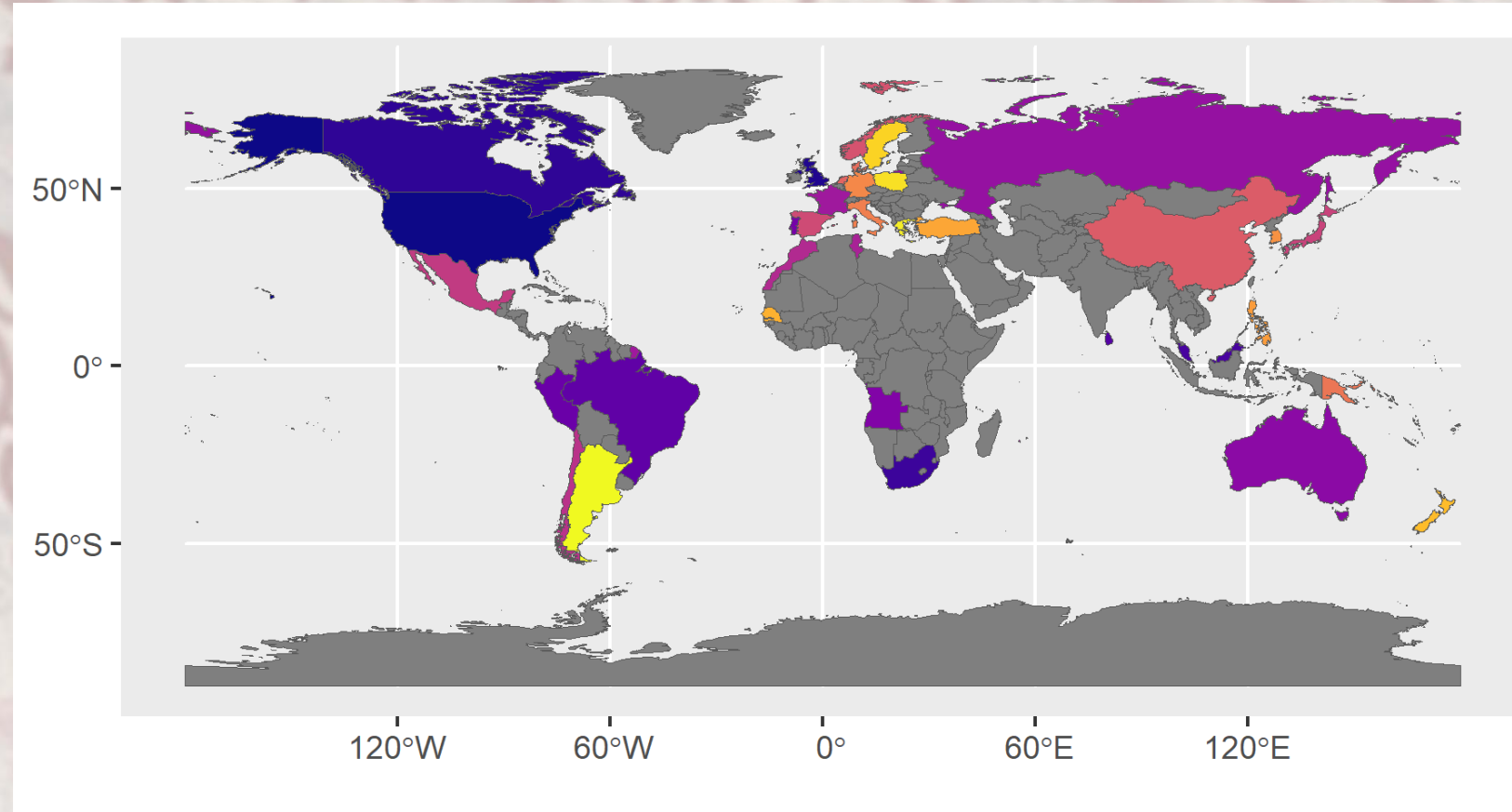


Plenary Session Summary

Chris Rooper, Stefan Koenigstein, Robert Wildermuth, Jaclyn Cleary, Mariana Hill, Criscely Luj n, Dongwha Sohn, Rebecca Asch, Francis Juanes, Marta Moyano, Henn Ojaveer, Patrick Polte, Martin Huret, Jacob Burbank, Leire Ibaibarriaga, Motomitsu Takahashi, Susana Garrido, Leonardo Castro, Anela Choy, Brian Hunt, Ruben Rodriguez-Sanchez, Naiara Rodriguez-Ezpeleta, Tatsuya Sakamoto, Marcelo Vasconcellos, Merete Tandstad, Chis Lynam, Carryn de Moor, Elisabetta Morello, Kazuhiro Oshima, Mariana Toussaint, Mariana Toussaint, William Griffin, Shirlene Anthonysamy, Libby Woodhatch, Isaac Kaplan, Cecilie Hansen, Felipe Quezada-Escalona, Patrick Polte, Rebecca Asch, Francis Juanes, Marta Moyano, Henn Ojaveer, Alex Jensen, Jennifer Boldt, Kym Jacobson, Carryn de Moor, Margaret Siple, Maria Manuel Angelico, Benoit Berges, Stefanie Haase, Niels Hintzen, Brian Hunt, Qiuyun Ma, David McGowan, Heidi Pethybridge, Fernando Ramos, Naiara Rodriguez-Ezpeleta, Matthew Baker, Susana Garrido, Niels Hintzen, Renato Salvattecí, David Field, Dimitri Gutierrez, Salvador Lluch-Cota, Daniela Silva, Luis A. Cubillos, Shota Nishijima, Iosu Paradinas, Rebecca Scott, Ashley Wilson, Marian Kjellevold, Alexandra Pounds, James Robinson, Shakuntala Thilsted, Temiloluwa Akinyemi, Maria Wik Markhus

Who are we and where did we come from?

- 226 participants
- 36 Countries
- 6 Continents
- 130 organizations represented
- 105 Early Career Ocean Professionals (46%)



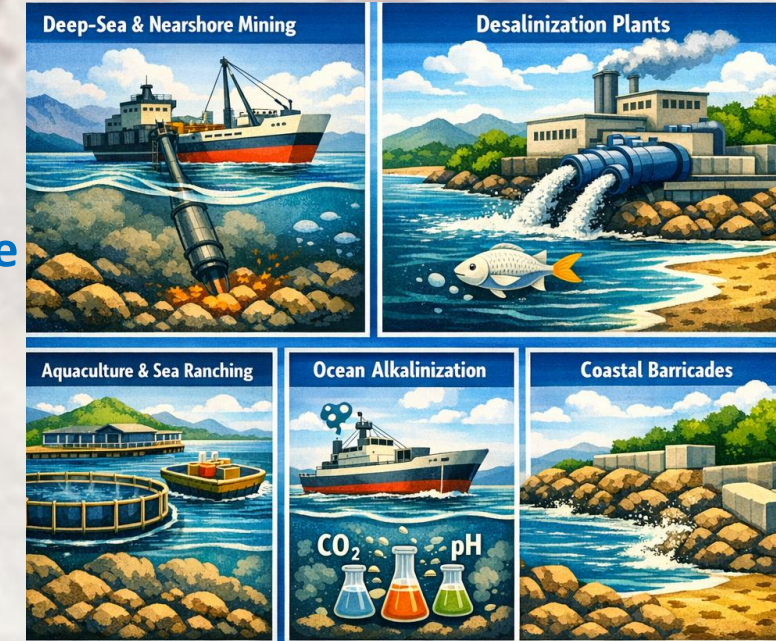
What did we do?

- 8 workshops
- 10 Sessions
- 174 Oral presentations
- 56 Posters



W1: Conceptualizing a Vulnerability Analysis for Anthropogenic Stressors on Small Pelagic Fish Communities

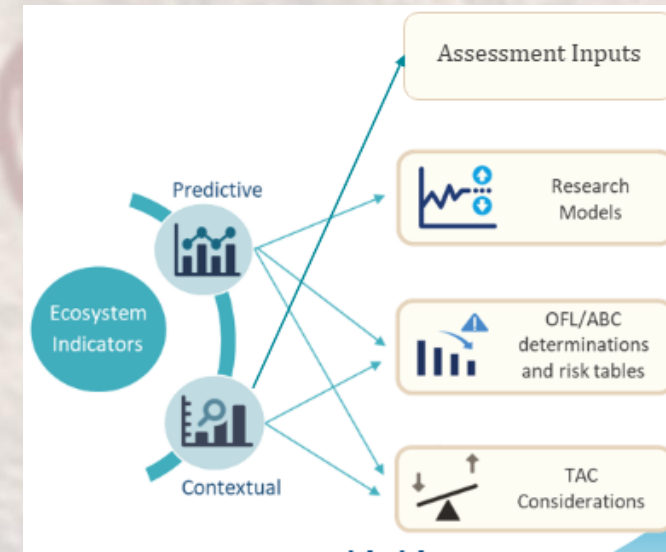
- Key messages
 - **Climate vulnerability assessments can be adapted** to rapidly assess other types of anthropogenic impacts and prioritize the most vulnerable species
 - This can help with mitigating climate change impacts since **we can regulate other anthropogenic impacts locally** but climate require global action
 - **Consider distinct life history stages**, stages of infrastructure development, uncertainty, cumulative impacts, and interacting effects
- What will 2050 look like?
 - Understanding of how **traits** affect vulnerability
 - Better **uncertainty quantification and understanding of cumulative and interacting effects** of anthropogenic impacts



AI-generated

Workshop 2: BEST PRACTICES FOR IMPROVING ASSESSMENT OF SMALL PELAGIC FISHES USING ENVIRONMENTAL INDICATORS

- **Goal:** Identify commonalities, challenges, and opportunities integrating the environment in SPF assessments and management
- ~78 participants (69 in-person, 9 online)
- Global Reach: Canary Current Upwelling System and California Current Ecosystem, as well as breakout group discussions covering case studies from the Pacific Ocean, Atlantic Ocean, Mediterranean Sea, Baltic Sea, and North Sea
- Key insights included: **1) tradeoffs in modeling different life history processes; 2) recommended workflows for variable selection and assessment modeling; 3) need for standardization, reproducibility, and interdisciplinary communication; 4) persistent challenges, including scale mismatch between processes and models**
- Future actions
 - Submit a peer-reviewed manuscript to CJFAS/MEPS

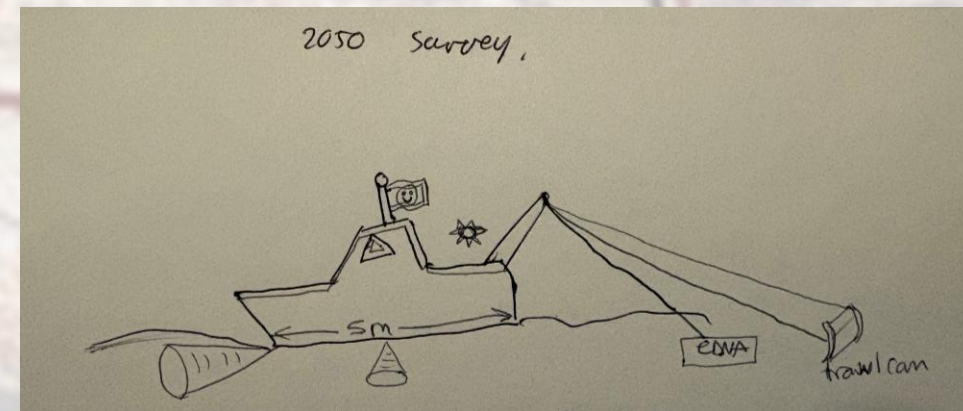


W3. Addressing Knowledge Gaps and Future-proofing Monitoring of SPF Using Novel Methods and Technologies

- **Ecosystem surveys** should be the standard
- **Data integration methods** are key to bringing in new/auxiliary data (eDNA, industry instrumentation, etc)
- **Maintain cost efficiency** (e.g. trade-off between new technology and better data)
- **Observation system simulation experiments** to identify data needs/adaptive sampling

Surveys in 2050

- Same surveys with new auxiliary data or Robots only
- “No fishermen on vessels in 2050”



Workshop 4: Identifying Management- and Industry-informed research priorities for small pelagic fisheries

Coordinate engagement between fishery scientists, managers and fishing industry on setting priorities for research that leverage industry interests

Summary

- Development of survey to solicit industry input (10 distinct LMEs represented, 15 fisheries)
- Short talks from industry leads and fishermen

Future actions

- Solicitation of more industry participation in online survey
- Development of Workshop Report for various fishery management forums
- Development of a manuscript



Workshop 5: REVISITING THE POTENTIAL OF SEDIMENTARY RECORDS: NEW ANSWERS TO OLD (AND EMERGING) QUESTIONS ON FORAGE FISH ECOLOGY VERSUS CLIMATE VARIABILITY

Participants and Key Topics

- Oxygen & climate mechanisms as key drivers of SPF variability
- Paleo-data for rates of change, early warning signals, and refugia
- Integration of paleo records into models and management

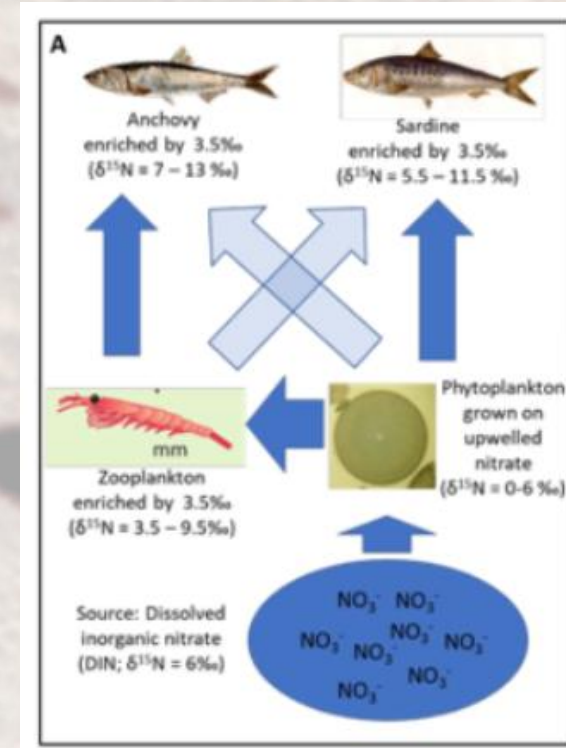
Goal: Bridge paleo records with fisheries science and prediction frameworks

Future Actions: Develop paper + potential paper (paleo–model integration), more paleo records

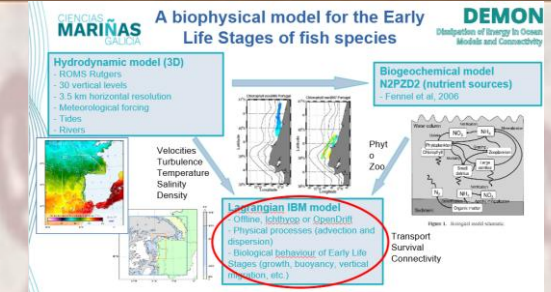
Future Directions (PICES/ICES SPF WG):

- Focus on oxygen, habitat constraints, and climate–ecosystem links
- Use paleo as training data for model: We move from models trained on recent variability to models trained on the full range of natural variability to improve future projections under CC

Collaborations: Strengthen links between paleo, fisheries, and modeling communities



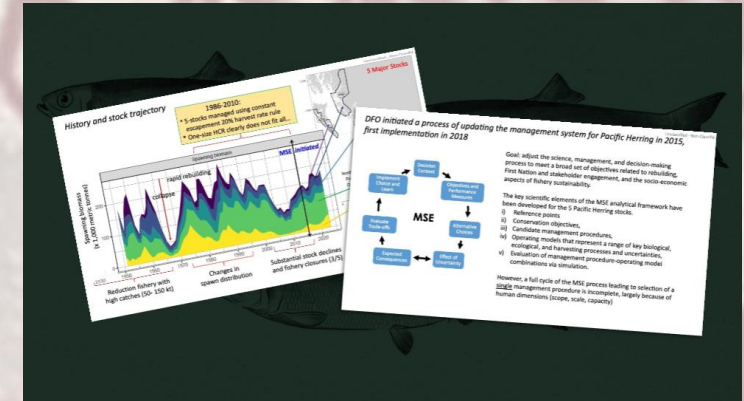
Workshop 6: ADVANCING SPATIO-TEMPORAL SPECIES DISTRIBUTION MODELS FOR FISH: CHALLENGES, METHODOLOGIES, AND COLLABORATIVE SOLUTIONS



- Key challenges discussed included **sampling bias, excess of zeros, spatial misalignment, hyperstability of fisheries, and data integration limitations in spatial ecology.**
- Different SDM frameworks provide complementary perspectives, reinforcing that **model choice should depend on ecological questions, available data, and research objectives.**
- **Goal: Explore spatial and spatio-temporal approaches for understanding SPF dynamics,** addressing key data challenges, and discussing modern SDM frameworks and applications.
- Future actions:
 - **Post-workshop survey** to identify collaboration interests, expertise and datasets to participate in future initiatives.
 - Development of **collaborative review paper**
 - Create a **shared communication and resource**

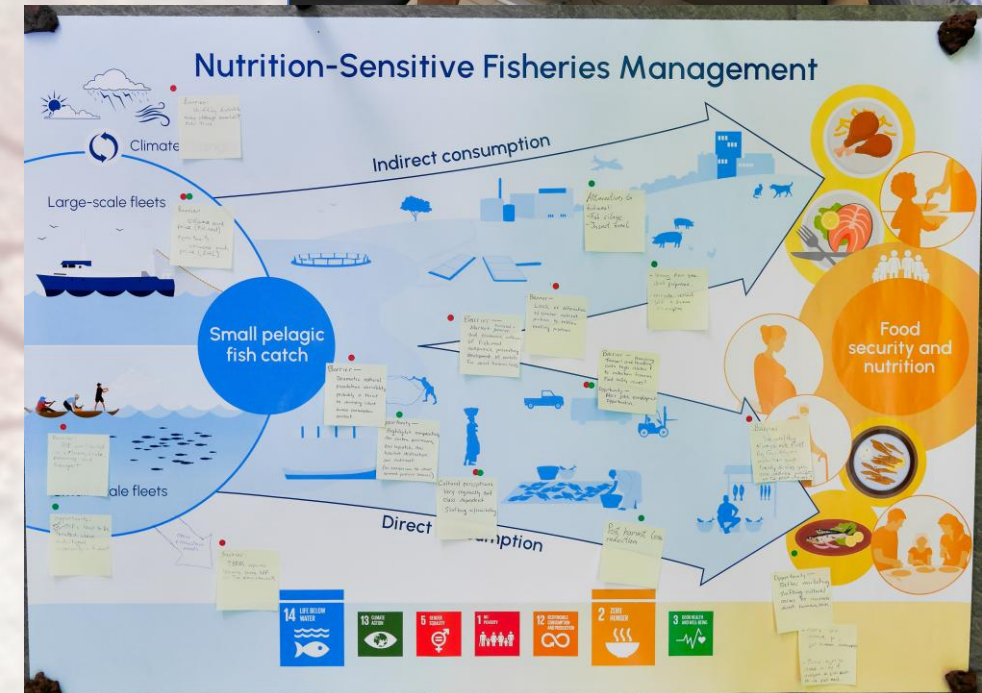
Workshop 7: OPERATIONALIZING ECOSYSTEM-BASED MANAGEMENT OF FORAGE SPECIES USING MSE

- **Goal:** To help progress the operationalization of EBFM in forage fisheries MSE
- **What happened:**
 - ICES ecosystem based management
 - Approaches to incorporate EBFM into MSE
 - MSE under shifting forage fish productivity and distributions in the California Current
 - Integrating Environmental Variability into MSE Frameworks
 - Knowledge co-production in the Pacific Herring MSE process
 - New MSE Tools: Climate Test for climate-ready MSE, EcoTest for multi-stock MSE, and an MSE framework for short-lived species
- **Future actions:**
 - A workshop summary report to be shared with the PICES-ICES SPF Symposium, potentially modified for submission to relevant RFMO fora.
 - Potential inputs on MSE and EBFM in a scientific article in collaboration with other sessions- Session 01/ Workshop 2?
 - Future topics/directions for PICES-ICES Small Pelagic Fish Working Group - *Consider the applications of MSE's to include ecosystem considerations and environmental drivers/ impacts in the evaluation and adoption of Management Procedures.*



W8: Maximizing Nutrient Yield from Marine Ecosystems: Nutrition-sensitive Management Strategies Based on the Nutrient Composition of Small Pelagic Fish

- Short talks and discussions in small groups
- **Goal:** Identify key actors and intervention points for nutrition-sensitive aquatic food systems (NSAF) across production, processing, distribution, and consumption.
- *Happiest workshop in La Paz
- Write collaborative scientific paper on key opportunities/barriers for developing **nutrition-sensitive food systems for SPF.**



S1: Bridging the Gap: From Ecological Data and Models to Fisheries Decision-Making

Stefan Koenigstein (Germany), Robert Wildermuth (USA), Jaclyn Cleary (Canada), Mariana Hill (Germany), Criscely Luján (Peru) and Dongwha Sohn (Korea)

- 1) Advances integrating environmental and ecosystem indicators in management
- 2) Applications of multi-species models to assess management tradeoffs (e.g. MICE)
- 3) Key processes included in models, and advances in their quantification
- 4) Model design: Balancing complexity with applicability and communication
- 5) Advances in coupling SPF to regional ocean and biogeochemical models
- 6) Quantifying and communicating uncertainty in models to advance their use
- 7) Applying different model types according to their strengths, in the right management framework/process

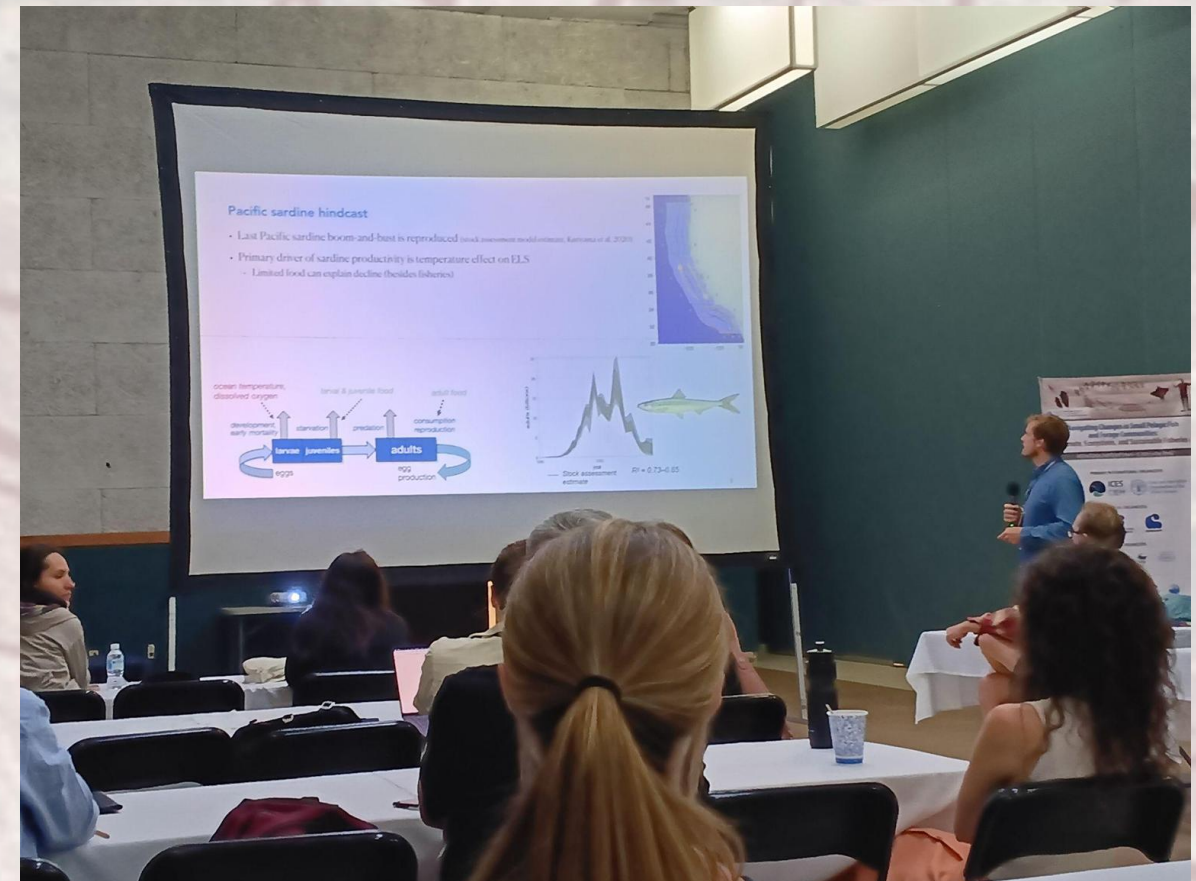
Key Messages

- Ensemble and multi-model approaches have high potential for assessing uncertainty in data and model structures
- Integrative, multivariate indicators and data streams can improve environment-/ ecosystem-responsive management
- Environmental variability (and climate change) are dominant drivers of small pelagic fish dynamics
- Management Strategy Evaluation (MSE) frameworks and operating models are critical bridges to decision-making
- Communication is key: quantifying uncertainty, balancing ecol. realism (complexity) and statistical robustness can help



Next steps

- Drafting review paper on: “Channeling advances in ecological modelling of small pelagic fish into climate-adaptive & ecosystem-based fisheries management”



Session 2 (Activity 5)

New approaches for assessment of human impacts beyond fisheries

Convenors: Rebecca Asch, Marta Moyano, Francis Juanes, Patrick Polte

Key Message (s)

- Anthropogenic impacts on SPF species are ubiquitous but poorly studied. Most SPF science focuses on fisheries ecology, environmental change, and management.
- Novel technologies can help studying these anthropogenic impacts, e.g. acoustic telemetry, otolith microchemistry, imaging
- Baseline data over relevant temporal and spatial scales are often missing. We need to develop creative approaches to address this issue.
- Communication with the public and policy makers about impacts is important but often challenging due to the urgency of finding climate solutions, which can potentially include anthropogenic impacts, such as offshore wind and ocean alkalization.

Key Open Questions & Recommendations for Future Actions, Potential Conditions in 2050?

- Cross-disciplinary collaboration is needed. There is a community that studies many of these impacts in fish and plankton, but not necessarily SPF.
- Applied science needs to be valued in our community so that ECOPs (and others) are encouraged to develop actionable science on a wider variety of topics.
- Communication training is needed among scientists so that we can speak to different audiences (including policy makers) in a way that is effective and so that statements are not misconstrued.

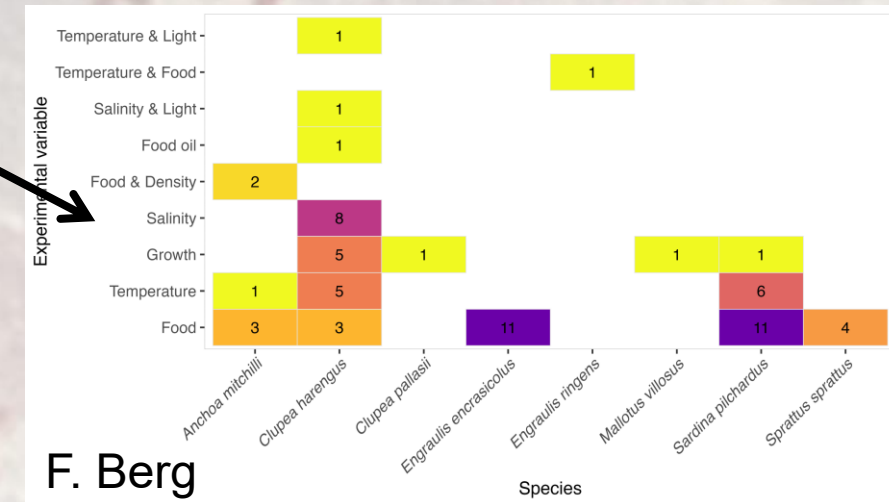
S3: Life History Variation Across Space, Time, and Ontogeny: Implications for Populations, Ecosystems, and Fisheries

Martin Huret (France), Leire Ibaibarriaga (Spain), Jacob Burbank (Canada),
Motomitsu Takahashi (Japan)

- ✓ 1) Ecological and environmental drivers of changes in life history traits and vital rates across all life stages, using field observations, experimental research, or modeling approaches;
- ✓ 2) Population-level consequences – How changes in traits (growth, fecundity, mortality, ...) affect population structure and dynamics, including implications for resilience, long-term productivity, and the integration of trait variability into stock assessment frameworks;
- ✗ 3) *Trophic implications of changes in LHT– Cascading through food webs*
- ✗ 4) *Impact onto the fishing industry and markets*

Key Open Questions & Recommendations for Future Collaboration, Potential Conditions in 2050?

- More cross-stock and cross-regional analysis through **increased collaborations** (better than Lisbon but still to improve)
- **More data and experiments** needed for process and modelling studies
- Need of more **mechanistic understanding** of the decrease in fish quality
- **Mortality and survival** (relative to growth) are still the neglected research area, conceptual frameworks exist but constantly need to be re-evaluated.
- **Harvest effect** on change in LHT need to be evaluated
- Improve model ability to project LHT trends **towards 2050**, relies on continuous fundamental studies
- Decreasing trends in SPF size and quality is strong, **adaptation needed** for species and human activities



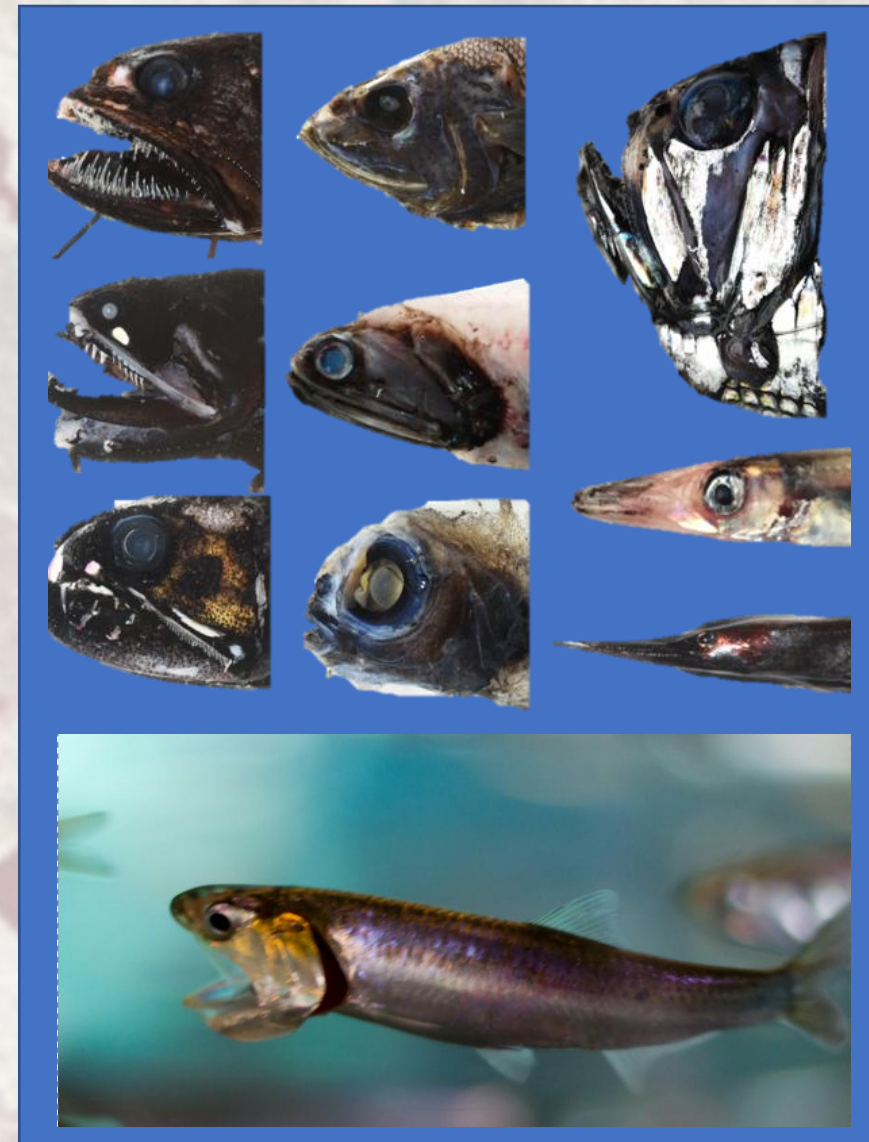
S4: Forage Fish and Food Webs

Susana Garrido (Portugal), Brian Hunt (Canada), Leonardo Castro (Chile),
Anela Choy (USA)

- Influence of climate variability on the phenology, abundance, and composition of key prey taxa;
- Impact of non-climate anthropogenic stressors on food web processes that forage fish depend on;
- Use of traditional, molecular, biochemical, and numerical modelling techniques to better quantify and predict trophic dynamics; and
- Role of forage fish as consumers, competitors, and prey, including their availability, nutritional quality, and influence on predator foraging behaviour and population dynamics.

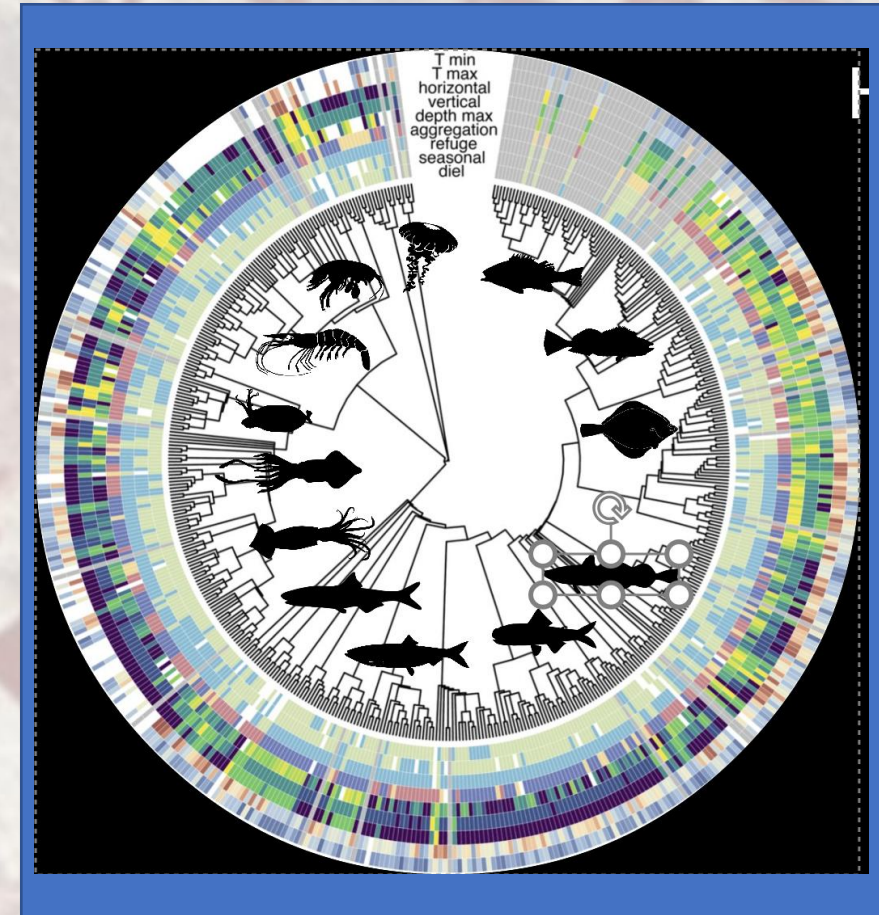
Key Message (s)

- Future looks good:
 - 15 ECOP
 - Diversification of food web research
- Combination of established techniques and new approaches
- Although identified as a key gap at the last symposium, larval studies were nearly absent at SPF26
- missing research from Africa, Asia, freshwater



Key Open Questions & Recommendations for Future Actions, Potential Conditions in 2050?

- Future Actions?
 - Similar approaches in different systems: potential for comparisons (models, isotope studies)
 - Synthesis of trait & nutrient data
 - Preserve analytical skills / capacity
- What will 2050 look like?
 - Application of food web metrics in management
 - Consolidated and shared analytical labs
 - Shared FAIR data systems



S5: Spatiotemporal Dynamics of Small Pelagic Fishes in a Changing Ocean

Ruben Rodriguez-Sanchez (México), Naiara Rodriguez (Spain), Tatsuya Sakamoto (Japan)

From the research results presented in Session 5, three process-oriented themes emerged, each linked to how oceanographic characteristics operating at different spatiotemporal scales shape biological patterns and fisheries management outcomes.



Theme (a) – Genetic and Structural Diversity Shaped by Oceanographic variables and processes

Focus: How basins, fronts, shelf transitions, and coastal heterogeneity maintain or modify population genetic structure and phenotypic divergence.

Example:



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EUROPEAN COMMISSION

EUSKO JAURLARITZA
GOBIERNO VASCO

ICES

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

Marina Puebla-Aparicio¹, Alice Manuzzi¹, Natalia Díaz-Arce¹, Pierre-Alexandre Gagnaire², Kenza Mokhtar-Jamai³, Naiara Rodriguez-Ezpeleta¹

¹AZTI, Marine Research, Basque Research and Technology Alliance (BRTA), Sukarrieta, Spain.
²ISEM, Univ Montpellier, CNRS, EPHE, IRD, 34093 Montpellier, France.
³Institut National de Recherche Halieutique (INRH), Centre Régional d'Agadir, Laboratoire de Génétique des Populations Halieutiques, Agadir, Morocco.

Theme (c) – Population Trajectories Distribution Implications

Focus:



Implications of herring and sardine on the
Shelf, consequences for fisheries

Speiser, Rosana Ourens and Susan Kenyon



S6: Managing Small-Pelagic Fisheries within an Ecosystem Approach: Lessons, Challenges, and Outlook

M. Vasconcellos (FAO), M. Tandstad (FAO), C. Lynam (ICES), C. de Moor (South Africa), E. Morello (GFCM), K. Oshima (NPFC, Japan)

- 1) Integrating social, economic, and ecological dimensions of SPF in fisheries assessment and management;
- 2) Assessment and management of transboundary SPF resources;
- 3) Adapting fisheries management to climate change and other stressors;
- 4) Practical experiences in participatory fisheries management: strengthening collaboration between science, industry and management.

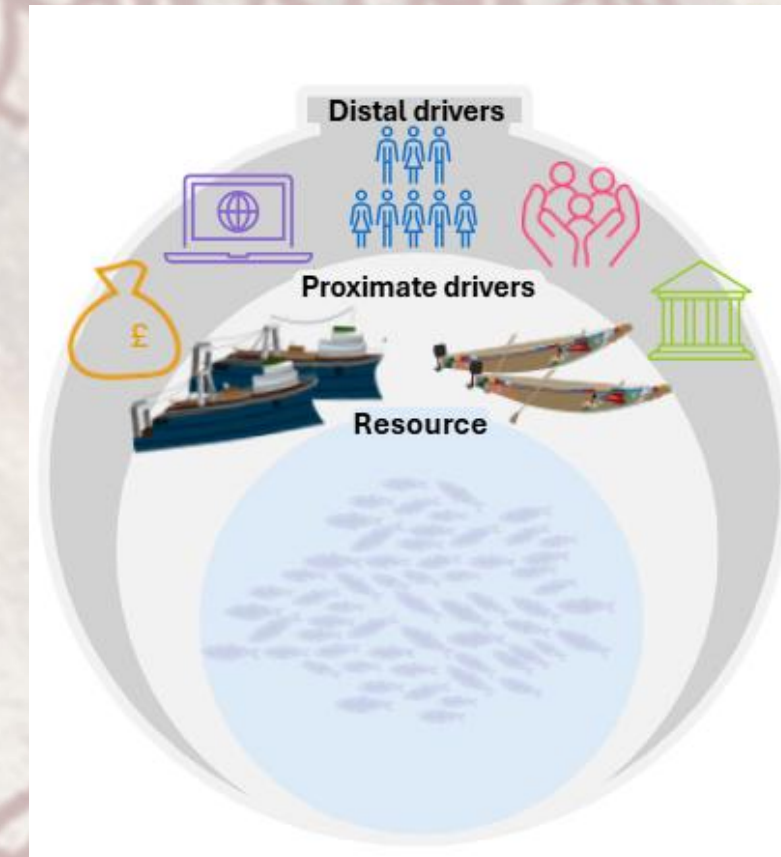
Key Message (s)

- Small pelagic fisheries are affected by a **wide range of natural and anthropogenic stressors and drivers**, including climate change, environmental variability, pollution from catchment areas, predator–prey relationships, technological change, markets, demographics, and governance.
- These drivers influence not only stock productivity and ecosystem structure, but also **human behavior, fishing pressure, and the sustainability of fisheries-dependent communities**.
- Time varying natural mortality, non-stationarity and ecosystem interactions mean traditional approaches **may not work**
- Fisheries management needs to consider the socioeconomic consequences of these policy choices while ensuring stock sustainability, particularly in developing nations.
- EAF/EBFM are becoming increasingly important frameworks for SPF



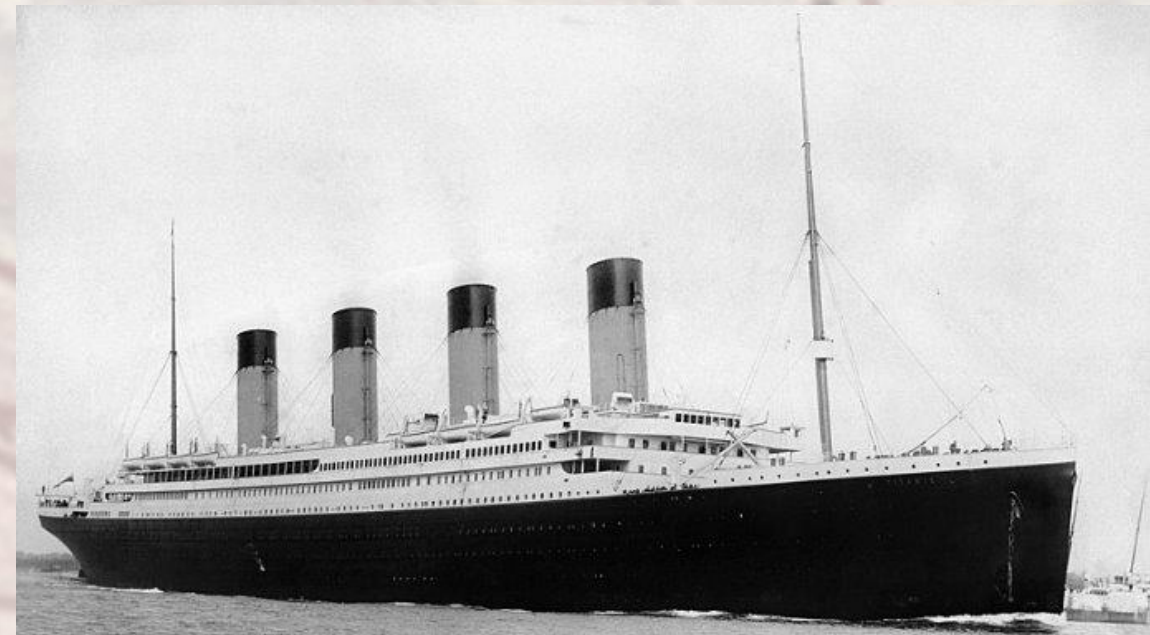
Key Message (s)

- There is no single pathway to EAF/EBFM implementation but there are several common criteria that were identified
 - that adaptive management,
 - participatory governance,
 - regional cooperation,
 - clear management objectives,
 - risk and trade-off evaluation, and
 - stronger science–policy integration are all essential components
- Key issues
 - need to involve stakeholders in scientific and decision-making processes,
 - improve ecological and socioeconomic understanding, and
 - strengthen governance systems.
- Challenges include
 - limited institutional commitment, constraints in long-term financing, poor visibility of small-scale SPF fisheries, compliance issues, limited integration between fisheries and environmental institutions, and persistent science–policy gaps



S7: Integrating Social Metrics into Economic Growth Strategies for Small Pelagic Fisheries

Cor Blonk (PFA)
Mariana Toussaint (FAO)



Titanic fatalities: 1503 Fishing industry 32,000 per year.
=
21 Titanic disasters annually

Key Message (s)

- **Decent work should be treated as a core component of fisheries sustainability,** alongside environmental and economic objectives. Sustainable fisheries require not only healthy ecosystems, but also secure livelihoods, decent work, and inclusive institutions.
- **Fishers and fish workers are fundamental** to global food security, nutrition, trade, and coastal livelihoods. However, **they remain vulnerable** to unsafe working conditions, human and labour violations and abuse, particularly women, migrant workers, children and coastal communities.
- Despite their importance, **social aspects in fisheries often remain underrepresented in policies and management systems.**
- **Measuring social aspects in the sector is critical for better policy decisions, fisheries governance and effective management.** Better social indicators, transparency systems, and traceability tools can improve accountability and protection of workers.
- Improving quality, **reducing post-harvest losses, and strengthening domestic trade** can directly improve livelihoods without increasing fishing pressure.

Key Open Questions & Recommendations for Future Actions, Potential Conditions in 2050?

• Future Actions?

- How can social indicators become as important as biological and economic indicators in fisheries management?
- How can social indicators be systematically integrated into fisheries management frameworks?
- Integrate labour rights, safety, climate adaptation, and fisheries management into a single coordinated approach.

• What will 2050 look like?

The future of fisheries sustainability will depend on:

- climate-resilient fisheries,
- inclusive governance,
- stronger social protection systems,
- and people-centered management approaches.

Challenge ahead:

NO FISHER OR FISH WORKER IS LEFT BEHIND towards sustainable fisheries

S8: Maximising Value and Sustainability

William Griffin (FAO), Jogeir Toppe (FAO), Liam Campling (UK), Soeon Ann (Korea), Marcelo Hidalgo (Papua New Guinea), Fatima Ferdouse (Malaysia), James Hinchcliffe (Denmark)

The role of small pelagics and improved utilisation in food security

The economics and geopolitics of distant water fisheries access arrangements

The value gap in fishery by-products in Korea

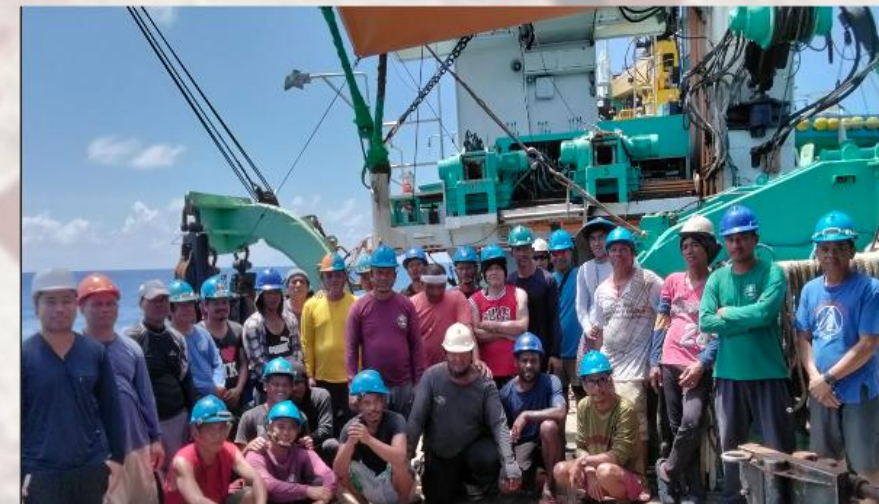
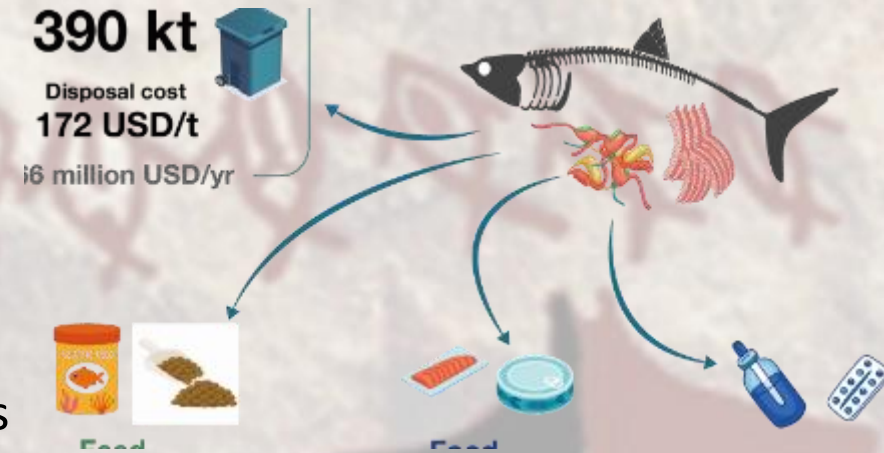
The role of certification in trade of small pelagics

Supply, demand and market trends of small pelagics in Asia

Marine ingredients as strategic ingredients in aquafeed

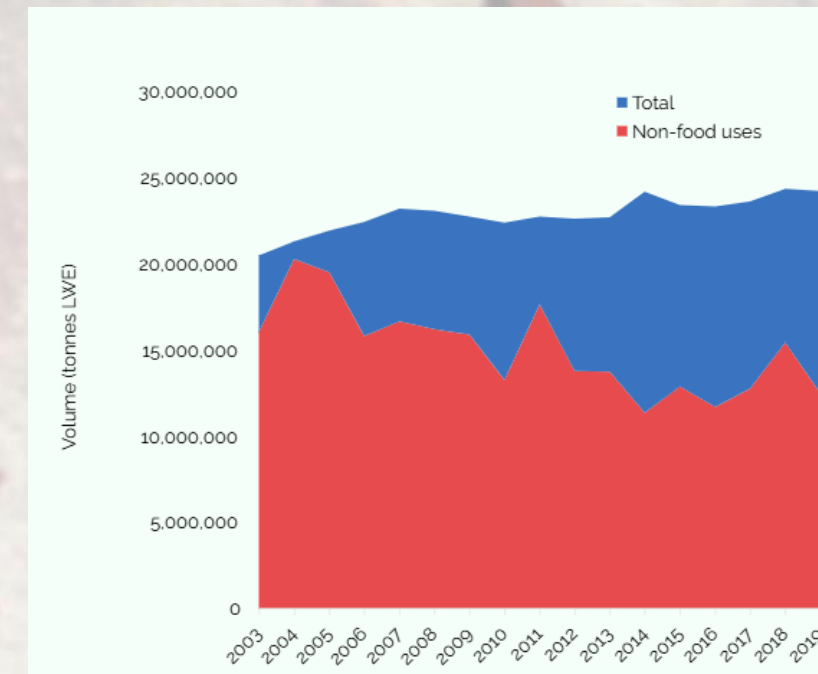
Key Messages

- **By-products are a cornerstone of fishmeal and fish oil production (a change from 20 years ago).** When processed correctly they hold enormous nutritional value, and support cost effective malnutrition programmes.
- Only a **small fraction of their potential is currently realised**, pathways to facilitate and incentivise their use must continue to be developed.
- **Fisheries need to work for fishers and the people who rely on the industry for their livelihoods.** Well formulated national strategies bring direct improvements to crew welfare, sector incomes and national development while maintaining stock sustainability.
- **Consumption of small pelagics has grown increasing prices** with new global trade flows.
- **Fisheries access arrangements** underpin a significant proportion of global catches, geopolitics and economics shape their nature



Key Open Questions & Recommendations for Future Actions, Potential Conditions in 2050?

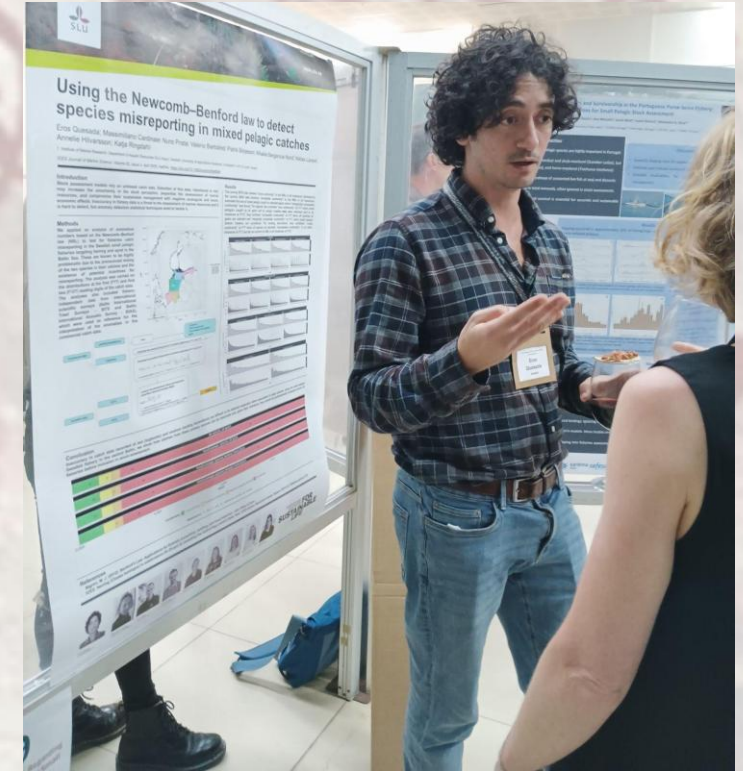
- Future Actions?
 - Supporting national action for progressing by-product utilisation.
 - Continued optimisation of feed formulations.
 - Development of national action plans that support fishers and the fishing industry.
 - Improving bargaining power of developing countries in fisheries access arrangements.
- What will 2050 look like?
 - Near-full utilisation of catch and by-products as standard practice



S9: Modeling Human Choices Regarding Harvest and Management of Small Pelagic Fish Stocks

Felipe Quezada-Escalona (Chile), Isaac Kaplan
(USA), Cecilie Hansen (Norway)

- 1) Methodologies for modeling fisher and manager responses to fluctuating opportunities.
- 2) Model development and analytical tools that are necessary to represent humans in socio-ecological small pelagic systems



ECOP in action (Eros Quesada)

Key Messages

- SPF can be central to the Blue Economy, but this will require more engagement with the social contexts surrounding fisheries.
- Fishers' adaptation strategies depend on specific context, such as cost of switching.
- New techniques are available, ranging from machine learning, to new interview techniques, to game-based learning.
- Multiple well-developed methodologies exist for modeling fisher location choice and participation.
- Improved knowledge is possible via direct input from fishers and industry



Collaborative serious game (Frederike Tirre)

Key Open Questions & Recommendations

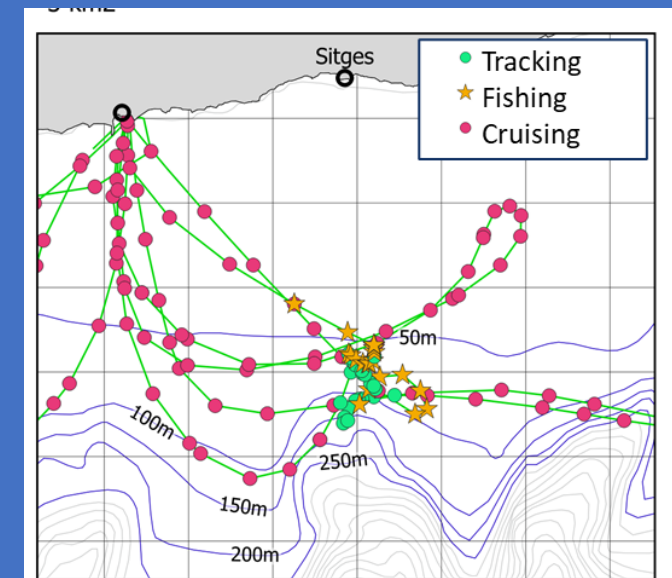
• Future Actions

- Working group discussions this weekend, under Activity 9 (Socio-ecological systems)
- Follow up on new tools, ranging from machine learning to semi-structured interviews.
- Sharing of code/methodologies.

• What will 2050 look like?

- Fishing activities will be influenced by the broader employment and labor landscape
- Environmental change will drive fish populations, and subsequent fishing decisions
- Increased need for cooperative strategies, for transnational SPF stocks.
- Adaptation may be limited by regulations and/or lack of political collaboration

Machine learning methods for classifying purse seine vessel operations. Sala-Coromina et al. 2026, *Fish and Fisheries*.



Summary

- Changes in spatio-temporal distributions are challenging fisheries management across the globe
- Genomics methods help unraveling SPF population structure and stock mixing processes, thus providing actionable guidance for fisheries management and conservation
- Combined analyses of survey data and commercial data are particularly powerful for advancing our knowledge on SPF dynamics and distributions
- Archeogenomic techniques are a powerful tool for investigating historical perceptions of population diversity
- Need to refine our understanding on population connectivity and phenotypic adaptations under climate-driven distributional changes
- New advances have allowed re-examination of old paradigms –
- Human consumption v. human consumption (via aquaculture)
- Fishers entering the ecosystem (and especially fishers health)
- Conflicting results – study design, multi-model ensembles, transparency
- What we didn't see – squid! Predators?
- We've done something on recruitment, perhaps?
- At times our ecosystems are changing faster than we can include them in models and management systems
- EAFM is an obligation, not an option!
- “It's a great time to be alive” – Andrew Thomson