MODELING MARINE ECOSYSTEMS
WITHOUT HIDING UNCERTAINTY

MIMI PROJECT - WORKSHOP 1 - 30 September 2021

ORGANIZED WITHIN THE FRAMEWORK
OF THE CNPMEM-IFREMER PARTNERSHIP GROUP

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Sharing the representations, knowledge, and uncertainties of marine socio-ecosystems

CONTENTS

MODELING AND UNCERTAINTY WORKSHOP

Marine ecosystems are complex and often observed indirectly and only partially.
This results in simplified representations called models, which may appear far removed from the actual functioning of ecosystems. There are many models whose purpose and operationality vary. For example, Ifremer has developed ISIS-Fish, a fishery dynamics model used to test management scenarios in research projects and scientific committees close to management. The acceptability of these models as tools to support fisheries management is facilitated by the endorsement of these ecosystem representations.

Therefore, raising awareness about models, and identifying and sharing both the convergences and divergences in ecosystem representations, is a key challenge for fisheries management.

Although we all have an implicit grasp of uncertainty, particularly in our everyday decision-making, the uncertainty associated with models is rarely presented to stakeholders. Yet, failing to present uncertainty can create the illusion that model outputs are certain, potentially leading to inappropriate decisions. Conversely, placing too much emphasis on uncertainty in models can reduce their credibility.

A major challenge in communicating uncertainty for fisheries management is to present the sources of uncertainty in models without leading to misunderstanding or inaction on the part of decision-makers.

As part of the MIMI project (Models, Imaginaries and Uncertainties), a workshop of the CNPMEM-IFREMER partnership working group was held to build and share a simplified representation of a marine ecosystem, based on the perceptions and expert knowledge of the participants, and to highlight the uncertainties in their graphical model.

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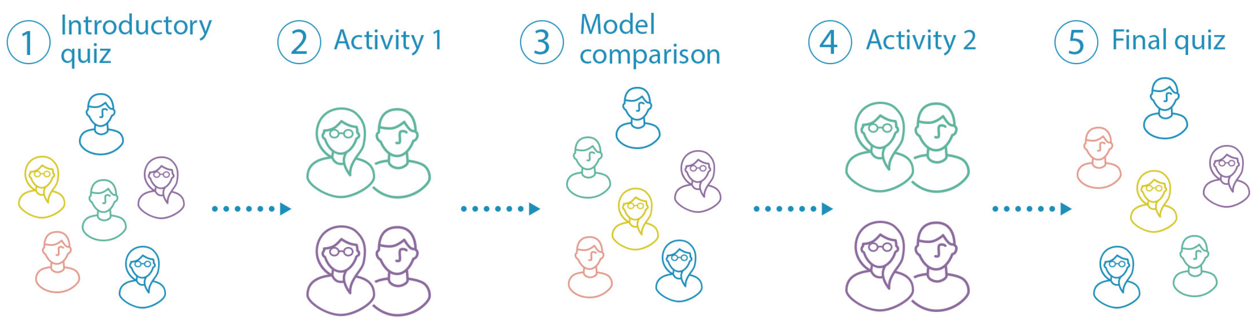
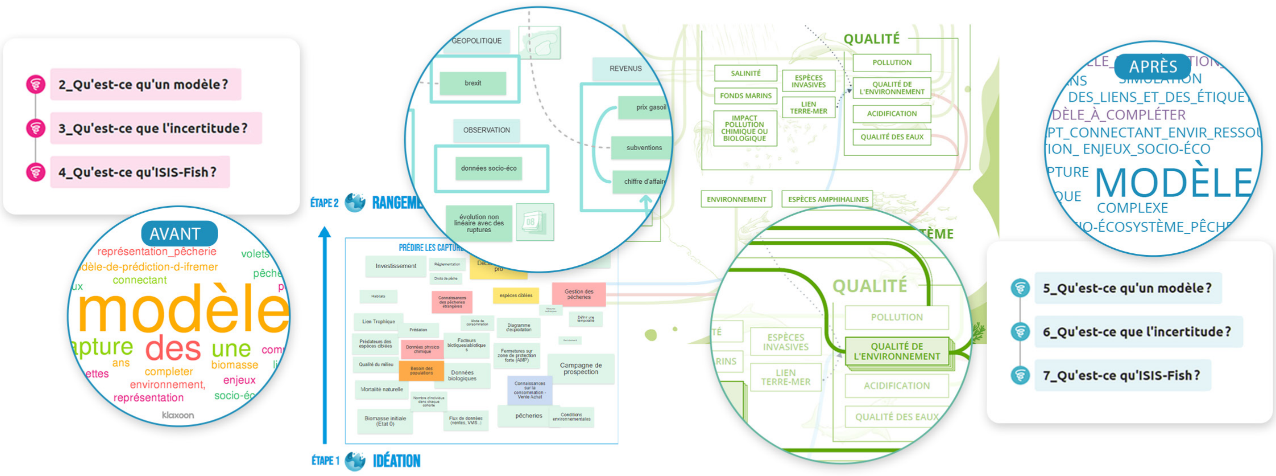
WORKSHOP PRESENTATION

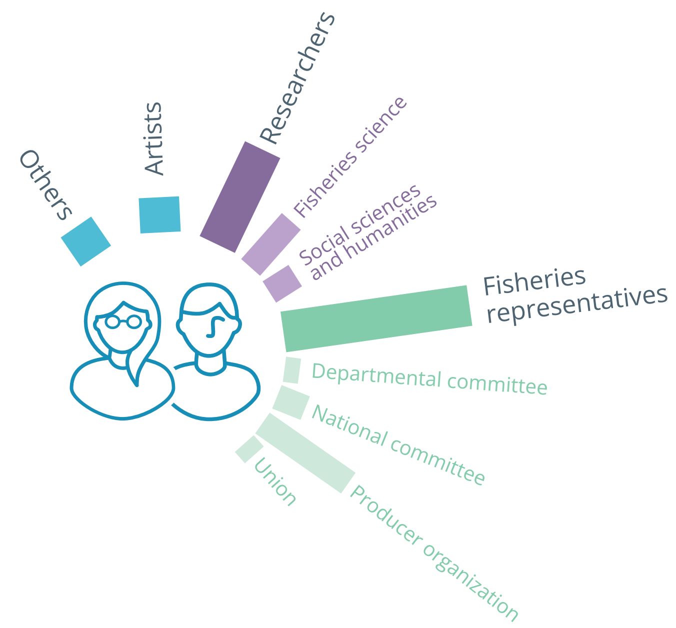
The workshop was held on 30 September 2021 as a full-day videoconference. It was structured around short presentations followed by sessions based on a participatory method using a digital whiteboard with sticky notes (Klaxoon software).
The participants, mainly from producer organizations and fisheries committees (national, regional, departmental), represented different maritime fronts of French fisheries and various types of fisheries (pelagic, demersal, benthic, coastal, offshore).
To allow everyone to speak, two groups were formed and carried out in parallel the same sequence of time-constrained activities, framed by three periods of exchange with all participants.

WORKSHOP PROCEEDINGS

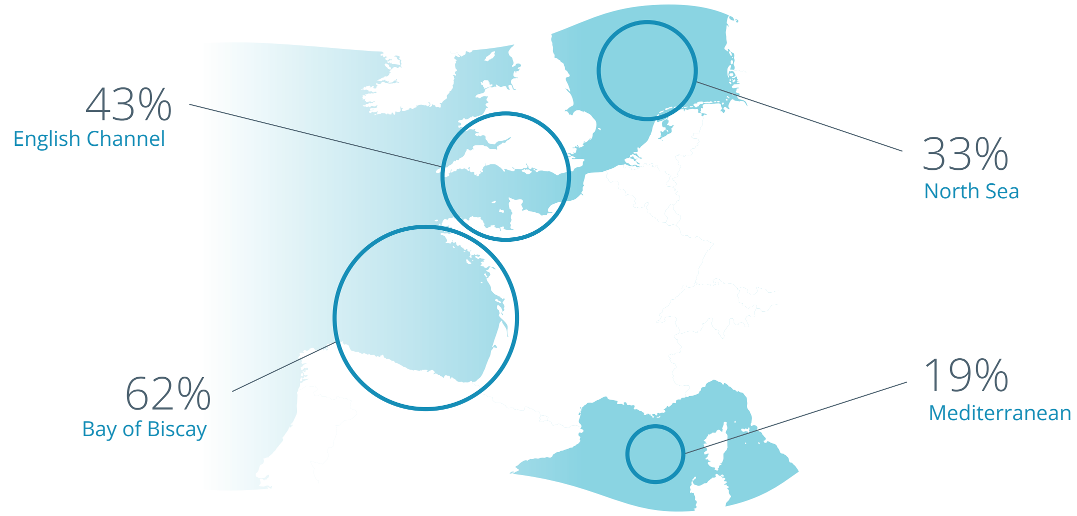




25 **PARTICIPANTS**



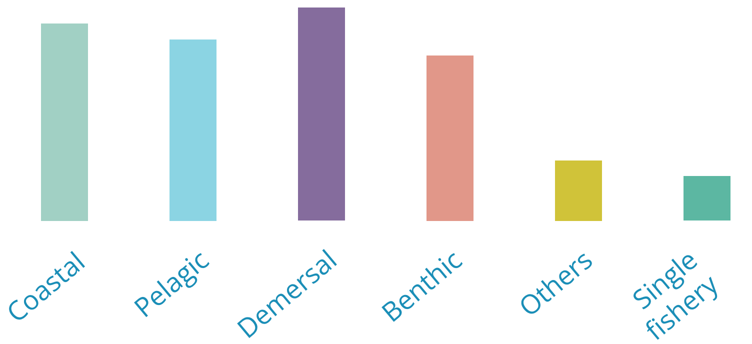
48% ARE INTERESTED **IN SEVERAL MARITIME FRONTS**



OTHER AREAS OF INTEREST

Celtic Sea, West of Scotland, West of Ireland, Indian Ocean, Atlantic, Saint Pierre, French Southern and Antarctic Territories, the outermost seas, and distant waters.

FISHERIES OF INTEREST



Others :
- Oceanic purse seine
- Toothfish longline
- Offshore fishery

ACTIVITY **1**

MODEL CONSTRUCTION

FRAMING

This first activity aims to collectively build a marine ecosystem–fishery model by identifying the different elements that compose it (sticky notes) and the links between these elements (arrows or lines).

A MODEL IS A SIMPLIFIED REPRESENTATION OF REALITY.

A model is built to meet a **specific objective**, here: **to predict ecosystem biomasses and fishery catches in 5 years**. By setting this time scale, the aim is to restrict the model to objects and links that influence biomasses and catches. For example, sea level rise or ocean warming will not be significantly different between today and 5 years from now, and therefore these objects or their influence do not necessarily need to be described in the model.
The model to be built in this activity is not a mathematical model in the sense that it does not involve equations, but rather a graphical representation of what makes up the marine ecosystem–fishery and how it functions.

THIS MODEL-BUILDING EXERCISE IS ORGANIZED IN SEVERAL STEPS:

1. Ideation of the elements making up the ecosystem (6 min),
2. Presentation of the ecosystem compartments (Natural environment, Resource, Fishery, Socio-economic environment, Management) (10 min) and placement of the elements identified in step 1 into the compartments (10 min),
3. Addition of missing elements and links between elements, compartment by compartment (15 min/compartment).

Refer to the two "model" diagrams to see the results of the working groups.
The results are analyzed in the following pages.

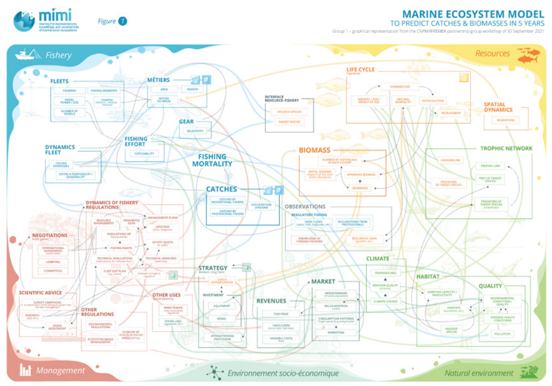


Figure 1
Marine ecosystem model – Group 1 - pages 8|9

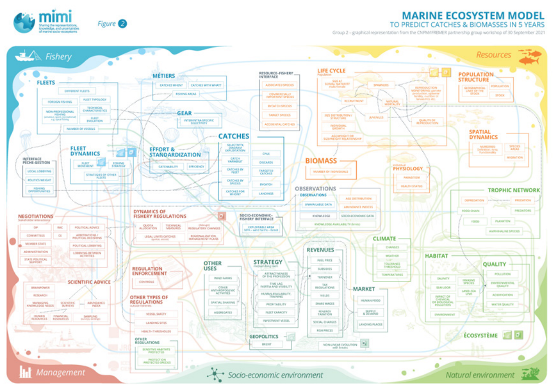


Figure 2
Marine ecosystem model – Group 2 - pages 12|13

ACTIVITY **2**

IDENTIFICATION OF UNCERTAINTIES

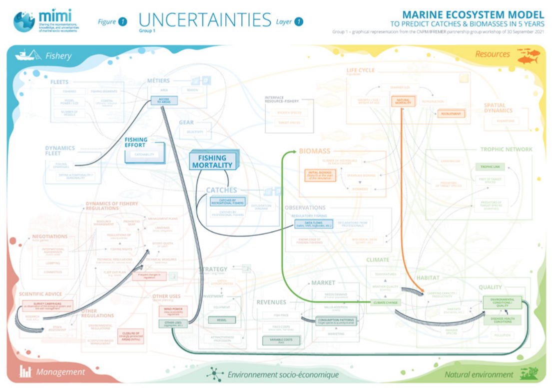
FRAMING

The marine ecosystem is perceived and understood imperfectly. This second activity aims to individually identify the uncertain objects within each compartment of the model and to assess the level of consensus on these uncertainties within each group.

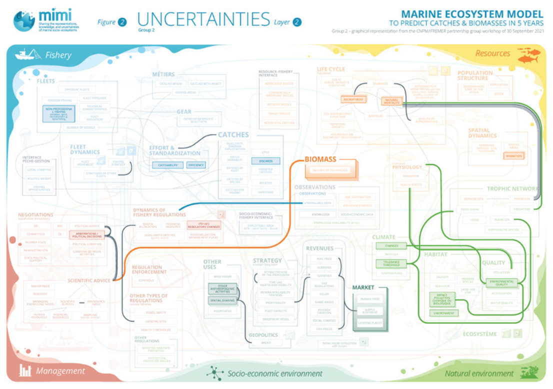
THIS EXERCISE IS ORGANIZED IN SEVERAL STEPS:

1. Identification of uncertain objects in the model for each compartment (5 min)
2. Voting using the "like" mode for the most uncertain objects in each compartment (2 min)

Consult the two "model" diagrams to discover the results of the working groups.
The results are analyzed in the following pages.



Layer 1
Uncertainties – Group 1 - pages 10|11



Layer 2
Uncertainties – Group 2 - pages 14|15

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Figure 1

MARINE ECOSYSTEM MODEL
TO PREDICT CATCHES & BIOMASSES IN 5 YEARS

Group 1 – graphical representation from the CNPM/IFREMER partnership group workshop of 30 September 2021

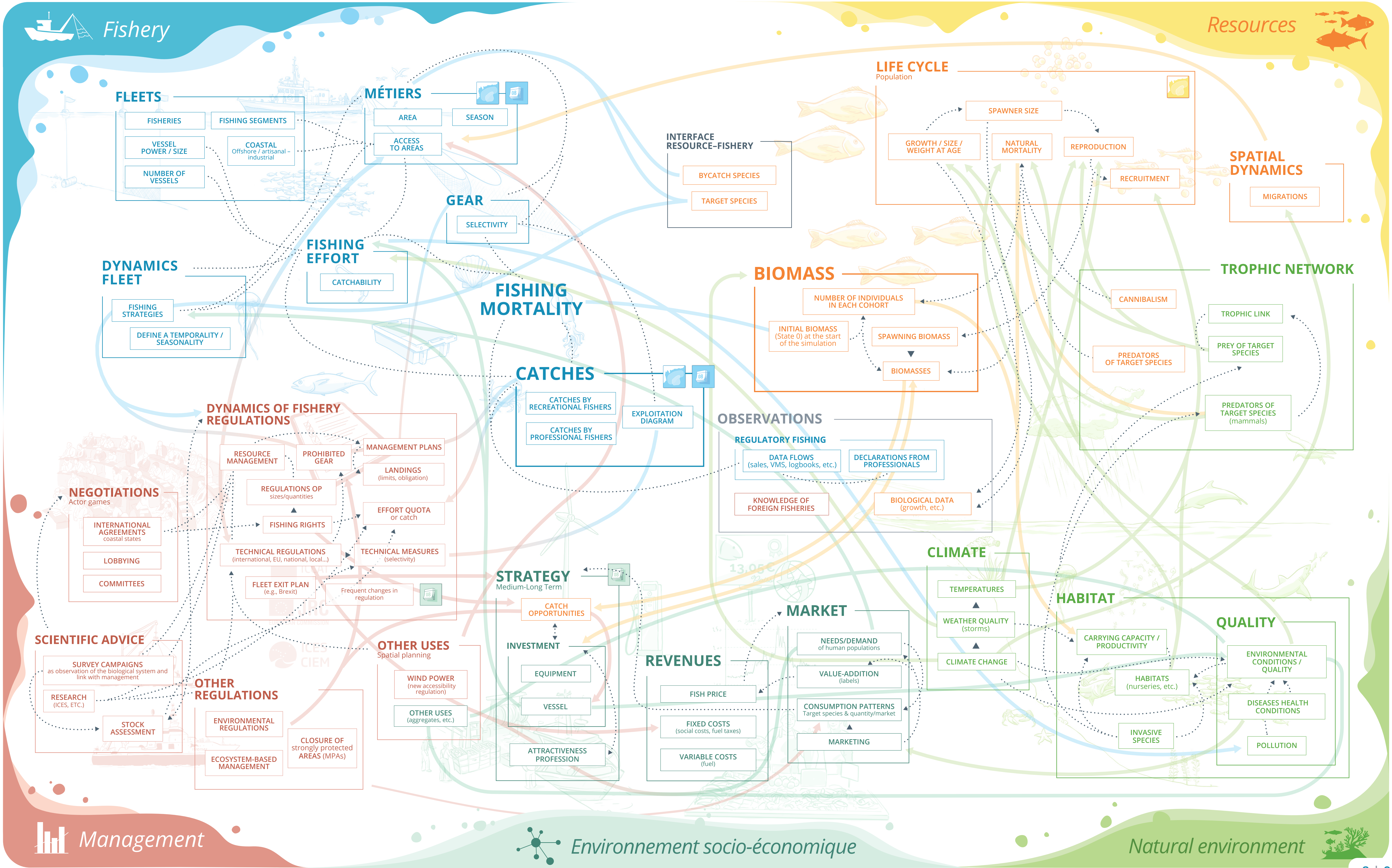

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Figure 1 UNCERTAINTIES *Layer* 1
Group 1

MARINE ECOSYSTEM MODEL
TO PREDICT CATCHES & BIOMASSES IN 5 YEARS

Group 1 – graphical representation from the CNPM/IFREMER partnership group workshop of 30 September 2021

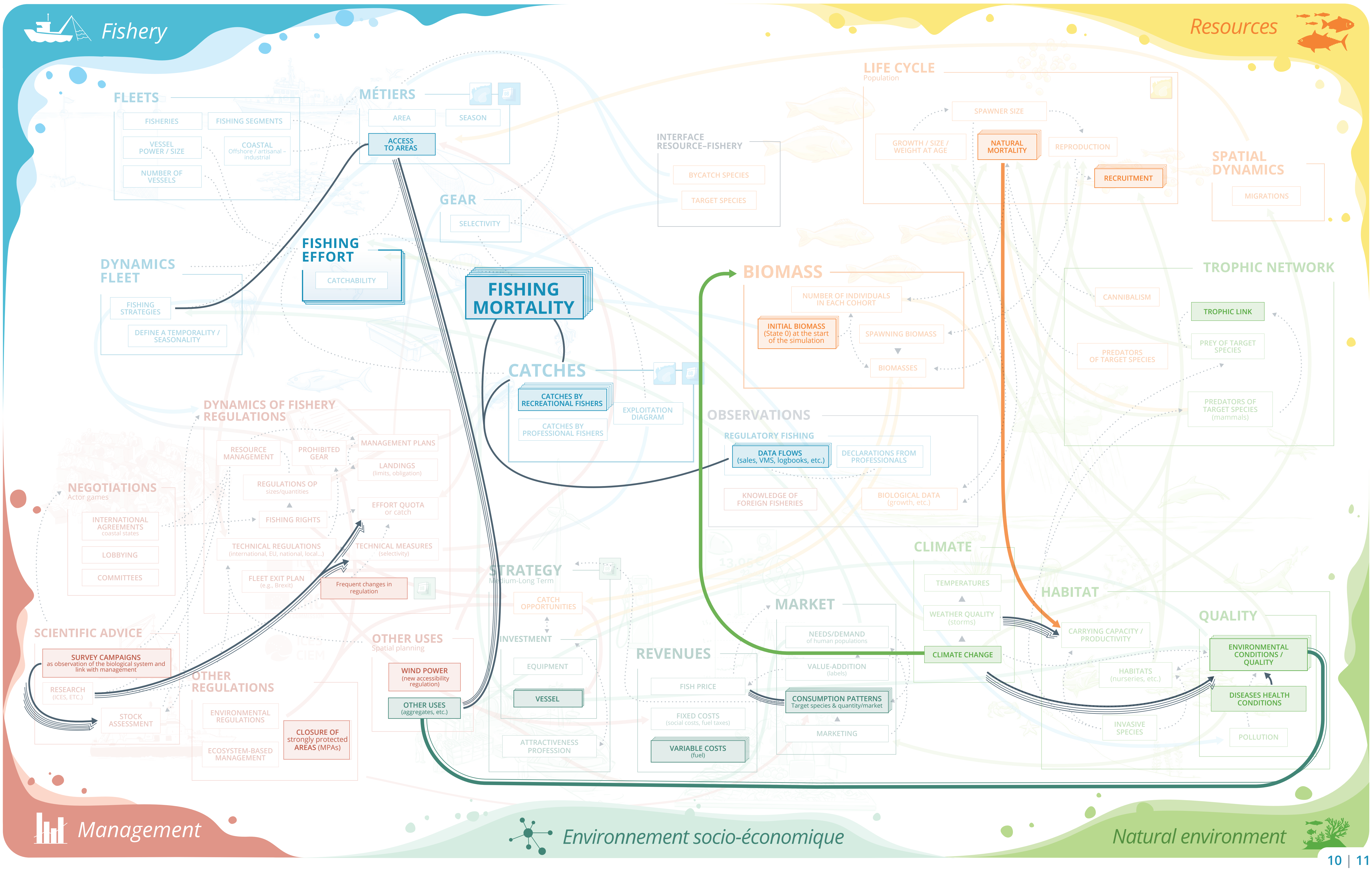

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Figure 2

MARINE ECOSYSTEM MODEL
TO PREDICT CATCHES & BIOMASSES IN 5 YEARS

Group 2 – graphical representation from the CNPM/IFREMER partnership group workshop of 30 September 2021

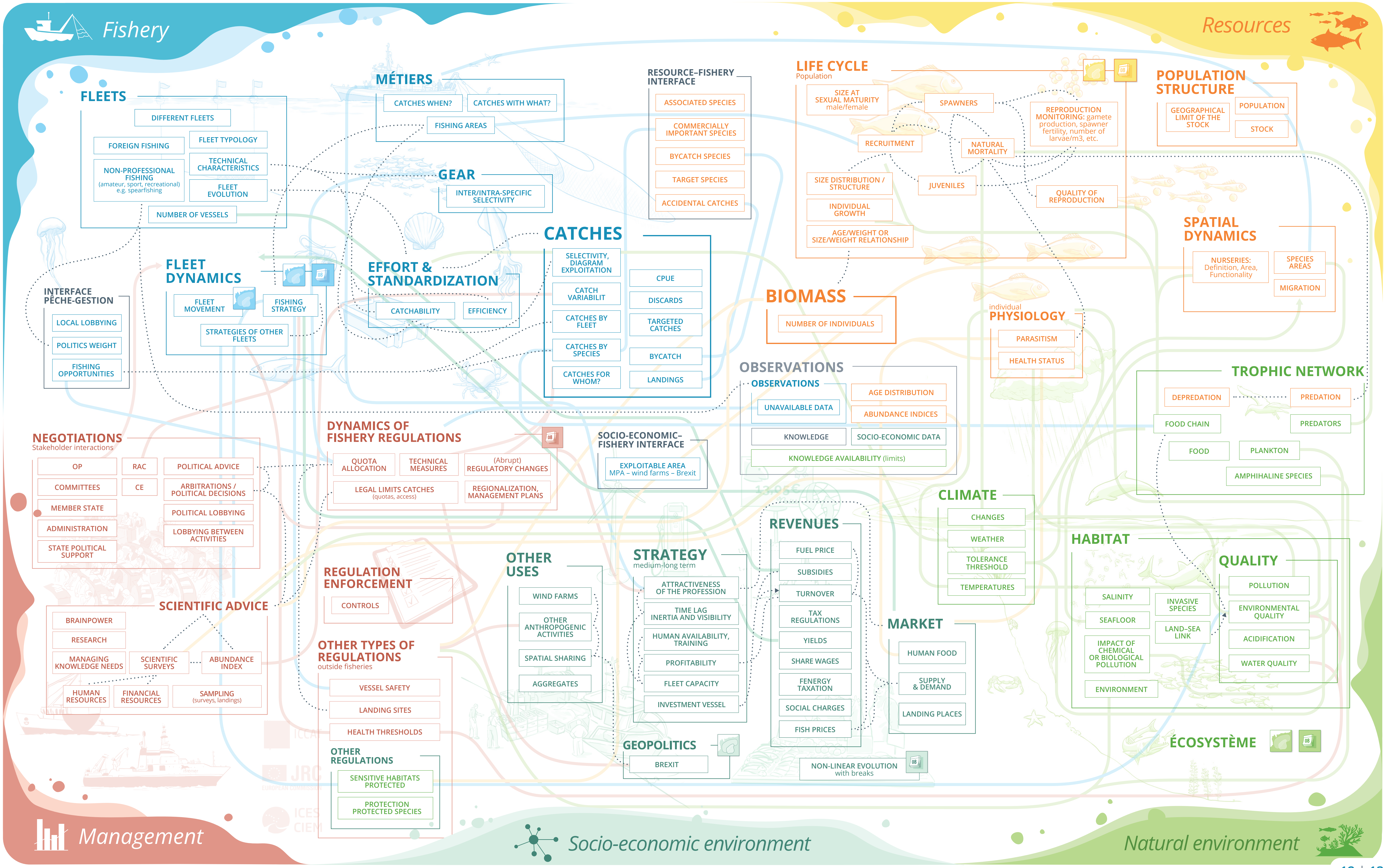

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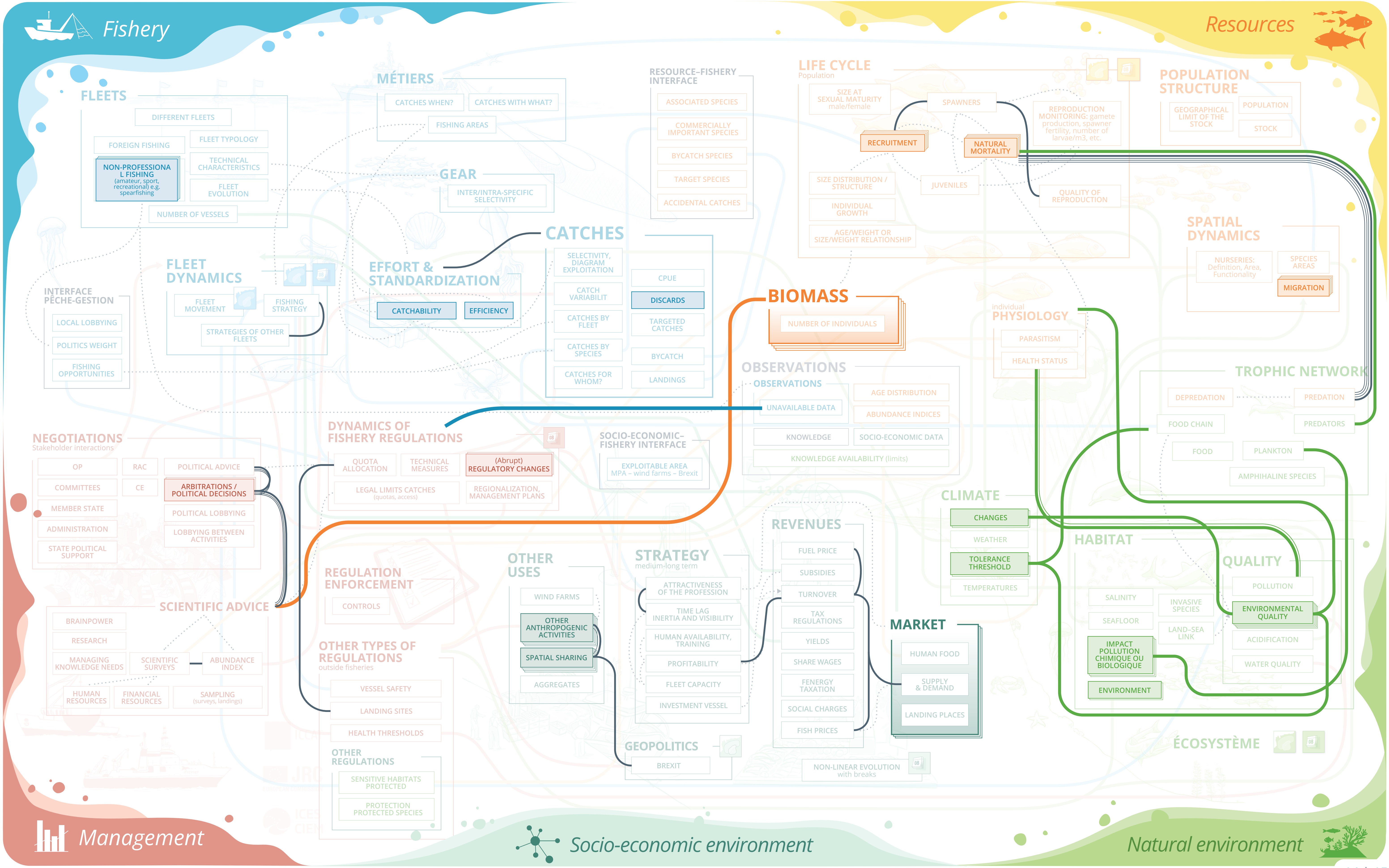
Figure 2 UNCERTAINTIES *Layer* 2
Group 2

MARINE ECOSYSTEM MODEL
TO PREDICT CATCHES & BIOMASSES IN 5 YEARS

Group 2 – graphical representation from the CNPM/IFREMER partnership group workshop of 30 September 2021



RESULTS OF ACTIVITY **1**

MODEL CONSTRUCTION

The two models (Figure 1, Figure 2) **thus constructed reflect a complex representation of the marine ecosystem, with varying levels of detail, from which a consensual structure can nevertheless be drawn. Both groups identified observations as a necessary element for describing each compartment of the ecosystem. Finally, in both models, the interactions between compartments are numerous, with the highest density between the resource compartment and the natural environment compartment.**

RESOURCE

The resource compartment focuses on the life cycle of populations (growth, reproduction, and mortality) with a life-stage structure. The two models differ in their description of reproduction quality and maturation, and in the use of an individual-level description of fish. Spatial structuring emerged as an important dimension, used for example to describe habitats and stock in Group 2, and movements in Group 1.

FISHERY

The fishery compartment is organized in a similar way in both models. The prediction of catches involves describing fleets and fishing strategies, whose dynamics depend on regulatory constraints and other uses (management), yields, and the market (socio-economic environment). Catches vary with gear selectivity, seasonality, and the fishing grounds of métiers, and result from fishing effort and catchability. For Group 2, they are broken down according to the targeting and economic interest of species. Group 1 explicitly mentioned fishing mortality. A strong separation was expressed between national and foreign fishing, and between professional and recreational fishers.

MANAGEMENT

Within the management compartment, both groups described management in detail and emphasized its rapid dynamics. Beyond measures directly affecting fishing activity and its production, the repercussions of other regulations, particularly those associated with other uses of marine space, were described. Only Group 2 mentioned control. According to the group, the complexity of management is mainly reflected either in the explicit role of the various actors, particularly scientists, and the weight of negotiations, or in the detail of the levels of decision-making and implementation of measures (from international to local).

SOCIO-ECONOMIC ENVIRONMENT

The socio-economic environment compartment is structured identically for both groups around short-term elements (revenues), medium- to long-term strategy, and the market. Revenues are strongly impacted by variable costs (fuel price). The issue of the attractiveness of the profession is important for fishing strategy. Relations with new uses are very present, particularly in connection with evolving regulations (management). Group 2 mentioned the effects of Brexit.

NATURAL ENVIRONMENT

The natural environment compartment is organized around climate, habitats, and the trophic network. It is the most connected compartment to the others, and particularly to the resource compartment. Environmental factors impacting the population may be biological (trophic relationships or invasive species), physico-chemical (water quality, pollution), or climatic in the short or medium/long term (temperature).

RESULTS OF ACTIVITY **2**

IDENTIFICATION OF UNCERTAINTIES

For both groups (Layer 1, Layer 2)**, the fishery compartment is the least uncertain, with on average one third of the elements considered uncertain across the two groups. Conversely, the natural environment and the socio-economic environment appear to be the most uncertain, with roughly two thirds of the elements considered uncertain.**

RESOURCE

The major uncertainties in the resource compartment unanimously concern recruitment, natural mortality linked to environmental carrying capacity in one group and to the trophic network in the other, and biomass, associated with the scientific assessment in one group and its input value in the models in the other. Group 2 identified migrations and reproduction as highly uncertain.

FISHERY

In the fishery compartment, both groups share the same perception of uncertainties, which focus on elements of fishing effort, fishing mortality and their link with catches, as well as on regulatory or unavailable data for management, such as discards or recreational fishing. Group 2 considered the link between strategies to be uncertain.

MANAGEMENT

In the management compartment, regulatory changes (including access to areas) linked to new uses and political trade-offs are sources of uncertainty for both groups. There is also uncertainty around research: links between scientific advice, political decision-making, and landings; time lag between observations, assessment, and implementation of political decisions; link between scientific surveys and abundance indices; and research funding.

SOCIO-ECONOMIC ENVIRONMENT

In the socio-economic environment compartment, both groups agreed on uncertainties regarding the impact of changing consumption patterns on the market and target species, fuel price trends, the effects of new uses, and profitability. Group 2 identified uncertainty over the evolution of spatial sharing after Brexit.

NATURAL ENVIRONMENT

In the natural environment compartment, environmental quality, climate-related changes, and the links between the natural environment and the resource compartment are the most uncertain elements for both groups. In Group 2, uncertainties regarding the impacts of pollution on habitats and on the health status of marine populations were unanimously noted.

COMPARISON OF THE TWO MODELS
WITH THE ISIS-FISH MODEL

During a previous workshop (31 August 2021), scientists familiar with the ISIS-Fish model carried out a timed exercise to construct a graphical representation of the ISIS-Fish model, using the same framing as in Activity 1 and the same tool. The result (Figure 3, A3 format) was presented to the participants, showing the common points and differences between the three models, without much time to discuss this comparison.

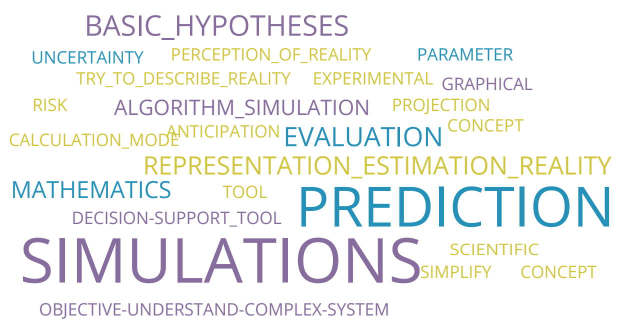
The models built during this workshop are much more complex than the ISIS-Fish representation. While the Fishery and Resource compartments show many similarities and a comparable level of detail in the description of elements and links, the other three compartments are far more simplified in the ISIS-Fish model. These differences can be easily explained by the specific nature of the ISIS-Fish model, which describes a fishery rather than an ecosystem.

QUIZ MODEL, UNCERTAINTY, ISIS-FISH

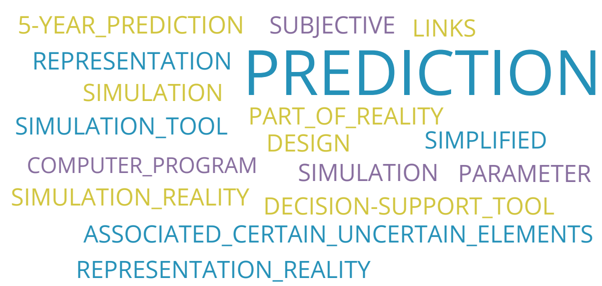
Model and uncertainty are broad and vague concepts, whose use in everyday language may differ from their technical use in modeling for decision support. The quiz conducted at the beginning and end of the workshop aimed to assess the diversity of participants' definitions and to measure the changes induced by participation in the activities. The quiz responses are represented by word clouds.

MODEL WORD CLOUDS

before



after



The 4 most common expressions (simulation, prediction, representation, simplification of reality) are the same at the beginning and at the end of the workshop. They demonstrate an understanding of the concept, its use for prediction, as well as the difference between the model and the system it describes prior to participation in the workshop. Even though the number of words or expressions chosen to define a model was smaller after the activities than at the beginning of the workshop, new words borrowed from the vocabulary of the model construction activity (links and elements) appeared in the list at the end. It is also noted that the words "mathematics" and "basic hypothesis" disappeared and were replaced by the term "subjective", which can be explained by the graphic model-building exercise carried out without recourse to mathematical equations.

UNCERTAINTY WORD CLOUD

before

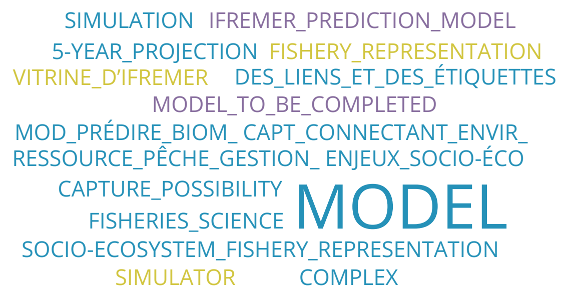
after

The notion of uncertainty appeared familiar to participants from the very beginning of the workshop. By the end of the workshop, the expressions were fewer, more precise, and contained little subjective interpretation, unlike the pre-workshop list (e.g., beauty, human). The most frequently cited expressions decreased from seven to three and generally fell within the language register related to the model. Only the notion of the unknown remained among the most common expressions at the end of the workshop. It should be noted that the notions of hazard and risk disappeared by the end, the latter being specified as "error risk." This can be explained by the concentration of post-workshop responses around the notion of uncertainty directly linked to a model.

ISIS-FISH WORD CLOUD

before

after

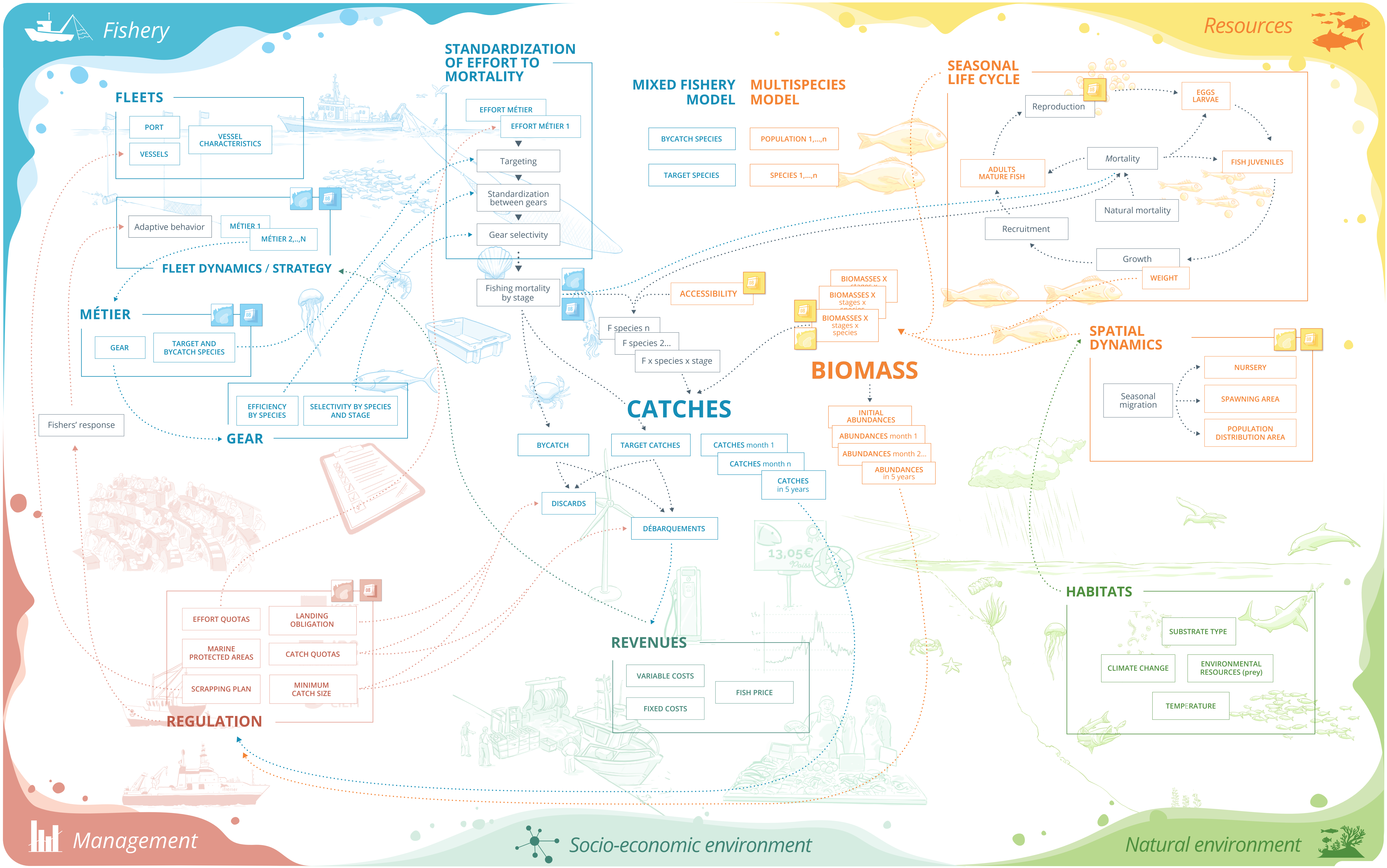


Unlike the other two terms, the number of words used to define ISIS-Fish at the end of the workshop was greater, and the vocabulary more precise, than at the beginning. Long expressions were noted, reflecting the compartments of a marine ecosystem described in ISIS-Fish and the vocabulary used during the model-building activity. This workshop enabled all participants to understand that it is a model for simulating fisheries (the most frequent expressions, with vague expressions disappearing by the end of the workshop).

Figure 3

ISIS-FISH MODEL
GRAPHICAL REPRESENTATION
Diagram from the scientific workshop of 31 August 2021

ISIS-Fish



CONCLUSIONS

Participation in this workshop was active, both in written contributions and in spoken interventions by all participants.

MODÈLE

- **The two groups built, without difficulty, two marine ecosystem models** that provide an exhaustive and consensual graphical representation of the ecosystem without using mathematical equations. **These two models demonstrate a shared understanding** of how ecosystems function, both in the life cycle of species exploited by fisheries and in the strong links between these species and the natural environment. The spatial and seasonal dimension often emerged to characterize elements of all ecosystem compartments, giving a dynamic perspective to this static representation.

- The participants paid particular attention to describing in great detail the management and socio-economic environment compartments, as well as the links between these compartments and the fishery compartment. Despite the two groups sharing the same representativeness of fishing stakeholders, differences emerged between the two models (e.g., fishing mortality made explicit in one, the physiology of individual resources in the other), **demonstrating that there is not a single possible and credible representation of a marine ecosystem, but several.**

- Despite the time constraint for construction, **the representations abound with boxes and links, reflecting the complexity of ecosystems and the associated models**, which the participants themselves described as a "gas factory."

- In addition to the spatial and seasonal dynamics described within the five compartments, more complex notions of ecosystem dynamics were made explicit, such as abrupt changes and threshold effects, mainly in connection with the natural and socio-economic environment.

- The responses to the question "what is a model?" at the beginning and end of the workshop, as well as the construction of the graphical representation of a marine ecosystem to predict catches and biomasses in 5 years, demonstrate that **the concept of a model is understood as a simplified representation of reality and a tool for simulation and prediction.** The workshop demonstrated that by describing the elements that make up the marine ecosystem and the links that connect them, **stakeholders could easily produce a graphical representation of the ecosystem to answer a specific question**.

UNCERTAINTY

- **The identification of uncertainties in the models built during the workshop posed no difficulty, reflecting an easy handling of this concept.**

- Both groups share a common perception of the elements or mechanisms poorly understood in the model. **As expected, the fishery compartment appears to be described with the greatest certainty, while the socio-economic environment, the natural environment, and management raise many uncertainties.**

- The analysis of uncertain elements brought to light links that had not been identified during the model-building stage, showing that if the model construction exercise had lasted longer, the model would probably have been even more complex, and that uncertainties in ecosystem elements raise questions about the mechanisms between them. **Acknowledging that these links are themselves uncertain highlights the importance of improving knowledge about the elements and the mechanisms between them in order to refine predictions of catches and biomasses.**

The organization of this workshop under "covid" conditions provided an opportunity to propose an innovative and reusable/reproducible method (Klaxoon + work sequence) for building 1) a graphical representation of a marine ecosystem and 2) a description of uncertainties within this representation. It helped to demystify models, to share representations of the marine ecosystem, and also to reveal common understandings and misunderstandings of the elements and mechanisms of the marine ecosystem.

PROJECT CONTACTS

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THE SCIENTIFIC TEAMS FACILITATING THE 2 GROUPS

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GROUP 2 : Stéphanie Mahévas (facilitator for model and uncertainty), Sigrid Lehuta (facilitator for model and uncertainty), Vincent Badts (scribe).

THE PARTICIPANTS (NON ACADEMIC FISHING STAKEHOLDERS, ACADEMIC SCIENTISTS, ARTISTS)

GROUP 1 : Margot Angibot, Alain Biseau, Christian Cloutour, Jérôme Fihey, Marc Ghiglia, Salomé Khatib, Nicolas Michelet, Perrine Mornay, Solène Prevalet, Gaëlle Renard, Dominique Thomas, Morgane Ramonet.

GROUP 2 : Cécile Beaudéan, Fiona Bigey, Jérôme Blin, Perrine Cuvilliers, Jérôme Jourdain, Gilles Lazuech, Frank Le Barzic, Solene Repairs, Marion Thomas.

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