Activity 1: Spatiotemporal processes affecting life history

Leaders: Rebecca Asch (USA), Brad Erisman (USA), Daniela Silva (Portugal)

Background

Small pelagic fish (SPF) and other forage species play a crucial role in marine ecosystems and global fisheries, yet their populations are highly dynamic and sensitive to environmental variability. Understanding the spatiotemporal processes that influence their life history parameters, such as reproductive phenology, growth rate, ontogeny, movement, and distribution patterns, is essential for improving stock assessments and developing effective management strategies. These processes are driven by complex interactions between environmental factors (*e.g.*, temperature, salinity, and primary and secondary productivity), species-specific traits, and anthropogenic pressures, making it necessary to adopt a multidisciplinary approach that integrates diverse datasets and analytical methods. This aligns with the *ToR 1*, ensuring that research on SPF is both globally relevant and locally applicable.

The Activity 1 aims to advance our understanding of how these factors shape SPF populations across different ecosystems. By leveraging ongoing research within the WG, this activity brings together several sub-activities that address key knowledge gaps, including the thermal sensitivity of reproductive phenology, environmental drivers of spatial distribution, characterization of biological populations and managed stocks, and the integration of fisheries-dependent and independent data for improved modeling approaches. Additionally, new efforts will focus on refining methodologies for assessing reproductive phenology, defining best practices for applying life history traits to stock characterization, and investigating spatial predator-prey interactions within SPF-dominated ecosystems. Collectively, these sub-activities will contribute to a more comprehensive understanding of SPF dynamics, supporting international comparative studies and enhancing predictive capacities for population responses under changing environmental conditions.

Objectives of the activity for 2024–2028 [with links to WG's ToR]

- Identify trends, interannual variability, and environmental drivers of reproductive phenology (*i.e.*, temperature, chlorophyll-*a* concentration) in SPF and ecologically similar species (*ToR 2 & 3*)
- Evaluate environmental sensitivity in pelagic forage fish spatial distributions through the analysis of interspecific and intraspecific responses of SPF distributions to environmental variables, such as temperature and salinity (*ToR 2 & 3*)
- Determine best practices for applying life history traits to define SPF populations and stock characterization by investigating growth patterns, spatiotemporal dynamics of spawning, larval dispersal and recruitment, seasonal migrations, ontogenetic shifts in habitat, and other life history aspects across different pelagic forage stocks (*ToR 2 & 4*)
- Enhance understanding of spatiotemporal abundance and distribution patterns of SPF and other forage species by joint modelling fishery-dependent and fishery-independent data sources (*ToR 2, 3 & 4*)
- Develop best practices for assessing reproductive phenology using maturity and gonado-somatic index (GSI) data by establishing standardized methodologies for analyzing maturity status and GSI data

Description of sub-activities

- **Continuing sub-activity 1**: **Trends and thermal sensitivity of reproductive phenology**
  Lead: Rebecca Asch

  Focus: Analyze trends, variability, and thermal sensitivity in the reproductive timing of SPF and other forage species, with an initial focus on North America.

Expected outcomes:
(1) Identification of phenological shifts in response to temperature variations, informing predictive models for climate-induced changes in reproductive cycles;
(2) Understanding of the relative influence of interannual variability vs. long-term changes driven by temperature shifts on reproductive phenology;
(3) Comparisons among species, regions, and latitudinal gradients.

Status: Updated datasets have been compiled; templates for data analysis have been developed, including trends, variability and regression analyses linking temperature data to phenological responses. Final data analysis will commence.

(Potential) Challenges: Data sharing constraints could affect project geographic expansion; local expertise needed for analysis decisions.

Future directions: Initial work is focused on North American datasets due to data accessibility. A second manuscript may be developed with a greater geographic scope. The original objectives of this sub-activity also included understanding the influence of a greater diversity of environmental and biotic variables on phenology and examining the influence of parental effects. These are topics that could be addressed in the future.

- **Continuing sub-activity 2: Environmental sensitivity in spatial distribution**
  Lead: *Marta Moyano, Martin Lindegren*

  Focus: Evaluate interspecific and intraspecific responses to environmental factors (*e.g.*, temperature, salinity) in SPF spatial distributions, with an initial focus on European waters.

  Expected outcomes: A broader understanding of the key environmental drivers determining past and current distributions of SPF and the variability in the inter- and intraspecific (ecoregion) responses.

  Status: Data have been compiled; next step involves re-running GAMs and finalizing the ongoing paper.

  Future directions: As of now, this sub-activity will focus on finalizing the ongoing paper. Other datasets were identified beyond European waters (*e.g.*, anchovy in Peru and Chile, SPF is Benguela) that would be adequate to expand this initial study or to develop new ones with a different scope. Also, there is a potential to perform similar analyses on egg survey data to assess patterns across ELHS.

  Suggestion: Increased representation from Canary Current in the WG would be desired. Also, there is an interest in adding data from South Africa, if available.

  Additional notes: Compiled datasets and those identified outside European waters could complement ongoing work planned by Daniela Silva.

- **New sub-activity 1 (sub-activity 3): Stock characterization related to life history traits**
  Lead: Brad Erisman

  Focus: Life history traits related to growth, spawning, movement, and ontogeny and other factors are commonly used to define, delineate, and discriminate between stocks of managed SPF and other forage species, but the approaches vary considerably among stocks, species, and regions. Stock characterizations of SPF also vary in their alignment with principles and criteria of biological populations. Such variations can hold serious implications for fisheries stock assessments and management. We seek to develop standardized best practices for the application of life history traits to characterize SPF stocks consistently and in alignment with the principles of population biology.

Expected outcomes: Identification of best practices in SPPF stock characterization and management, with case studies highlighting regional successes, challenges, and data gaps.

Status: Beginning project.

Additional notes: (1) Potential integration or transfer of this project to the new activity focused on stock structure and connectivity research; (2) A potential case study could focus on Pacific sardine (population structure) and Japanese sardine (interspecific connectivity) along the Pacific coast of North America.

- **New sub-activity 2 (sub-activity 4): Joint modeling using fisheries-dependent and independent datasets**
  Lead: *Daniela Silva*

  Focus: Integrate fisheries-dependent and fisheries-independent datasets to improve understanding of SPF and forage species spatial dynamics. Future work may expand the model to look at predator distribution jointly alongside SPF.

  Expected outcomes:
  (1) Enhanced knowledge of pelagic forage species spatial-temporal distribution by leveraging multiple data sources;
  (2) Better insight into predator-prey dynamics in response to environmental factors;
  (3) Improved understanding of fishing patterns through analysis of catchability effects and spatio-temporal patterns of where effort is concentrated.

  Status: Beginning project.

  Next steps: Aggregate data from different marine regions; both fishery-independent and fishery-dependent data sources will be used.

  (Potential) collaborations with: Marta Moryano (data sharing), Leire Ibaibarriaga, Iosu Paradinas, Latin American countries and surveys in Morocco.

- **New sub-activity 3 (sub-activity 5): Using maturity status and GSI data to look at phenology**
  Lead: *Susana Garrido (potential leadership transition)*

  Team: Susana Garrido, Cristina Nunes, Laura Wise, Daniela Silva, Rebecca Asch, Jennifer Boldt, Jacob Burbank, Marta Albo and Brad Erisman.

  Focus: Investigating reproductive phenology through time series of maturity status and GSI data, linking patterns to environmental variables (temperature and chlorophyll-a concentration).

  Expected outcomes: Development of best practices for phenological studies, leading to two distinct papers on methodology and inter-stock comparisons. First paper would focus on methodological recommendations, while the second paper would be on geographic and interspecific patterns.

  Status: Compiling and analyzing data.

  Challenges: Defining thresholds for maturity.
  Data: Time series data from Portuguese mainland coast (starting 1987) are available. Additional datasets will be integrated through the collaborations. Rebecca Asch has a meta-data from Continuing Sub-activity 1 on many surveys that have maturity data that may be applicable. Jennifer Boldt, Jacob Burbank, Rebecca Asch, and Marto Albo also intend to contribute by providing data.

  Next steps: Compile and integrate new data to proceed with the analysis.

Data needs

Biomass index data of SPF (sardine) with geographic (coordinates) and temporal (day) information, derived from both fishery-independent sources (surveys) and fishery-dependent sources (commercial data, VMS data, AIS data) – sub-activity 5 (new sub-activity 3).

Deliverables and anticipated timeline

Deliverable/objective	Timeline
Sub-activity 1: Presentation of final results at SPF Symposium (SPF-2026)	May 2026
Sub-activity 1: Paper submitted to a special issue associated with SPF-2026	August 2026
Sub-activity 1: Gathering of data and preliminary analyses for global comparison	December 2026
Sub-activity 1: Global comparison paper written	December 2027
Sub-activity 2: Presentation of final results at SPF-2026	May 2026
Sub-activity 2: Paper submitted to a special issue associated with SPF-2026	August 2026
New Sub-activity 1: Presentation of initial case study at PICES-2025 meeting	November 2025
New Sub-activity 1: Initial case study submitted for publication	Winter/Spring 2026
New Sub-activity 1: Review paper with examples from several sardine and anchovy stocks	November 2027
New Sub-activity 2: First publication demonstrating methodology for one region	December 2025
New Sub-activity 2: Workshop at SPF-2026 to establish database for larger regional collaboration	May 2026
New Sub-activity 2: Follow up papers considering larger region	December 2026
New Sub-activity 3: Present analysis at PICES-2025 to obtain feedback	November 2025
New Sub-activity 3: Draft paper	Underway
New Sub-activity 3: Compile data for different marine regions	Spring 2026

Membership (This list is based solely on those who expressed interest in this activity during the February 2025 WG meeting in Lisbon)

Name	Institution	Email address
Rebecca Asch	East Carolina University, USA	ASCHR16@ecu.edu
Brad Erisman	NOAA SWFSC, USA	brad.erisman@noaa.gov
Daniela Silva	IPMA, Portugal	daniela.dasilva@ipma.pt
Susana Garrido	IPMA, Portugal	susana.garrido@ipma.pt
Chris Rooper	Department Fisheries and Oceans, Canada	Chris.Rooper@dfo-mpo.gc.ca
Jennifer Boldt	Department Fisheries and Oceans, Canada	Jennifer.Boldt@dfo-mpo.gc.ca
Hannah Murphy	Department Fisheries and Oceans, Canada	Hannah.Murphy@dfo-mpo.gc.ca
Martin Huret	IFREMER, France	martin.huret@ifremer.fr
Jacob Burbank	Department Fisheries and Oceans, Canada	jacob.burbank@dfo-mpo.gc.ca
Isabel Riveiro	Centro Oceanografico de Vigo, Spain	isabel.riveiro@ieo.csic.es
Leire Ibaibarriaga	AZTI, Spain	libaibarriaga@azti.es
Vladimir Radchenko	VNIRO (TINRO), Russia	vladimir.radchenko@tinro.vniro.ru
Marta Moyano	NIVA, Norway	Marta.Moyano@niva.no
Motomitsu Takahashi	FRA, Japan	takahamt@fra.affrc.go.jp
Dongwha Sohn	Pusan National University, Korea	dongwhasohn@gmail.com
Paul Kotterba	Thünen Inst. of Baltic Sea Fisheries, Germany	paul.kotterba@thuenen.de
Brian Hunt	University of British Columbia, Canada	b.hunt@oceans.ubc.ca
Sebastián Vásquez	INPESCA, Chile	svasquez@inpesca.cl

Jeroen van der Kooij	CEFAS, UK	jeroen.vanderkooij@cefas.gov.uk
Benoit Berges	Wageningen University, The Netherlands	benoit.berges@wur.nl
Cristina Nunes	IPMA, Portugal	cnunes@ipma.pt
Claudia Namiki	University of Sao Paulo, Brazil	namiki@usp.br
Fernando Ramos	Centro Oceanografico de Cadiz, Spain	fernando.ramos@ieo.csic.es
Valerio Bartolino	SLU, Sweden	valerio.bartolino@slu.se
Ana Moreno	IPMA, Portugal	moreno@ipma.pt
Laura Wise	IPMA, Portugal	lwise@ipma.pt
Mathiew Baker	North Pacific Research Board, USA	Matthew.Baker@nprb.org
Akinori Takasuka	University of Tokyo, Japan	atakasuka@mail.ecc.u-tokyo.ac.jp
Ignacio Catalan	IMEDEA, Spain	ignacio@imedea.uib-csic.es
Ryan Rykaczewski	NOAA-PIFSC, USA	ryan.rykaczewski@noaa.gov
Marta Albo	Institute of Marine Science, Spain	marta.albo.puigserver@gmail.com
Stefan Koenigstein	Leibniz ZMT, Germany	stefan.koenigstein@leibniz-zmt.de
Maxime Olmos	IFREMER, France	Maxime.Olmos@ifremer.fr