamics present a challenge for establishing a pragmatic rebuilding plan for WCVI herring.

This project is led by the Nuu-chah-nulth First Nations for whom WCVI herring are important as both commercial and traditional sources of food. This collaboration, which includes Fisheries and Oceans Canada, aims to develop a holistic, ecosystem approach to herring rebuilding and management. As the first step toward meeting this goal, we developed a model of intermediate complexity (MICE) of herring and their key predators in the WCVI. This approach characterizes the trade-offs between ecosystem needs (predator consumption rates), herring stock growth, and harvest opportunities under alternative rebuilding policies, and has since been integrated into the Pacific Herring MSE process.

This project is the first to provide tactical, ecosystem-based advice for rebuilding herring populations in the Pacific Northwest.

S06, Oral, AbstractID=19069, (ECOP)

Managing round sardinella *Sardinella aurita* in the eastern Mediterranean: Stock-unit identification, assessment, and management advice in the context of an Ecosystem Approach to Fisheries

Reda M. Fahim[1,2], Hatem H. Mahmoud[2], Abdelnasser Madi[3], Savaş Kiliç[4], Süleyman Öztürk[4], Ali Cemal Gücü[5], Myriam Lteif[6], Sharif Jemaa[6], Stefano Lelli[1], John G. **Ramirez**[1] and Elisabetta B. Morello[1]

[1]General Fisheries Commission for the Mediterranean, Palazzo Blumenstihl, Via Vittoria Colonna, 1, 00193, Rome, Italy. E-mail: john.ramireztellez@fao.org
[2]College of Fisheries and Aquaculture Technology, Arab Academy for Science, Technology and Maritime Transport, Alexandria, Egypt.
[3]Ministry of Agriculture, Gaza, Palestine
[4]Mediterranean Fisheries Research Production and Training Institute, Antalya, Türkiye
[5]Institute of Marine Sciences, Middle East Technical University, Erdemli-Mersin, Türkiye
[6]National Center for Marine Sciences, Beirut, Lebanon

Round sardinella (*Sardinella aurita*), a warm-water small pelagic species with a "wasp-waist" trophic role, is increasingly influential in eastern Mediterranean food webs and coastal fisheries. In this area, rising sea temperatures are hypothesized to interact with anthropogenic nutrient enrichment along the Nile Delta arising from fertilizer and sewage inputs since construction of the Aswan High Dam. Against a naturally oligotrophic background, Nile-derived nutrients, historically natural and increasingly anthropogenic, periodically enhance coastal productivity and fish landings. Given these environmental and anthropogenic dynamics, determining stock status and formulating management advice under limited, heterogeneous data and unresolved stock-unit boundaries was a key challenge. A coordinated effort was developed under the UN FAO's General Fisheries Commission for the Mediterranean (GFCM), spanning Geographical Subareas (GSAs) 24 (Türkiye), 26 (Egypt), and 27 (Palestine and Lebanon). Drawing on the FAO regional project EastMed's activity (FISHBONE), two assessment units were treated: north (Türkiye–Lebanon) and south (Egypt–Palestine) using a holistic, multi-evidence framework. Historical information was compiled and indices prepared to track stock evolution, and a stochastic surplus-production model in continuous time (SPiCT) was fitted to fishery-dependent and -independent data from the subregion. The final model runs indicated sustainable exploitation for the northern unit (Türkiye–Lebanon), whereas the south-eastern unit (Egypt–Palestine) is at increased risk of being overexploited and in overexploitation. These differences require a tailored approach to management prioritizing the Ecosystem Approach to Fisheries (EAF). Building on the appraisal undertaken by the GFCM's Subregional Committee for the Eastern Mediterranean (SRC-EM), a toolbox of measures was formulated comprising temporal closures; minimum landing size; spatial restrictions; gear standards; and effort controls. Furthermore, a data-limited Management Strategy Evaluation (MSE) is being explored to test candidate harvest rules and area/gear licensing under opportunistic targeting, linking stock-structure hypotheses to robust, climate- and nutrient-attuned advice.

S06, Oral, AbstractID=19070

Management of shared sardinella in Northwest Africa

Khallahi Brahim[1], Mika T. Diop[1], Coumba Ndoffène Diouf[2], Fambaye Ngom Sow[3], Cheikh-Baye Braham[4], Momodou Sidibeh[5], Momodou Jallow[5], Matthieu Bernardon[6], Mostafa ElHalimi[6], Tarub Bahri[6] and Merete **Tandstad**[6]

[1]Sub-Regional Fisheries Commission (SRFC/CSRP), Secrétariat Permanent, BP 25 485, Dakar-Fann, Sénégal
[2]Directorate of Maritime Fisheries of Senegal, Dakar, Senegal
[3]Institut Sénégalais de Recherche Agricole (ISRA), Centre de Recherche Océanographique de Dakar-Thiaroye (CRODT), BP 2241, Centre PRH, Dakar, Sénégal
[4]Institut Mauritanien de Recherches Océanographiques et des Pêches (IMROP), Noukachott, Mauritania
[5]Fisheries Department, 6 Marina Parade, Banjul, The Gambia
[6]Food and Agriculture Organization of the United Nations, Rome, Italy.
E-mail: merete.tandstad@fao.org

This talk will provide an overview of recent actions to strengthen the science policy pathway for the management of sardinella (*Sardinella aurita* and *S.maderensis*) in Northwest Africa. It will focus on activities that bring research and decision-making together, showing how scientific results (including stock assessments through the Fishery Committee for the Eastern Central Atlantic (CECAF)) are translated into management measures (e.g. seasonal closures, minimum sizes, gear controls) via institutional mechanisms (national committees, consultation platforms) and guidance documents (policy briefs, management plans) at the national and subregional levels.

Sardinella species (*Sardinella aurita* and *S. maderensis*) are among the most important small pelagic fish resources in Northwest Africa, sustaining the food security, nutrition and livelihoods of millions of people. These species are central to artisanal and industrial fisheries and constitute a key source of affordable animal protein and nutrients, especially for low-income households. The stocks migrate across the waters of Mauritania, Senegal, The Gambia and Guinea-Bissau, following the seasonal dynamics of the Canary Current upwelling system. Their transboundary nature makes regional cooperation essential for ensuring long-term sustainability. Recent scientific assessments by CECAF have confirmed the overexploited status of these stocks and recommended substantial reductions in fishing mortality. With the above in mind, the EAF-Nansen Programme of FAO launched the Shared Sardinella Initiative jointly with regional and national partners in 2021. The initiative combines regional and national actions for sustainable fisheries management in Northwest Africa, and involves the development and implementation support of EAF-aligned fisheries management plans for sardinella in Senegal, The Gambia, Mauritania and Guinea-Bissau and through a regional management framework under the Sub-regional Fisheries Commission. This talk will demonstrate how scientific evidence, institutional cooperation and stakeholder engagement can converge to address transboundary resource management challenges, highlighting lessons learned.

S06, Oral, AbstractID=19071, (ECOP) (CANCELLED)

Overexploitation of round sardinella may lead to the collapse of flat sardinella: What lessons can be drawn for shared stocks (North West Africa)

Cheikh-Baye **Braham**, Mohamed Ahmed-Jeyid, Jilali Bensbai, Fambaye Ngoum, Ad Corten d and Jo Gascoigne

Institut Mauritanien de Recherches Océanographiques et des Pêches (IMROP), Nouadhibou, Mauritania. E-mail: baye.braham@gmail.com

This paper describes the fisheries and presents quantitative stock assessments for two stocks of Sardinella in the waters of NW Africa. More robust stock assessments are now possible because of improved sampling in Mauritania and Senegal. Round sardinella (*S. aurita*), which has a wider distribution than flat sardinella (*S. maderensis*), is the most important species targeted by the different artisanal and industrial fleets. The industrial fleet is located beyond 13 miles from the coast, taking mainly adults. The average fish size in the offshore fishery, although it has decreased, remains above 26 cm. The species is also exploited by an artisanal fleet using small purse seiners. Two types of assessment model were applied: a production model and size-based model. The abundance indices were consistent, and showed a continuous decline, increasing in rate in recent years. The Just Another Bayesian Biomass Assessment (JABBA) model (applied for the first time) appeared to be appropriate for the abundance indices (Root Mean Squared Error (RMSE) 18.3–19.2 % for the two models). The results of the two models are consistent in showing increasing fishing mortality and declining biomass for both stocks over the time series. According to the JABBA model, the situation for the round sardinella stock is now critical (biomass at approximately 5 % of unexploited biomass (B0) and 10 % of biomass capable of producing maximum sustainable yields (Bmsy), with fishing mortality 2.5 times above Fmsy), and the flat sardinella is also overfished and suffering massive overfishing (B estimated at 18 %B0 and 25 %Bmsy, with fishing mortality more than 11 times above Fmsy). The results of the Length-based Bayesian Biomass (LBB) model are much more optimistic. It still concludes that both stocks are suffering overfishing (round sardinella F at ~1.4 times Fmsy proxy, flat sardinella ~2.2 times Fmsy proxy), but estimates that only the flat sardinella is overfished (B 28%B0 and 80 %Bmsy), while the round sardinella stock is not overfished (B 40 %B0 and 120 %Bmsy). However, these results are not consistent with the abundance index from acoustic surveys (used in the JABBA model) and overall are thought to be less robust. Signs of heavy exploitation have been observed for round sardinella for several years. This situation has been exacerbated since the arrival in late 2016 in the Mauritanian zone of efficient semi-industrial purse seiners targeting small pelagics. The various indirect assessment models used show a difficult stock situation for the round sardinella, on which many fishing communities in the area depend. Abundance indices from acoustic survey confirm the state of overexploitation of this resource. This situation has directed effort towards the flat sardinella, which is characterized by a more coastal distribution and limited migration. This species has been showing signs of overexploitation since 2019. We highlight this result for flat sardinella, which was previously not thought to be overexploited, and propose that managers should also consider how the estimated maximum sustainable catch and fishing mortality can be appropriately distributed between the different fleets in different countries, to ensure that future industry planning in the countries of the region is compatible with the sustainability of these critical stocks. This is a very complex

task, as it involves not only discussions between neighboring countries, but also difficult decisions within countries about the economic and socio-economic importance of different fisheries sectors. It is essential that these reflections start immediately.

S06, Oral, AbstractID=19086

Regional management of small pelagic fisheries in the West Central Gulf of Guinea

Antoine Gaston Djihinto[1], Kossi Ahoedo[1], Victor Okpeitcha[2], Samantha Osei Vida[3], Matthieu Bernardon[4], Mostafa El Halimi[4] and Merete **Tandstad**[4]

[1]Fishery Committee for the West Central Gulf of Guinea (FCWC), Tema, Ghana
[2]Direction des Pêches, Cotonou, Bénin
[3]Fisheries Scientific Survey Division, Fisheries Commission, Ghana
[4]Food and Agriculture Organization of the United Nations (FAO), Rome, Italy.
E-mail: merete.tandstad@fao.org

This talk will provide an overview of recent actions to strengthen the science-to-policy pathway for the management of small pelagic fisheries in the West Central Gulf of Guinea (WCGG). It will highlight how scientific results, including stock assessments under the Fishery Committee for the Eastern Central Atlantic (CECAF), are being translated into management measures (e.g. seasonal closures, minimum sizes, gear standards) through institutional mechanisms (national committees, consultation platforms) and guidance instruments (policy briefs, management plans) at both national and regional levels.

Small pelagic fish resources -including sardinellas (*Sardinella aurita* and *S. maderensis*), anchovy (*Engraulis encrasicolus*), horse mackerels (*Trachurus trecae*, *Decapterus* spp.) and chub mackerel (*Scomber japonicus*)- rank among the most important marine resources in Benin, Côte d'Ivoire, Ghana and Togo. These species sustain millions of livelihoods across artisanal, semi-industrial and industrial fleets and represent a key source of affordable animal protein and nutrients for coastal communities. They migrate along the four countries' coasts following the seasonal upwelling dynamics of the Guinea Current Large Marine Ecosystem, making regional cooperation essential for long-term sustainability. Recent CECAF scientific assessments confirm that most small pelagic stocks in the WCGG are fully exploited or overexploited, recommending significant reductions in fishing mortality to rebuild biomass and secure food supply.

Responding to this challenge, the EAF-Nansen Programme of FAO, in partnership with the Fishery Committee for the West Central Gulf of Guinea (FCWC) and national institutions, launched a joint initiative in 2024 to develop a regional, Ecosystem-Approach-to-Fisheries (EAF) aligned management framework for shared small pelagic stocks. The initiative bridges science and management by producing policy briefs that translate CECAF advice into operational options and by guiding the multi-level validation of a coordinated regional management plan through FCWC governance bodies.

This talk will demonstrate how scientific evidence, institutional cooperation and stakeholder engagement can converge to address transboundary small pelagic fisheries management challenges in the Guinea Current system, highlighting lessons learned from strengthening the science-policy interface and enhancing regional collaboration for sustainable small pelagic fisheries in the West Central Gulf of Guinea.

SESSION 6

Managing Small-Pelagic Fisheries within an Ecosystem Approach: Lessons, Challenges, and Outlook

Poster Presentations

S06, Poster, AbstractID=18313, PosterID: S06-P1, (ECOP)

A sudden decline in sardinella populations in West Africa linked to environmental change and fishing pressure: The case of Senegal

Bocar Sabaly **Baldé**[1*], Saliou Faye[1] and Patrice Brehmer[1,2,3]

[1]Institut Sénégalais de Recherches Agricoles (ISRA), Dakar, Sénegal.
E-mail: bocarbalde2005@hotmail.com
[2]IRD, Univ Brest, CNRS, Ifremer, UMR Lemar, BP 1386, Dakar, Sénégal
[3]Commission Sous Régionale des Pêches, CSRP, Secrétariat Permanent de la CSRP, BP 25485, Dakar-Fann, Sénégal
*Corresponding author

The round sardinella (*Sardinella aurita*) is a small thermophilic pelagic clupeid fish exploited by purse seine fisheries throughout West Africa. In Senegal, it is crucial for coastal populations in terms of employment and food sources. Recently, catches and size structures of round sardinella, as reflected in purse seine catches, have progressively decreased over the years (2001 to 2020). This progressive decrease is linked to the increase in fishing effort and the decrease in sea surface temperature observed during the study period in Senegal. Changes in catch quantities and population size structures can have adverse ecological effects on the community and ecosystem and affect the economics of local fisheries. This approach, which also takes into account the socio-economic context of the fishery, enables management advice to be developed within the framework of ecosystem-based fisheries management. The results of the model will guide governmental and non-governmental institutions in adapting conservation and restoration objectives to climate change mitigation and adaptation strategies.

Keywords: Data poor fisheries, Environmental variability, West Africa, Size structure, Small pelagic.

S06, Poster, AbstractID=18782, PosterID: S06-P2, (ECOP)

Diagnosing artisanal small-pelagic fisheries in São Tomé and Príncipe: Key findings and management implications

Wilfred Boa Morte **Zacarias**[1,2*], Mario Pinho[1,2] and Régis Santos[1,2]

[1]School of Science and Technology, Azores University, Horta, Açores, Portugal.
[2]Orkeanos/ Azores University, Horta, Açores , Portugal. E-mail: wilfredzacarias@live.com

Artisanal small-pelagic fisheries are fundamental to food security and local livelihoods in São Tomé and Príncipe (STP), yet long-term patterns in catch composition, fishing effort, and fleet behavior remain poorly documented. This study provides the first integrated historical assessment of the artisanal small-pelagic sector (1952–2024), encompassing fishing practices, species composition, effort indicators, vessel dimensions, gear performance, and the socioeconomic conditions of fishing communities. A descriptive-analytical framework was applied, supported by quantitative and comparative approaches. Data were collected by the Directorate of Fisheries and Aquaculture under the FISH4ACP program. Eight key species were analysed—*Caranx crysos*, *Euthynnus alletteratus*, *Cheilopogon melanurus*, *Hemiramphus balao*, *Decapterus macarellus*, *Sardinella aurita*, *Seriola rivoliana*, and *Decapterus punctatus*—which together accounted for 63% of total landings between 2021 and 2024. The results show a pronounced rise in total landings, from roughly 2,500 t/year in the 1950s to a peak exceeding 12,000 t/year in 2015. This increase was followed by moderate declines and, more recently, a stabilization, despite increasing fishing effort and widespread motorization of the artisanal fleet. Among small-pelagic species, *E. alletteratus*, *C. crysos*, *C. melanurus*, and *D. macarellus* were dominant, accounting for up to 35% of total landings. Smaller pelagic species, including. Notably, a substantial post-2000 increase in the 'other species' category indicates a growing diversification of catches. Fleet motorization expanded sharply after 2010, with motorized vessels accounting for more than 70% of totais trips, while oar/sail vessels showed a continuous decline. Socioeconomic data revealed low profitability, and structural constraints that limit the adaptive capacity of communities. This study provides the first baseline characterisation of artisanal small pelagic fisheries in the archipelago and offers essential scientific evidence to support future assessment initiatives and the development of sustainable fisheries management strategies.

S06, Poster, AbstractID=18839, PosterID: S06-P3

Assessment and management of the thread herring stock complex (*Opisthonema* spp.) in the southern gulf of California, 2024

Mercedes L. **Jacob-Cervantes**[1], Carolina, Espino-Leal[2], Efraín Delgado-Robles[2], Diana L. Cervantes-Rendón[2] and J. Carlos Díaz-Figueroa[2]

[1]Instituto Mexicano de Investigación Pesquera y Acuicola Sustentable, Mazatlán, Sinaloa, México. E-mail: laura.jacob@imipas.gob.mx
[2]Maz Sardina S.A. de C.V. Mazatlán, Sinaloa, México.

In the southern gulf of California, small pelagic fishes are an important commercial resource. Among them, three species of thread herring (*Opisthonema libertate*, *O. medirastre*, and *O. bulleri*) stand out, which are caught simultaneously and managed as a single stock complex. This study presents the population assessment of the *Opisthonema* spp. complex for the 1988–2024 period using a Statistical Catch-at-Age (SCA) model that incorporates fishery-independent indices. In parallel, the Stock Synthesis 3 (SS3) model is being implemented. For 2024, the SCA model estimates 214,180 t of recruits, 290,516 t of spawning biomass, and a fishing mortality (F) of 0.150. The model explains 97.8% of the variation in the observed catch. The estimated biological reference points were B_{MSY} = 240,128 t; F_{MSY} = 0.299; and B_{MIN} = 25,292 t. The management quantities calculated for 2024 are: Reference Catch (CR) = 68,635 t; Allowable Catch Limit (LCA) = 82,648 t; and Overexploitation Limit (LSE) = 86,998 t. From an ecosystem-based perspective, the Noxicline reference point (HR_i = 0.4–0.45 biomass) indicates that the CR (HR_i = 0.013) does not compromise the organization or functioning of the ecosystem. Overall, the results reflect a healthy stock and an exploitation level consistent with ecosystem resilience, suggesting that the *Opisthonema* spp. complex maintains a favorable balance between fishery sustainability and ecosystem integrity.

S06, Poster, AbstractID=18865, PosterID: S06-P4, (ECOP)

Assessment and management of the southern stock of *Sardinops sagax* and the central stock of *Engraulis mordax* on the west coast of the Baja California Peninsula, Mexico

Concepción **Enciso-Enciso** and Manuel O. Nevárez-Martínez

Instituto Mexicano de Investigación en Pesca y Acuacultura Sustentables (IMIPAS), Ciudad de México, México. E-mail: concepcion.enciso@imipas.gob.mx

The Pacific sardine (*Sardinops sagax*) and the northern anchovy (*Engraulis mordax*) are the two main species of small pelagic fish (SPF) present on the western coast of the Baja California Peninsula. They contribute an average catch volume of approximately 330,000 tons per year and represent 88% of catches (72% and 16%, respectively). Both resources exhibit large fluctuations in their distribution and abundance, primarily due to environmental variability. To maintain the resilience of their abundances, Mexico has a management plan that includes two categories: active management (in the case of *S. sagax*) and passive management (in the case of *E. mordax*). Both categories prevent overexploitation and their main objectives are to evaluate biomass and recruitment, conserve yield, and, above all, economic benefit. To this end, indicators of overexploitation, overfishing, and optimal yield have been defined (through Harvest Control Rules). This study evaluates the level of exploitation of both species over the period analyzed. It is inferred that the current state of both resources is being exploited to the maximum sustainable level, as corroborated by the Kobe Diagram.

Keywords: Pacific sardine, Northern anchovy, Abundance, Harvest Control Rule, Dynamic Management.

S06, Poster, AbstractID=19028, PosterID: S06-P5, (ECOP)

Abundance and length-based indicators to monitor trends of by-catch and secondary stocks for purse-seine fishery management in mainland Portugal

Gaël **Grand-Garcia**[1], Paola Ossa[1], Ana Moreno[1], Diana Feijo[1], Santiago Cerviño[2] and Alexandra A. Silva[1]

[1]Instituto Portugês do Mar e da Atmosfera (IPMA), Lisboa, Portugal.
E-mail: gael.garcia.formacao@ipma.pt
[2]Centro Oceanográfico de Vigo, Instituto Español de Oceanografía (IEO-CSIC), Vigo, Spain

Purse seine is the most important fishery in mainland Portugal inducing pressure on target sardine (*Sardina pilchardus*), but also on secondary or by-caught stocks such as Atlantic chub mackerel (*Scomber colias*) stocks, blue jack mackerel (*Trachurus picturatus*) and Mediterranean horse mackerel (*T. mediterraneus*). These competitors and predators of sardine have not been subject to dedicated management programs, and little information is known about their stock status. Here we evaluated trends in the abundance and Length-Based Indicators (LBI) of stock status, using data from bottom-trawl and acoustic surveys since 1995. Preliminary results from acoustic surveys indicated that Mediterranean horse mackerel was distributed mostly in the southern waters of the Iberian Peninsula and occurred almost every year. Trends of mean length in samples showed a slight decrease over the years. The abundance of Atlantic chub mackerel and blue jack mackerel showed a shallow increasing trend. For both species, LBI related to the conservation of juveniles were below standard reference points with a negative trend. Those related with large fish conservation were above the reference points but also showed negative trends. These results suggested that the conservation of large fish is not a matter of concern. However, juveniles are predominant in the catches. While fishery independent data may be used to derive LBIs, estimates based on fishery-dependent data are acknowledged to perform better and need to be analysed to support the present results. This work is expected to give a more holistic approach to purse seine fishery management.

S06, Poster, AbstractID=19091, PosterID: S06-P6, (ECOP) **(CANCELLED)**

Impacts of climate change and fishing pressure on bioenergetic trade-offs and community structure in small pelagic fish

Peng **Sun**, Wenbo Deng, Jianchao Li and Yongjun Tian

Ocean University of China, Qingdao, Shandong, China, PR. E-mail: sunpeng@ouc.edu.cn

Abstract：Small pelagic fish play a key role in marine ecosystem, serving as a critical link in the transfer of energy across trophic levels and contributing to the stability and biodiversity of ecosystems. Despite the recognized importance of fisheries and climate change in reshaping small pelagic fish populations, a quantitative understanding of how these factors influence population dynamics and bioenergetic trade-offs from an ecosystem perspective remains lacking of exploration. In this study, we used OSMOSE ecosystem model to simulate the dynamics of community structure and diversity in different functional groups of fish under different scenarios of climate change, larval mortality, and fishing. Our results show that climate change and fishing pressure significantly affect the biomass, age structure, and trophic levels of small pelagic fish, leading to a marked decline in functional evenness and energy transfer efficiency within communities. Furthermore, our findings highlight that climate change, larval mortality, and fishing pressure are key factors influencing the community structure and functional diversity of small pelagic fish, impacting ecosystem energy flow and stability. This study provides a comprehensive quantitative evaluation of the ecosystem's health by integrating these factors, providing new insights for ecosystem-based fisheries management.

Keywords: small pelagic fish, ecosystem model, ecological indicators, energy flow, community structure

SESSION 7

Integrating Social Metrics into Economic Growth Strategies for Small Pelagic Fisheries

Oral Presentations

S07, Invited, AbstractID=19084

Decent work and sustainable livelihoods: An institutional and international perspective

Mariana **Toussaint**

FAO, Rome, Italy. E-mail: mariana.toussaint@fao.org

The fisheries and aquaculture sector, including the small-pelagic fisheries sector, is a cornerstone of global food security, nutrition, and poverty reduction, particularly in developing coastal regions where small-pelagic species constitute an affordable source of animal protein and essential fatty acids. Beyond its nutritional contribution, the small-pelagic fisheries subsector sustains millions of livelihoods across capture, processing, and trade. According to FAO, around 62 million people are directly employed in primary fisheries and aquaculture production, with small pelagic fisheries accounting for a substantial share of capture employment, especially in small-scale and artisanal operations that underpin local economies and women's participation in post-harvest activities. Furthermore, hundreds of millions more depend at least partially on the sector, magnifying its socio-economic importance for many coastal and inland communities.

The importance of ensuring decent working conditions in this subsector is underscored by the challenges it faces. High labour intensity, seasonal variability, informal employment, and exposure to occupational risks both at sea and in processing are some examples of these challenges. In addition, quantifying social dimensions in this sector remains difficult. Data on employment quality, gender roles, and income distribution are often fragmented or absent, particularly for small-scale operators, women and migrant workers. This limits institutional capacity to monitor progress toward decent work and inclusive growth.

International normative instruments are essential to translate broad development objectives into concrete protections and decent work outcomes across the value chain of this sector. The FAO Code of Conduct for Responsible Fisheries and the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries, provide essential normative foundations for improving labour conditions, social protection and governance across the small-pelagic value chain. Furthermore, strengthening data systems, while advancing the implementation of international instruments is thus central to ensuring that the small-pelagic sector contributes not only to sustainable food systems but also to fair and resilient livelihoods.

S07, Oral, AbstractID=18902, (ECOP) (CANCELLED)

Anchors of resilience: Cultural significance of small pelagic fish in South African coastal communities

Simo **Ntombela**

University of Cape Town, Cape Town, Western Cape, South Africa.
E-mail: ntombelasimo1@gmail.com

Small pelagic fish are central to both marine ecosystems and coastal livelihoods in South Africa, yet their abundance, distribution, and cultural meanings are shifting under the pressures of climate change, environmental variability, and governance transformations. While much research has examined the ecological dimensions of these changes, less attention has been paid to how coastal communities themselves interpret and adapt to them. This study investigates how the cultural significance of small pelagic fish shapes pathways of socio-ecological resilience among indigenous coastal communities in Umgababa, KwaZulu Natal South Africa. Using a socio-ecological systems lens, the research combines narrative interviews, policy analysis, and place-based ethnographic methods to explore how communities experience environmental change, reinterpret traditional ties to fish species, and draw on local knowledge to navigate uncertainty. Findings reveal that cultural attachments to small pelagic fish are not static; they evolve through memory, identity, and everyday practices of food and livelihood. Despite exclusionary governance systems and uneven access to fisheries resources, these communities exhibit adaptive capacity grounded in cultural continuity, collective learning, and intergenerational exchange. By foregrounding the lived experiences and knowledge of indigenous fishers, this study challenges top-down approaches to resilience that overlook culture as a key dimension of adaptation. It argues for more inclusive forms of marine governance that integrate social, ecological, and cultural perspectives—especially critical in the Global South, where the wellbeing of coastal communities is tightly bound to the resilience of the ocean systems they inhabit.

S07, Pre-recorded, AbstractID=19075, (ECOP) (CANCELLED)

Linking social equity to economic resilience in Mozambique's small pelagic fisheries

Feryal **Aladwan**

University of Jordan, Amman, Jordan. E-mail: aladwanferyal74@gmail.com

Social and income inequalities within small-scale fisheries affect both community well-being and sustainable resource use. This study explores these inequalities in the coastal fisheries of Mozambique, where thousands of artisanal fishers depend on small pelagic species such as sardine and anchovy. Using four main measures the Gini index, skewness, coefficient of variation, and the share of total landings and income by larger boats we analyzed how benefits are distributed among fishing households.

The results show that most of the catch and income are concentrated in a small number of vessel owners, while many small fishers earn little despite high effort. Even after adjusting for differences in gear and working hours, inequality remained high, with national Gini values close to 0.80 for landings and 0.76 for revenues. These results reveal strong imbalances between small and medium fishers, leading to social tension and economic insecurity.

The Mozambican case shows that reducing inequality is not only a social goal but also an economic one. Fair access to markets, credit, and decision-making can improve both livelihoods and fishery productivity. Policies that integrate social equity into economic planning are essential for sustainable growth in small pelagic fisheries.

S07, Pre-recorded, AbstractID=19076, (ECOP) (CANCELLED)

Assessing social and economic sustainability in Morocco's small pelagic fisheries

Mohd **Basheer**

University of Jordan, Amman, Jordan. E-mail: mohammedmustafa205169@gmail.com

Small-scale and industrial fisheries in Morocco support thousands of coastal families but face growing social, economic, and environmental challenges. Many communities rely heavily on this sector, especially in remote coastal areas where fishing is the main source of income. This study provides a first comparative assessment of the sustainability of Morocco's fishing fleet, focusing on three main segments small-scale fishers, trawlers, and purse seiners across social, economic, and environmental dimensions.

A composite sustainability index was created using a multi-criteria decision approach to evaluate performance. Environmental indicators included fuel use, discards, and greenhouse gas emissions. Social factors covered employment opportunities, crew salaries, and income fairness. Economic indicators focused on profitability, labor productivity, and market diversity.

Results show that small-scale fisheries perform best overall due to stronger community engagement, local employment, and lower environmental impact. Purse seiners also show positive results under social and economic conditions, proving that commercial operations can be both profitable and socially responsible. In contrast, trawlers perform poorly, mainly due to high fuel use and ecosystem impacts.

The findings highlight the need for inclusive fisheries policies in Morocco that promote fair income distribution, social equity, and investment in cleaner, more efficient fishing technologies.

S07, Oral, AbstractID=19077

Measuring what matters: Social dimensions and market opportunities in Mexico's Small Pelagic Fisheries

Luis **Bourillón**[1], Citlali Gómez-Lepe[1], Pablo Ferrer[1,2] and Laura del Castillo-Munera[3]

[1]Consejo Mexicano de Promoción de los Productos Pesqueros y Acuícolas, A.C. (COMEPESCA), Mexico City, Mexico. E-mail: lbourillon@gmail.com
[2]Comercializadora El Sargazo, Ensenada, Mexico
[3]Global Sustainable Seafood Initiative (GSSI) Haarlem, the Netherlands

Small pelagic fisheries in Northwestern Mexico, particularly in the Gulf of California and along the Pacific coast, offer valuable lessons on how sustainability initiatives can evolve to better capture social outcomes. While several of these fisheries have achieved or are pursuing MSC certification, most of their catch—around 390,000 MT in 2023—continues to be reduced into fishmeal and fish oil for export markets. Only a small portion, such as Monterey sardine (*Sardinops sagax*), reaches consumers directly.

This presentation explores how shifting part of the production toward direct human consumption can open new avenues for inclusive and socially resilient blue economies. Drawing on examples from local enterprises such as Comercializadora El Sargazo, which connects fishers to domestic foodservice markets, we will discuss how such initiatives can improve livelihoods, create better employment opportunities, strengthen community ties, and secure food security. We will also reflect on emerging social metrics that could help capture these dynamics, such as employment quality, gender participation, community well-being, and access to nutritious seafood, and how they can complement existing sustainability and certification efforts.

By linking market diversification with measurable social outcomes, Mexico's experience highlights how small pelagic fisheries can move beyond ecological sustainability to deliver tangible social and economic benefits for coastal communities.

S07, Oral, AbstractID=19079

Integrating social metrics into economic growth strategies for small pelagic fisheries

Mario G. **Aguilar** S.

Grotius Consulting, Mexico, cdmx, México. E-mail: mariogaguilars@gmail.com

Unlimited fisheries resources was a "creed" that in a long gone past oriented the undertaking of several fisheries around the world. This view led in many cases to significant reduction or collapse of fish stocks. As nations recognized the risk of losing the availability due to unappropriated management of such important resources and its consequent impact in terms of economics, food security, social stability and development, amongst others, improved fishing practices started to be developed. In many cases these have been integrated into fisheries public *policies* which when comprehensive enough are an effective tool to harvest marine resources in a sustainable and productive way.

Public policies evolve continuously relying in a number of factors like science, sustainability, economics, rights, etc. However, no matter what the goal of a Policy might be, if indicators based on specific metrics are not clear, the established objectives and benefits may be elusive and, in some cases, counterproductive. Although it is a well-established view that metrics are indispensable to measure the effectiveness of measures, social indicators are yet to become an integral part along with other types of indicators that are more commonly used.

In the case of small pelagic fisheries, being one of the most significant in many parts of the world, the use and continuous improvement of social metrics as indicators, must be considered indispensable.

Also, it is equally important that such indicators should be sufficiently comprehensive considering all participants, directly involved like the fishermen in as much later stages such as processing, trading and other parts of the value chain, not restricted to the traditional extractive activity as usually occurs.

It is to be noted that being restrictive or omissive of parts of the fishery will only offer segmented view of the activity and thus will not be helpful enough to establish a sound public policy.

In the case of small pelagics, particularly sardines and anchovies, in addition to consider all participants in the activity another consideration is in order, that is the use of the fish. These species are used for direct and indirect human consumption; however, they are also widely used for fish meal production, indispensable for other uses such as animal feed and fertilizers. It is to be realized that depending on its use the social effects may vary but the benefits although significant may not be so clearly evident and possess a significant social effect.

Other factors may also be relevant in terms of social effects, and it would be advisable to consider them; amongst them could be the local use of fish, a wider distribution at national level and even export markets as their final destiny.

All in all, dispersion of benefits including social does not necessarily mean lack of their existence, thus all impacts specially those of social nature must be considered and accounted for in as much as possible.

That is the objective of this analysis.

S07, Oral, AbstractID=19081 (CANCELLED)

Enhancing resilience of coastal communities in coral reef ecosystems by integrating social metrics into co-management strategies for small pelagic fisheries

Anthony **Chawin**[1], Carlos Arango[1], Atanasio Brito[2] and Stuart Campbell[3]

[1]Rare, Arlington, Virginia, U.S.A. E-mail: achatwin@rare.org
[2]Rare, Mozambique
[3]Rare, Indonesia

Small pelagic fisheries (e.g., sardine, anchovy) play a key role in the food security and livelihoods of coastal communities in coral reef ecosystems but often operate under open access, chronic overcapacity, and income volatility. Prioritized access-based "Managed Access with Reserves (MA+R)" programs have shown promise when paired with behavior-change approaches, yet the pathways from social change to inclusive economic growth are rarely specified or measured. We propose and test an integrative resilience focused approach that embeds social metrics into community led fisheries strategies for small pelagic fish across Philippines, Indonesia, and Mozambique. We operationalize Household Survey indicators—i.e. knowledge of regulations, participation in management, social capital, financial resilience, and perceptions of fishery status—to (i) build capacity of community based fishery management bodies; (ii) target interventions (e.g. Fisher registration, management plan adoption, financial literacy training, and savings groups participation campaigns) that stabilize incomes and increase resilience; and (iii) track progress along an explicit impact pathway from behavior adoption to economic outcomes.

Using panel data from MA+R sites where small pelagics are an important component of landings, we outline a quasi-experimental evaluation design linking social-metric improvements to fisheries management effectiveness, catch and income stability. We illustrate how these metrics inform reserve placement and harvest rules (ecological Resilience), reinforce co-management legitimacy (Social Resilience), and improve cashflow or access to savings (Financial Resilience). The result is a practical dashboard that aligns community actions with an ecosystem-based management agenda that treats social change as both a precondition and a measurable driver of enhanced resilience of coastal communities in coral reef based small pelagic fisheries.

Keywords: small pelagics; community resilience, social metrics; managed access; behavior change; inclusive growth; co-management.

S07, Oral, AbstractID=19082, (ECOP)

Measuring social impacts of aquaculture production on communities in Honduras and Scotland

Gaynor **Jones** and Ingrid Kelling

Heriot-Watt University, Edinburgh, Scotland, United Kingdom. E-mail: gj3001@hw.ac.uk

As global seafood demand increases, both aquaculture and small pelagic fisheries are under pressure to demonstrate sustainability beyond environmental performance. While environmental and economic indicators are well established, social sustainability metrics remain comparatively underdeveloped, limiting understanding of how aquaculture production impacts on communities. This research seeks to develop a comprehensive social impact measurement framework, aligned with the United Nations Sustainable Development Goals (SDGs), that integrates social indicators into sustainability assessments to better understand the social implications of aquaculture within coastal communities.

There is limited empirical attention afforded to social sustainability of aquaculture, particularly its influence on community wellbeing. Adopting a comparative approach, the study examines *Litopenaeus vannamei* (whiteleg shrimp) aquaculture in Honduras and *Salmo salar* (Atlantic salmon) aquaculture in Scotland's Western Isles. These cases represent contrasting Global South and Global North contexts where aquaculture intersects with traditional fishing livelihoods, resource access, and social structures. The study explores how aquaculture influences wellbeing, generating benefits such as employment and skills development while also posing challenges related to resource use, inequality, and governance.

By creating a relevant social impact framework, this research proposes a replicable model for evaluating the social sustainability of aquaculture within the communities in which it operates. The findings are expected to reinforce the imperative of placing human wellbeing at the core of fisheries and aquaculture management, while informing policy, certification standards, and governance frameworks that advance accountability and transparency. Ultimately, the study contributes to embedding the social dimension of the three pillars of sustainability within aquaculture's discourse and practice, promoting a more equitable and resilient seafood sector.

S07, Oral, AbstractID=19083 (Pre-recorded)

Integrating social and technological innovations to reduce post-harvest losses and improve livelihoods in Sri Lanka's small pelagic fisheries

Susantha Kahawatta and Sinesha **Karunarathne**

Department of Fisheries and Aquatic Resources, Matara, Southern, Sri Lanka.
E-mail: sineshak@gmail.com

Sri Lanka is an island nation with a long coastline where small pelagic fisheries have been a traditional livelihood for coastal communities for centuries. Among these, the Indian scads (*Decapterus russelli*), locally called *Linna*, is one of the most important species contributing to food security and rural employment. Many fishing groups specialize in this species using traditional surrounding nets and small boats. *Indian scads* plays a crucial role in the production of fresh fish, dry fish, Maldive fish, and raw material for the growing canned fish industry, forming a vital part of both local consumption and national trade.

However, the small pelagic fishing sector remains highly traditional and technologically underdeveloped compared to other countries. Fishing operations still rely on manual methods, outdated gear, and limited onboard facilities. Lack of modernization in harvesting, handling, and preservation leads to serious inefficiencies throughout the value chain. These challenges not only constrain modernization but also threaten global food security and the sustainability of fish stocks. Many fishers believe that increasing the quantity of their catch is the only way to raise income, without considering the importance of maintaining quality. Due to this mindset, combined with low-quality onboard storage, poor handling, and inadequate temperature control, fish often deteriorate soon after harvesting. This leads to significant post-harvest losses, reduced market value, and lower overall income for fishing households.

The poor handling and storage practices during long fishing trips cause significant quality degradation of the catch, with an estimated 40% post-harvest loss in *Indian scads* landings. This directly reduces the income of fishing families and limits access to high-quality raw materials for processors. As a result, fishers remain in economically vulnerable conditions, facing fluctuating market prices and limited bargaining power. To ensure inclusive growth, it is critical to improve the fishers' income, change traditional attitudes toward post-harvest handling, and enhance the entire value chain—from capture to marketing—through social empowerment and awareness building.

This project proposes a comprehensive approach to identify and address weaknesses across the small pelagic fishery value chain. The study will assess current practices, identify constraints and opportunities, and develop pilot interventions for sustainable improvement.

Key components: Include the introduction of selective fishing gears, enforcement of minimum catch sizes, identification of spawning seasons, and seasonal closures for stock protection. The project also recommends fisher awareness programs, adoption of new onboard technologies, and the establishment of cooperative cold storage and flake ice systems. Through these actions, the initiative aims to minimize post-harvest losses, improve social well-being, and strengthen the

economic resilience of Sri Lanka's small pelagic fishing communities in alignment with FAO's ecosystem-based and socially inclusive fisheries management frameworks.

S07, Oral, AbstractID=19094

Social metrics and KDE to assess progress in Small Scale Fisheries

Marcelo **Hidalgo**[1,2]

[1]Fishing Industry Association of Papua New Guinea, Port Moresby, Papua New Guinea.
E-mail: contact@seafoodmatter.eu
[2]Seafoodmatter.com

The Papua New Guinea Fisheries, both Industrial (70') and Small Scale Fisheries (80'), have been well-managed and are one of the longest-serving commercialised fisheries in the history of Papua New Guinea and in the Pacific region, which is well over five (5) decades.

The Fishing Industry Association of Papua New Guinea (FIA PNG) was founded in 1991 with the sole aim to lobby the government on fisheries rights. Since 2018, FIA PNG has been collaborating with Seafoodmatter, a consultancy firm based in the Netherlands with vast experience in fisheries matters.

The Seafoodmatter benchmark labour tool, developed in 2014, was later replaced in 2020 by the Social Accountability standard checklist, based on ILO Convention 188 and used by the Tuna Purse Seine fleet FIA PNG, as part of the FIA PNG Responsible Sourcing or RSP, which is an Initiative based on market requirements. Since 2020, this Social Accountability tool has been collecting data from the tuna industrial fishery and reporting on an annual basis. The RSP is a proven model that has enhanced the FIA PNG market access based on deliveries of our mission, vision and commitments. Having this proven model and experience for more than five years, in 2023, we started the RSP implementation in the first Small Scale Fisheries. Data collection and KDE have been adapted to add value to our SSF and the coastal communities that rely on it.

This talk will discuss challenges like financial, capability building, data collection, data analisys and positive impacts like the creation of a multi-stakeholder MSC Technical Working Group advising the government on fisheries management, increasing awareness among divers, lobster processors, and exporters on sustainability requirements. How these collaborations provide metrics to monitor and assess social accountability improvement.

We are moving toward the FIA PNG RSP model, three more SSF fisheries: Lobster, Pranws and Mangrove Crab. The FIA/NFA MSC technical working group will lead the implementation and commercial outreach for these small-scale but high-potential fisheries. Our Responsible Sourcing Policy (RSP) Initiative has four pillars includes traceability, divers' welfare, and ghost gear mitigation.

SESSION 8

Maximizing Value and Sustainability in Small Pelagic Fisheries: Markets, Nutrition, and the Post-Harvest Sector

Oral Presentations

S08, Invited, AbstractID=19066

The role of certification and eco-labelling in the small pelagic trade

Marcelo **Hidalgo**[1,2], Nialingis Posanau[1] and Stephanie Pokajam[1]

[1]Fishing Industry Association of Papua New Guinea, Port Moresby, Papua New Guinea.
E-mail: contact@seafoodmatter.eu
[2]Seafoodmatter.com

The lobster fishery is well-managed and is one of the longest-serving commercialised fishery in the history of Papua New Guinea since 1985, which is well over three (3) decades. This is due to it being co-managed with Australia under the Torres Strait Treaty Arrangements. The lobster fishery currently involves more than five hundred divers annually and generates an annual estimated average of about 100 metric tonnes of live exports and frozen tails that reach overseas markets in Japan, Singapore, and Australia, with an export market value of K4 million alone per annum. FIA PNG believes that we can reach far better heights for premium markets, and with a modernised fisheries management plan, including lobster, it is a journey that is worth taking. The recent developments of our Tropical Rock Lobster fishery, which had undergone a full assessment for MSC certification, are now a certified fishery. In line with the association's sustainability objective and market response, Lobster exporters had embarked on another milestone – the MSC Certification underlines the fishery's commitment to sustainable fishing practices and responsible sourcing. This is the first of several small-scale fisheries (SSF) that FIA PNG and National Fisheries Authority (NFA) will put into the MSC program to boost the PNG economy and the country's image as a Seafood source of responsible and well-managed fisheries

This talk will discuss challenges like financial, capacity, and data collection, and positive impacts like the creation of a multi-stakeholder MSC Technical Working Group advising the government on fisheries management, increasing awareness among divers, lobster processors, and exporters on sustainability requirements.

We aim to enhance the FIA PNG SSF image in global markets, adding value with our Responsible Sourcing Policy (RSP) Initiative that includes traceability, divers' welfare, and ghost gear mitigation.

We are moving toward the MSC fishery certification of two more SSF - Pranws and Mangrove Crab – The FIA/NFA MSC technical working group will lead implementation, and commercial outreach for these small-scale but big in potential fisheries.

S08, Invited, AbstractID=19067

Sustainable fisheries and food security: The contribution of improved utilization of small pelagic fish and the circular economy

Jogeir **Toppe**, Omar Peñarubia and Molly Ahern

Food and Agriculture Organization, Rome, Italy. E-mail: Jogeir.toppe@fao.org

Small pelagic fish play an essential role in global food security and serve as major raw materials for fishmeal and fish oil production. Compared to larger species, they are relatively low-cost, reproduce rapidly, and are available in large quantities. Nutritionally, they are of high value as they are often consumed whole, providing quality protein, essential micronutrients, and beneficial omega-3 fatty acids.

In the absence of cold chain, small pelagic fish deteriorate rapidly due to their small size, large surface area, high levels of unsaturated fats, and elevated enzymatic and microbial activity. These factors contribute to their limited use for direct human consumption, resulting in considerable post-harvest losses. Implementing better handling practices, rapid chilling, and appropriate processing methods can significantly reduce these losses and enhance their contribution to food supplies.

In recent years, the share of small pelagic fish used for fishmeal and fish oil has declined, even though total production of these products has remained stable. This trend is mainly due to the increased utilization of fish-processing by-products which now serve as significant raw material sources. During industrial fish processing, 30% and 70% of the fish become by-products, which are increasingly recovered and repurposed rather than discarded. This shift reflects the growing adoption of circular economy principles in the fisheries sector.

Consequently, the circular economy has reshaped the role of small pelagic fish, enabling a greater share to be directed toward food purposes. Currently, about 54% of fish oil and 39% of fishmeal are produced from by-products. This has reduced the reliance on small pelagic fish for industrial uses by around 40%, thereby increasing their availability for human consumption and contributing to food security without adding pressure on fish stocks.

S08, Invited, AbstractID=19100 (PRE-RECORDED)

Distant water fishing fleets and the geopolitical economy of access arrangements

Liam **Campling**

School of Business and Management, Queen Mary University of London, UK
E-mail: l.campling@qmul.ac.uk

The presence of distant water fishing (DWF) fleets from advanced fishing nations in coastal states' waters is commonplace, especially in African, Latin American and Pacific EEZs. Coastal states use fisheries access arrangements to permit a foreign state, firm, or industry association to fish within its waters. Aside from the obvious commonality of the hunt for fish, access arrangements come in diverse forms that are shaped by the contingent relations among DWF fleets and coastal states. This presentation maps these arrangements focusing on the analytical prism of geopolitical-economic dynamics, which will arguably become more pronounced in our turbulent world.

S08, Oral, AbstractID=18881, (ECOP)

The value gap in fishery by-products in Korea: Challenges and strategies for a circular bioeconomy

Soeon **Ahn**, Seungjae Baek, Do-Hyung Kang, Soo-Jin Heo, Duckhee Jang and Chulhong Oh

Korea Institute of Ocean Science and Technology (KIOST), Jeju, Korea, R.
E-mail: soeonahn@kiost.ac.kr

Despite the large-scale generation of fish by-products in Korea, most remain underutilized or downcycled, posing a significant missed opportunity to advance a circular bioeconomy. This study quantitatively assessed national trends in fish by-product utilization and identified key barriers to high-value valorization. We analyzed national statistics (2011–2022) and conducted a nationwide survey of 330 companies across the supply and demand sectors. Results reveal a structural imbalance: 92.2% of utilized domestic by-products are channeled to the low-value feed sector, while the high-value nutraceutical industry relies entirely on imports. This disconnect largely stems from the mismatch between low-grade domestic handling practices and the stringent quality standards of high-value industries. A pronounced spatial disparity was also observed between coastal production regions and metropolitan processing hubs. A key bottleneck lies in the fragmented supply chain, characterized by weak quality-control systems—especially for spoilage prevention—and poor information flow across sectors. A dual strategy is proposed to foster a sustainable circular bioeconomy: (1) revise the Fishery By-Products Recycling Promotion Act (FBRPA) to encompass all organic by-products under explicit safety standards; and (2) complement this legal reform with practical support for infrastructure, standardization, and market development.

S08, Oral, AbstractID=19000, (ECOP)

The strategic value of marine ingredients in the blue value chain

James **Hinchcliffe**

European fishmeal and fish oil producers (EFFOP)-Marine Nutrients Europe, København, Denmark. E-mail: jh@maring.org

Small pelagic fish such as anchovies, blue whiting, and sprat form the foundation of many marine food webs and are central to the blue economy through their conversion into high-quality marine ingredients—fishmeal and fish oil. These ingredients provide the benchmark for nutritional quality in feed, offering highly digestible proteins, essential amino acids, and long-chain omega-3 fatty acids (EPA and DHA) that support animal health and welfare. Yet, their strategic value is often underestimated in policy and management discussions, which tend to assess reduction fisheries solely in terms of catch volume and ecosystem impact.

This presentation explores the evolving role of marine ingredients in aquafeed production and nutrition, highlighting how fishmeal and fish oil have transitioned from bulk feed components to "strategic ingredients." By enabling feed producers to incorporate lower-cost raw materials while maintaining performance, marine ingredients act as critical carriers of essential nutrients and functionality in modern aquafeeds. Drawing on examples from the European and North Atlantic industries, we examine how small pelagic resources flow from capture to end use, emphasizing their nutritional yield, multiplier effects, and contribution to food security through aquaculture production. Ingredient evaluation is a multidimensional process that must consider proximate composition, digestibility, palatability, pellet functionality, nutrient assimilation efficiency, and the influence on end-product quality. When combined with life-cycle assessment and carbon footprint analysis, these factors provide a comprehensive framework for evaluating true feed performance. By integrating nutritional science, circular bioeconomy principles, and science-based management, this presentation highlights how marine ingredients remain key enablers of efficient nutrient conversion—transforming low-trophic biomass into high-value protein and essential fatty acids—and ensuring the resilience and sustainability of blue food systems, even when used indirectly through feed pathways.

S08, Pre-RecordedInvited, AbstractID=19065 (PRE-RECORDED)

Supply, demand, and market trends for small pelagics in Southeast Asia and the Far East

Fatima **Ferdouse**

International Fisheries Expert: Trade and Marketing, Kuala Lumpur, Malaysia.
E-mail: fatimaferdouse@hotmail.com

Consumer demand of fish and seafood has been high in Southeast Asia and the Far East. As of 2024, reported per capita consumption of fishery products in the region was double than that of the global average. The small pelagics species namely sardines, mackerels and anchovy contributed significantly in the region's food security programs, where the fishes are available in fresh, frozen, dried, and canned forms.

Along with rising per capita income of the regional populations and increasing disposable income, consumer demand for small pelagics has improved in Southeast Aia and the Far East which is supplemented through imports of tropical and cold-water species, particularly for mackerels

Stagnant catches and increased consumer demand of small pelagics in the regional waters also resulted a three-fold rise in prices, particularly for whole frozen mackerels and dried anchovy. In the recent years, a large portion of Asian anchovy is processed to value added consumer packs where the product group fetches record high prices (US$20-25/kg) in the retail trade. Niche markets are also been shaped up for the high value canned sardine and mackerel produced in Spain, Portugal, and Morocco.

Factor influencing fish consumption

Macau – 70.26 kg per capita
Macau, a Special Administrative Region of China, boasts a high per capita fish consumption of 70.26 kilograms. The region's culinary landscape is heavily influenced by its maritime heritage, with seafood playing a central role in daily meals. Dishes like *bacalhau* (salted cod) and various shellfish preparations are commonly enjoyed. The proximity to abundant marine resources contributes to the accessibility and popularity of seafood in Macau.

Hong Kong – 65.79 kg per capita
Hong Kong's status as a global culinary hub is mirrored in its high fish consumption rate of 65.79 kilograms per person annually. The city's diverse population and rich cultural tapestry have fostered a deep appreciation for seafood, with dishes like dim sum featuring various fish preparations. The bustling seafood markets and numerous fish restaurants underscore the integral role of fish in Hong Kong's food culture.

Malaysia – 53.33 kg per capita
Malaysia, with its diverse culinary traditions, has a per capita fish consumption of 53.33 kilograms. The nation's coastal regions provide abundant marine resources, making seafood a central component of the diet. Popular dishes include *ikan bakar* (grilled fish) and *asam pedas* (spicy fish stew). The fishing industry supports both domestic consumption and export markets.

SESSION 8

Maximizing Value and Sustainability in Small Pelagic Fisheries: Markets, Nutrition, and the Post-Harvest Sector

Poster Presentations

S08, Poster, AbstractID=18834, PosterID: S08-P1, (ECOP)

Are horse mackerel, mackerel, and round sardinella viable complementary species to the sardine?

Judith **Ollé-Vilanova**[1], Xènia Frigola-Tepe[2], Odei Garcia-Garin[2], Jordi Viñas[1] and Marta Muñoz[2]

[1]Laboratori d'Ictiologia Genètica, Universitat de Girona, Girona, Spain.
E-mail: judith.olle@udg.edu
[2]Institute of Aquatic Ecology, Universitat de Girona, Girona, Spain

The European sardine (*Sardina pilchardus*) faces several challenges including a fishing pressure that should be regulated to ensure the long-term sustainability of the resource. Its decline highlights the need to consider complementary blue fish, which can help diversify consumer choices. In an effort to identify alternative fish species, the current study examined the physiologic condition, reproductive state and fat content of sardines and three other blue fish species throughout the complete annual cycle. These species include the Atlantic horse mackerel (*Trachurus trachurus*), the Atlantic mackerel (*Scomber scombrus*), and the round sardinella (*Sardinella aurita*). The extensive sampling effort, conducted at nearly monthly intervals, yielded a total of 5,358 individuals across the four species. The Atlantic horse mackerel exhibited high reproductive success, rapid post-spawning recovery, and favourable muscle fat content, emerging as a strong candidate to complement or replace sardine in the market during closures or fishing bans. Although the Atlantic mackerel was a promising candidate, the evidence of poor physiological condition indicates that its populations may be under considerable stress. As such, we cannot currently recommend this species as a sustainable resource, but emphasise the need for continued monitoring. The low fatty acid levels in the round sardinella limits its potential as a direct replacement for sardines. However, given its favourable characteristics, such as low parasite counts and low mercury levels, it could be considered a suitable option. Our results highlights the importance of constantly review the knowledge and status of commercially exploited fish populations.

Keywords: Blue fish, *Trachurus trachurus*, *Sardina pilchardus*, Mediterranean Fisheries, Sustainable Fisheries, Condition.

S08, QR-Poster, AbstractID=18872, PosterID: S08-P2

Small pelagic fish for feed or food? Household dietary impacts of proximity to fishmeal and fish oil factories in West Africa

Cristina **Ruano-Chamorro**, Eva Maire, Mark Hamilton, Felix Conteh and James **Robinson**, Christina Hicks

Presented by James Robinson

Lancaster University, Lancaster, United Kingdom.
E-mail: cristina.ruanochamorro@gmail.com

The fishmeal and fish oil (FMFO) industry, promoted as a driver of West African economic growth, has intensified the exploitation of small pelagics, with adverse implications for food security and small-scale fishing economies. Yet empirical evidence on how FMFO affects household fish consumption and which social groups are most vulnerable remains limited. We examined the association between the FMFO industry and household food security in Mauritania, Senegal, and The Gambia. Using secondary data from more than 7,000 households, we analysed the role of fish in food security across the region, including patterns of access and consumption, and how the proximity to FMFO factories influences household fish consumption while identifying the groups most affected. We found that proximity to FMFO factories is associated with lower household fish consumption, particularly of fresh sardinella, the FMFO industry's primary target, with the largest reductions among the poorest households. These effects are critical because our study shows that fresh sardinella is the most consumed fish, compared to dried fish and other fresh species; fish is key for meeting minimum dietary diversity (MDD) among children aged 6–23 months, yet 80% fail to achieve it; and poverty and lack of women´s employment already constrain access to fish. Overall, the dietary impacts of FMFO expansion are mediated by intersecting geographic and socioeconomic factors, disproportionately affecting vulnerable groups and reinforcing existing inequalities. Our results call for equity-centred governance strategies that prioritise local food security and the needs of the poorest and most vulnerable to advance equitable and sustainable food systems.

S08, Poster, AbstractID=18890, PosterID: S08-P3, (ECOP)

Beyond TAC: The nutritional wealth of northeast Atlantic pelagic fish stocks

Joseph W **Watson** and Susan Kenyon

Centre for Environment, Fisheries & Aquaculture Science, Lowestoft, United Kingdom.
E-mail: joseph.watson@cefas.gov.uk

As people aim to balance personal health with environmental sustainability, there is increasing interest in diets that are both nutritionally complete and low carbon. Health bodies such as the UK National Health Service (NHS) and British Heart Foundation promote eating small pelagic fish as a way of accessing essential nutrients including omega-3 fatty acids and vitamin D. In addition to the health benefits of small pelagic fish, eating these is considered to have a lower carbon footprint than most land-based animal proteins. The northeast Atlantic has some of the most abundant and valuable fishing in the world and is home to three large stocks of small pelagic fish: Atlantic mackerel (*Scomber scombrus*), blue whiting (*Micromesistius poutassou*) and Atlanto-Scandian (Norwegian Spring Spawning) herring (*Clupea harengus*). The combined biomass of these stocks is estimated at 11.7 million metric tonnes (MMT), and 2.5 MMT was advised as a maximum combined catch in 2025. Whilst the negotiation of how this combined catch is distributed between countries continues to be problematic, there is an opportunity to reframe these fish stocks in terms of their nutritional value rather than simply biomass. Here we aim to quantify and highlight the nutritional potential of these pelagic stocks to fishers, managers and consumers and help inform healthy and sustainable human dietary choices.

S08, Poster, AbstractID=18986, PosterID: S08-P4, (ECOP) (CANCELLED)

Small pelagic fish as a cheap source of healthy fatty acids for humans: A study from Sri Lanka

Weligodage De **Silva**[1] and Chamika W.A.S[2]

[1]Ocean University of Sri Lanka, Tangalle, Sri Lanka. E-mail: chsamaraweera@gmail.com
[2]Institute for Research and Development, Battaramulla, Sri Lanka. E-mail: shiranc@ocu.ac.lk

Fatty acids, especially omega-3 types, are found in many marine food organisms and are now accepted as a notable benefit of marine biodiversity for humans. More attention is focused on docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) because they are known to be important for human nutrition and health as a result of their impact on the proper functioning of the cardiovascular, renal, nervous, immune, and reproductive systems in humans. Therefore, the current study focused on the fatty acid composition of five small pelagic fish species in Sri Lanka with special reference to their price and availability. *Amblygaster sirm, Sardinella albella, Sardinella gibbose, Stolephorus commersonnii,* and *Stolephorus indicus* were collected from local fish markets and were properly identified with reference to standard guides. The fish were cleaned, gutted, and homogenized separately. Fish oils were extracted using n-hexane and the fatty acid composition was analyzed using gas chromatography (GC). Production, availability, and price pattern data were obtained from local databases. According to the results, all species presented considerable content of both EPA and DHA where *Amblygaster sirm* was the most significant source. As all of the species are widely available for a low price, they could be a cheap source of healthy fatty acids for consumers.

SESSION 9

Modeling Human Choices Regarding Harvest and Management of Small Pelagic Stocks

Oral Presentations

S09, Invited, AbstractID=18912, (ECOP)

The choice to stay: Modelling labor choices within and beyond fishing

Seleni J. **Cruz**

Texas A&M University, Galveston, TX, U.S.A. E-mail: scruz@tamu.edu

Climate variability creates shocks in fishery production and can lead to income instability in fishing communities. Adaptive strategies, such as diversification within (e.g. species diversification) and across (labor reallocation) sectors can mitigate these risks. However, the costs of diversification remain understudied, particularly in rural settings where communities have limited capital and skill transferability. Here, I examine the impact of the El Nino Southern Oscillation (ENSO) on labor allocation, income, and fishery production in small-scale fishing municipalities in Mexico, many of which depend on small pelagic species such as sardines, mackerels, and anchovies. I explore how fishing communities adjust strategies, effort, and sectoral participation in response to changing environmental conditions, emphasizing the role of switching costs in shaping these adaptive choices. Rather than diversifying, fishers reallocate effort within the fishing sector towards more productive and accessible species, reflecting flexibility enabled by a large choice set and low costs of switching across species, conditions rarely present in large-scale fisheries, where gear and capital constraints often limit adaptability. This behavioral response amplifies the contribution of small pelagic fisheries to local livelihoods even under climate shocks. By linking human decision-making and climate variability, this work contributes to the development of models that better represent fisher behavior in dynamics systems.

S09, Pre-RecordedOral, AbstractID=18982, (ECOP)

Estimating slipping rates and survivorship in the portuguese purse seine fishery: Implications for small pelagic stock assessment

Diana **Feijó**[1,2], Alberto Rocha[1], Ana Marçalo[3], Laura Wise[4], Isabel Riveiro[5] and Alexandra A. **Silva**[4,6]

Presented by Andreia Silva on behalf of Diana Feijó

[1]Instituto Português do Mar e da Atmosfera, Matosinhos, Portugal. E-mail: dfeijo@ipma.pt
[2]UVigo - Universidade de Vigo, Vigo – Pontevedra, Spain.
[3]CCMAR - Centro de Ciências do Mar, Universidade do Algarve, Faro, Portugal.
[4]Instituto Português do Mar e da Atmosfera, Algés, Portugal.
[5]IEO CSIC - Instituto Español de Oceanografia, Centro Oceanográfico de Vigo, Vigo - Pontevedra, Spain.
[6]MARE - Marine and Environmental Sciences Centre, U-Lisboa, Portugal.

The purse seine fishery is the most important fishery in Portugal, accounting for around 50% of total landings by weight. Following the decline of the sardine (*Sardina pilchardus*) stock and the consequent reduction of annual quotas in the late 2010s, this fleet has increasingly targeted other small pelagic species such as chub mackerel (*Scomber colias*), horse mackerel (*Trachurus trachurus*), and anchovy (*Engraulis encrasicolus*). Due to the imposition of daily catch limits and closure periods for sardine fishing, it is likely that both the frequency and volume of sardine slipping events have increased. This occurs as the fleet redirects its fishing effort toward mixed pelagic aggregations where sardine is commonly present, potentially creating larger discrepancies between catches and landings. Unlike typical discarding, slipping may lead to survivorship, as part of the catch is released alive. However, survival rates depend on several factors, including species, fish size, and the size of fishing sets, among others. This study evaluates variations of slipping rates in a period from prior and during the decline of sardine (2005-2019) and explores two different approaches to estimate slipping rates using onboard observer data: the Cochran slipping ratio and Bayesian hierarchical modelling (RTMB package). Species-specific survival rates for sardine and chub mackerel derived from at-sea experiments will then be applied to estimate survivorship. Potential adjustments to fishing mortality and quotas will be discussed in the context of improving small pelagic stock assessment and supporting more effective fishery management.

Keywords: purse seine fishery, sardine, chub mackerel, slipping, survival rate.

S09, Oral, AbstractID=18814, (ECOP)

The impact of environmental variability on fishers' harvest decisions in Chile using a multi-species approach

Felipe J. **Quezada-Escalona**

Departamento de Economía, Universidad de Concepción, Concepción, Biobío, Chile.
E-mail: felipequezada@udec.cl

In this paper, we aim to answer how fishing decisions, aggregate catch levels, and the price of marine resources will be affected under different climatic scenarios in the multi-species small pelagic fishery (SPF) in Chile, composed by anchoveta (*Engraulis ringens*), jack mackerel (*Trachurus murphyi*), and sardine (*Strangomera bentincki*), among others. By doing this, we expect to understand better how Chilean fishers and fishing communities will adapt to climate change. To address our research question, we will estimate a multi-species harvesting model. This model considers species' economic and biological interrelation to study the effect of climate variability on harvest decisions and substitution between species and determine the impact of different climatic scenarios on the well-being (e.g., profits) of fishers and fishing communities in Chile. We hypothesize that if the availability of a main target species is reduced, fishers will switch to the closest substitute if the expected revenue obtained from targeting this new species is high enough to cover the expected cost. Otherwise, the vessel would decrease fishing effort or even exit the fishery due to the lack of economically viable substitutes. Moreover, we expect that this behavior is heterogeneous depending on the geographical area of operation -- as it determines the availability of other species-- and the gear type used.

S09, Oral, AbstractID=18820, (ECOP)

Identifying purse seine vessel operations through machine learning models for better spatial fishing effort estimates

Joan **Sala-Coromina**[1,2,3], Mireia Silvestre[1,2,3], Felipe H. Coutinho[2], Marta Carreton[1,2], Marta Blanco[1,2], Jordi Ribera-Altimir[1,2,3], Laura Recasens[1,2] and Joan B. Company[1,2]

[1]Institut Català de Recerca per a la Governança del Mar (ICATMAR), Barcelona, Catalonia, Spain. E-mail: jsala@icm.csic.es
[2] Institut de Ciències del Mar (ICM-CSIC), Barcelona, Catalonia, Spain
[3] Universitat de Barcelona (UB), Barcelona, Catalonia, Spain

Spatial fisheries management requires precise spatial-explicit information on species distribution and fishing impacts, especially when studying highly dynamic populations such as small pelagic fish (SPF). The distribution of these stocks in the NW Mediterranean are currently evaluated based on acoustic scientific surveys performed once a year. Even if precise, these estimations might not have enough temporal resolution to capture population dynamics. Analysing fishing fleet spatial behaviour allows to estimate fishery impacts and can help uncover patterns of target species at high temporal resolution. Positioning systems such as the Vessel Monitoring System (VMS) data are analysed to this aim although studies focusing on purse seiners remain scarce. At present, methodologies detecting vessel operations on positioning systems for purse seiners have mainly focused on binary classifications (fishing / non-fishing) and fleets targeting large pelagic species. This is the first study using machine learning models to classify multiple vessel operations for purse seiners targeting SPF populations. Using field sampling data, a random forest model was trained to classify VMS data into fishing, tracking and cruising operations. The resulting fishing effort estimates were compared to the results of a binary classification model and a simple speed threshold method. Machine learning models highly improved the accuracy of fishing effort estimates even if its accuracy can vary depending on the spatial grid resolution used. The methods developed in the present study can improve Catch per Unit Effort (CPUE) estimates for SPF as well as the accuracy of the information needed for spatially manage of this fishery.

S09, Oral, AbstractID=18822, (ECOP)

Spatio-temporal shifts in Atlantic mackerel exploitation by the Scottish pelagic fleet

Maria Iohara **Quirino-Amador**[1], Katie Bridgen[1], Steve Mackinson[2], Campbell Pert[3] and Beth Mouat[1]

[1]Shetland UHI (SUHI), Academic Partner of the University of the Highlands and Islands (UHI), Shetland, United Kingdom. E-mail: iohara.quirino@uhi.ac.uk
[2]Scottish Pelagic Fishing Association (SPFA), Fraserburgh, United Kingdom
[3]The Scottish Governments Marine Directorate - Science (MD), 375 Victoria Road, Aberdeen, Scotland

Understanding spatio-temporal changes in the fisheries sector provides a basis to evaluate the sustainability of high value species exploitation, such as Atlantic mackerel (*Scomber scombrus*). These dynamics are influenced by environmental changes, the distribution of pelagic fish, and socio-ecological interactions, which are particularly relevant in Scotland, where the pelagic fleet plays a strategic role in food security and the local economy. Here, we investigate patterns and trends in the activity of the Scottish pelagic fleet over a 24-year period (1999 to 2023), focusing on how maritime space was utilised to target mackerel. Analyses draw on a novel industry dataset, combining fishing tracks and marks, together with haul data from a self-sampling programme led by industry partners. Vessel tracks provide precise spatial records of fishing activity, with positional fixes at intervals of up to two seconds, enabling fine scale coverage of fleet operations. This high-resolution dataset allows us to capture fishing activities with higher accuracy, enabling the identification and integration of long-term spatio-temporal patterns of pelagic fisheries. To evaluate whether the fleet's fishing activities have changed over time, we integrated statistical and geospatial approaches to quantify the distribution of fishing tracks. The application of multiple metrics, combining clusters and hotspots evaluation, has the potential to reveal long-term consistencies and abrupt shifts linked to specific events. These findings improve our understanding of how exploitation patterns have shifted in space and time, providing valuable information for management, and a robust basis from which to investigate spatio-temporal drivers in a changing ocean.

S09, Oral, AbstractID=18825, (ECOP)

Drivers in the selection of fishing areas by the scottish pelagic fleet

Maria Iohara **Quirino-Amador**[1], Katie Brigden[1], Steve Mackinson[2], Campbell Pert[3] and Beth Mouat[1]

[1]Shetland UHI (SUHI), Academic Partner of the University of the Highlands and Islands (UHI), Shetland, United Kingdom. E-mail: iohara.quirino@uhi.ac.uk
[2]Scottish Pelagic Fishing Association (SPFA), Fraserburgh, United Kingdom
[3]The Scottish Governments Marine Directorate - Science (MD), Aberdeen, Scotland

Understanding the spatio-temporal distribution of fishing fleets can reveal complex interactions between ecological, economic and social drivers that shape fisher decision-making. This study asks how the spatio-temporal patterns of mackerel exploitation have changed over the past decades, what has driven these changes, and what this means for future sustainability. To explore this question, we are focusing on Scottish pelagic mackerel fisheries using a leverage points framework. Novel sources of industry-derived data are combined with stakeholder knowledge to examine the change in fishing areas from 1999 to 2023. Through a scoping review of peer-reviewed literature and semi-structured interviews with fishing industry members, we will map the factors influencing mackerel exploitation and identify the most relevant drivers of fisher location choices. For example, changes in environmental conditions, market dynamics, and vessel technology can shape where fishers choose to operate, with socioeconomic implications. This mixed-methods approach enables the detection of both consistencies and abrupt changes linked to the drivers. By integrating spatial analysis with stakeholder knowledge, this work helps inform interventions and sustainability opportunities for mackerel fisheries. Altogether, the study contributes to a more holistic understanding as a social-ecological system, highlighting where small changes may generate significant impacts.

S09, Oral, AbstractID=18859

How routine semi-structured interviews with skippers help us better understand the ecosystem and find the needle in the data-haystack

Niels. T. **Hintzen**[1], Lina de Nijs[1], Marloes Kraan[2] and Nathalie A. Steins[3]

[1]Pelagic Freezer Trawler Association, Zoetermeer, The Netherlands.
E-mail: nhintzen@pelagicfish.eu
[2]Wageningen Social and Economic Research, Wageningen, The Netherlands
[3]Wageningen Marine Research, IJmuiden, The Netherlands

Marine data availability has increased tremendously in recent years, with a growing wealth of routine Earth observations, multifrequency acoustic surveys, fisheries observer reports, vessel tracking data, and industry-based catch self-sampling now accessible for research. Yet, more information does not necessarily provide more insight. Even more so, the multitude of potentially relevant variables — but also the complexity of their interactions — poses a significant analytical challenge. We argue that increased interaction with fishers, systematically documented, contributes to more insight.

To better understand main drivers in the system, including that of fishing itself, scientists can draw on the experiential knowledge of skippers. Their day to day interaction with the system provides valuable insights that help formulate hypotheses about change, which help to recognize patterns in the data that may otherwise remain hidden. Over the past three years, industry-employed scientists have conducted semi-structured interviews with skippers immediately after fishing trips to document their perceptions of how fishing activity is influenced by environmental conditions, location choices, resource distribution, interactions with other fleets, incidental bycatch, and gear innovations.

Our findings show that other factors (i.e. wind) than currently acknowledged, might play a larger role in catchability of stocks. It also shows that fishers' perceptions and scientific data or stock assessments do not always align. Although this is not a new insight per se, the systematically collected qualitative data helps us understand these differences and their implications. They can be explained by the contrast between local fishers' knowledge and fleet-scale trends, but also by the different nature of surveys and commercial fisheries. We further discuss how the fishing industry can contribute to optimizing scientific surveys to ensure more representative data collection — particularly when resource distributions deviate from established patterns — and how fishers themselves can play a key role in improving stock assessments through the information they provide.

S09, Oral, AbstractID=18882

Gambling for the future: A collaborative serious game for ecosystem-based management of small pelagic fisheries

Frederike **Tirre**[1], Julia Löwe[2], Dennis Nissen[3] and Rüdiger Voss[1]

[1]Kiel University, Kiel, Schleswig-Holstein, Germany. E-mail: ftirre@uv.uni-kiel.de
[2]Pixelfeuerwehr, Stralsund, Mecklenburg- Vorpommern, Germany
[3]Naymspace, Kiel, Schleswig-Holstein, Germany

We present a serious game designed to foster collaborative learning and strategic thinking around the management of small pelagic fisheries (SPF) in coastal regions. The game places players in the role of decision-makers/stakeholders tasked with balancing ecological integrity, social well-being, and economic viability in a changing environment. By simulating pressures such as overfishing, habitat degradation, and climate variability, the game creates a dynamic setting where participants must negotiate trade-offs, implement adaptive measures, and co-develop strategies for sustainable resource use. Special emphasis is placed on transdisciplinary challenges and the need for regional coordination, reflecting the role of regional fisheries management organizations and other collaborative bodies. Beyond raising awareness, the game provides a participatory platform to test ecosystem-based approaches to SPF management, encouraging dialogue among scientists, managers, and stakeholders. Insights from pilot sessions highlight its potential to identify knowledge gaps, promote system thinking, and enhance resilience-oriented strategies. This research-based and co-developed gamification approach contributes both to playful education and to the practical exploration of adaptive, ecosystem-based fisheries management and nature-based solutions under conditions of uncertainty and change.

S09, Oral, AbstractID=18932, (ECOP) (Pre-recorded?)

Ecosystem-based spatial modelling for marine conservation prioritization along the Moroccan Atlantic coast: Implications for biodiversity and fisheries management

Ilham **Ouissoule**, Elkalay Khalid and Khalil Karima

Laboratory of Interdisciplinary Research in Environment, Management, Energy, and Tourism (LIREMET), Essaouira, Morocco. E-mail: i.ouissoule.ced@uca.ac.ma

Marine ecosystems along the Moroccan Atlantic coast face increasing pressures from fishing, particularly on small pelagic and forage species, compounded by climate variability and human impacts, highlighting the need for spatially explicit approaches that balance biodiversity conservation with fisheries sustainability. This study implements a systematic conservation planning framework using the prioritizr R package to identify spatial priorities for sustainable management within Morocco's EEZ. The approach integrates biodiversity features, habitat data, spatial fishing effort, and socio-economic cost layers. Using mixed-integer linear programming, multiple optimization scenarios were simulated to explore trade-offs between ecological targets and fisheries-related costs, accounting for spatial constraints and conservation targets tailored to species' threat status. Results reveal substantial spatial variability, highlighting regions consistently critical for meeting conservation objectives. Comparative analysis of solution portfolios and ranking of planning units identifies areas that effectively balance biodiversity protection and socio-economic feasibility. Incorporating socio-economic dimensions is essential to reconcile conservation and fisheries objectives. Scenario comparisons reveal the proportion of conservation targets achieved and expose significant gaps in the current spatial conservation strategy. The study offers recommendations to improve MPA management and zoning, supporting ecosystem-based, data-driven planning and contributing to the UN Decade of Ocean Science and the global 30% CBD conservation target.

S09, Oral, AbstractID=18944, (ECOP)

Spatio-temporal analysis of catch composition and size structure in the purse seine fishery targeting small pelagic fish in the Northwestern Mediterranean

Mireia **Silvestre**[1,2], Marta Carretón[1,2], Joan Sala-Coromina[1,2,3], Adrià Martí-Comas[1,2], Jordi Ribera-Altimir[1,2,3], Joan Mir-Arguimbau[1,2], Alba Rojas[1,2], Laura Recasens[1,2] and Joan B. Company[1,2]

[1]Institut de Ciencies del Mar (CSIC), Barcelona, Spain. E-mail: mireia.silvestre1@gmail.com
[2]Institut Català de Recerca per a la Governança del Mar (ICATMAR), Barcelona, Spain.
[3]Universitat de Barcelona (UB), Barcelona, Catalonia, Spain

In the Mediterranean Sea, the anchovy (*Engraulis encrasicolus*) and the European sardine (*Sardina pilchardus*) are the most ecologically and commercially significant small pelagic fish (SPF) species, mainly targeted by the purse seine fleet. Although both species have been extensively studied from a biological perspective, important knowledge gaps remain concerning the broader fishery system, particularly on-board operations, fleet dynamics, and catch composition. Moreover, their high spatio-temporal variability in distribution and abundance complicates efforts to establish reliable long-term trends. To address these gaps, a locally-based purse seine fishery monitoring program was initiated in 2019 along the Catalan coast (northern GSA 6), collecting monthly samples of anchovy and European sardine from commercial landings at key ports. In 2022, for the first time in the NW Mediterranean, on-board sampling aboard commercial vessels was integrated into the monitoring program. Catch composition of years 2022 to 2024 was analyzed to evaluate potential differences according to fishing depth, seasonality and fishing area. Additionally, size-frequency distributions of the target species were assessed to detect spatio-temporal patterns in population structure. These analyses provide insight into how environmental and operational factors may influence catch variability. The knowledge acquired is contributing to a more comprehensive understanding of the dynamics of SPF fisheries and is essential for developing adaptive, science-based management strategies tailored to the purse seine sector in the region.

S09, Oral, AbstractID=19018, (ECOP)

Using the Newcomb – Benford Law to detect species misreporting in mixed pelagic catches

Eros **Quesada**, Massimiliano Cardinale, Nuno Prista, Valerio Bartolino, Patrik Börjesson, Mikaela Bergenius Nord, Niklas Larson, Annelie Hilvarsson and Katja Ringdahl

Swedish University of Agricultural Sciences, Lysekil, Vastra Gotland, Sweden.
E-mail: eros.quesada@slu.se

Modern stock assessment models used to provide management advice rely on unbiased catch data. Distortion of this data may increase uncertainty in the stock perception, jeopardize the assessment of resources and compromise their sustainable management with negative ecological and socio-economic effect. In this study, we applied the Newcomb - Benford Law (NBL) to test for fisheries catch misreporting. We focus on the Swedish small pelagic fisheries targeting herring and sprat in the Baltic Sea, which are known to be problematic due to the mixing of the two species and potential incentives for misreporting. We analyzed also fishery independent data to interpret the anomalies in the commercial catch data. We demonstrate that data from two Baltic fishery independent surveys conformed to the NBL while Swedish commercial catch data did not, indicating inaccurate reporting of commercial catches. While nonconformity to the NBL may not be considered as proof of misreporting, we discuss the possible reasons for the observed deviations from the model. We question whether the management should rely on less accurate but more spatially resolved data. The presented method may represent a supporting tool to investigate potential misreporting and improve our understanding of self-reported fisheries data in many other important stocks.

SESSION 9

Modeling Human Choices Regarding Harvest and Management of Small Pelagic Stocks

Poster Presentations

S09, Poster, AbstractID=18982, PosterID: S09-P1, (ECOP)

Estimating slipping rates and survivorship in the portuguese purse seine fishery: Implications for small pelagic stock assessment

Diana **Feijó**[1,2], Alberto Rocha[1], Ana Marçalo[3], Laura Wise[4], Isabel Riveiro[5] and Alexandra A. **Silva**[4,6]

Presented by Andreia Silva on behalf of Diana Feijó

[1]Instituto Português do Mar e da Atmosfera, Matosinhos, Portugal. E-mail: dfeijo@ipma.pt
[2]UVigo - Universidade de Vigo, Vigo – Pontevedra, Spain.
[3]CCMAR - Centro de Ciências do Mar, Universidade do Algarve, Faro, Portugal.
[4]Instituto Português do Mar e da Atmosfera, Algés, Portugal.
[5]IEO CSIC - Instituto Español de Oceanografia, Centro Oceanográfico de Vigo, Vigo - Pontevedra, Spain.
[6]MARE - Marine and Environmental Sciences Centre, U-Lisboa, Portugal.

The purse seine fishery is the most important fishery in Portugal, accounting for around 50% of total landings by weight. Following the decline of the sardine (*Sardina pilchardus*) stock and the consequent reduction of annual quotas in the late 2010s, this fleet has increasingly targeted other small pelagic species such as chub mackerel (*Scomber colias*), horse mackerel (*Trachurus trachurus*), and anchovy (*Engraulis encrasicolus*). Due to the imposition of daily catch limits and closure periods for sardine fishing, it is likely that both the frequency and volume of sardine slipping events have increased. This occurs as the fleet redirects its fishing effort toward mixed pelagic aggregations where sardine is commonly present, potentially creating larger discrepancies between catches and landings. Unlike typical discarding, slipping may lead to survivorship, as part of the catch is released alive. However, survival rates depend on several factors, including species, fish size, and the size of fishing sets, among others. This study evaluates variations of slipping rates in a period from prior and during the decline of sardine (2005-2019) and explores two different approaches to estimate slipping rates using onboard observer data: the Cochran slipping ratio and Bayesian hierarchical modelling (RTMB package). Species-specific survival rates for sardine and chub mackerel derived from at-sea experiments will then be applied to estimate survivorship. Potential adjustments to fishing mortality and quotas will be discussed in the context of improving small pelagic stock assessment and supporting more effective fishery management.

Keywords: purse seine fishery, sardine, chub mackerel, slipping, survival rate.

S09, Poster, AbstractID=19018, PosterID: S09-P2, (ECOP)

Using the Newcomb – Benford Law to detect species misreporting in mixed pelagic catches

Eros **Quesada**, Massimiliano Cardinale, Nuno Prista, Valerio Bartolino, Patrik Börjesson, Mikaela Bergenius Nord, Niklas Larson, Annelie Hilvarsson and Katja Ringdahl.

Swedish University of Agricultural Sciences, Lysekil, Vastra Gotland, Sweden.
E-mail: eros.quesada@slu.se

Modern stock assessment models used to provide management advice rely on unbiased catch data. Distortion of this data may increase uncertainty in the stock perception, jeopardize the assessment of resources and compromise their sustainable management with negative ecological and socio-economic effect. In this study, we applied the Newcomb - Benford Law (NBL) to test for fisheries catch misreporting. We focus on the Swedish small pelagic fisheries targeting herring and sprat in the Baltic Sea, which are known to be problematic due to the mixing of the two species and potential incentives for misreporting. We analyzed also fishery independent data to interpret the anomalies in the commercial catch data. We demonstrate that data from two Baltic fishery independent surveys conformed to the NBL while Swedish commercial catch data did not, indicating inaccurate reporting of commercial catches. While nonconformity to the NBL may not be considered as proof of misreporting, we discuss the possible reasons for the observed deviations from the model. We question whether the management should rely on less accurate but more spatially resolved data. The presented method may represent a supporting tool to investigate potential misreporting and improve our understanding of self-reported fisheries data in many other important stocks.

WORKSHOP 2

Best Practices for Improving Assessment of Small Pelagic Fishes Using Environmental Indicators

Oral Presentations

W02, Oral, AbstractID=18827, (ECOP)

Environmental drivers and recruitment dynamics of *Sardinella* spp. in the Canary Current upwelling system: A case study from Senegal

Bocar Sabaly **Baldé**[1]*, Saliou Faye[1] and Patrice Brehmer[2]

[1]Institut Sénégalais de Recherches Agricoles (ISRA), Dakar, Sénegal.
E-mail: bocarbalde2005@hotmail.com
[2]IRD, Univ Brest, CNRS, Ifremer, UMR Lemar, BP 1386, Dakar, Sénégal
*Corresponding author

Small pelagic fishes in Eastern Boundary Upwelling Systems are highly sensitive to environmental variability, with implications for both ecosystem structure and fisheries sustainability. In Senegal, *Sardinella aurita* and *Sardinella maderensis* are critical to food security, livelihoods, and regional trade, yet recent decades have seen marked declines in biomass and shifts in size structure. Using two decades of fishery-dependent and environmental data (2001–2020), we combined Virtual Population Analysis (VPA) with Generalized Additive Models (GAMs) to evaluate the influence of spawning stock biomass (SSB), sea surface temperature (SST), and the Coastal Upwelling Index (CUI) on recruitment dynamics. Our analyses reveal nonlinear, species-specific environmental windows for successful recruitment. For *S. aurita*, optimal recruitment occurred under moderate SST and strong upwelling, whereas *S. maderensis* recruitment was more resilient to variability in CUI but showed stronger sensitivity to SST anomalies. Fishing mortality further compounded these patterns, accelerating declines during environmentally unfavorable years. These findings highlight the importance of integrating climate and oceanographic indicators into assessment frameworks for small pelagics, particularly in regions where data limitations constrain traditional stock assessments. The Senegalese case study demonstrates how environment–recruitment models can improve early warning of stock vulnerability, inform adaptive harvest control rules, and support transboundary management of forage fish resources in the Canary Current Large Marine Ecosystem.

Keywords: *Sardinella aurita*, *Sardinella maderensis*, stock–recruitment, environmental indicators, Canary Current, upwelling ecosystems

WORKSHOP 3

Addressing Knowledge Gaps and Future-proofing Monitoring of Small Pelagic Communities Using Novel Methods and Technologies

Oral Presentations

W03, Oral, AbstractID=18831, (ECOP)

Linking oceanographic variability and Jack Mackerel (*Trachurus murphyi*) abundance dynamics off Chile: Insights from hydroacoustic observations and data-driven modeling

Francisco **Plaza-Vega**[1*], Montserrat Aránguiz[1], Víctor Catasti[2] and Eleuterio Yáñez[3]

[1]Universidad de Santiago de Chile, Santiago, Región Metropolitana, Chile.
E-mail: francisco.plaza.v@usach.cl
[2]Instituto de Fomento Pesquero, Chile.
[3]Profesor Titular Pontificia Universidad Católica de Valparaíso, Chile.
[*]Presenting author.

The jack mackerel (*Trachurus murphyi*) is a key pelagic species in the South Eastern Pacific, sustaining one of Chile's most important fisheries and playing a critical ecological role in regional trophic dynamics. Understanding its abundance variability and spatial distribution is essential for adaptive and ecosystem-based management, particularly under the influence of large-scale climatic processes such as ENSO.

This study examines the spatial and temporal variability of jack mackerel acoustic abundance (Sa) using hydroacoustic data collected by the Instituto de Fomento Pesquero (IFOP) between 2019 and 2024, integrated with environmental variables derived from oceanographic monitoring. The combined dataset was analyzed to classify abundance levels (high, medium, low) and explore their relationships with environmental drivers.

Machine learning methods, including Random Forest and XGBoost, were applied to identify the most influential environmental predictors associated with changes in acoustic abundance. Both models exhibited strong predictive accuracy and stability, highlighting the importance of sea surface temperature, chlorophyll-*a*, and depth as dominant factors explaining spatial heterogeneity in jack mackerel distribution. These results reveal a consistent coupling between oceanographic variability and the formation and persistence of fish aggregations.

By merging hydroacoustic observations with data-driven modeling, this work provides quantitative evidence linking environmental forcing and pelagic fish behavior. The findings contribute to a better understanding of how changing ocean conditions affect aggregation dynamics, offering valuable insights for the sustainable management of small pelagic fisheries in the South Eastern Pacific.

Keywords: Jack mackerel, hydroacoustics, environmental variability, small pelagic fish, machine learning, South Eastern Pacific.

W03, Oral, AbstractID=18862, (ECOP)

Integrating USVs into small pelagic fish monitoring: A case study from norwegian fjords

Florian **Berg**[1], Cecilie Kvamme[1], Arne Johannes Holmin[1], Sindre Vatnehol[1], Nils Olav Handegard[1] and Espen Johnsen[1,2]

[1]Institute of Marine Research (IMR), Bergen, Norway. E-mail: florian.berg@hi.no
[2]Department of Biological Sciences, University of Bergen, Bergen, Norway

Monitoring small pelagic fish populations using traditional acoustic surveys is time-consuming and costly, highlighting the need for new technologies to reduce costs and improve efficiency and coverage. In summer 2025, the Institute of Marine Research (IMR) conducted their annual sprat survey in Norwegian fjords, fully incorporating uncrewed surface vehicles (USVs) for the first time to complement research vessel operations. The USV performed acoustic transects 2–3 days ahead of the vessel, continuously uploading data to a cloud platform. Real-time analysis of these data allowed identification of small pelagic fish aggregations, enabling optimization of trawling effort. The research vessel focused on collecting biological samples and captured sprat at all trawl stations. Using USVs, IMR successfully covered four of the largest Norwegian fjords.

This approach demonstrates the potential of USVs to reduce vessel time used for acoustic sampling while maintaining robust biological sampling. Future plans include automating analysis of acoustic data, for example acoustic target classification, with AI and developing spatially explicit models to predict sprat abundance and guide trawling strategies. Integrating emerging survey technologies, such as USVs and cloud-based processing, represents a step toward more efficient, predictive, and management-relevant small pelagic surveys.

W03, Oral, AbstractID=18951

Better quantification of fishery observations using a non-catch electronic reporting system

Denham **Cook**[1,2], Kath Large[3], Kusal Ekanayake[3], Simon Winter[3], Finlay Thompson[3], David Middleton[4] and Philipp Neubauer[3]

[1]Coastal Marine Field Station, University of Waikato, Tauranga, New Zealand.
E-mail: denham.cook@waikato.ac.nz
[2]Faber R&D Ltd, Tauranga, New Zealand.
[3]Dragonfly Data Science, Wellington, New Zealand
[4]Pices Research Limited, Wellington, New Zealand

Electronic Monitoring (EM) has emerged as a robust tool for collecting fisheries-dependent data, supporting both resource management and scientific inquiry. EM systems, which in many instances is superseding traditional paper logbooks, facilitate systematic documentation and distribution of fishing effort and catch composition, including discard rates and interactions with protected species. These systems predominantly focus on catch-related metrics such as species landed and geospatial fishing effort, primarily for regulatory compliance purposes.

However, catch data alone provides a limited perspective on fishing activity. Fishers routinely observe a broader suite of ecological and environmental phenomena that, while uncaptured by standard EM protocols, hold significant operational and scientific value. We refer to these as non-catch observations. Recognizing the potential to expand EM capabilities, the inshore pelagic fishery of New Zealand initiated the development and deployment of a novel EM-based reporting framework designed to capture these non-catch phenomena. This system emphasizes the collection of information on search effort—the observational and decision-making processes preceding catch events—thereby enriching the dataset with behavioral and ecological context. We detail the design, implementation, and integration of this bespoke EM system into routine fishing operations, and present preliminary data outputs. This approach offers notable benefits: increasing the quantity and quality of data for scientific analyses, enabling adaptive fisheries management, and enhancing strategic decision-making within the fishery.

W03, Oral, AbstractID=18965, (ECOP)

Co-producing knowledge: A participatory mobile application for integrating fishers observations into the scientific monitoring of small pelagic fisheries

Adrià **Martí-Comas**[1,2], Mireia Silvestre[1,2], Joan Sala-Coromina[1,2,3], Jordi Ribera-Altimir[1,2,3], Laura Recasens[1,2] and Joan B. Company[1,2]

[1]Institut de Ciències del Mar (ICM-CSIC), Barcelona, Spain. E-mail: adria.marti@icm.csic.es
[2]Institut Català de Recerca per a la Governança del Mar (ICATMAR), Barcelona, Spain.
[3]Universitat de Barcelona (UB), Barcelona, Catalonia, Spain

Small pelagic fish (SPF) research often suffers from limited spatial and temporal coverage, while fishers hold rich, experiential knowledge of marine ecosystems gained through daily practices. This pilot study, conducted in the Northwestern Mediterranean (Catalan coast), addresses the gap between scientific data and fishers' observations by developing a mobile application designed to facilitate the exchange of information between fishers and scientists.

The app enables fishers to systematically report fishing activity, including both catch composition and spatial location. Beyond standard data, it allows fishers to share ecological observations that typically remain inaccessible to scientists, as they are not reflected in official landing records. This includes information on species encountered but not landed—either due to low commercial value or because individuals fall below the legal minimum size. Additionally, the app facilitates reporting of interactions with predator species that interfere with fishing operations. With a user-friendly interface tailored for on-board use, it supports offline data entry and synchronizes collected information to a centralized database once connectivity is available. Additionally, fishers can review their fishing history, map their spatial trajectories, and receive real-time oceanographic updates.

Data collected via the app provide diverse insights, including spatial-temporal patterns of fish distribution and catch dynamics, while fostering ongoing communication between fishers and researchers. This bidirectional exchange enhances the integration of local ecological knowledge into scientific workflows. The implementation of this tool contributes to a more comprehensive understanding of SPF fisheries and marine environments, promoting adaptive, evidence-based resource management. Moreover, it strengthens collaboration between fishers and scientists, demonstrating the value of co-produced knowledge in tackling complex environmental and fisheries management challenges.

W03, Oral, AbstractID=19023

"Eyes" on the net: Integrating eDNA with net sampling to refine acoustic biomass estimates

Janet C. **Coetzee**[1,2], Nerine van Wyk[3], Dagmar Merkle[1] and Sophie von der Heyden[3]

[1]Fisheries Research and Development, Branch Fisheries Management, Department of Forestry, Fisheries and the Environment (DFFE), Cape Town, South Africa. E-mail: jcoetzee@dffe.gov.za
[2]Department of Biodiversity and Conservation Biology, University of the Western Cape, Cape Town, South Africa
[3]Department of Botany and Zoology, Stellenbosch University, Stellenbosch, South Africa

Three small pelagic schooling fish species including anchovy (*Engraulis encrasicolus*), sardine (*Sardinops sagax*) and round herring (*Etrumeus whiteheadi*), support an economically important commercial purse-seine fishery off the coast of South Africa. Estimates of their biomass, obtained from bi-annual hydroacoustic surveys, are key to their sustainable management. The accuracy of these surveys relies on, amongst others, the ability to determine the species composition that gives rise to the total backscattered acoustic energy, which is contingent on regular mid-water trawl sampling. Behavioural differences among species and size classes, diel vertical migration, schooling behaviour and avoidance may, however, lead to biased catch compositions and introduce large uncertainty in acoustic biomass estimates. To evaluate the magnitude of such bias, environmental DNA (eDNA) 'metaprobes' were attached to 20 trawls conducted during a routine acoustic survey. Environmental DNA metabarcoding revealed 13 families detected through both eDNA and trawling and an additional 17 families detected with eDNA. Read abundance and trawl catch were found to be positively correlated at the family level. To quantify the extent of species-specific bias from misrepresentative trawl sampling, we replaced the catch composition derived from trawl samples with that based on eDNA biomass (% biomass per species) in our estimation of fish density and biomass. With sufficient future deployments, eDNA metabarcoding could be used to quantify and model the bias associated with trawl sampling for each species and reduce uncertainty in management advice.

W03, Oral, AbstractID=19062

Using egg production surveys to monitor the pelagic ecosystem: Findings and recommendations from an Australian study

Timothy **Ward**[1], Gretchen Grammer[2], Sharon Appleyard[3], Frederic Bailleul[2], Sarah Catalano[2], Alex Ivey[2], Annette McGrath[4] and Anthony Miskiewicz[5,6]

[1]Institute of Marine and Antarctic Studies, University of Tasmania, Hobart, Tasmania, Australia. E-mail: timothy.ward@utas.edu.au
[2]South Australian Research and Development Institute, Adelaide, South Australia, Australia
[3]CSIRO Australian National Fish Collection, Hobart, Tasmania, Australia
[4]Data 61, CSIRO, Brisbane, Queensland, Australia
[5]School of Biological, Earth & Environmental Sciences, University of New South Wales, Sydney, NSW, Australia
[6]Ichthyology Department, Australian Museum Research Institute, Australian Museum, Sydney, NSW, Australia

In this study, we used morphological methods and two mitochondrial DNA (mtDNA) assays to identify fish eggs and larvae in plankton samples collected during four applications of the Daily Egg Production Method. Each survey cost hundreds of thousands of dollars and involved collecting several hundred samples over areas spanning tens of thousands of square kilometres. Despite the clear potential for using these surveys to monitor the pelagic ecosystem, acquiring funding required to expand their focus beyond the target species has proven challenging. A key objective of our study was to identify how future surveys might be used to monitor the entire ichthyoplankton assemblage. We found that morphological methods provided reliable estimates of abundance for a few taxonomic groups (often only families) but required high levels of taxonomic skill and many hours of microscopic analysis and had significant potential for identification errors. In comparison, the two cytochrome oxidase sub-unit I (COI) mtDNA assays that we evaluated identified more species of eggs (>30 times) and larvae (>7 times) in each sample than the morphological approach. Both assays identified 82% of eggs (total of 172 species) and 81% of larvae (195 species), but each assay also identified some species that the other did not. These limitations likely relate, at least in part, to the relatively small sections of the mtDNA gene (at opposite ends of the fragment) that the two sets of primers amplify. Future studies could consider using primers that amplify more of the mtDNA gene and technologies that allow for longer-reading sequencing outputs. We emphasize the critical importance of comprehensive reference sequence databases for successful application of these methods.

WORKSHOP 5

Revisiting the Potential of Sedimentary Records: New Answers to Old (and Emerging) Questions on Forage Fish Ecology versus Climate Variability

Oral Presentations

W05, Oral, AbstractID=18797

Clarifying the role of local climate anomalies in a historic Baltic herring fishery collapse: A call for interdisciplinary collaboration

Rudi **Voss**[1,2], Jörn O. Schmidt[2,3], Oliver Lehmann[2], Daniel Okamoto[4], Patrick Polte[5], Kira Lancker[6], Anja Grunwald[7], Marco Scotti[8,9] and Renato Salvatteci[2]

[1]Biodiversity Economics, German Centre for Integrative Biodiversity Research (iDiv),Halle-Jena-Leipzig, Deutscher Platz 5e, 04103 Leipzig, Germany
[2]Center for Ocean and Society (CeOS), Kiel University, Kiel, Germany.
E-mail: voss@economics.uni-kiel.de
[3]International Council for the Exploration of the Sea (ICES), Copenhagen, Denmark
[4]Department of Integrative Biology, University of California, Berkeley, California, U.S.A.
[5]Thuenen Institute of Baltic Sea Fisheries, Alter Hafen Süd 2, Rostock, Germany
[6]Department of Food and Resource Economics, University of Copenhagen, Copenhagen, Denmark
[7]Information management and media, University of Applied Sciences Karlsruhe, Karlsruhe, Germany
[8]GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel, Germany
[9]Institute of Biosciences and Bioresources, National Research Council of Italy, Firenze, Italy

In the Late Middle Ages, the western Baltic herring fishery played a central role in Europe. Salted herring was the basis of both welfare and political power. Around 1570 this fishery suddenly collapsed, causing large-scale trade disruptions and triggering major social and political consequences. To understand the potential drivers of this collapse and what ultimately led to the fishery's demise, we analyzed a 400-year time series of Baltic herring catches (years 1200-1600). Using a loop modeling, we find that climate change, in combination with overfishing and socio-economic factors, led to the drastic collapse of the fishery. For the climatic context, we used interpolated data from a large-scale climate field reconstruction. Since these data are not region-specific, important questions remain open. Higher-resolution climate and oceanographic data (e.g. temperature, oxygen, marine productivity) from sedimentary records are needed to fully understand the impact of the Little Ice Age on Western Baltic herring dynamics, its possible spatial redistribution, and the phenomenon of increasing shifting dunes that contributed to the fishery's collapse. Moreover, independent records of small pelagic fish variability (e.g. herring and sprat) could be reconstructed from sediment cores by analyzing preserved fish scales and vertebrae. We identified suitable cores that could address these questions. Such insights into the interplay between climate variability and forage fish ecology are highly relevant for todays' fisheries management.

W05, Oral, AbstractID=18818, (ECOP)

Beyond the Scales: Marine archaeogenomics for the conservation and restoration of fisheries

Lane M **Atmore**[1] and Bastiaan Star[2]

[1]University of British Columbia, Vancouver, BC Canada. E-mail: lane@palaeome.org
[2]University of Oslo, Oslo, Norway

Protecting and restoring marine environments is essential for food security and climate change mitigation. Yet, conservation and restoration targets are often based on data from ecosystems that have already been fundamentally altered by anthropogenic change. While the unique temporal perspective of ancient DNA has rewritten our understanding of human impacts on past terrestrial ecosystems, its application to the study of marine environments remains limited. So far, valuable genetic insights from ichthyo-archaeology have been based on amplification-based approaches targeting a relatively limited number of markers. Now, the combination of ancient DNA and whole-genome approaches (archaeogenomics) is revolutionizing the field of marine historical ecology. In this presentation, we clarify direct pathways for integration between archaeogenomics, conservation, and fisheries management using the Atlantic herring as a case study. Recent studies on the Atlantic herring have revealed the utility of ancient DNA in assessing shifting population dynamics over time, such as range contraction and population isolation after heavy exploitation, differential stock responses to climate change, and significant reductions in genetic diversity. These studies illustrate how archaeogenomics can be used to inform contemporary management by augmenting stock assessments, facilitating the development of genetic tools, informing genetic diversity baselines, and inform predictions of future stock responses to fishing pressure and climate change.

W05, Oral, AbstractID=18975

Bridging past and future oceans: Paleo-reconstructions as windows into forage fish responses to climate change

Renato **Salvatteci**

Kiel University, Kiel, Schleswig-Holstein, Germany. E-mail: renato.salvatteci@ifg.uni-kiel.de

Sedimentary archives from the world's eastern boundary upwelling systems and other productive coastal regions have long provided invaluable insights into the linkages between climate variability and the dynamics of forage fish populations. Paleo-reconstructions from sites such as Peru, Chile, Namibia, California, and British Columbia have revealed diverse patterns of small pelagic fish fluctuations and large-scale ecosystem reorganizations over millennial to centennial timescales. Recent work from new sites, including Japan, together with opportunities in underexplored regions such as the Baltic Sea, highlights the potential for expanding these reconstructions into new oceanographic and climatic contexts. In this keynote, I will discuss the methodological advances that are transforming the scope and resolution of paleo-ecological and paleo-climatological studies. These include the combined use of fish scales and bones to reconstruct past population dynamics alongside paleoceanographic proxies such as redox-sensitive metals and organic biomarkers, which reveal past oxygenation and productivity regimes. The measurement of bulk and compound-specific nitrogen isotopes ($\delta^{15}N$) enables the reconstruction of past trophic structures and biogeochemical cycles, while emerging sedimentary DNA techniques open new possibilities for tracking changes in species abundance and distribution through time. Finally, I will outline a series of conceptual and integrative questions that should guide future research: How do regional and global climate indices translate into ecological responses of small pelagic fishes? To what extent do oxygen and other habitat variables mediate population variability across systems? How can emerging paleo-records inform predictive frameworks for future climate–ecosystem interactions? And which past warm intervals (e.g., the Last Interglacial [MIS 5e], the Medieval Climate Anomaly) are most relevant for understanding the responses of forage fish to future climate change? Addressing these questions through coordinated methodological and conceptual efforts will be essential for bridging past and future oceans—advancing our understanding of the long-term dynamics of forage fish and their sensitivity to a rapidly changing climate.

W05, Oral, AbstractID=19011

Sedimentary ancient DNA for detecting multidecadal changes in fish community structure of the northern Humboldt Current System

Dimitri **Gutiérrez**[1,2], Giovanna Sotil[1,3], Bryan Llatance[3], Deivis Cueva[1], Paul Guarnizo[1], Mónica Sócola[3], Federico Velazco[1], José Solís[2], Jorge Cardich[3], Renato Salvatteci[4], Matthieu Carré[2,5], Jacoby Baker[6] and Francisco Chavez[6]

[1]Instituto del Mar del Peru (IMARPE), Callao, Peru. E-mail: dgutierrez@imarpe.gob.pe
[2]Laboratorio de Ciencias del Mar, Facultad de Ciencias e Ingeniería, Centro de Investigación Para El Desarrollo Integral Y Sostenible (CIDIS), Universidad Peruana Cayetano Heredia, Lima, Peru
[3]Facultad de Ciencias Biológicas, Universidad Nacional Mayor de San Marcos (UNMSM), Lima, Peru
[4]Center for Ocean and Society, Kiel University, Germany
[5]Laboratoire d′Océanographie et du Climat, Expérimentations et approches numériques (LOCEAN), CNRS-IRD-MNHN-Sorbonne Université, Paris, France
[6]Monterey Bay Aquarium Research Institute, Moss Lanfing, California, U.S.A.

Paleoceanographic studies based on sediment cores from the Peruvian continental margin have revealed major changes in oxygenation and productivity, associated with climatic fluctuations on multiple time-scales since the last deglaciation. However, these reconstructions have been limited by the reliance on biogenic indicators from organisms that leave fossil remains, which are subject to post-depositional alteration and selective preservation. Sedimentary ancient DNA (*seda*DNA) offers new opportunities to overcome some of these constraints by detecting and quantifying past biodiversity changes across multiple taxonomic groups preserved in marine sediment records. In this study we explore changes in marine biodiversity of the northern Humboldt Current system (NHCS) over the last millennium, with a particular focus on shifts in fish community structure in response to natural climate variability and the recent global change. Sediment cores were collected from three sites along the Peruvian upper continental margin differing in their exposure to upwelling dynamics, terrestrial run-off and intrusion of subtropical waters. Subsamples were collected onboard and preserved at –80 °C for *seda*DNA extraction and analyses, while additional samples were taken for conventional biogenic, geochemical, and isotopic paleoproxies. Fish community composition through time is assessed using *seda*DNA metabarcoding of the mitochondrial DNA 12S gene, amplified and sequenced through Next Generation Sequencing (NGS). Sediment cores were dated from ^{210}Pb and ^{14}C analyses. Preliminary results detected the characteristic pelagic and mesopelagic fish species of the NHCS. These molecular data are compared with conventional paleoproxies and published paleoenvironmental records to characterize multidecadal to centennial-scale changes in marine fish biodiversity in relation to oceanographic and climatic variability during last millennium.

W05, Oral, AbstractID=19024, (ECOP)

Reconstructing the last millennium fish community structure in the northern Humboldt Current system using *seda*DNA

Bryan **Llatance**[2], Deivis Cueva[1], Paul Guarnizo[1], Jacoby Baker[4], Kobun Truelove[4], Federico Velazco[1], Dimitri Gutiérrez[1,3], Francisco Chavez[4] and Giovanna **Sotil**[1,2]

[1]Instituto del Mar del Peru (IMARPE), Callao, Peru.
[2]Facultad de Ciencias Biológicas, Universidad Nacional Mayor de San Marcos (UNMSM), Lima, Peru. E-mail: bryan.llatance@unmsm.edu.pe
[3]Laboratorio de Ciencias del Mar, Facultad de Ciencias e Ingeniería, Centro de Investigación Para El Desarrollo Integral Y Sostenible (CIDIS), Universidad Peruana Cayetano Heredia, Lima, Peru
[4]Monterey Bay Aquarium Research Institute, Moss Lanfing, California, U.S.A.

Significant fluctuations of pelagic fish, based on records of fish scales and bones preserved in the sediments, have been reported in the Humboldt current system in response to large-scale climatic variations. Recently, the study of fish community diversity through sedimentary ancient DNA -*seda*DNA- using the mitochondrial 12S gene analysis, has emerged as a powerful, noninvasive paleogenomic tool. We present the workflow used to reconstruct variations in fish community structure during the last millennium in the northern Humboldt Current system, based on *seda*DNA analysis. Three representative Peruvian continental margin sites were selected, in which multicore, gravity core and piston core samplers were used to collect the records. The cores were subsampled immediately onboard and the subsamples were preserved at –80 °C until the extraction of *seda*DNA at lab facilities. The extractions were performed under clean-lab conditions to recover fish-derived *sed*aDNA. The 12S gene libraries were sequenced using NGS technology, and data were processed with the Banzai Dada2 Pipeline, which integrates primer removal, quality filtering, denoising, and chimera detection to infer high-resolution amplicon sequence variants (ASVs). Taxonomic assignment was performed through blastn searches against reference databases and refined with MEGAN6 using a lowest common ancestor algorithm. After MEGAN6 filtering was applied to ensure that only sequences with ≥97% identity were assigned at the species level, and sequences with ≥95% identity were assigned at the genus level. Resulting OTU tables were analyzed in R to assess alpha and beta-diversity, enabling the reconstruction of the fish community composition in relation to oceanographic and climatic variability. Radiocarbon dating of the bulk sediments confirmed that the records span the last millennium, allowing to resolve changes at multidecadal to centennial time scales. An integrative approach, combining *sed*aDNA metabarcoding, paleoceanographic proxies, and climatic reconstructions provides novel insights into the long-term ecological dynamics of the northern Humboldt Current System and its sensitivity to past environmental variability.

WORKSHOP 6

Advancing Spatio-Temporal Species Distribution Models for Fish: Challenges, Methodologies, and Collaborative Solutions

Oral Presentations

W06, Oral, AbstractID=18907

Impact of fishery research survey reduction on stock assessment indices: Jack Mackerel Stock as an example

Yuga **Kisara**, Shota Nishijima, Mikio Watai and Tohya Yasuda

Japan Fisheries Research and Education Agency, Yokohama, Japan.
E-mail: kisara_yuga83@fra.go.jp

Egg and larval surveys in Japan have played a crucial role in fisheries stock assessment and ecological research of various species. In particular, along the Pacific coast, extensive surveys conducted monthly and covering their major spawning grounds and seasons have been conducted throughout the year for approximately 45 years, resulting in a globally unique long-term time series dataset. In Japan's stock assessments, spatio-temporal egg and larval survey data are used as fisheries independent indices for spawning biomass for multiple fish species. However, due to the spatial and temporal diversity of spawning events among species, such surveys require substantial financial and human resources. In recent years, budgetary and staffing constraints have led to increasing instances of missing surveys. Missing surveys, however, could bias the estimation of these indices. This study aimed to quantify the impact of missing surveys on the estimation of standardized spawning biomass indices, focusing on Japanese jack mackerel (*Trachurus japonicus*), a key coastal fishery species managed under Total Allowable Catch system. Egg survey data were standardized using the Spatio-Temporal model to estimate egg abundance indices. To evaluate the potential effects of missing survey, we simulated reduced survey effort by removing part of the dataset at various durations and intervals, and re-estimated standardized indices. The simulation analyses revealed that the estimated standardized indices were biased, with the magnitude and direction of bias depending on the temporal distributions of data. This study demonstrates that reduced survey can compromise the reliability of spawning biomass indices used in stock assessments. Maintaining sufficient survey effort is essential for robust stock assessment. Our findings contribute to the optimization of survey design and the sustainable management of fisheries resources.

W06, Oral, AbstractID=18963, (ECOP)

Numerical modelling of early life stages of small pelagic in the Atlantic Iberian Margin and the Mediterranean Sea for fish stock assessment

Adrián **Sanjurjo-García**[1], Sofía González-Pérez[1], Daniel Rodríguez-Abal[1], Manuel Ruiz-Villarreal[1], Luz M. **García-García**[1], Gonzalo González-Nuevo[1], Justino Martínez[2], Emilio García-Ladona[2], Jordi Isern-Fontanet[2] and Ana Sabatés[2]

[1]Centro Oceanográfico A Coruña (IEO-CSIC), A Coruña, Spain.
E-mail: adrian.sanjurjo@ieo.csic.es
[2]Institut de Ciències del Mar (ICM-CSIC), Barcelona, Spain.

Two Individual Based Models (IBMs) for the Early Life Stages (ELS) of Iberian sardine (Sardina pilchardus) and anchovy (Engraulis encrasicolus), two small pelagic species, have been implemented in the state-of-the-art trajectory model OpenDrift, a framework for Lagrangian particle tracking simulation. Biophysical offline particle-tracking models simulate the advection, dispersion, flotability and growth of egg and larvae in an environment characterised by hydrodynamic and biogeochemical models. We have applied the model to the Atlantic Iberian Margin during spring, coinciding with PELACUS surveys, and also to the Mediterranean Sea and we show how it enables detailed analysis of egg and larval transport, distribution and development in response to environmental variability. We will illustrate the insight provided into spatial retention areas, dispersion patterns, and potential recruitment zones for both species with simulations run in the Atlantic and in the Mediterranean, using ROMS and CROCO model output as forcing. Diagnostic metrics, such as particle density, depth distribution, and growth, have been integrated to better interpret biological responses to environmental drivers. Additionally, we will show how the results of the simulations and the in situ data used in model evaluation are distributed in data catalogues and standard services. and This work, part of DEMON and Phys2Fish projects, strengthens the relationship between physical ocean processes and early life stage ecology, providing valuable information for ecosystem-based fisheries management.

W06, Oral, AbstractID=18964, (ECOP)

IBM models for simulating the Early Life Stages of small pelagic: A generic code approach

Sofía **González-Pérez**, Adrián Sanjurjo-García, Luz M. García-García, Daniel Rodríguez-Abal, Gonzalo González-Nuevo and Manuel Ruiz-Villarreal

Centro Oceanográfico A Coruña (IEO-CSIC), A Coruña, Spain.
E-mail: sofia.gonzalez@ieo.csic.es

In recent years, Early Life Stages (ELS) models, which simulate fish eggs and larvae as Lagrangian particles within coupled oceanographic and ecological numerical models, have become a key tool in marine research. These biophysical models include horizontal and vertical advection and dispersion, as well as biological processes such as buoyancy changes, larval migration, and growth as functions of temperature and food availability. In the framework of several projects in cooperation with fish biologists, we have developed with this IBM approach modules for small pelagic fish such as Atlantic Iberian sardine (*Sardina pilchardus*) and European anchovy (*Engraulis encrasicolus*), for other fish species like European hake (*Merluccius merluccius*) and for the cephalopod common octopus (*Octopus vulgaris*). A unified code has been developed for all these species as a module the state-of-the art offline trajectory model OpenDrift, which was distributed with a model for the North Atlantic cod. This common code allows efficient ELS simulations of different species driven by the output of 3d ecological models, but also is a tool for checking our knowledge of the ecology of ELS of these species since it is necessary to integrate information of egg development and flotability, larval growth and behavior (vertical migration and other feeding behavior) as well as mortality and survival. Results show that differences in hydrodynamic model configurations —such as initialization, resolution, and forcing— and also biological behaviour —sucas egg buoyancy and larval diel vertical migration— affect larval transport and distribution, highlighting the importance of model evaluation when interpreting dispersal patterns. Special emphasis will be made on presentation of the differences in ELS models for sardine and anchovy. This work has been carried out within the framework of the DEMON, PHYS2FISH and CLONES projects.

W06, Oral, AbstractID=19045

Spawning of two small pelagic fishes exhibits a shared progressive spatiotemporal structure in central–southern Chile

Luis A. **Cubillos** and Leonardo R. Castro

COPAS Coastal Center, University of Concepción, Concepción, Chile.
Email: lucubillos@udec.cl

The spawning activity of small pelagic fishes is spatially structured according to reproductive habitat conditions, with recurrent spawning areas that tend to persist over time. We evaluated the spatiotemporal structure of anchovy (*Engraulis ringens*) and common sardine (*Strangomera bentincki*) spawning between 2007 and 2024 in central–southern Chile. We contrasted alternative hypotheses: (1) annual independent realizations, and (2) a progressive spatial structure correlated through time. In addition, we tested a shared-component spatiotemporal model to assess the degree of similarity between species.

Egg counts were modeled using a negative binomial distribution within a hierarchical Bayesian spatiotemporal framework implemented in INLA (Integrated Nested Laplace Approximation). Model parsimony was evaluated using WAIC and DIC criteria. The best-fitting models revealed marked spatiotemporal changes with similar spatial structures for both species. Estimated spatial correlation ranges were 71.8–74.5 km, while temporal autocorrelation coefficients ranged from 0.72 to 0.77 for anchovy and sardine, respectively. The progressive spatiotemporal structure was effectively represented by a shared-component model, indicating that both species exhibit a comparable reproductive dynamic and respond similarly to environmental forcing.

Uncertainty, expressed as the posterior standard deviation, was lowest (<2 units) within the core spawning areas, highlighting their temporal persistence. Integration of model-based estimates produced an egg abundance index that revealed an alternation in dominance between species, with a sustained increase in anchovy spawning activity from 2012 to 2023. These results provide robust evidence of shared reproductive strategies and spatial connectivity in small pelagic fish assemblages of central–southern Chile.

W06, Oral, AbstractID=19052, (ECOP) (CANCELLED)

Can a spatial population dynamic model reflect historical shift in spatial distribution? The case of the Northeast Atlantic mackerel

L. Merillet[1], O. Titaud[1], G. Briand[2] and Anna **Conchon**[1]

CLS, Ramonville Saint Agne, Occitanie, France. E-mail: aconchon@groupcls.com

From 2007 to 2016, the northeast Atlantic mackerel *Scomber scombrus* summer feeding areas expanded north and west ward, respectively by about 400km and 1600km. According to literature, this expansion was primarily driven by increase in stock size as well as the availability of preferred temperature habitat. This increase in stock size might have been caused by favourable conditions on the spawning and nursing grounds. However, mechanisms at play remains under investigation and poorly modelled.

The SEAPODYM model (Spatial Ecology And Population Dynamics model) is a eulerian, age-structured model based on advection-diffusion equations, accounting for spawning, growth, movement and mortality of top predators. Initially developed for tropical tunas, the model was adapted to northeast Atlantic mackerel. Movement is based on two types of habitats, according to the life stage and season: spawning habitat depending on the presence of optimal temperature, food and predators of the larvae; and feeding habitat depending on the presence of optimal temperature, oxygen and prey (zooplankton). The zooplankton fields were computed with SEAPODYM-LMTL (Low and Mid Trophic Levels) model and are available in the MICRORYS CMEMS product (https://data.marine.copernicus.eu/product/GLOBAL_MULTIYEAR_BGC_001_033/description). The model accounts for spatialized fishing since the mortality has two components, a natural and a fishing mortality component. Different datasets were used to validate each component of the model. The spatio-temporal distribution of adults was validated with ICES InterCatch dataset while the spawning habitats were compared to the ICES Eggs and Larvae dataset.

A particular attention was given to the modelling of realistic seasonal migrations, from the Bay of Biscay to the Norwegian coasts, as well as the spatial shift of the summer feeding grounds.

The validation shows a relatively good agreement of the spawning grounds with the observation data. Seasonal migrations are partly reflected so as the historical shift in summer feeding grounds. Despite some refinements in the definition of favourable feeding grounds is needed for that species, this application of the SEAPODYM model to northeast Atlantic mackerel illustrates the interest of a spatial, determinist modelling, in addition to the IBM, statistical and stock assessment modelling already existing.

WORKSHOP 6

Advancing Spatio-Temporal Species Distribution Models for Fish: Challenges, Methodologies, and Collaborative Solutions

Poster Presentations

W06, Poster, AbstractID=19053, PosterID: W06-P1, (ECOP) (CANCELLED)

An ensemble run to quantify the uncertainty of the Low and Mid-Trophic Levels component of the Spatial Ecosystem And POpulation DYnamic Model

Olivier Titaud[1], Laurène Mérillet[1], Nicolas Roche[1] and Anna **Conchon**[1]

CLS, Ramonville Saint Agne, Occitanie, France. E-mail: aconchon@groupcls.com

The Lower and Mid Trophic Levels (LMTL) component of the Spatial Ecosystem And POpulation DYnamic Model (SEAPODYM) estimates, at a global scale, the spatial distribution of biomass densities of meso-zooplankton and micronekton (functional group of organisms with size between 2 and 20 cm). This model is based on a system of advection-diffusion-reaction equations forced by ocean currents, temperature, and Net Primary Productivity (NPP). NPP acts as a biomass source throughout an energy transfer coefficient. Ocean currents control the transport of organisms, and the temperature affects their development and mortality.

Since mid-2019, this model has been used to produce the "Global Ocean low and mid trophic levels biomass content hindcast" product (also known as MICRORYS) of the Copernicus Marine Environment Monitoring Service (CMEMS) catalogue. This product of the green ocean is particularly relevant for studies of ecosystem and fisheries dynamics as micronekton is the food of numerous emblematic and fishery targeted species, respectively such as dolphins and tunas. The MICRORYS product is forced by the CMEMS Global Ocean Physics Reanalysis and the NPP computed from chlorophyll a of the CMEMS Global Ocean Colour multiyear product (satellite observations).

We will present an ensemble run based on different sets of physical and biogeochemical reanalyses to quantify the uncertainty of the model with respect to forcings. We will focus this presentation on the micronekton functional group of organisms that perform the largest migrations, between lower meso-pelagic during daytime and epipelagic layers during nighttime, because of its influence on carbon export.

WORKSHOP 7

Operationalizing Ecosystem-Based Management of Forage Species using Management Strategy Evaluation

Oral Presentations

W07, Invited, AbstractID=19097

New MSE Tools: The Climate Test and a framework for short-lived species

Tom **Carruthers**

Blue Matter, Vancouver, BC, Canada. E-mail: tom@bluematterscience.com

This presentation will introduce two tools currently being developed within the OpenMSE framework. First, we detail a new suite of tools specifically developed for short-lived taxa, such as cephalopods, shrimp, and small pelagics. There is increasing interest in the development of responsive and robust management procedures for short-lived species, which often require operating models that account for seasonal cycles in recruitment and growth, and management procedures that can respond to in-season data. This new suite of tools will enable the simulation testing of assessment models, the specification of operating models and the development of management procedures specifically tailored for short-lived species. Second, we introduce the "Climate Test," which provides strategic information to fishery managers about the relative climate robustness of various candidate management options. Forecasts of climate impacts on marine populations are highly uncertain, and forecasting challenges have been an impediment to the adoption of climate-ready fishery management practices. To alleviate the need for a defensible forecast, the Climate Test focuses on the relative performance of management options given increasingly extreme climate scenarios —analogous to a pilot navigating a flight simulator under increasingly challenging weather conditions. For a set of candidate management procedures whose performance are otherwise comparable, managers will have the option of adopting a procedure that has been shown to withstand more extreme climate tests.

W07, Invited, AbstractID=19098 (CANCELLED)

Unraveling the significant ecosystem services of small forage

Ling **Cao**[1] and Sunny **Chen**[2]

[1]Xiamen University, Fujian Province, China, PR. E-mail: caoling@xmu.edu.cn
[2]First Institute of Oceanography, MNR, Qingdao, China, PR. E-mail: qdcs@163.com

Forage fish are low-trophic-level, small pelagic fish that provide critical ecosystem services. As key trophic links, they regulate and stabilize ecological dynamics while also contributing to carbon sequestration. Their sustainable management is crucial not only for ecological conservation but also for maintaining socio-economic stability. In socio-ecological systems, small forage fish are indispensable to global food and nutrition security, providing affordable, nutrient-rich fish to 72% of low- and middle-income countries (Robinson et al., 2022). SFF support livelihoods and economic stability, with 39% of small-scale marine fisheries catches comprising herring, sardine, anchovy, and other pelagic species (FAO, Duke University & WorldFish, 2023). Their role extends beyond direct consumption, as SFF are deeply embedded in local cultures and are vital to global supply chains, supporting employment and trade (Konar et al., 2019). However, rising demand for fishmeal and processed products has raised concerns about sustainability and equitable resource extraction and distribution (Basurto et al., 2025). Beyond human exploitation, climate change is altering the distribution and abundance of SFF populations. Rising ocean temperatures drive species toward higher latitudes (Sarre et al., 2024) or cause population declines (Heneghan et al., 2023), disrupting marine food webs and impacting dependent species. These shifts also threaten coastal livelihoods and global fisheries supply chains. Meanwhile, high fishing pressure, driven by increasing demand for fishmeal and fish oil in aquaculture, further exacerbates population collapse risks, particularly in regions with declining productivity. By deepening our understanding of their ecological roles and socio-economic importance, we can foster conservation and management strategies that ensure the resilience of marine ecosystems while supporting sustainable livelihoods.

W07, Invited, AbstractID=19099

Explicitly incorporating Ecosystem-Based Fisheries Management into Management strategy evaluation, with a focus on small pelagics

Carryn **de Moor**

University of Cape Town, South Africa. E-mail: carryn.demoor@uct.ac.za

The need to transition from traditional single-species fisheries management approaches towards Ecosystem-Based Fisheries Management (EBFM), or an Ecosystem Approach to Fisheries, is widely recognised. EBFM is particularly important when considering management actions for economically valuable fisheries for small pelagic forage fish, given their key ecological role. Management Strategy Evaluation (MSE) is an effective approach to advance the quantitative implementation of EBFM by enabling stakeholders to explore trade-offs among competing ecosystem-related objectives. This talk puts forward different approaches to explicitly advance EBFM with MSE, by taking advantage of data and research already available and by guiding future research. These include a) using an ecosystem Operating Model (OM), b) coupling the OM with key ecosystem components in a uni-directional manner, c) adjusting natural mortality to consider predation mortality explicitly, d) using ecosystem-related thresholds in performance statistics, e) pre-specifying Harvest Control Rule parameters, or f) adjusting reference points to account for ecosystem aspects. This review demonstrates that immediate steps can be taken to implement EBFM targeted at quantitative tactical management, even without a complex, data-rich ecosystem model.

W07, Oral, AbstractID=18903

From climate forcing to fisheries management: Integrating environmental variability into MSE frameworks

Ricardo **Oliveros-Ramos**

MARBEC, Univ Montpellier, IRD, CNRS, Ifremer, Montpellier, France
E-mail: ricardo.oliveros@ird.fr

Incorporating environmental variability into Management Strategy Evaluation (MSE) is essential for developing adaptive and climate-ready fisheries management procedures. However, this requires more than simply linking existing climate forcing to biological models. The design of climate scenarios that are both ecologically relevant and statistically realistic remains a major methodological challenge.

Species respond to climate drivers through different mechanisms and spatial scales, meaning that even a common variable such as temperature may have multiple operational definitions: surface temperature, depth-averaged temperature, or spatially weighted means over variable habitats. The selection and construction of these variables directly influence parameter estimation in climate-enhanced stock assessment models and the plausibility of projections used in MSE frameworks.

Furthermore, while most available climate scenarios focus on long-term trends, fisheries management also needs *weather simulators*: tools capable of reproducing realistic short-term, high-frequency climate fluctuations such as *El Niño* and *La Niña* events. These are critical to test management robustness to unpredictable climate shocks that cannot be forecast with sufficient lead time.

We illustrate these concepts through the design of an MSE for the jumbo squid (*Dosidicus gigas*) in the Eastern South Pacific Ocean, where productivity and distribution are strongly influenced by environmental variability. The talk discusses methodological challenges such as downscaling, bias-correction, and scenario realism, and outlines pathways for integrating environmental drivers into MSE in a consistent way.

W07, Oral, AbstractID=19038

Knowledge co-production in the Pacific Herring MSE process

Jaclyn **Cleary**[1], Ashleen Benson[2] and Sean Cox[2]

[1]Fisheries and Oceans Canada, Nanaimo, BC, Canada. E-mail: Jaclyn.Cleary@dfo-mpo.gc.ca
[2]Landmark Fisheries Research, Port Moody, BC Canada.

Canada's Pacific Herring fisheries face the challenge of adopting an ecosystem approach to management, adjusting to an evolving set of policies related to Fisheries and Oceans Canada (DFO's) Sustainable Fisheries Framework, and recognition of shared management responsibility among users.

In 2015, DFO began updating the management system for Canadian Pacific Herring, adjusting the science, management, and decision-making process to meet a broad set of objectives for rebuilding, First Nation and stakeholder engagement, and socio-economic aspects of fishery sustainability. MSE provided the structure for this process, and thus far key scientific elements of an MSE analytical framework have been developed for the 5 Pacific Herring stocks, including i) conservation objectives, ii) management procedures, iii) a range of operating models representing key biological, ecological, and harvesting processes, and iv) evaluation of management procedure-operating model combinations.

This talk will discuss the lessons learned in Herring MSE, including:

i) Failure to distinguish early on between means (how to) and ends (what to achieve) objectives resulted in objectives being defined by science rather than co-developed with First Nations and stakeholders, leading to a lack of MSE ownership and delays in implementation;
ii) Knowledge co-production is most effectively addressed and incorporated into operating models rather than any other phase of MSE;
iii) Honest efforts at knowledge co-production can have substantial relational benefits that extend beyond MSE to other areas of science and management (e.g. the Nuu-chah-nulth *ʔuuʔaaɬuk ƛusmit* Research Partnership and the Haida Gwaii ′íináang | iinang Pacific Herring: An Ecosystem Overview and Ecosystem-based Rebuilding Plan).

W07, Oral, AbstractID=19089

Operationalising Ecosystem-Based Management for forage species through ICES experience

Jacob W. **Bentley**[1], Colm Lordan[2], Chris **Lynam**[2], Marie-Julie Roux[2,3], Nathalie Steins[4], Jonathan White[5] and David Reid[2]

[1]Natural England, Marsham Street, London, United Kingdom.
E-mail: jacob.bentley@naturalengland.org.uk
[2]International Council for the Exploration of the Sea (ICES), Copenhagen, Denmark
[3]Fisheries and Oceans Canada, Quebec Region, Mont Joli, QC, Canada
[4]Wageningen University & Research, The Netherlands
[5]Marine Institute, Oranmore, Co. Galway H91 R673, Ireland

There are increasing efforts across the ICES community to develop approaches and identify opportunities to communicate how forage fish both influence and respond to wider ecosystem change. This growing momentum is supported by the development of the ICES Framework for Ecosystem-Informed Science and Advice (FEISA), which promotes a risk-based approach to integrate ecosystem information into advice. At present, ecosystem effects are primarily addressed implicitly in forage fish stock assessments through observed stock-recruitment ranges, variable natural mortality, life-history parameters and qualitative considerations, while explicit approaches that link forage fish productivity and fishing opportunities to ecosystem conditions and function remain largely limited, owing to system complexity with multiple effect/affect processes (including institutional and governance) across ecosystems. Developing work across ICES aims to bridge this gap by incorporating environmental and ecological information, such as oceanographic drivers and related changes in distribution, productivity, and phenology, into advice frameworks via FEISA. These developments reflect growing recognition that the main drivers of risk to forage fish increasingly stem from climate and ecological change rather than fishing pressure alone. At the same time, there are growing calls for integrated advice that accounts for social and economic dimensions and considers the needs of dependent predators and food webs. This presentation explores ICES progress and ambitions at the interface between science, policy, and stakeholder engagement, with a pragmatic focus on feasible pathways, past experiences, and remaining challenges in developing ecosystem-informed advice for forage fish.

W07, Oral, AbstractID=19090

Management Strategy Evaluation under shifting forage fish productivity and distributions in the California Current

Isaac **Kaplan**[1], Stephanie Hopkins[1,2], Robert P. Wildermuth[3], Caitlin Allen Akselrud[3], Alexander Jensen[3], Peter Kuriyama[3], Charlie Hinchliffe[4] and Desiree Tommasi[2]

[1]Conservation Biology Division, Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, Washington, U.S.A.
E-mail: isaac.kaplan@noaa.gov
[2]University of California, Santa Cruz, Institute of Marine Sciences' Fisheries Collaborative Program, Santa Cruz, California, U.S.A.
[3]Fisheries Resources Division, Southwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, La Jolla, California, U.S.A.
[4]Centre for Freshwater Ecosystems, La Trobe University, Wodonga, VIC, Australia

The California Current ecosystem on the west coast of North America is characterized by strong fluctuations in species such as sardine (*Sardinops sagax*), northern anchovy (*Engraulis mordax*), and Pacific hake (*Merluccius productus*), likely driven by highly variable oceanography. The ecosystem and forage base respond to oceanographic phenomena such as El Niño and the Pacific Decadal Oscillation, resulting in changes in species distribution, growth, mortality, and recruitment. All of these changes can challenge stock assessment models and management of harvested stocks. Here we present case studies from the Future Seas project, which use Management Strategy Evaluation (MSE) and ecosystem-informed harvest control rules to find robust management options. These case studies evaluate novel single-species and multi-species harvest rules, tested within operating models that range from a single-species sardine model to a complete end-to-end Atlantis ecosystem model. Additionally, we highlight how output from a collection of process-based ecological models can be used to develop climate change uncertainty scenarios for MSE. These ecological models explore possible futures for California Current species, utilizing approaches including relatively simple species distribution models, mechanistic age-structured models, and individual-based and end-to-end ecosystem models. Focusing on sardine, we illustrate patterns in productivity and spatial distribution expected from these ecological models, and how these patterns and climate uncertainty can be included within MSE. Overall, we illustrate Future Seas efforts that aim to bridge from ecological research models to management-relevant analyses, including via MSE and exploration of ecosystem-based approaches.

GENERAL PAPER SESSION

Poster Presentations

GP, Poster, AbstractID=18799, PosterID: GP-P1

Secular range shifts of fishes in the California Current Ecosystem over seven decades

Andrew **Thompson**

NOAA/Southwest Fisheries Science Center, La Jolla, CA, U.S.A.
E-mail: andrew.thompson@noaa.gov

Elucidating responses of species to climate change is the fundamental task of modern ecology. In the northern hemisphere, many marine species are predicted to shift poleward in response to a warming ocean. Tests of this forecast are somewhat lacking, however, due to limited temporal or spatial time series. We evaluate trends in movement (leading edge, center of distribution and trailing edge) of 178 species from the world's longest fisheries oceanographic monitoring program, California Cooperative Oceanic Fisheries Investigation (CalCOFI)/ Investigaciones Mexicanas de la Corriente de California (IMECOCAL) that have systematically sampled larval fishes and oceanographic conditions quarterly from approximately 150 stations along a ~1500 km stretch between Punta Eugenia, Baja California Sur, Mexico and San Francisco, California, USA from 1951-2019. Movement patterns were highly dependent on spawner adult habitat. 25/27 mesolpelagic fishes exhibited secular movement north but only 2/10 shallow, benthic species significantly changed position. Shifts in distribution for fishes that moved tended to be episodic rather than linear with large, lasting pulses of northward shifts in 1976 and 2015. On the whole, responses of fish to climate change in the California Current Ecosystem over seven decades were nuanced and highly affected by life history.

GP, Poster, AbstractID=18828, PosterID: GP-P2

A decade of warming and declining productivity in the Gulf of California: Exploring the drivers

Carlos Robinson **Mendoza**

UNAM Institute of Marine Sciences, Mexico, México. E-mail: robmen@unam.mx

The Gulf of California is a tropical–subtropical ecosystem of global importance, hosting exceptional biodiversity and one of the highest zooplankton biomasses among comparable marine environments. Its mesotrophic conditions sustain high levels of primary and secondary production, contributing approximately 60–70% of Mexico's total fish landings. During the past decade (2014–2024), regional and local increases in sea surface temperature (SST) have coincided with a significant decline in mean chlorophyll-a (Chl-a) concentrations, raising concerns about ecosystem productivity and resilience. This study synthesizes recent observations and analyses to explore the factors driving these changes. Primary productivity in the Gulf is largely governed by wind-driven upwelling, which enhances nutrient supply and phytoplankton growth. Therefore, changes in wind intensity and direction are likely to play a critical role in the observed decline of productivity. Identifying the atmospheric and oceanographic drivers of these shifts is essential for understanding their ecological implications and for anticipating impacts on fisheries that depend on the system's productivity. The findings from this case study provide broader insights into how climate-driven variability in physical forcing mechanisms may alter productivity in subtropical seas worldwide, with direct consequences for fisheries management and food security.

Keywords: Gulf of California, climate change, sea surface temperature, chlorophyll-a, upwelling, small pelagic fisheries

GP, Poster, AbstractID=18829, PosterID: GP-P3, (ECOP) (CANCELLED)

A tale of two sisters: *De novo* genome assembly and comparative genomic analysis of two *Decapterus* species, *D. macarellus* and *D. macrosoma*

Zae-Zae A. **Aguinaldo**[1], Ricardo P. Babaran[2] and Arturo O. Lluisma[1]

[1]The Marine Science Institute, University of the Philippines–Diliman, Quezon City, Philippines. E-mail: zaaguinaldo@up.edu.ph
[2]Institute of Marine Fisheries and Oceanology, College of Fisheries and Ocean Sciences, University of the Philippines Visayas, Miagao, Iloilo, Philippines

Round scads (*Decapterus* spp.) are highly migratory pelagic fishes that support major fisheries throughout Southeast Asia, including the Philippines. The close morphological similarity among species within this genus complicates taxonomic identification, particularly for the sister species shortfin scad (*D. macarellus*) and mackerel scad (*D. macrosoma*). Despite their ecological and economic importance, genomic resources for *Decapterus* remain limited, hindering comparative genomic studies that could elucidate patterns of genetic divergence, evolutionary relationships, and adaptive traits.

Here, we present the first de novo genome assemblies of *D. macarellus* and *D. macrosoma*. The *D. macarellus* assembly comprised 1,478 contigs with an N50 of 1.88 Mb and a total size of 674 Mb, while *D. macrosoma* contained 440 contigs with an N50 of 20.45 Mb and a total size of 718 Mb. Genome completeness was high for both assemblies, with 97.80% for *D. macarellus* and 98.30% for *D. macrosoma* when compared against 3,640 single-copy orthologs from the ODB10 Actinopterygii set. Repetitive elements accounted for 24.93% of the *D. macarellus* assembly and 28.00% of the *D. macrosoma* assembly. Annotation identified ~26,000 protein-coding genes in both species, where ~99% were functionally annotated. Comparative genomic analyses revealed structural variations, gene family differences, and phylogenomic relationships among *Decapterus* and other Carangidae, with several genes showing signatures of positive selection.

These high-quality genomic resources establish a foundation for comparative and evolutionary studies of round scads, advancing our understanding of their biology and providing essential tools for sustainable fisheries management in this economically important genus.

GP, Poster, AbstractID=18844, PosterID: GP-P4, (ECOP)

Phylogenetics and Phylogenomics along with Differential Growth Patterns Indicate the Cryptic Speciation of Little Tunny (*Euthynnus alletteratus*)

Judith **Ollé-Vilanova**[1], Rubén Muñoz-Lechuga[2,3], Pedro G. Lino[2], Rosa M. Araguas[1], Núria Sanz[1] and Jordi Viñas[1]

[1]Laboratori d'Ictiologia Genètica, Universitat de Girona, Girona, Spain.
E-mail: judith.olle@udg.edu
[2]Portuguese Institute for the Ocean and Atmosphere, Olhão, Portugal
[3]Department of Biology, University of Cadiz, Cadiz, Spain

The Little tunny *Euthynnus alletteratus* have great economic importance with a large volume of catches. Recently, both the south-eastern and northern stocks were found to be at high and moderate risk of overfishing, respectively. Here we investigated the stock structure of *E. alletteratus* and the phylogenetic relationships by a combination of genomic and growth analysis. The mtDNA CR consisted of 263 haplotypes among 633 individuals from nine locations. The SNPs dataset included 81 individuals and 37,888 variants. A total of 466 dorsal fin spines were analysed for growth studies, distributed in 207 from Northeast Atlantic and 259 individuals from Tropical Southeast Atlantic. A large genetic discontinuity was detected by genetic (mtDNA CR) and genomic markers (SNPs) that agree with different growth patterns observed between the northern and tropical individuals. Thus, genetic and biological data supported the same hypothesis, and it can be ascertained that two species conform the distribution of the *Euthynnus* within the Atlantic. Moreover, shallow genetic differentiation was detected between the species *E. lineatus* and *E. affinis* using genomic and genetic markers. That suggest the re-evaluation of these two species as a putative single unit. Genetic intraspecific differences were detected within the two species recognised before as the former *E. alletteratus*. Three different populations were detected in the northern species, that adds to the three populations detected in the tropical species, providing a more complex population structure.

Keywords: *Euthynnus*, Little tunny, Black skipjack, Kawakawa, growth patterns, population genetics, phylogenetics, stock structure, fishery management.

GP, Poster, AbstractID=18857, PosterID: GP-P5, (ECOP) (CANCELLED)

Beyond compliance: Electronic Monitoring as a tool for inclusive governance in pelagic fisheries

Chelsey **Karbowski**

Teem Fish Monitoring, Dartmouth, Nova Scotia, Canada. E-mail: chelsey@teem.fish

Electronic Monitoring (EM) technologies, including video systems, gear sensors, and spatial data tools, are increasingly central to how pelagic fisheries are monitored and governed.

While often introduced as compliance mechanisms, EM holds much broader potential: to expand stakeholder participation, reinforce community priorities, and foster more adaptive and inclusive governance systems.

This presentation explores how EM, when co-developed with fishing communities and regional partners, can advance data sovereignty, strengthen monitoring capacity, and support equitable decision-making in pelagic fisheries. Drawing on case studies from diverse contexts, we highlight strategies for embedding local and Traditional Knowledge into EM frameworks, ensuring that data generated by these systems directly serve community, scientific, and management needs.

We also examine persistent challenges, including funding models, regulatory harmonization, and the need for cultural relevance in system design, and consider how governance structures can evolve to address them. By framing EM as a tool for shared stewardship rather than solely for compliance, this talk underscores its potential to build trust, support co-management, and contribute to sustainable and resilient pelagic ecosystems.

Ultimately, EM offers not just new streams of data, but a means of rethinking participation and accountability in fisheries governance, helping to align science, policy, and community priorities in an era of rapid environmental change.

GP, Poster, AbstractID=18863, PosterID: GP-P6

Recruitment regimes of the common sardine (*Strangomera bentincki*) and anchovy (*Engraulis ringens*) off Chile: An application of Hidden Markov Models

Luis A. **Cubillos**[1] and María José Cuevas[2]

[1]University of Concepción, Concepción, Chile. E-mail: lucubillos@udec.cl
[2]Lab. EPOMAR, Universidad de Concepción, Concepción, Chile. E-mail: lucubillos@udec.cl

We analyzed a historical time series (1960–2023) of the biomass, fishing mortality, and recruitment of common sardine (*Strangomera bentincki*) and anchovy (*Engraulis ringens*) in central-southern Chile to assess their long-term variability and potential regime shifts. We applied an age-structured production biomass fitted to the catch and biomass indices to estimate recruitment, spawning biomass, and fishing mortality. Both species exhibited strong historical fluctuations in recruitment and abundance, as well as periods of high fishing mortality between the 1970s and the 2000s. Recruitment showed contrasting patterns: the common sardine displayed large pulses exceeding 400 million recruits, whereas anchovy recruitment was more intermittent and had a lower amplitude. Hidden Markov Models (HMM) were applied to identify recruitment regimes and their transition probabilities. For common sardines, two regimes were detected: a low-productivity state ($\mu \approx 15.8$ million recruits) and a high-productivity state ($\mu \approx$ 182 million recruits). Both states showed high persistence (0.83 and 0.79), yet relatively frequent transitions (0.17–0.21) in recent decades, corresponding to short-lived regimes lasting, on average, 2–5 years. Anchovy exhibited three regimes with increasing means ($\mu \approx 0.3$, 7.4, and 46.8 million), characterized by high persistence (0.81–0.92) and long duration—up to nearly two decades— although recent years revealed higher variability and dominant transitions between extreme states, reflecting abrupt but structured recruitment changes. These findings indicate that sardine and anchovy recruitment is non-stationary and follows identifiable regime-type variability. Incorporating this regime behavior into stock assessment models could provide a more realistic and constrained framework, improving the ability to project future scenarios and support adaptive control rules for sustainable fishery management.

GP, Poster, AbstractID=18876, PosterID: GP-P7

Using deep hydrographic profiles and eDNA samples to investigate fish populations along the axis of the Gulf of California

Adrian **Munguia-Vega**[1,2], John A. Barth[3,4], Thomas Keffer[4] and Jenni Johnson[4]

[1]Conservation Genetics Laboratory, School of Natural Resources and the Environment, 1064 E. Lowell St, University of Arizona, Tucson, Arizona, U.S.A.E-mail: airdrian@arizona.edu
[2]Applied Genomics Lab, La Paz, BCS, México
[3]Oregon State University, Corvallis, Oregon, U.S.A.
[4]Western Flyer Foundation, Moss Landing, California, U.S.A.

We use conductivity-temperature-depth-oxygen profiles and surface and deep eDNA samples collected in April 2025 from the historic vessel *Western Flyer* to investigate the relationship between fish populations and hydrographic features along the axis of the Gulf of California. The stations spanned over 500 km from San Francisquito in the south to Punta Refugio in the north. An along-axis section reveals the hydrographic regimes in the south, across the midriff islands, and to the north. A comparison between data collected in April 2025 and in March 1970 reveals lower oxygen levels (up to about 50 micromoles/kg) in recent years below about 50 m to the bottom and to the south of about Santa Rosalia. eDNA metabarcoding analyses show high levels of fish (12S gene) and eukaryotic (18S gene) diversity in both surface and deep (200-500 m) stations, with dozens of fish families and over 40 different phyla. We detected significant levels of community structure along the depth gradient, indicating a relatively small fraction of species and genetic variants within species is shared between different depths. Notably, about half of the fish and eukaryotic sequences from the deep samples do not have close matches in global genetic reference databases and cannot be assigned to lower taxonomic levels. We observed a positive relationship between the number of different fish Amplified Sequence Variants (ASVs) and total sequence reads for most of the abundant fish families, suggesting eDNA has high potential for monitoring the dynamics of presence and abundance for pelagic resources.

GP, Poster, AbstractID=18877, PosterID: GP-P8

Modeling recurrent larval transport routes in the Northern Gulf of California during February, exemplified with *Merluccius productus* larvae

Laura **Sánchez-Velasco**[1], Jorge Montes[2], Amelia Sánchez-Pérez[1], S. Patricia Jiménez-Rosenberg[1] and Victor Godínez[3]

[1]Instituto Politécnico Nacional, La Paz, BCS, México. E-mail: lsvelasc@gmail.com
[2]Universidad de Guadalajara, Guadalajara, Jalisco, México
[3]Centro de Investigación Superior y Científica de Ensenada, BC, México

Northern Gulf of California, home to a high fish species diversity, is characterized by seasonally reversible circulation, influencing larval transport routes. This study aims to identify and model recurrent larval transport routes and connectivity from positive larval collection sites (e.g., *Merluccius productus*) during February 2006, and to compare them with simulations from February 2024. Despite continuous environmental changes at different scales, it is proposed that certain mesoscale structures, and consequently larval transport routes, can be persistent, but with local variations. A monthly climatology of sea level anomaly and derived geostrophic current data from COPERNICUS (2004-2024) revealed that the circulation is dominated by an anticyclonic structure southwest Northern Gulf, which is associated with a southward-flowing current along the mainland coast. Similar circulation patterns were identified in hydrographic observations from February cruises. Lagrangian simulations using OpenDrift and HYCOM indicated that particles released from the northernmost sites followed trajectories influenced by the anticyclone for up to 10 days, whereas those released from southern sites were advected southward, captured by local currents in the Midriff Archipelago Region during February 2006 and February 2024. Connectivity matrices showed that ~ 98 % of particles at 10 days remained within the Northern Gulf and the Midriff Archipelago Region. It was speculated that the fish species such as *M. productus*, February spawners, are recruited close to their spawning areas, being the south of the Midriff Archipelago, a boundary of the larval dispersion of these species. Enhancing the efficiency of this technique could support fisheries management and ecosystem conservation.

GP, Poster, AbstractID=18888, PosterID: GP-P9

Sub-populations in small pelagic fish stocks and challenges presented for fisheries management

Richard D.M. **Nash**[1], Aaron Brazier[1], Susan Kenyon[1], David Murray[1] and Niels Hintzen[2]

[1]Centre for Environment, Fisheries & Aquaculture Science, Lowestoft Laboratory, United Kingdom.
E-mail: richard.nash@cefas.gov.uk
[2]Pelagic Freezer Trawler Association (PFA), Louis Braillelaan 80, 2719 EK Zoetermeer, The Netherlands

There is structure within many marine fish populations/stocks. Often this relates to spatial aspects of the stock or population distributional area and results in identifiable differences in several biological traits (ranging from vertebral counts, through variability in body morphometry to genetic differences). Here we will primarily concentrate on the case of North Sea herring. Components or sub-stocks of herring in the North Sea has been recognised for a long time, each associated with the mosaic of spawning grounds. The separate spawning locations (one for each sub-stock) still exist but the North Sea is considered and assessed as one stock. The recognised components constitute four spawning grounds in coastal waters of the western North Sea and in the eastern Channel (from north to south: Orkney/Shetland, Buchan, Banks and Downs). Spawning starts in late August in the north and finishes in February in the eastern Channel. The Downs component is considered a 'winter' spawner whereas the others are considered 'autumn' spawners. Currently, genetic techniques classify the Downs component as separate from the others and there is the possibility of following this genetic identity of individual fish through both the survey and the commercial catches. The challenges are, whether sufficient information can be obtained to assess at least two sub-stocks and follow their dynamics independently or whether they should be considered separate stocks and thus have separate advice. Having separate advice raises questions over how these putative stocks can be managed sustainably when the principal fishery occurs during a period of mixing.

GP, QR-Poster, AbstractID=18917, PosterID: GP-P10, (ECOP)

Molecules in action: Shifts of molecular forms of lipids of the myctophid fish *Lampanyctus macdonaldi* in the Irminger Sea (North Atlantic) as an adaptation to different depths

Viktor P. **Voronin**[1], Alexey Yu. Rolskii[2], Alexei M. Orlov[3] and Svetlana A. Murzina[1]

[1]Institute of Biology of the Karelian Research Center of the Russian Academy of Sciences, Petrozavodsk, Russia. E-mail: voronen-viktor@mail.ru
[2]Polar Branch of the Russian Federal Research Institute of Fisheries and Oceanography (FSBSI "PINRO" named after N.M. Knipovich), Murmansk, Russia
[3]Shirshov Institute of Oceanology of the Russian Academy of Sciences, Moscow, Russia

This study examines shifts and alterations in the lipid profile of male and female *Lampanyctus macdonaldi* (Myctophidae) at different depths in the Irminger Sea (North Atlantic). Abiotic factors (hydrostatic pressure, temperature, etc.) are known to affect the physiological state of the organism. Among the mechanisms of compensatory response to environmental factors are changes in the qualitative and quantitative lipid profile of organs and tissues. Lipid molecules can ensure and maintain homeostasis within the organism, allowing deep-sea aquatic animals to survive in near-extreme conditions. The structural diversity of lipid molecules maintains a variety of biochemical mechanisms of adaptation. The biology of *L. macdonaldi* stands out among many other deep-sea fish species due to the accumulation of large amounts of fat deposits in the muscles, and its direct dependence on the depth of its habitat. Studying the molecular forms of lipids and phospholipids in this member of the Myctophidae family will allow us to better understand the different mechanisms underlying the adaptation of this species, as well as other mesopelagic fish, to deep-sea habitats in the North Atlantic. Models of metabolic pathways based on the lipidomic status of aquatic organisms can be used in developing measures of the sustainable use of marine bioresources, as well as in the technological industry for the isolation of structurally unique lipid compounds.

This work was supported by a state assignment to the Karelian Research Center of the Russian Academy of Sciences (project no. FMEN-2022-0006).

GP, Poster, AbstractID=18973, PosterID: GP-P11

Small pelagic fish and zooplankton distributions in Iberian coastal waters

Maria Manuel **Angélico**, Elisabete Henriques, Paulo Oliveira, Hugo Mendes, Anxo Conde and Ana Moreno

IPMA - Portuguese Institute for the Ocean and Atmosphere, Alges, Portugal.
E-mail: mmangelico@ipma.pt

A crucial aspect in understanding marine population dynamics is the identification of the main regulating factors (biotic and abiotic) that shape its spatio-temporal fluctuations. Hydrodynamics, topographic features and the optimization of feeding conditions, while avoiding predation, determine fine-scale distribution of pelagic forage fish.

Zooplankton constitutes a major trophic resource for planktivorous pelagic fish and its fluctuations may have significant effects on fish dynamics affecting their distribution, individual body condition and reproductive success. Despite the relevance of zooplankton, data availability is limited in part due to the complexity of sampling the system components with appropriate spatial (and temporal) scales and because zooplankton collection and analyses are quite specific and laborious.

Fisheries surveys provide regular data on small pelagic fish populations to feed stock assessment modelling and simultaneously offer the opportunity for concurrent plankton sampling, enabling parallel analyses for fish and zooplankton spatial distributions. Developments in image analyses and automatic recognition techniques allow a valuable, and agile, way to obtain zooplankton data on community sizes and composition and it is therefore feasible to map fish and prey distributions.

In this study, we show the results on small pelagic fish and mesozooplankton distributions, obtained during acoustics surveys conducted in 2023 and 2024, in Atlantic Iberian waters. Fish data was gathered using a scientific multi-frequencies echosounder and pelagic trawls while mesozooplankton samples were collected with a Bongo net. The zooplankton information results from image analyses procedures employing a *Flowcam macro* and libraries and analyses developed within the *Ecotaxa* environment. The hydrodynamic conditions were reproduced by model reanalyses and *in situ* data.

GP, Poster, AbstractID=19010, PosterID: GP-P12 (ECOP) (QR-Poster)

Thermal gradients and ecological responses of small pelagic fish to sea surface temperature variability in the Western Mediterranean

Imene Nouali, Yousra **Zaoui** and Mohammed Kacher

Presented by Yousra Zaoui on behalf of Imene Nouali

National School of Marine Science and coastal Management (ENSSMAL)., Algiers, Tunisia.
E-mail: yousra.zaoui@enssmal.edu.dz

Understanding how temperature structures pelagic habitats is fundamental for predicting fish distribution under changing climatic conditions. In the Mediterranean Sea, small pelagic species such as sardine (Sardina pilchardus), round sardinella (Sardinella aurita), and anchovy (Engraulis encrasicolus) are known to react strongly to fluctuations in sea surface temperature.

This study explores how different temperature ranges (thermal gradients) influence the spatial behavior and aggregation of small pelagic fish along the Algerian coast of the western Mediterranean. Using satellite data of sea surface temperature combined with purse-seine landing, temperature intervals were classified to identify the most favorable environmental conditions for fish concentration.

The results reveal that moderate SST bands between 20 °C and 22 °C correspond to dense aggregations and enhanced ecosystem productivity, whereas both cooler and warmer waters are linked to more scattered distributions. These findings highlight the importance of temperature gradients as ecological indicators for understanding habitat variability and anticipating the impacts of climate-induced changes on Mediterranean pelagic resources.

Keywords: thermal gradients; habitat variability; small pelagic fish; sea surface temperature; ecological indicators; Mediterranean Sea