Deliverable 1.5

SURIMI toolbox's co-design

31/3/2025 | Version 1

Ana Rodriguez

Visibility (Public)

Funded by the European Union

Funded by the European Union under the Horizon Europe Program, Grant Agreement No. 101157456 (SURIMI). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor the granting authority can be held responsible for them.

UK Research and Innovation

UK participants in SURIMI are funded by the UK Research and Innovation (UKRI) under the UK government's Horizon Europe funding Guarantee [grant number 10132993].

DOCUMENT INFORMATION

Grant Agreement	101157456
Project Acronym	SURIMI
Project Title	Integration of innovative and reliable socio-ecological models and user-driven solutions into the Digital Twin Ocean, to facilitate what-if scenarios and decision support, under a co-creation approach.
Deliverable Number	D1.5
Work Package Number	WP1
Deliverable Title	SURIMI toolbox's co-design
Lead Partner	European Marine Board
Author(s)	Ana Rodriguez, European Marine Board
Due Date	30.04.2025
Submission Date	29.04.2025
Dissemination Level	Public
Type of Deliverable	Report

Version	Summary of Changes
Version 0	First draft reviewed by SURIMI partners
Version 1	Version 1 submitted to the portal

SUMMARY

SURIMI aims to provide the world with easy-to-use and freely available tools that draw on expert fisheries dynamics models to better understand the effects of fisheries management interventions. Such expert models are rarely used outside the scientific realm despite their huge societal potential. SURIMI therefore aims to make them more easily accessible to non-experts. To this end, stakeholder engagement is a key component of the project.

The first of three stakeholder workshops was held on 11 February 2025. Its aim was to present the SURIMI project and the scientific models it will integrate to key fisheries stakeholders, understand these stakeholders' needs and concerns, and collect their input to guide tool development and design. It was attended by 31 external participants representing policy makers, scientific advisory bodies, advisory councils, NGOs, the fishing industry and scientists.

The workshop consisted of seven sessions, which covered stakeholder data and decision-making needs and concerns, graphical user interface requirements, and in-depth conversations on the models that the project will integrate. The key interests and questions of participants were centred around four topics: model uncertainty, i.e. the realism of the models and their trustworthiness; the quality of the data used in the models and how this data will be standardised; how the integration of the different models will work and whether it will be able to improve the overall modelling results; and the potential of the SURIMI tools for users and decision-makers.

The workshop provided important insights for the SURIMI consortium going forward and very fruitful conversations between participants and modellers. The main findings from the workshop are outlined in this report, and will guide the development of the SURIMI Toolbox going forward.

CONTENTS

1. INTRODUCTION

SURIMI aims to provide the world with easy-to-use and freely available tools that draw on expert fisheries dynamics models, to better understand the effects of fisheries management interventions. These tools – the SURIMI Toolbox – will include some of the most advanced fisheries-relevant socio-economic and ecological models, a graphical user interface, and the possibility of running model simulations and obtaining results through written text. To enhance the reach of these tools, the SURIMI Toolbox will be integrated into the EU Digital Twin Ocean (EU DTO), a virtual information system of the EU's waters, which is freely accessible and will be able to visualize and forecast Ocean data and what-if scenarios.

Models are rarely used outside the scientific realm despite their huge societal potential. SURIMI therefore aims to make the use of expert fisheries models more easily accessible to non-experts. To this end, SURIMI will draw on four existing and well-established models (Poseidon, Ecopath with Ecosim and its associated Value Chain, and CMSY++) and develop three additional models (a System Dynamics Model to fill data gaps, an AI model to interact with users through natural language, and a Management Strategy Evaluation model[1]). Because each model has its own strengths and limitations, SURIMI will create a protocol that will allow models to "talk to each other", meaning that they will be able to exchange information and be used in combination to improve predictions. This protocol will also be easily usable by other EU DTO projects that require communication between models. Moreover, to improve accessibility and promote usage, SURIMI will develop a user-friendly graphical interface with two components: The first will focus on data visualization, bringing together SURIMI's social, ecological, biological and economic data under a single interface. The second will be a Management Strategy Evaluation decision support tool that will allow users to pick scenarios, define geographical boundaries, and incorporate supplementary data and expert knowledge. The SURIMI Toolbox will allow users to obtain a deeper, more nuanced understanding of fisheries systems and help create policies that balance marine conservation with the needs of fishing communities.

To ensure that the SURIMI Toolbox is relevant to the end-users, stakeholder engagement is a core component of SURIMI. To this end, three main stakeholder workshops will be organised throughout the project. The first of these workshops was held in February 2025. Its aim was to present the SURIMI project and the scientific models it will integrate to key stakeholders, understand the stakeholders' needs in terms of data for decision-making and user interface requirements, and collect their input to guide tool development and design. The results of the workshop are summarised in this report.

2. METHODOLOGY

[1] Management strategy evaluation (MSE) is a collaborative process between scientists and decision makers that involves using computer simulation to compare the relative ability of different Management Strategies at achieving previously agreed management objectives.

The first workshop was held as a full-day online event on 11 February 2025 and was facilitated by Lizzie Crudgington[2], a professional facilitator. It was attended by 31 external participants representing policy makers, scientific advisory bodies, advisory councils, NGOs, the fishing industry and scientists, as well as 14 SURIMI Consortium members, the professional facilitator and three additional breakout room facilitators (Fig. 1 and 2).

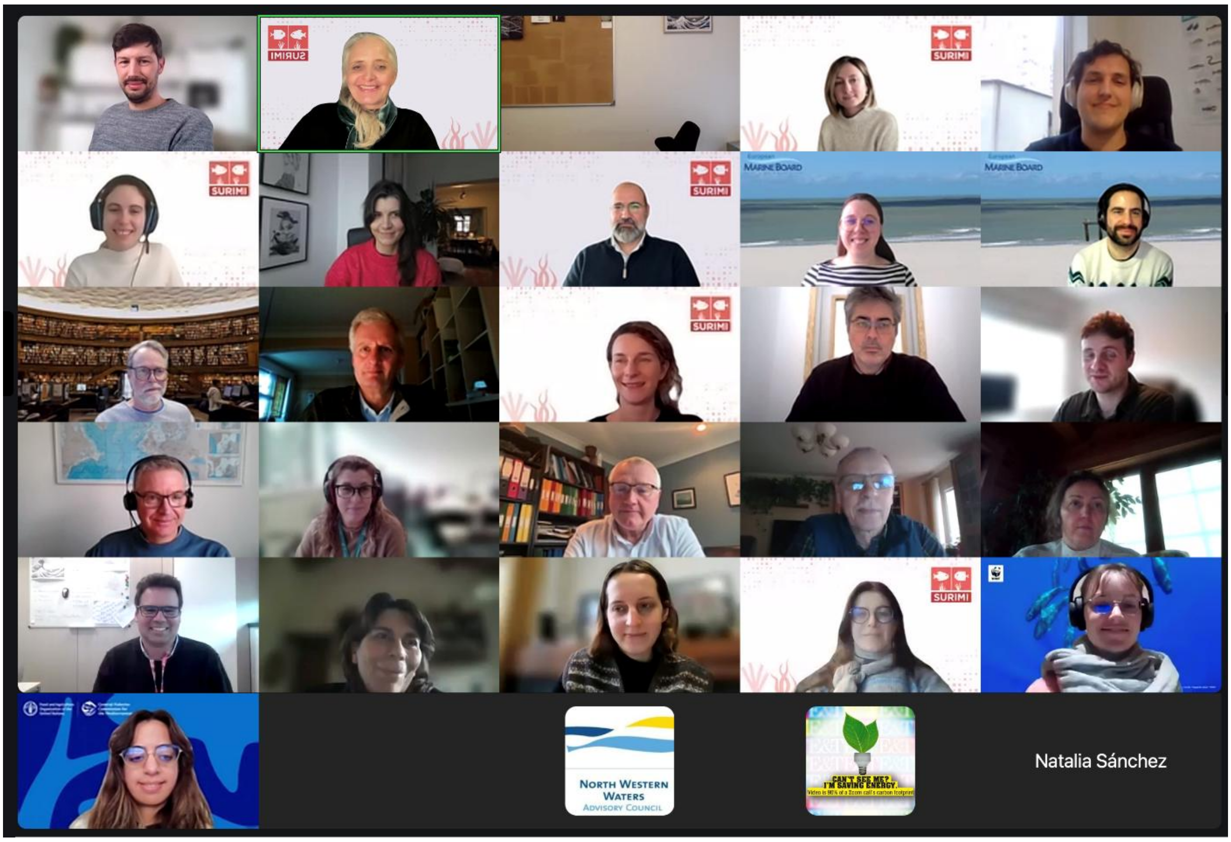

Figure 1: Group photo 1

[2] https://www.iaf-world.org/site/members/elizabeth-crudgington/284

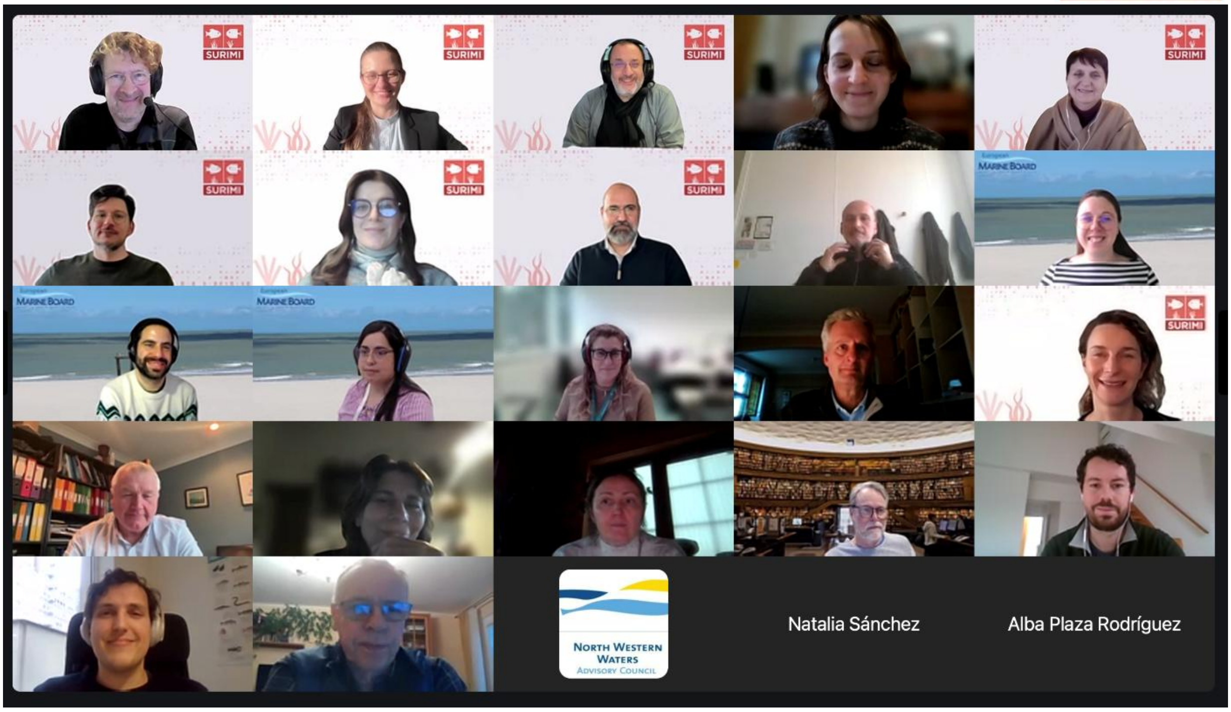

Figure 2: Group photo 2

Throughout the workshop an online mural (Fig. 3) was used to capture participants' reflections and comments, and the different sections of the mural were revealed in the respective sessions.

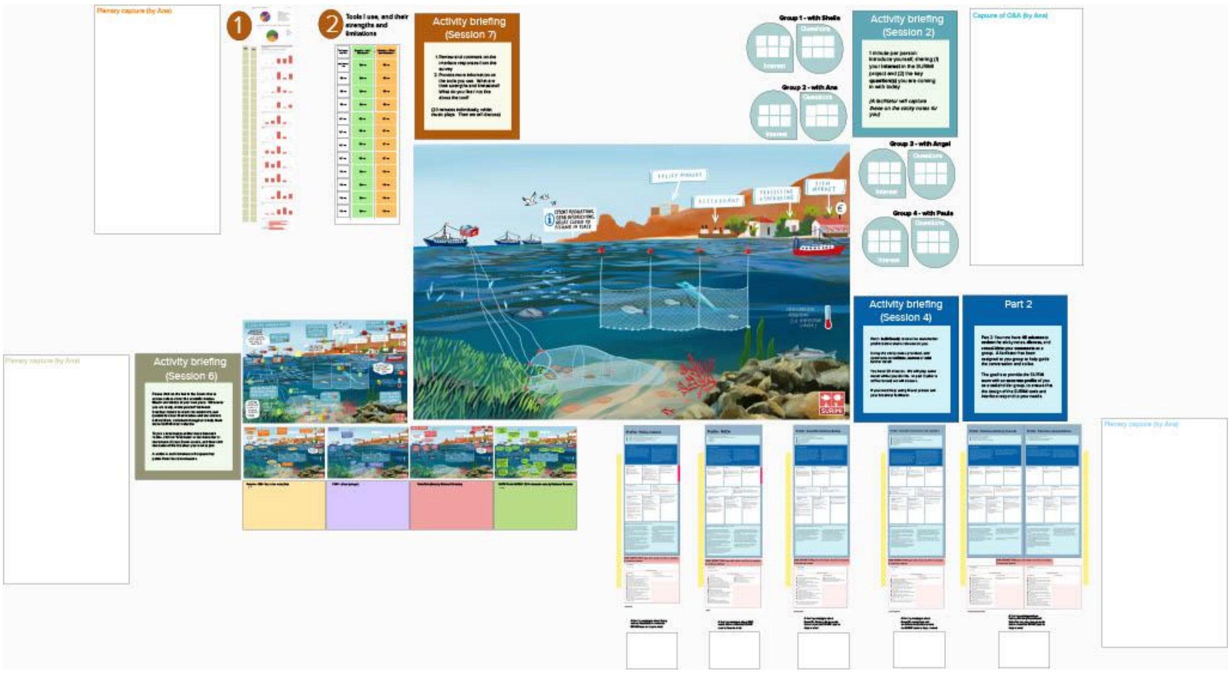

Figure 3: The Mural used during the workshop to capture the workshop participants' comments and reflections

The workshop consisted of seven sessions (see agenda in Annex 1):

- Session 1: Opening

- Session 2: A brief intro to the SURIMI project
- Session 3: Exploring stakeholder needs (survey responses)
- Session 4: Who needs what, why and how? (stakeholder profiles)
- Session 5: Summarising key messages so far
- Session 6: Learning about the science behind SURIMI
- Session 7: Needs and preferences for the graphical user interface
- Closing and next steps

In the opening session, the desired outcomes of the workshop, the workshop agenda, the methodology and the participants were introduced. This was followed by session 2, where the SURIMI project was introduced by means of three short videos:

1. Introducing the SURIMI project[3]: the official video created as part of the workshop
2. Introduction to SURIMI[4]: an introductory video more tailored towards the workshop participants
3. Introduction to the SURIMI models[5]: a short introduction the models SURIMI will use

Participants were then divided into four random groups where they briefly introduced themselves and shared their interest in the project and key questions they had coming into the workshop. A summary of these discussions was presented in plenary.

Sessions 3 to 5 focused on stakeholder needs. In the third session, some of the needs reported by the participants ahead of the workshop in an online survey were outlined. This was followed by session 4, where various stakeholder "future-user" profiles were created, including use of data, data needs and concerns, and interface requirements. In session 5, the key messages from each stakeholder group were reported back in plenary.

Session 6 delved deeper into the science behind SURIMI. By means of five short videos, each model was explained to the workshop participants in more detail, including their capabilities, strengths and weaknesses, and how combining the models can help improve predictions. The following videos were used for this purpose:

- POSEIDON – a fisheries agent-based model[6]
- CMSY++ – a stock assessment model[7]
- Ecopath with Ecosim – a marine ecosystem model[8]
- Value Chain – an extension of the Ecopath with Ecosim model[9]

[3] Introducing the SURIMI project: https://www.surimi-project.eu/overview/
[4] Introduction to SURIMI for the workshop participants: https://youtu.be/VeCBahxraQY?si=9-vHWWrvpRzikAH4
[5] Introduction to the SURIMI models: https://youtu.be/Rk6whwQVbNI?si=vkqah1ZZ_NhKqJWU

[6] Poseidon: https://youtu.be/W_A52O_A84g?si=fctzLAA6u9iRg0Nz
[7] CMSY++: https://youtu.be/E1GU7_n1giM?si=xVHI1tZvSdzfHM_Z
[8] Ecopath with Ecosim: https://youtu.be/lZaPsg5qVbU?si=SQYAkHykCQaf5NUg
[9] Value Chain: https://youtu.be/lWVfgNWRLC4?si=jR4qMrDNwJB_6Nv1

- System Dynamics – a model used to fill socio-economic data gaps[10]

Participants were asked to watch the videos at their own pace, and then had the opportunity to ask questions and voice concerns or comments they had on the models in breakout rooms. Each model had a dedicated breakout room where the respective SURIMI modeller was, and the workshop participants were able to move in and out of each model breakout room at their own pace, spending as much or as little time in a breakout room as they wished. At the end of this session, the key messages, questions and concerns for each model were reported back in plenary.

The final session was used to gain insights around stakeholder experiences and needs/preferences with regard to the graphical user interface. Stakeholders were asked to first review and comment on the interface responses in the survey, and then provide details on graphical user interface tools they use, as well as their strengths and limitations, and what they like or do not like about them and why. The workshop was closed with some key reflections and next steps.

3. WORKSHOP RESULTS

3.1. INTERESTS AND KEY QUESTIONS OF PARTICIPANTS

The key interests and questions of participants were centred around the following topics:

1. The realism of the models and trustworthiness;
2. The quality of the data used in the models and how this data will be standardised;
3. How the integration of the different models will work and whether it will be able to improve the overall modelling results; and
4. The potential of the SURIMI tools for users and decision-makers.

Regarding the realism of the models and their trustworthiness, participants wondered how realistic the models are, particularly in terms of human behaviour; how we will convince our stakeholders that our models are trustworthy; what kind of assumptions and uncertainties are included in the models; and how these assumptions and uncertainties are translated and communicated in the outputs.

In terms of data, the stakeholders wondered what types of data we will use; how these data will be managed, and how we will deal with the different types of data in a standardised manner; what the quality of our data is; and how we will deal with fishing activity when stocks are shared with non-EU countries and the data is poor.

Many workshop participants had questions or comments on the topic of integration of the models. It was noted that the holistic part of the project is very interesting, particularly the integration of the social and ecological models, but they wondered how we will integrate the models. In this context, it was mentioned that they would like to know how we will combine the ecosystem approach to fisheries and the stock assessment model; how the models and the combination of models will work; whether and how we will integrate the expert knowledge (qualitative part) and the quantitative part; how we foresee that the combination of models will reduce uncertainty and the what the limitations

[10] System Dynamics Model: https://youtu.be/cK8JoxFI6bU?si=f8KWC0Sfuporm6o9

associated with combining the models are; whether the linkage of individual fleets and the food web models will improve the results of the modelling; and how the models will be integrated into the larger EU DTO. One participant also noted that it would be interesting to know the challenges we are facing in trying to link the models to learn from each other, since JRC is doing similar things in the context of integrating models into the EU DTO.

Another central theme of questions was on the potential of the SURIMI tools to be used by non-experts and other users, as well as for decision-making. The workshop participants noted that currently models are mainly used for science, and therefore wanted to know what the potential is for civil society to use them. They further wondered what the potential applications of the models are; how the models will integrate data collected under official data collection frameworks; whether stakeholders can input their own data into the models; what kind of data can be fed into the models; and how the models can be used to support decision-making. They also noted that many decision-support tools lack flexibility and wanted to know how we will deal with that. Finally, it was also suggested that looking into the future, it will be important to understand the gaps that we need to fill, but also the procedural and methodological developments that SURIMI will need to establish to move into more advanced applications.

3.2. STAKEHOLDER NEEDS: A SUMMARY OF THE PRE-WORKSHOP SURVEY

The SURIMI pre-workshop stakeholder survey was completed by 22 out of the 31 workshop participants, with the different stakeholder groups being more or less evenly represented: four policy makers, three from scientific advisory bodies, five advisory councils' representatives, three from NGOs, four scientific researchers/modelers and three fisheries representatives. The main insights from their answers are:

<u>Use of fisheries data</u>:

Most of them use fisheries data to provide advice (73.7%), inform discussions (63.2%), recommend policy/management actions (63.2%), inform decisions (57.9%), do research/analyses (52.6%), and write papers/reports for external use (52.6%).

<u>Key data/information needs and detail needed (e.g. individual/aggregated)</u>:

The following key data/information needs were identified:

- All data requested for fisheries management (incl. Data Collection Framework and Control Regulation);
- As much non-aggregated data on fisheries management as possible and highly detailed data on landings;
- Environmental impacts of fisheries, socio-economic data, biological data (niches of species), physical data and acoustic data;
- Data on climate change impacts on fish stocks, vulnerable species, and invasive species;
- Simulations of management measures and their impacts on social, economic and biological factors;
- Data concerning decision-making: e.g. behaviours displayed, choices made by individuals/vessel level;

- Accurate and detailed data on catches rather than landings (essential to understand fish stocks, but is currently impaired by the landing obligation because of consequences of any small discard for fishers);
- Better discard data;
- Data on environmental impacts, recreational activities, pelagic commercial fisheries and qualitative information/social data;
- Standardised data collection and sharing;
- More and better recreational fishing catch and socio-economic data; and
- Socio-economic data linked to fishing.

Data and decision-making challenges:

Most of the survey respondents reported the following data and decision-making challenges: lack of data (70%), conflicting stakeholder interests (65%), difficulty in balancing environmental, social, and economic objectives (60%), difficulties in accessing data (60%), data not available at the resolution needed (55%), and not enough information on data uncertainties (50%).

Existing decision-support sources and tools:

The main existing decision-support sources and tools were: scientific papers and reviews (80%), scientific advisory bodies (75%), knowledge and input of stakeholders (75%), advisory councils (70%), reports and other grey literature (65%), fisheries models, such as stock assessment models (60%), data from official governmental/international fisheries surveys (55%), and marine ecosystem models (50%).

Additional decision-support tools needed and currently missing:

The respondents indicated that the following, currently missing decision-support tools would help them in achieving their fisheries-related goals: Tools related to the ecosystem approach to fisheries management; tools that would ensure greater transparency in fisheries (e.g. fishing opportunities allocation); models of socio-ecological systems; science-industry partnerships; and real-time monitoring and live tracking of data.

Importance of fisheries related data points:

Respondents were asked to indicate the importance to their work (irrelevant/slightly important/fairly important/very important/indispensable) of a number of fisheries related data points on the impacts of policies, fishers/fishing fleet behaviours, fish stock status, and ecological/environmental interactions (see Table 1). All data points were rated as very relevant or indispensable by the majority of respondents, except for ‘price for consumers’, ‘availability of fish products for consumers’, ‘market demand’, and ‘the fishery value chain’. The most important indicators were those related to fish stock status, as well as changes in species distribution. Respondents also added that the impact of offshore renewable energies on the fishing industry is of great relevance.

Table 1: Fisheries related data points, which respondents were asked to rate on a scale of importance ranging from irrelevant to indispensable

Overarching theme	**Specific components**	**Rated very important to**

		indispensable *(by >50% black, by <50% grey)*
Impacts of policies / regulatory changes	Gear restriction	73%
	MPAs	77%
	Effort regulation	77%
	Seasonally closed fishing areas	68%
	Landing obligation	59%
Socio-economic aspects (and the impacts of these)	Fishers' economic viability	68%
	Employment and livelihoods	64%
	Fishers' income	64%
	Costs incurred by fishers	59%
	Subsidies	55%
	Fishery Value Chain	45%
	Availability of fish products for consumers	45%
	Market demand	41%
	Price for consumers	36%
Fisher/Fishing fleet behaviour (and the impacts of these)	Fishing effort	86%
	Landings	82%
	Gear use	82%
	CPUE	82%
	Fishing behaviour (e.g. adaptability, compliance)	77%
Fish stock status (and the impacts of these)	Stock health and sustainability	95%
	Stock biomass	91%
	Stock growth/recovery potential	91%
	MSY	91%
Ecological/environmental interactions	Changes in species distribution	91%
	Seabed habitats health and recovery potential	86%
	Climate change impacts	86%
	Food web/ Species interactions	86%
	Biodiversity health and recovery potential	77%
	Invasive species	68%

Importance of example questions which SURIMI might answer with the project:

Nine hypothetical questions were presented to stakeholders in the survey as an example of questions SURIMI might be able to answer with the project. The stakeholders were asked to rate their importance using the same scale as for the fisheries related data points (irrelevant/slightly important/fairly important/very important/indispensable). All questions were rated as very important or indispensable by the majority, except for question 9 (on availability of fish in local markets and the broader supply chain). The most important question was the effect of environmental changes on fish stock dynamics and the fishery value chain (Table 2).

Table 2: Examples of questions which SURIMI might answer and their relevance to the stakeholders.

Questions (ordered by relevance)	**Rated very important to indispensable by:**
1. How do **environmental changes** (e.g., habitat loss, climate change) **affect fish stock dynamics** and the **fishery value chain**?	91%
2. What will be the **medium- and long-term effects of climate change** on fish stock distribution, biomass and the economics of the fishery sector in specific EU regions?	86%
3. To what degree can **different management strategies reduce the amount of by-catch** of vulnerable species and what are the implications for the wider ecosystem and fishers' revenue?	86%
4. What are the **impacts of different fishing control strategies** (e.g. effort control, seasonal closures, or restricting days at sea) on fish stock sustainability, the wider marine ecosystem and fisheries profitability over the next 5 years?	86%
5. What is the **effect of reducing a certain fishing technique** in an area on the diversity and richness of other marine species, and fishers' catch and revenues?	82%
6. How will proposed **fishing quotas affect** the **stock's biomass and fisher's revenue**, and will these quotas **leave enough forage fish for marine predators**?	73%
7. **Which areas would benefit most from strict protection** in terms of biodiversity and how would the introduction of these protected areas **affect fishing strategies** (e.g. fishing effort displacement) **and revenue**?	73%
8. How should **EU subsidies for fuel, fishing gear, or other industry costs be adjusted** to **promote sustainable fishing practices** without undermining the revenue of fishers, the price of seafood for consumers and the fish stock biomass?	64%
9. How will proposed **fishing restriction**s **affect the price and availability** of the **species in local markets** and the **broader supply chain**?	45%

<u>Data/models results visualisation interface:</u>

Almost all stakeholders access or interact with data visualisation tools regularly. 73% do this often to very often and 91% occasionally to very often.

The stakeholders indicated that if data from the integration of expert fishery dynamic models were made available via an online interface, they would prefer the following in each of the spectrums shown below. The number indicates their average preference on a 5-point scale, 3 means equally important and the on average more importantly rated priority is highlighted in red:

1. Simplicity >>> **High interactivity (e.g. filter by time, region, species):** 4.2
2. High-level results >>> **Detailed results and analyses**: 3.9
3. Simple indication of uncertainty >>> **Detailed data uncertainty statistics**: 3.5
4. Undetailed immediate results >>> **Detailed results within a few days**: 3.6
5. Outputs as graphics and key values >>> Generate customisable written reports: 2.6
6. Data about the past and present >>> Projections into the future simulated from scientific models: 3.4
7. Exporting conclusions >>> Exporting raw data: 2.5
8. **Using data already in the system** >> Inputting my own data: 2.1
9. Using it as a stand-alone interface >>> Combining it with other models I use: 2.5
10. Asking questions using a chatbot (chatGPT-like) >>> **Selecting options in a user-interface:** 3.5
11. No metadata being displayed >>> **Access to detailed metadata (e.g., data sources, quality)**: 3.6

3.3. STAKEHOLDER "FUTURE-USER" PROFILES

A stakeholder "future-user" profile was created for each stakeholder group, based on information collected via the survey and the participants' feedback during the workshop. The PDFs with the final profiles are embedded below:

Policy Makers.pdf

Scientific Advisory Bodies.pdf

Advisory Councils.pdf

Fisheries Representatives.pdf

NGOs.pdf

Scientific researchers and modellers.pdf

Some key messages from these profiles are:

Policy makers:

- Rarely use raw data themselves, but rather data processed by others and summarised by means of reports or pieces of scientific advice.
- One challenge they face is that it is difficult to quantify long-term benefits of protection as opposed to short-term financial gains, therefore results of simulation models that can support this are useful.

- For them it is important to move from ecosystem-based fisheries management (EBFM) to an ecosystem management approach, as human activities cannot be managed in isolation.
- A key data and decision-support need is knowledge on uncertainty, even though it might be challenging to quantify. Therefore, in the user interface they need access to details on the uncertainty, not just a simple indication.
- Spatial scale is very important, and depending on the question the scale that is needed might change (e.g. from EU basin to local port scale).
- Understanding fisher's reaction to management changes is important for them.
- Scenario questions need to be specific if they are to be useful for them.

Scientific advisory bodies:

- They don't perform research themselves, but rather help coordinate available science for the advice. They have Working Groups to do so.
- Some of their key goals are to align the objectives of multiple policy instruments, do horizon scanning for future threats and establish trust (which is a key aspect of scientific advice).
- A challenge is that they don't always get feedback on whether the advice was taken up (advice often stays on paper).
- Another challenge is that data goes with the knowledge of those that collect it and that knowledge needs to be included (data collection knowledge), but it is often not included. This information is important for them to understand potential local issues in the data collection.
- Key data and decision-support needs are:
    - Accurate and detailed data on catches (rather than landings) (e.g. including species, sizes, gear, location and vessel information);
    - Models of socio-ecological systems;
    - Spatial trade-off analyses data and broader trade-off analyses;
    - Fishing effort, specifically spatially;
    - Interaction between marine renewables and fisheries; and
    - Biology, age at maturity stages.
- Dynamic visualisations are relevant for them (e.g. being able to zoom in and out to see the bigger picture and the local level) to be able to give advice at different scales.

Advisory councils:

- One of their main goals is to work towards consensus between the industry and other interest groups (e.g. NGOs). They work hard to create a common understanding between different stakeholders.
- A key role/responsibility is to provide a nuanced picture of the industry and avoid overgeneralisations.
- Their main use of data is to inform discussions and provide advice. They also use data for sense testing/validation of displayed data. For instance, sometimes there is noise in the data or wrong interpretations, which the stakeholders can identify.
- Key data and decision-making challenges are:
    - Data sensitivity and privacy: how to ensure that data is not misused, for instance to punish.

- Problem of timing of data, because it generally arrives too late. Therefore, it is not possible to have a state-of-the-art picture (e.g. with 2 years old data)
    - Lack of consistency and harmonization of datasets nationally and internationally, and lack of standardisation of different data collection frameworks.
- A key data need is to complement historical data with real-time, e.g. VMS data. They noted that ICES is the only one getting access to that data at the moment.
- A question that is very relevant for them is the effect of introducing offshore renewable energy on the fisher's catch and revenue.
- Advisory Councils use maps, such as Emodnet MAP viewer, GeoFish or NWWAC Fishmap as data and decision-support resources/tools. They also collaborate with scientific experts or scientific advisory bodies (e.g. GFCM) to obtain the information they need. If needed, they also ask members about scientific experts they might know to help answer a certain question.
- They would use the SURIMI visual interface if it was simple and easy to understand.

Fisheries representatives:

- Their main goals are to exploit fish stocks sustainably, provide a decent standard of living for the fishers, and to maintain and sustain fishing communities and cultural values.
- One of their key roles is to provide feedback on what is happening in the field for policy-making.
- They use data to evaluate potential future opportunities and also to better protect stocks that may require particular attention or protection.
- They noted that data from stock surveys is important to feed into stock assessments, but data from the deck is essential. In this context, better discard data is essential to produce accurate assessment. However, all output data is important to assess the real impacts on fish stocks.
- A key data and decision-making challenge is the lack of trust of the fishing sector in the stock advice and the assessments that create this advice. This is because results of the data analysis and modelling does not necessarily match what fishers see and experience at sea, therefore most members lack trust in the results and/or interpretation of the data. How to bridge that gap is a challenge.

NGOs:

- Their goals are to ensure fisheries management also brings prosperity to non-outsourceable economies and local communities; increase transparency in fisheries management, fisheries data, and economic drivers behind overfishing; and advocate for a holistic approach of ocean governance including all sectors, to combine conservation objectives and sustainable use of the oceans.
- Key roles/responsibilities are to ensure that decisions are taken according to the best science available, with stakeholder engagement, and taking into consideration all pressures on the environment and socio-economic impacts; as well as to bring the voice of civil society to decision-making.
- Three main ways they use data are to: 1) do science-based advocacy; 2) increase transparency of decisions; and 3) disseminate good practices to the wider public, decision makers and fishers to increase buy-in.

- Important data for their work are:
  - All different types of data relevant to obtaining a comprehensive overview for an ecosystem approach: including fish stocks, economic and social data.
  - As much non-aggregated data on fisheries management as possible (e.g. fishing effort, landings per vessels, segments of the fleet, VMS data, detailed data on allocation of subsidies, infringements and sanctions, etc).
  - Aggregated data on climate change impacts on fish stocks, vulnerable species, and invasive species. As well as aggregated social and economic data such as employment levels, FTE, gross operating surplus, added value, salary costs, subsidies, indirect employment levels within a 50km area, etc.
  - Socio-economic data: e.g. on employment (to know how decisions will impact it), on gender aspects (including workforce income), profit (to know where the profit goes), and a breakout of the different fleet segments to see the impacts per fleet segments (e.g. small-scale coastal, large scale below 24m, large-scale above 24m and distant-water)
- Key data and decision-making challenges are the lack of transparency in data (e.g. quota allocation and boat ownership) and how decisions are made; trade-offs in short-term versus long-term gains (and some gains are difficult to translate from socio-economic data); and that some data are not accessible, but important (e.g. VMS data) or very difficult to extract.
- They use the European Market Observatory for fisheries and aquaculture products (EUMOFA), STECF, EEA, EC and EP research bodies, national scientific bodies, and RFMOs as data and decision-support tools.
- A key data and decision-support need is to have greater traceability of key data (e.g. catch area, fish species, fishing gear) along the supply chain until the end consumer for all seafood product types. Moreover, they need more encompassing and less aggregated data.

Scientific researchers/modelers:

- Their roles/responsibilities include collecting a lot of scientific data to understand interactions between fishers, fish, and ecosystems; making the fish/marine ecosystem model output datasets freely available for downstream use; and developing models relevant to sector rather than management.
- Their goals include making models more accessible to those who need advice but are unable to generate it themselves; placing fisheries within an ecosystem context and understanding dynamics retrospectively; and providing analyses and predictions of changes in marine ecosystems.
- Some of the key data they need are:
  - Effort, landing and catch data by species and fleet;
  - Fleet capacity data;
  - Survey and monitoring data on stock status, as well as fish data to calibrate, validate and assimilate models;
  - Biological data (niches of species), physical data and acoustic data;
  - Multispecies activities versus single-stock advice and management. Better understanding of multispecies/stock dynamics and its link to fishers’ decisions and socio-economic results;
  - Socio-economic data linked to fishing activity and output;

- Data concerning decision-making and differences in behaviours related to social factors and the biophysical environment: e.g. behaviours displayed, choices made by individuals/vessel level, information about whether and how fishers/traders interact with each other and about what, how they organise themselves, etc;
  - Data/information on the response of the fishery sector to climate change and introduction of wide-scale installations like offshore renewable energy.
  - Data and outputs in connection to space; and
  - Metadata on all data collected, to help explain data and how to interpret it.
- Live tracking of data is important for them.
- Three key data and decision-making challenges are: 1) Lack of trust of some stakeholders in modelled data: e.g. fishers often argue with officially gathered data; 2) Defining the amount of metadata needed now or in the future to make a correct interpretation of the models; and 3) Long-term feasibility of the use of ecosystem information in an advisory and policy context, because no structured pipeline exists similar to that of fisheries advice.

3.4. LEARNING ABOUT THE SCIENCE BEHIND SURIMI: QUESTIONS AND ANSWERS ON THE MODELS SURIMI WILL USE AND THEIR INTEGRATION

This section captures the conversations (questions and answers) that were held in each breakout room. Text in red and italics are the questions and comments of participants. The black text indicates the modelers' answers or questions to the participants. The answers to each question are given as bullet points below, with a new bullet point indicating another person speaking.

3.4.1. POSEIDON

Stakeholders questions and comments

Where is your data coming from and what are the validation processes which you are following? Who is collecting behavioural data for fishers?

- The basic data that is used in Poseidon is the characteristics of the fleet you are trying to model. Poseidon requires data about individual fishing vessels, how big they are, how much space they have in their hold, how fast they go, what is their fuel autonomy, etc. And then we require some kind of data about the actual fishing, for instance what kind of gear they use, but also historically where they have made their catches and landings, what types of species they target, etc. But I have the feeling you might be wondering more about psychological data, including their behaviours, their strategies, etc.
- *When we are speaking about agent-based models we are speaking about general behaviour, but one of the issues that is problematic in all coastal marine management, is the fact that behaviour is not limited by regulation, climate, or stock levels. It is determined by personal choices. In the past some scientists were reluctant to use these kinds of models and call them behavioural. I am sure things have moved forward and I also think there are ways of using these behavioural assessments to run scenarios, which I find very interesting. But at the same time, I am wondering about the data and the validation of these types of instruments. Are*

there data related to behaviour and choices of fishers and fleets? Do you use these data or will it be necessary for your work?

- If you are talking about interview data for example, we don't have this kind of information at the moment, but we have some money to acquire more data, so we could add extra social data, such as cultural, etc. We would like to do that.

  If you are talking about Poseidon, this is something that has been done in the past for different applications of Poseidon. For instance, fishers were interviewed in small Indonesian villages for a month and this yielded interesting insights. We also have a previous project in the eastern Pacific Ocean with the tropical tuna fisheries, where we run interview questionnaires with fishers. But all those data-gathering exercises were geared towards a very specific application of Poseidon. In the context of the case studies that we are producing for SURIMI, there might be something like that that is involved. However, if the question is, do we have behavioural data about fisheries that would give us some general insights into how to model fisheries in a universal behaviour way, then we are not there yet.

- *What will be important for this project is to identify the socio-economic data that is missing. Because we are meticulously collecting environmental data, but the socio-economic we collect differently. We don't have the same time-scales or spatial scales. It would be very helpful to show what data we need and miss, to make sure we can collect this in the future if possible.*

- *Indeed, DG MARE is putting effort to also collect the social data systematically and they are working intensively with social scientists to create national and community profiles for fisheries across the EU. So, if you identify any gaps, now is the moment to inform DG MARE and the social scientists that are collecting these data.*

- *Creating profiles sounds interesting, but on the actual sociology and psychology of fishers, I don't think that profiles will be as useful as the specific user cases with interviews, as mentioned before. But I was surprised that it is only interviews that were used in the past with Poseidon. Recent work used not only interviews but also experimental games, to see how decisions are made. I think that gives more insight into how people react, including personal characteristics. So, in terms of the type of data we need: if we want to be very fine grained, we need very fine grain data.*

- One of the challenges is how to capture different types of fisheries accurately. For example, in the previous project of Poseidon with the tropical tuna fisheries in the eastern Pacific Ocean, we were representing an industry that is highly driven by economic incentives. These vessels are money making machines and all decisions are taken with an economic perspective in mind. In contrast, in the Indonesia project, it was an artisanal fishery, where the decision to go fishing or not on a particular day might depend on family factors, cultural factors, religious factors, all sorts of things that didn't enter into the decision-making in this other fishery. I don't think it is possible to have a general abstract approach to these questions, and it needs to stay case by case.

Will the integration of the models happen dynamically or statically? Are the models running in parallel or is it simultaneously (i.e. simulations run separately and then feed each other)?

- Our objective is to have the models run in parallel and handle their own part of the simulations. Our two main models in that respect are Poseidon and Ecopath with Ecosim: Ecopath with Ecosim will handle the biology and Poseidon will handle the fishing fleet behaviour. The way it is going to work – and that is something we still need to build, which is what SURIMI is about from a technical perspective – is that bridge between the two models, where Poseidon simulates fishing for a certain time period, sends fishing data to Ecopath with Ecosim, which then does all the biological calculations, updates the biomass and species in the different locations, and sends that back to Poseidon, who simulates a bit of fishing, and like that you have the back and forth that is projected in time. In that way we get each model to capitalise on their strength: Poseidon has been used before with some simplistic biological models, but never with something as sophisticated as Ecopath with Ecosim. The hope is that by having them talk to each other we will get the best of each world.

It was very useful to have the case studies where Poseidon has been used before. But I noticed that there was no EU case study and I was wondering what the reasons for that are.

- It just happened that we worked mainly with Ocean Conservancy, which is an American NGO and they were interested in applications that didn't happen to be in the EU. But in the context of SURIMI, the case studies that we will look at will be inside the EU. The first one that we will work on is the fisheries in the Catalan Coast.

I would like to ask the people in this room, who are not necessarily familiar with agent-based modelling, how are these models perceived in your field or the type of work you are doing? Because fisheries have used all types of models traditionally, but very few agent-based models. So I'd be curious to hear your thoughts on the perception of agent-based models, and whether you think they will be useful or if you have scepticism about what they can do.

- *I do to some degree. I am a fisheries biologist and modelling fish is easier, because their behaviour is more predictable. But when it comes to wide human-based models, I think some of them are useful, but I interpret them more as wide guidelines rather than predictions of what will happen. It's more saying if we do this, what might happen is scenario 1, 2, 3, or 4, rather than scenario 3 is going to happen.*

- That is a very good point in terms of setting expectations. We try to be as predictive as possible, but the real insight comes from comparing scenarios. We do not know exactly how an MPA will influence catches, but we do know that it will impact them more if we put it here than in that other location. So those relative comparisons are where we can contribute more than with point-predictions.

  It all comes back to the fact that humans are more difficult to model than fish. And the data that we have about behaviour can only tell us so much about how the decision-process of the fishers works in the real world. We see the results of the actions, but the mechanisms are more obscure. We are trying to make progress on that, but it is a difficult endeavour. We cannot promise fully realistic models of human behaviour, we can only promise approximations, but approximations which still bring important insights. Agents in these models adapt to certain circumstances in a way that just modelling fishing as amount of fish caught does not give you. We can have our agents make decisions, reacting to regulations, learning from the environment and modifying their behaviours depending on circumstances. That is the goal, and we have been relatively successful so far.

- *From a fisher's perspective, it is indeed difficult to model anyone's behaviour, but if you are modelling the behaviour of a fisher, it is probably the same as in any other section of society: it is the least amount of effort for the maximum gain. That is a good approximation. Then it is important to have as much accurate data on all the related aspects: the level of the stocks, the effort that is on them, the actual amount that is being taken out of them and how we can maximise what is being taken out to gain the most value. The issue might be how accurate the data is that we have.*

- Thanks for that insight. And yes, to a certain degree that is how we have approached it. When it comes to the model itself it comes down to very simple, discrete decisions, such as: What kind of gear should I use? Should I head out now or wait? When I head out, where should I go? When I go out, how long should I stay there? Should I stay there, go back to port or choose another fishing location? It is all these concrete decision points, but if you have a whole fleet of agents making these decisions simulated day after day, you get an emergent behaviour that hopefully gives a nice portrait of the fishery and how it is reacting to the regulatory conditions, and the status of the stocks and the species.

I was wondering whether seeing the results of your behaviour in the models can change your behaviour in the future? Can it help you become more reasonable in the way you approach your activities and is the model also able to capture that? I think it would also be very important to incorporate overshooting in the models.

- As regards to whether seeing the results of your behaviour would make you change your behaviour in the future, we have never tried to model something like that. In theory, we could do it, but the question is how that would affect the concrete decisions of the fishers, and the problem is that we don't have that data, nor a good theory about it. From a modelling perspective there is also the question whether we make the fishers as greedy as possible or give them a more conscious behaviour. But that would lead to the question whether that even helps us make better predictions about the trajectory of the fishery. In the simplest cases, we assume that all agents behave the same, but that is of course not always true in reality. Within Poseidon we have worked in the past things with things like levels of compliance. There are regulations in place and you can make a certain percent of the fleet go against the regulations. That helps you see the impact that "cheating" has on the fishery. But this is something we have only done from a hypothetical perspective – we of course didn't have empirical data on that, and it is a delicate thing to work on.

Is there a layering between the different fleets and dynamics? Is it differentiated between large scale and small scale, and within that is it differentiated between the different gears and metiers? Because the reality is that certain fishers can be extremely different from the others. So, what is the actual level of detail that the model is aiming for? What kind of grain are you aiming for?

- The grain that we are aiming for is individual vessels. To the extent that we can get the data on the vessels, we aim to model them with their own capacity, size, speed, operating costs, equipment, etc., ideally. If we don't have that data, we can make assumptions on what an average fishing vessel in that fleet looks like. So, it really depends on what is available, but we are aiming for individual level detail.

Coming back to your previous question on how agent-based models are perceived: For me, this is an area that I don't know very well, I use single-species models. But I do think we need to move towards more complex models.

3.4.2. CMSY++

Stakeholders questions and comments

One of my key concerns with CMSY++ is that the steady-state assumptions may be violated in the context of a changing climate. Using that as an assessment model is thus a concern, because you are ignoring the changing dynamics.

- That is true and it is an issue of every stock assessment model. The difference with CMSY++ is that it uses r, which is the maximum intrinsic population increase of a species, which can be modified according to the effect of climate on the phenology of the species. So, if species grow faster because of climate change, r can be increased and incorporated into the model. SURIMI has not done it yet, but it is a way of incorporating climate effects, especially the effects of temperature on the biological characteristics of a stock.
- *When you look at a lot of the data-rich stocks you can see how dynamic things like growth and maturity are. But when you are dealing with data-limited stocks you have to make some assumptions about that and then you might not know the impact on productivity. I suppose it will be a matter of teasing those things out.*
- Yes, if the growth parameters, for example natural mortality of a species or stock has changed, then the r-max will be recalculated. Apart from that, CMSY++ is a stock assessment model with all its strengths and limitations, but the reason why we chose it is because it can be used in data limited situations, like in the Mediterranean.
- *Is r a parameter that is estimated in the model?*
- No, it's an input into the model estimated from growth parameters, natural mortality, fecundity and maturity of the stock.
- *This is a huge challenge for the stock assessment groups globally: how to integrate these changes in the models.*

Does CMSY++ take into account different spatial components within a stock?

- Not easily. We can compare or combine two different stocks from an area, for instance deep water and shallow water, but not really.

From what I understood the SURIMI tool is going to explore spatial management options.

- CMSY++ uses the management unit to assess stocks in that area. We will match the spatial area of all models, to be able to combine them.

Why do we only have CMSY++? Is there a plan to include other models?

- The initial idea was to choose a surplus-production model, because for example in the Mediterranean there are only a few stocks that have been assessed. The other models need a lot of data to which we might not have access in all the case study areas.

How does it work with the data and in practice?

- You provide raw data into the model and then it runs the assessment of all the stocks one after the other. We have also created an R-shiny app, so that non-experts in programming can run these analyses, such as NGOs.

It's a pity that for the stocks where you have data-rich information, you are losing a lot of information (e.g. age-structured studies).

- We can do the multiple assessment for the stocks we are familiar with, but then it is only a confined number of stocks for an area. Whereas with CSMY++ as long as you have the catch and abundance data, then you can run up to 30-40 stocks, but with the limitations, of course, of this model. This is also easier to group in functional groups and compare with Ecopath with Ecosim outputs - it's a better link to account for as much as the catch or biomass that is landed as possible.

Where is the data for the Mediterranean coming from?

- From the DCF.

Forecasting and predictions: how are you doing that?

- The new model we are developing has retrospective analyses and a short-term forecast for 3 to 5 years for fishing mortality and biomass in the short term. This is to comply with the summary sheets of ICES and the ones we use in GFCM.

Do you have management effort data in the Mediterranean?

- The actual effort we are struggling with in STECF meetings. We have data since 2017.
- *At JRC there is a long process for the assessment, not like in ICES where you run a single stock assessment model and you provide advice on that basis. In the Mediterranean, JRC provides stock assessment outputs to another working group that runs other models at the fleet level to provide advice of effort and make decisions. It is therefore more complex and difficult to integrate everything, at least for the western Mediterranean.*

In the video it says that the model is working in data limited conditions. What does this mean? Why can this model run in data limited conditions, but not others?

- This model has two components. The first uses fisheries catch and fisheries-independent survey data, like bottom trawl surveys. With that it behaves like a proper stock assessment model that can provide the required reference points for any stock that has catch and survey data. The second component is that the model can also run on catch only and provide good results if there is nothing but catch. It uses a statistical method called artificial neural networks to assign some priors that depend on the catch. The model has been trained using 1,000 full analytical assessments and is able to provide good results if there is nothing but catch. As a result, it can be used in cases where there is a lack of survey data spanning at least a decade or two, which is the minimum requirement for the model to run. This is the case, for instance, in Greek waters or the southern Mediterranean coastline of North African countries. But we only use the latter for the cases when there are data gaps.

For the EC, it is also important to know what level of data and what kind of data is necessary to run the models, to advance the conversation of what can be available to whom.

- The problem is that the data is not clear. STECF cleans these values (e.g. if a point is missing, so an anchovy appears to be 1 meter long) and then it is OK to use for the stock assessment.

3.4.3. ECOPATH WITH ECOSIM AND THE VALUE CHAIN

Stakeholders questions and comments

My question is on the social data relevant for these models. There is now social data that has to be collected under the DCF at a country level. But all the valuable STECF that is collected is very hard to get, especially the raw data, because of all the legal procedures associated with obtaining the data. Eventually it becomes partly public, but getting the raw data which is probably the most interesting input for the models is very difficult. Another difficulty of the DCF data is the complexity: you really need to speak to people to truly understand the dynamics of this data, and there is the question whether this data will be of the same quality for the different countries.

- For the Ecopath models we do not need all the raw data on the social interactions because EwE models are not social, but we need broad strokes of this data. But in the context of SURIMI, the raw data, especially of the fisheries sector, will be essential for Poseidon which aims to model the decisions of individual vessels.
- *With the current social data, it is still pilot studies. We don't know yet how feasible it will be to collect all this data. But it would be important, because many countries don't feel only economic pressure but also a huge social pressure. For instance, the Belgian fleet is not so much afraid of economic consequences or not being able to fish, but what they really fear is losing the skill of fishers. Because people that leave will probably never come back and getting young people trained to the level they need is very challenging today, as there are strict rules around safety, certificates and training hours.*

The value chain model seems very relevant in the context of legislation such as the Nature Restoration Law and the conversations around the impact it might have on food security, which is connected to all the value chain. My first question is whether you can use these ensembles of models to answer the question whether a certain type of measure is going to affect food security. And my second question is related to the fact that in the value chain you talk about processors and fish markets, and I was wondering which type of stakeholders you involve, for instance the processing industry, representatives of fish markers, retailers, where do you stop?

- I will start answering the second question: you define which stakeholders to include and you can go as far as the final consumer, so from the harbours, to the wholesalers, the transformers/producers, the retailers, which can be split in specialized shops and large-scale retailers, up to the household consumption consumers, but also to restaurants and food services. Then you have to define the material flow of the landed fish between the different stakeholders and the cost structures of each of the stakeholders you have identified, including wages, capital costs, etc. You can also introduce food waste in the model. That flow of landed fish and the cost structure is then influenced by what happens in the ecosystem and the landings.

- But there are of course some limitations. The first one is that you have to get all this information from the different stakeholders and this normally requires combining official statistics on fisheries (which often stops in the harbours), with information from private companies and interviews. This is of course not easy and depends a lot on the area. Then there is the second limitation which was also explained well in the video, which is the fact that once you set the structure you cannot change it over time. So, for instance, you cannot say that in 10 years the small fishmongers will disappear, so the flows will disappear. Maybe in the future we will be able to do so, but for the moment that is a limitation which affects the long-term quality of the predictions.

- In terms of the broader question on food security, the issue is that food security is a much bigger issue than just fisheries. So, the model could help address for instance the implications of climate change on fish production or the implications of eating different types of fish on food security for the wider public. But you would have to be aware that it is only a small part of what people eat, so you will not be able to address food security as a whole. Nevertheless, it can provide some inputs, for instance, the waste that is lost and how this is distributed between consumption in households and food services. But if you want a more holistic picture you would also need information on the total food consumption in the same area and compare that with the flow of fish.

- The value chain has also been very successful to help Peru see the huge socio-economic value of its anchovy fisheries. They did extensive research and built the total whole picture, and that completely prioritised the anchovies' fisheries in Peru based on what the Value Chain showed. But indeed, it is less suitable for long term predictions because the value chain is not static – but we do not know what will happen in 15 years, whether there will be more or less producers and whether new links will be created.

In one of the sessions in the morning, I added a list of economic indicators that would be interesting to consider in the models. For instance, having a full time equivalent alongside total employment as that would give an idea on the level of partial employment. Also adding insights on unpaid labour, such as in cases when family businesses are run by family members, that do not receive income for that. That information is interesting for the economic impact and profitability of some businesses. Another idea was to add something on gross product of businesses, to show investment and profitability of businesses, and to look at employment and indirect redistribution or economic creativity in a certain geographical area, to show the local impact of some fisheries on coastal communities that depend on them.

- For the first one, the in-kind contributions of family members, that can be accounted for in the fisheries related value chain (of course we don't take into account other value chains).

- Spatially, you can look with Ecopath at how fisheries interactions change as fish move in space and how that affects in a simple way costs and profits. So, if you just want to see where in space fish will be landed over time because of changes in ecosystems or because of adding a marine protected area, and how that affects costs and profits in time and space, that is possible. Looking at the value chain, which is the step after taking the fish from the harbour, can also be done to some degree. For instance, you can define that these are the retailers of interest in my area and all these other retailers outside that area, and you can define which parts of the fish flow goes where. But the problem is getting enough quality information to do that and to define which fluxes go which way. So, in this case it is more of a data issue, than a model issue.

- Regarding the question you raised on indicators, the basic indicators of the value chain are based on tonnes of fish landed. For example, you can have indicators such as profits, gross average, gross production, investments, profitability. But of course, you need to introduce again the data associated to that information. And the same goes for the fishing fleets: you can have subsidies and taxes, income of fishers and capital cost, i.e. all the sorts of costs you need for any accountability. So, those indicators can be done. What cannot be done, which you mentioned in your question, is to split how much of the working hours are part time and how much are full time. All the working hours are put together as a whole and that is a limitation.

I just had a really general question: is there an actual ecosystem you had in mind to focus on in this project, or what models are you looking to use regional wise?

- Yes, we are going to use these models in the Western Mediterranean to test the model interoperability and the link between Ecopath, Poseidon and CMSY++, because that is an area where we have a very well established Ecopath model and good data for the value chain – so it is a good platform to test whether the toolkit works. But once the models are coupled, we can deploy them in other parts.

I was wondering how the integration of Ecopath with the other models will reduce uncertainty, because in my view if you integrate various variables and additional factors, it should increase the uncertainty.

- You are right that by adding different angles you create more uncertainty, but how we see our modelling approaches is as a means for testing hypotheses. If you have more angles to look at a certain scientific or policy question, you can better explore the uncertainty ranges and find the commonalities. So you enrich your viewpoints onto a specific situation, which gives you a more complete picture and helps make better founded decisions.
- *So, if I understand right, in the process you would refine the selection of variables and factors in your model and that is why in the end you get something which is more representative of the reality?*
- Yes, that's correct. And in addition, if two or three models point you to the same answer, then that is an indication that you are going in the right direction, but if all three point in different directions, then you know there is something you don't understand there. That is another way to reduce uncertainty.

I would like to understand how the accuracy of fisheries management recommendations can improve when we combine the models, since there are the ecological uncertainties as well as the broad assumptions about fisher's behaviour and we cannot have certainty on those.

- The way we do it for the ecological part, is that we try to reproduce the ecology and the ecosystem going back in time. And once you get to understand all these interactions well enough, then you can use the model to make predictions in the future. We can also do that with the economics and social, but that is more difficult because there is often less data.

In addition, we have methods to explore the robustness of our modelling approaches, to "shake the tree" and see what falls out first and where you need to make improvements. Because of course no model is perfect, since it is only a limited representation of reality. But in the end having different viewpoints with a broader insight into the robustness of the modelling results helps you provide recommendations for policy decisions with some measure of certainty.

- *I would also like to add for the non-modellers, that when you are coupling different models, then they are more specialised to answer different questions of the ecosystem, which can help reduce uncertainty.*
- Indeed, if you have a model that describes the physics well, it's no use trying to reproduce that in an ecosystem model. Therefore, if you get a really well parameterised model of physics, and then you couple the ecosystem model to it, then you are reducing the uncertainty in your model by making sure the physics and the biochemistry is as correct as it can be.

Is the model coupled spatially/temporally?

- Not bidirectionally, but we have a spatial model like Ecopath with Ecosim and Ecospace, which can be influenced by changing environmental conditions, changing human behaviour, MSP activities, etc. And if you translate those into terms like noise and disturbance of artificial substrate etc., then all those activities and changes influence the habitability of different organisms that respond to complex food webs. So, it is a dynamic toolbox, where you can bring in various perturbations and explore the consequences.

I also had a question on the coupling: is it one-way coupling or dynamic coupling? If it is one-way, which way are you going to the other models, and which way are they coming back?

- In SURIMI we will have full coupling in all directions. For instance, our Ecospace model will predict where the fish are going to be. This information will be sent to Poseidon, who will then say, if that's where the fish distribution is, then this is where we will fish and this is where we'll not fish. That fishing information comes back to Ecospace, which then simulates the dynamics for another month, resulting in new distributions. That is how the models will interact. CMSY++ will also be involved in the same loop.
- Moreover, we are trying to make this a generic linkage, which all modelling approaches can use in the future to link different fisheries models together under the EU DTO. So in theory, you could switch Ecopath with Ecosim with another ecosystem model. We are not going to do that, but we are laying the foundation for it.

What we are basically trying to achieve is to deploy expert models to audiences that may not necessarily know how the models work and cannot parametrize the models. But they will be able to ask questions to the models within the models' context (e.g. in that case study area) and see what the consequences are. So, the heart of SURIMI is to make complicated models accessible for non-expert audiences. It will not be necessary to know all the complexity to use the models and get useful information.

I have a question regarding the dynamic coupling between the models, especially with the stock assessment one. Are you planning to have in your Ecopath with Ecosim model the same structure than in the stock assessment one? For instance, will all species you are doing the stock assessment for be represented in your model?

- The idea is to work the other way around: we will do the stock assessments based on the functional groups, as grouped in the Ecopath with Ecosim model. We will use the same area, the same stocks, the same biomass, the same landings and parameters, but for multi-species functional groups. So we will combine the stocks for the stock assessments and then provide a combined reference point time series as input into Ecopath. If there is a single species functional group, then we will use that species, without grouping.

I was wondering whether in your study you are building on previous studies that have done similar things, or whether you are starting from scratch. For instance, the DAMARA Project, which developed a scientific decision-support tool for the development of a management plan in the Celtic Sea in 2016, also worked on combining different models to produce what-if scenarios and predictions.

- Yes, we are certainly trying to build on other studies that have done similar things. We didn't know about that particular study, but we will look into it to see if there is something we can learn from.

In the videos it was mentioned that there are multiple assumptions and uncertainties in the models, but that combining them, for instance Ecopath with Ecosim and Poseidon, can help reduce these uncertainties. I wanted to understand more practically: how are you aiming to reduce the uncertainties through combination? And will that work?

- The idea is that we should see models more and more as a toolkit to better understand and explain how things interrelate and work. And the more you use your models as basically switchboards for trying different hypotheses to see which works best, rather than achieving a pinpoint prediction, the better your insights get. That's what we are trying to achieve. Of course, every new approach will introduce uncertainties, that's inevitable, but the strength lies in the different angles you can approach your problem or question to obtain a more comprehensive picture of what is happening, what matters and what does not matter. That I think is a great value, especially if you make the tools usable by non-experts so that they can try different hypotheses to see what happens.

I have just a quick comment: if you have various levels of interaction with the model, for instance quick answers from simplified models versus answers which require a couple of days of computing from more complex models, I suppose there should be some kind of warning to users to make them aware that this is a simplification of reality. This is important to manage expectations.

- Yes definitely. In a way all models are wrong in some ways, but the question is whether they are actually useful. That's the most important thing.

I think it is very important to remember that any model is not a tool or a solution on its own. We should educate people in higher policy to see models as tools for discussion and experimentation. Decisions are always based on more than the results of a model. The model is there to make knowledge more accessible and understandable and to widen the perspectives of what can happen. I also think that we should be more courageous in including socio-economic considerations in the models, as that is a way *to make them being more uptaken. Because to put an example of climate change, the blunt statement that temperature is going to rise by two degrees does not mean anything to most people. The fact that you're going to lose your job or your house because of it, that does mean something. For fisheries, it could mean that if we continue like this, the jobs in fisheries are going to be lost, and this is a pity, because we need these communities to stay active. So, I think that this kind of translation is necessary to make some impact.*

3.4.4. SYSTEM DYNAMICS MODEL

Stakeholders questions and comments

How will the System Dynamics model work in practice with the other SURIMI models?

- At the moment, there is no data on how much revenue the fishermen make from the fishing effort – therefore with the SDMs we will make a very simple model with a reproduction of the existing market models. This will feed the market prices of fish and how much revenue the fishers make into Ecopath with Ecosim and Poseidon. That is one gap that has been identified so far. But there are more elements that will come up once we work on the integration. Overall, the System Dynamics model will be a gap filler.

  In practice, we will start with integrating POSEIDON and EwE so that works flawlessly, and then we will build up on that and see how far we can extend it. Because you don't want to create something that has so many variables and so many things it wants to accomplish that the uncertainties become so big that you don't say anything anymore.

  SDMs is a visual way to create a system, as it shows components, interactions, flows and feedbacks. It can be used as a means to engage with stakeholders and for demonstration purposes as it is easier to understand and needs less input. It can also be used to test or run larger models with temporary input where more complex parts are not yet ready.

Will the model also have an input? For instance, if the biomass of a certain species is very low, then market price will go up?

- Yes, but this will probably come from Poseidon: when there is low stock a species and fishermen target it, then they will spend lots of time in the Ocean and that will increase the price. We will not have the actual market price, it will be more like a translation.

Is fish price the only gap identified?

- At the moment yes, but we might identify some more as the project progress. Maybe we can also add other factors if there is data like wellbeing of the fishers or health of the community, but it will not be a complex model. It will be something like if income of fishers decreases over the last 20 years, it will have a negative impact on the attractiveness of the job market of being a fisher.

How will the model work, because it is not yet developed?

- The existing core models that we have are Poseidon, Ecopath with Ecosim and CMSY++. In our approach we want to make them interoperable, which means they have to communicate with each other to solve more complex tasks. Each of these models has a very specific purpose and when you want to create a bigger picture there are aspects that they don't cover. And these aspects we will address with System Dynamics Models, which work like extensions, which you can plug in. One example we are working with at the moment is a market model. Because on the one hand we have a very detailed model with Poseidon that can predict fisher behaviour and on the other hand we have an underlying biomass model with EwE, so there will be a direct interaction between the social and ecological layer. But what is missing is how these interactions translate into market prices. So market prices would be calculated with a System Dynamics model. There will probably be more gaps we will have to address with these models. These models will be much simpler than Poseidon or EwE which are much simpler.

Will the System Dynamics model cover the integration of these models?

- Yes, although it is not necessarily the integration points. The integration will be done with a module and that module gives different attachments. For instance, if you want to know something about the market prices you can add on an additional model. The System Dynamics model is not doing the integration between Poseidon and EwE, it is adding something extra.
- *It is giving extra piece of the information?*
- Exactly.

Is everything going to run in parallel?

- The processes will run at the same time but there will be a specific order that needs to happen to support needed information exchange. There will be full integration of the models with two-way information exchange in 'real-time'. For instance, the ecosystem model runs during a time frame of three days. During that time frame a fishing boat fishes in specific areas of the sea and takes out some of the biomass. The information of how much the fishers take out it will be given as an information to the biomass model, and then that model will run further. So there is a direct exchange of information, it goes fully back and forth.

How will uncertainty be handled and calculated? Is it part of your work to calculate the different uncertainties that come from one model to another?

- This is a question that should be given to all modellers.

  One uncertainty comes from data. Given that these models tend to combine very different types of information and when we harmonise data we need to do some type of agreement to standardize the units and deal with the fact that the data is delayed (e.g. collected 1 year ago and no real-time data). The models that we do can deal with that because if the data comes with a parameter (e.g. 13) we can run the model with different values (e.g. 15 or 17) and see how this changes the model output. So we would do sensitivity analyses to check how that uncertainty on data impacts model results.

  Another type of uncertainty comes from the fact that every model is really a model of a causal mechanism, e.g. this happens because that happened, etc. (e.g. a fisher goes and fishes, then the fishes are caught, a larger boat will influence the fish fished, the weather will influence etc.). So there is uncertainty because a model is still a model. It is always a simplification, but the question is whether it is still useful and informative, despite the fact that it is simplified.

There are two levels of questions here. The first one is interesting for the scientific community which is how do we deal with this harmonization of data that are of different nature and different sources, and how do we standardize them, which methods work and which don't. And then there is the discussion towards the stakeholders - from policy makers to fishers. They will need to get a general understanding of what uncertainties are carried in with a model. Of course, it is not possible to go into detail conversations with them, but there is a methodological aspect on how to handle these discussions in order to outline the limitations and the potential despite the limitations. This is important if we want the stakeholders, who are the end-users, to take up these tools.

- That is spot on: when we think about uncertainty we also think about trust in the model. But the source of uncertainty matters, because depending on the source there are different methods that can be used to deal with that uncertainty. So, as mentioned earlier, if I don't know a parameter, I might try different values and there is a method for that and a way to communicate it. If there is an arbitrary decision of a modeler – that is a different type of uncertainty. Also, when we model what-if scenarios, some scenarios can happen, but the likelihood is very low. So, we really need to communicate that for instance this scenario has only 2% of happening, it is possible but not really likely.

  For us it is crucial to understand how stakeholders see uncertainty. Many people use data without realizing that this data has uncertainty. Therefore, it is important to get feedback on which way is best to communicate uncertainty, e.g. by looking into other interface examples.

  As for the other question on the data harmonization, we need to make sure we follow the same procedures than the other projects that will be uploading their models into the DTO. For instance, to have community recognized standards for harmonization of all the datasets that will be uploaded into the DTO and all of the data inputs that go into the models. Having these discussions with the other sister projects will therefore be important.

My question is about the structural uncertainty and the assumptions you have coded into the models. It seems that you are trying to link models through some sort of simplifications and in relation to this cause-effect which was mentioned earlier, to me this implies that there are some strong structural uncertainties which you are putting in to the models. That is a concern, because the relationships are not always predictable.

- What we try to do as scientists is for our models to reflect the state of knowledge as well as possible. For this there are different modelling approaches: e.g. EwE is based on equations that are agreed upon by the community and they have shown that these approaches work. But when you model human behaviour, especially when you think about social and economic aspects, things are not as easy – there are theories we can work with and there are assumptions we can make, like humans will want to have the maximum gain with the least amount of effort, but what does gain and effort mean for different humans is an open discussion. There is not one theory of human decision-making – therefore it is important to not have only one model that you can use, but rather a suit of models, from which you can choose from depending on what your question is or what you want to represent. The question is how do we communicate well enough in model documentation what the models can do and what the uncertainty is, so that people can decide which model do you use and why. Maybe we can use large language models for this: a large language model could query that documentation and give you the answer you need rather than having to read all the documentation. The issue is that SURIMI is only 1 of 4 projects that is putting models into the DTO and I am not sure if there will be a lot more models of human action in the ocean and of how humans take decisions. It would be helpful to have more models of humans so we can choose better.

I am interested in how to implement this human and ocean dimensions. Sometimes people complain that advice from scientific advisory bodies is only in terms of catch quotas and not in terms of social effects and so on. I think this is because it is extremely difficult. For instance, in Scandinavian fisheries are discarded flat fishes are discarded, while in other countries such as Poland and other eastern countries they are taking up and there is a market for this. Also, the behaviour of fishermen in different countries might be different because of culture, history, etc. To consider all these elements is extremely difficult and it might be the reason why so far it has been so difficult to integrate these human and social behaviour in scientific advices.

- I could not agree more. This is a very complex thing to model: fish are a lot more predictable than humans, and hence it is a lot easier to model them. But still there are patterns of behaviours we can model: the majority of people in a certain situations, given a certain culture and values, will tend to do something. We are not at a level of nuance yet, our models are quite crude, but nonetheless I think they can be quite representative for the majority of people we will calibrate the model to (i.e. our case study areas). Although we are not there yet, but there is room to grow, and that is very positive. The more conversation happens around this, the more effort we will put into this and the better our models will become.

If these models where available and people could play with them, do you think they would?

- *Yes, I think so. Years ago, in an EU project the aim was to combine fisheries assessment in terms of catch quotas with socio-ecological aspects. But the goals were not fully achieved because biologist and economist could not communicate well. This was 15 to 20 years ago and the problem was that they were using different language, so the communication was a problem. Now many years have passed, and the communication has improved and this project shows that.*
- *Yes, but what I struggle with is that when you deal with advisory requestors they normally want simple answers and when we start to bring in complexity they don't want to deal with the complexity and they push back to the scientist, saying you tell us what the best available science is. As scientists we keep saying our job is to assess the risk and communicate it, but that it is their job to manage the risk – so there needs to be dialogue around that but until now that hasn't really happened.*

3.5. GRAPHICAL USER INTERFACE NEEDS AND PREFERENCES

Most of the workshop participants use interface tools occasionally to very often (see survey results). In the last session, they provided a list of interface tools they already use as well as their strengths and limitations (see Table 3).

Table 3: Interface tools participants already use and their strengths and limitations

Tool	Strengths / What I liked about it	Limitations / What I don't like about it
AC FishMap https://acfishmap.eu	• Explores regulations, designations, and infrastructures of Europe's North Western Waters (NWW), so it allows to see the closures and regulations of an area.	Currently, it only covers NWW region and it does not have any real-time data.
ICES AdviceXplorer https://www.ices.dk/advice/Pages/adviceXplorer.aspx	• You can search for advice by filtering options such as assessment year, stock code, and species. The tool is underpinned by various databases. • Interactive form of ICES fisheries overviews	• Very much a single stock-based perspective. It provides a link to stock assessment summary outputs but not the detailed data. • It is still in development and many of the plots are not yet interactive.
GeoFish https://www.geofish.be		Currently only covers Belgian EEZ/, and it is only in Dutch, so there is a language barrier.
VISTools	• Strong science-industry partnership • Bottom-up approach • Large focus on trust building and maintenance • Effective address of industry • Concerns while enhancing scientific data and understanding	Not open to everyone.
EMODnet https://emodnet.ec.europa.eu/en	• Various layers • Add/retrieve data from the platform • Many types of information (catching zoning, bathymetry, MPA, MSPs plans etc.)	Miss analysis of data, and possibility to combine datasets, some datasets are not complete (MPA mapping).
Global Fishing Watch https://globalfishingwatch.org	• Open access • Online platform for visualization of vessel activity at sea • The user has an option to report a misrepresentation of data, so that they can correct it.	May present misrepresentations of fishing activity due to difficulty in classifying the actual activity from data (fishing vs transit).

Insight Platform - Fish-X project https://fish-x.eu/insight-platform/	• open access • show SSF • density of fishing vessel • presence and (to come) • detection of fishing gear	Limited (geographical) fishing vessel presence available to use case of the project.
OWEC: The Fisheries Sensitivity Mapping and Displacement Modelling	inter-institutional collaboration for enhanced data coverage	
Seafloor Footprint of Fishing by DTU Aqua and DFPO https://www.aqua.dtu.dk/english/advice/data-from-dtu-aqua/seafloor-footprint-of-fishing	industry driven science-industry partnership	
Reference Point Calculator https://shiny.bluematterscience.com/app/rpc	Very dynamic interface that allows users to upload stock data and calculate fisheries reference points	Might be too complex for non-specialists.

Regarding the design of the SURIMI interface they made the following comments:

- It would be helpful to have zoom options over different scales: e.g. the ecosystem as whole, species population, stocks, as well as small scale resolution for aquaculture, MPAs, renewable energy (wind), etc. So, a zooming in and out option to get the grand picture but to be able to check details when needed.
- A mixture of qualitative and quantitative information would be nice. But the question is, how to visualise both without bias towards one?
- Indication of uncertainty will be very important: not just a simple indication, but with details on the origin and the reasons, to be able to access those details
- They noted that it is difficult to recommend a particular type of visualisation prior to knowing what information the tool will be used to share: the answers to these questions will be subject to the output being explored.
- A database on who to contact when there are specific questions about results from models would be desirable.
- Important to have access to details on data collection methodologies, precision levels of data, coverage, anecdotal evidence, etc.
- A user-story approach to develop the interface, define scope, design GUI, etc. could be made.
- It will be important to update the tools as new data and information comes out. In that regard, they also questioned how the maintenance and update of the tool over time will work, as that is important for its longevity.

The participants overall preferences were to have a highly interactive interface, with filtering options (e.g. by time, region, species); to obtain detailed results and analyses; to have access to detailed metadata (e.g. data sources, quality); and to use data already in the system (see also survey results).

4. CONCLUSION

The workshop yielded a lot of interesting information and insights that will be very helpful for the project going forward. The key takeaways are:

1. Uncertainty in the models and their outputs was a key concern for stakeholders. For SURIMI it will thus be important to find a way to visualise the uncertainty, but also to explain the different types of uncertainties and why the source of uncertainty matters. For instance, the graphical user interface could offer details on the origin and reasons for the uncertainties. Communicating uncertainties well will be crucial for stakeholders to trust the model outputs.

2. The quality of the data used in the models, as well as their validation, limitations and standardisation was another key concern of stakeholders – particularly for the socio-economic data, where there are more gaps and uncertainties, such as when trying to model behaviour of fishers. It was noted that having access to detailed metadata will be important to understand the nuances and complexity of the data.

3. With regards to the socio-economic data, it was noted that it will be important for this project to identify the data that is missing. This is because environmental data is being collected meticulously at the moment, but the socio-economic data is collected differently and does not have the same time scales or spatial scales. So, knowing what data we need and lack will be helpful to improve data collection. Stakeholders also noted that while there are more limitations in the socio-economic data, this data is critical for the model results to become more relevant to society and be accepted.

4. Stakeholders showed great interest in the integration of the models, and had many questions on how that would work in practice. However, they also questioned why and how integrating the models can reduce uncertainty. While well-explained during the Q&A session, this could also be captured in the graphical user interface for other users.

5. Almost all questions and data points presented to the stakeholders during the survey were rated as very relevant, but the highest ranked questions and data points were those related to stock health and sustainability, and the effects of environmental changes (e.g. climate change) on fish stock distribution.

6. Most of the workshop participants are familiar with graphical user interfaces and use them fairly often. Their overall preferences for the SURIMI graphical user interface were to have a highly interactive interface, detailed results and analyses, access to detailed metadata, and to use data already in the system. It was also noted that being able to zoom in and out to see the bigger picture but also have access to details will be important, as well as to provide detailed indications of uncertainty, including origin and reasons.

ANNEX 1

SURIMI Stakeholder Workshop agenda

11 February 2025, 09:00 - 16:30 CET

Time	Session	Content
9:00	Session 1: Opening	• Welcome, objectives, introductions, agenda and methodology
9:15	Session 2: A brief intro to the SURIMI project	• The why, what, when, who and how of the SURIMI project
9:45	Session 3: Exploring stakeholder needs	• Looking at survey responses about the questions that SURIMI can help to answer, and reflecting on current sources of info / data / tools used at the moment
10:00	Session 4: Who needs what, why and how?	• Group work: Creating various stakeholder / “future-user” profiles, including data needs / concerns, as well as interface requirements
10:30	Coffee break	
11:00	Session 4: Who needs what, why and how? - Continuation	• Group work: Creating various stakeholder / “future-user” profiles, including data needs / concerns, as well as interface requirements
12:00	Session 5: Summarising key messages	• Plenary sharing and summarising of key messages emerging so far about the need / opportunity space
12:30	Lunch break	
13:30	Session 6: Learning about the science behind SURIMI	• Videos about the scientific models that will be combined in SURIMI, Q&A and stakeholder reflections on the potential value of this project to help address needs
15:00	Coffee break	
15:15	Session 7: Interface inputs – stakeholder needs	• Gaining insights around stakeholder experiences and needs / preferences
16:00	Closing and next steps	• Closing reflections, thanks and next steps
16:30	End	

Scientific Coordinator

Patrycja Antosz | paan@norceresearch.no

Project Management

Claudia Zoller | PMO-SURIMI@norceresearch.no

Press and Communications

Pamela Cardillo | pamela@erinn.eu

Ladina Jeisy | ladina@erinn.eu

More Information

Website | surimi-project.eu

X | @surimi_project

LinkedIn | SURIMI Project

Bluesky | @surimi-project.bsky.social

Funded by the European Union

Funded by the European Union under the Horizon Europe Program, Grant Agreement No. 101157456 (SURIMI). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor the granting authority can be held responsible for them.

UK Research and Innovation

UK participants in SURIMI are funded by the UK Research and Innovation (UKRI) under the UK government's Horizon Europe funding Guarantee [grant number 10132993].