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Author(s):

Yuliya Kharchenko, Robert Miskuf, Patrycja Antosz,

LeRon Shults, Markus Grendstad Rousseau,

Vanja Falck

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Deliverable Contributors				
	Name	**Organisation (acronym)**	**Title**	**E-mail**
Deliverable Leader	Robert Miskuf, Yuliya Kharchenko	PEDAL	CEO, Project Manager	r.miskuf@pedal-consulting.eu, y.kharchenko@pedal-consulting.eu
Reviewer n°1	LeRon Shults	NORCE	Research Professor	lesh@norceresearch.no
Reviewer n°2 (if applicable)	Rui Pereira	A4F	Head of Seaweed Division	rui.pereira@a4f.pt
Final review & quality approval	Xavier Ponte	NORCE	Senior Project Manager	xavi@norceresearch.no

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List of Acronyms

Acronym	Description
EU	European Union
T	Task
D	Deliverable
VC	Value chain
ISP	Innovative seafood products
EGD	European Green Deal
FPTM CC	From Product To Market Co-Creation
ABM	Agent-based modeling

Executive Summary

This report focuses on a comprehensive examination of consumer perceptions and societal norms influencing the adoption and consumption of innovative seafood products in European countries. The primary objective is to delve into the motives—such as values and norms—underpinning the fluctuations in the consumption patterns of innovative seafood products across the region.

The development of new value chains of innovative seafood products requires synergies and cooperation between various sectors, both along and across the value-chains, bringing all actors together, mobilizing the innovations and pulling the market by bringing new innovative seafood products. However, the interaction among processes and stakeholders between previously unconnected sectors carries various barriers that in many cases constitute obstacles towards the development of new value chains and sustainable innovative seafood products business models.

Moreover, each stakeholder occupies a dual position in the chain, both as a provider to each subsequent actor and as a client to each preceding one. The barriers posed in the interaction among them are therefore determined by both their initial identity (industry, brand owner, retailer. etc.) and their contextual role in the chain (provider or client).

Thus, this report was made to provide insight into the cooperation between the key actors of the innovative seafood products market landscape, putting emphasis on mapping the factors that hinder the collaboration amongst them, and investigate how trust and confidence between them can be enhanced towards the market uptake of innovative seafood products. To come to this, we identified the existing barriers in the interaction among industry stakeholders, brand owners and retailers, and consumers from each stakeholders' point of view. Moreover, the extensive gap analysis is accompanied by the From Product To Market Co-Creation (FPTM CC) methodological guidelines. FPTM CC is a novel mixed-method approach to developing novel algae-based food products concepts and market strategies, that maximize the uptake in the target population.

1. Introduction

The Farm to Fork Strategy, within the framework of the European Green Deal, has duly recognized the promising potential of algae as a significant source of alternative protein with a low carbon footprint. This recognition extends towards enhancing the sustainability and competitive edge of the aquaculture sector.

Simultaneously, the utilization of algae-derived seafood encounters several limitations, spanning from the initial raw materials to the ultimate end consumers. Notably, the European industry's involvement in this realm remains at an early developmental stage.

The task of conducting a gap analysis serves the purpose of meticulously scrutinizing the available data concerning consumer perspectives and societal norms that impact the adoption of pioneering seafood products. This undertaking additionally seeks to delve into the underlying motivations (inclusive of values and norms) that underpin the heightened, or diminished, consumption of innovative seafood offerings across European nations.

Furthermore, this task is dedicated to a thorough evaluation of the value chains encompassing innovative seafood items, with a specific emphasis on identifying segments within these chains that necessitate fortification. Particularly within the aquaculture ecosystem, this analysis is geared towards nurturing sustainability and safety considerations.

Within the document, innovative seafood ecosystem is analysed, including investigation of innovative seafood definitions, main actors of the ecosystem and their role, as well as the seafood ecosystem through the optics of end user and value chains.

Finally, preliminary conclusions regarding existing gaps in innovative seafood ecosystem are made.

1.1 Purpose of the document

The identified findings stemming from the gap analysis present a concise overview sourced from desk research conducted by PEDAL and NORCE. This overview delves into the recent trends surrounding the consumption of pioneering seafood products and how these trends

exert influence on consumer incentives towards such innovative seafood offerings. These findings are slated for comprehensive consideration within the scope of T1.3 activities.

The central objective of this task is to meticulously examine the existing body of information concerning consumer perceptions and societal norms that wield an impact on the consumption patterns of innovative seafood products. Additionally, the task seeks to attain a deeper comprehension of the motivations (encompassing values, norms, etc.) underpinning the escalated or diminished uptake of inventive seafood products across European nations.

Furthermore, a thorough assessment of the value chains encircling innovative seafood items is set to be undertaken as part of this endeavour. The specific focus here lies in the identification of segments, within these value chains, that warrant strengthening. This emphasis is particularly pronounced within the aquaculture ecosystem, as the analysis aims to bolster sustainability, safety, and sustenance considerations.

The main research question addressed in this report is: **How can we make consumer like our product?**

The research question to analyse innovative seafood ecosystem through the optics of end user is further divided into the following sub-questions:

- Level of awareness in and engagement in innovative seafood products
- Confidence and level of engagement in innovative seafood products
- The perceived benefits that drive from the use of innovative seafood products
- The perceived barriers that prevent a greater use of innovative seafood products

In addition, innovative seafood ecosystem is analysed through the optics of value chains.

Finally, all the previous analysis is used to define the existing and desired state of the innovative seafood ecosystem, to define the existing gaps and to propose possible solutions to resolve it.

1.2 Structure of the document

The approach employed in this task rests upon a methodology rooted in literature-based desk research. The outcomes delineated within this report are derived from an extensive desk research effort, encompassing an in-depth analysis of pertinent literature, the systematic classification of barriers, and the identification of gaps intrinsic to surmounting these impediments. Moreover, innovative seafood value chains were analysed. Afterwards, preliminary conclusions regarding the existing gaps and approaches to overcome them, were made. The literature analysis was undertaken with the intention of comprehensively reviewing the principal findings derived from extant literature sources. These sources primarily encompass a range of industry reports, ongoing or concluded EU projects, official reports emanating from EU and national platforms and networks of professionals, governmental reports, EU survey reports, and other pertinent non-academic references.

In total, 29 research articles were identified from an initial pool of 860 potentially relevant grey literature pieces. The relevant documents were reviewed by NORCE and PEDAL with contribution from consortium partners, such as: SEA EIGHT, VIVA MARIS, ALGEMY, A4F, PERSEUS BVBA.

The literature analysis has been conducted with a specific focus on innovative seafood products, novel food and food innovations. All findings are reflected in this report which is divided into 5 main chapters:

Chapter 2 describes the innovative seafood ecosystem, provides the definition of innovative seafood products and outlines the key stakeholders and their role in innovative seafood ecosystem. Also, this chapter defines the INNOAQUA end users.

Chapter 3 is dedicated to the gap analysis through the optics of an end user, their level of awareness and engagement in innovative seafood products. It reflects the level of confidence and perceives benefits that drive from the use of innovative seafood products as well as describes the barriers that prevent a greater use of innovative seafood products.

Chapter 4 is based on relevant literature review on the gap analysis through the optics of value chains. The research articles were divided and described by methodological approach

for data collection. The first and largest group included questionnaire only articles. The second group were in-person multi- or mixed-methods approached that sometimes included questionnaires.

Chapter 5 offers the preliminary conclusions and describes the current situation, desired state on innovative seafood products, existing gaps and preliminary proposals to mitigate them.

Chapter 6 presents a user guide to the From Product To Marker Co-Creation methodology - dedicated for practitioners developing novel, sustainable food products. The methodology is a mix of three social scientific approaches: qualitative co-creation, online surveys and social modelling. Each method is described with respect to its main goals, typical processes, resources and results. The methodology will be tested in the INNOQUA project that will help further develop the guide and share lessons learned through the project.

1.3 Relation to other project deliverables

The discerned gaps will be systematically addressed through the activities outlined in T1.3, which are specifically oriented towards comprehending consumer motivations and collaboratively formulating the final innovative algae-based food product concepts. In T1.3 and T1.4 subsequent parts of the FPTM CC will be carried out by project partners, implementing the methodology for the first time.

Moreover, the outcomes of the gap analysis will serve a pivotal role in the acquisition of requisite data for the execution of socio-economic, sustainability, and circularity assessments in the context of T5.1, pertaining to the "Goal and Scope Definition" within Work Package 5 (WP5). These insights will be instrumental in shaping the study's objective, delineating the product system and its boundaries, defining the functional unit, establishing impact indicators, setting allocation principles, and facilitating a comprehensive circularity assessment.

2. Innovative seafood ecosystem

2.1. Definition of innovative seafood product

Innovative seafood product: an innovative seafood product refers to any seafood-based item or dish that introduces new, original, or unconventional characteristics, features, or methods within the seafood industry. These products typically showcase novel approaches in terms of ingredients, preparation, processing, packaging, sustainability, taste, nutritional value, or consumer appeal. Innovation in seafood products often involves advancements in technology, culinary techniques, or creative combinations that enhance the quality, convenience, health benefits, or environmental impact of seafood offerings. This can include products like value-added seafood snacks, sustainable aquaculture-based alternatives, plant-based seafood substitutes, new seafood-based sauces or condiments, or unique seafood presentations that cater to evolving consumer preferences and market demands.

In a scenario where global food systems are being challenged due to the expected population growth, together with resource impoverishment and other environmental constraints, seafood has been identified as a vital source of food and a key component of a healthy diet. Nonetheless, decades of unsustainable overfishing practices are depleting aquatic ecosystems at a time when nearly one-fifth of all animal protein consumed by humans comes from seafood, reason why aquaculture has gained traction over wild fisheries. In fact, it has been the fastest-growing food industry globally for several decades and is expected to continue in the coming years despite a slight decrease in the annual growth rate.

However, intensified near-shore aquaculture raises environmental and resource-related questions, mainly due to waste-streams, dependence on wild fisheries for aquafeed, disease outbreaks and the potential introduction of invasive species resulting from escapes in ecosystems where they do not belong.

Innovative seafood product products: products derived wholly or partly from biomass, such as plants, trees or animals. The biomass may have undergone physical, chemical or biological treatments.

Biomass: material of biological origin excluding material embedded in geological formations and/ or fossilized. Examples: (whole or parts of) plants, trees, algae, marine organisms, microorganisms, animals etc.

Bioeconomy: the set of economic activities relating to the invention, development, production and use of biological products and processes.

Value chain: Understanding barriers among innovation seafood product actors means understanding their value chains. The term value chain describes the full range of activities which are required to bring a product or service from conception to life, through the different phases of production, delivery to final consumers, and final disposal after use. The value chain begins with the extraction or production of a raw material and the logistics to transport it to the first point of processing and continues with the intermediate product until the final product is reached, marketed, sold to the customer and serviced over its lifetime. The value chains could be also called "value added chains" reflecting the increase in value with each step applied. Thus, the value chain is integrated process scheme, from feedstock to end products and markets.

Innovation seafood end users: the end-users of innovative seafood products refer to the final consumers or individuals who directly utilize or consume these products. They encompass a diverse range of individuals and groups with varying preferences, dietary needs, and purchasing behaviours.

2.2. Key stakeholders

Stakeholders involved in the development, production, distribution, and consumption of innovative seafood products include:

Stakeholder	Description
Seafood Producers/Aquaculturists	Those involved in fishery management, aquaculture, and harvesting of seafood, including fishermen, aquaculture farmers, and seafood suppliers.

Food Manufacturers and Processors	Companies involved in processing, packaging, and manufacturing seafood products, applying innovative techniques to create value-added products.
Regulatory Bodies and Government Agencies	Entities responsible for setting food safety standards, regulations, and policies that impact the development and distribution of seafood products.
Retailers and Distributors	Supermarkets, grocery stores, wholesalers, and distributors involved in selling and distributing innovative seafood products to consumers.
Consumers	Those who purchase and consume seafood products, influencing demand and preferences for innovative products through their choices.
Restaurants and Food Service Providers	Chefs, restaurants, catering services, and foodservice establishments that incorporate innovative seafood dishes into their menus, often driving consumer trends.
Investors and Financial Institutions	Individuals or organizations providing funding, support, or investments for research, development, or commercialization of innovative seafood products.
Environmental and Conservation Groups	Organizations advocating for sustainable fishing practices, responsible aquaculture, and the conservation of marine ecosystems, influencing the direction of innovation towards sustainability.
Supply Chain Partners	Logistics companies, transportation providers, and other intermediaries involved in the efficient movement of seafood products from producers to consumers, impacting distribution and availability.
Scientific Community & Academia	Food scientists and researchers, all experts and individuals conducting research on seafood products, exploring new technologies, ingredients, and processes to create innovative seafood offerings. Innovators who are looking for the knowledge transfer, teaching facilitators and adapters of academic curricula.

Table 1 Key stakeholders

Collaboration and interaction among these stakeholders play a crucial role in shaping the development, adoption, and success of innovative seafood products in the market. Moreover,

the food scientists and researchers play the important role in the building trust and acceptance of the new products by users.

2.3. Role of key stakeholders in innovative seafood ecosystem

Each stakeholder occupies a dual position in the chain, both as a provider to each subsequent actor and as a client to each preceding one. The challenges posed in the interaction among them are, therefore, determined by both their initial identity and their contextual role in the chain.

- Seafood producers and aquaculturists are responsible for harvesting or farming seafood. In the context of innovation, they contribute by adopting sustainable practices, exploring new species or methods, and improving harvesting or farming techniques to ensure a consistent and quality supply of seafood.
- Food scientists and researchers are essential for advancing seafood innovation. They conduct research on new technologies, ingredients, preservation methods, and nutritional aspects of seafood. They develop new products, processes, and packaging techniques that improve quality, taste, safety, and sustainability.
- Food manufacturers and processors transform raw seafood into marketable products. In the innovative seafood ecosystem, manufacturers and processors implement cutting-edge techniques to create value-added products, explore alternative ingredients, and develop new processing methods that enhance taste, convenience, and health aspects.
- Regulatory bodies and government agencies establish guidelines, regulations, and standards for seafood production, safety, labeling, and sustainability. In the context of innovation, these entities encourage or enforce practices that drive sustainable innovation while ensuring consumer safety and fair trade.
- Retailers and distributors connect seafood products with consumers. In the innovative seafood ecosystem, retailers and distributors select, market, and sell innovative products, thereby influencing consumer choices. They also play a role in educating consumers about the benefits of innovative seafood.

- Consumers drive demand and preferences in the market. Their interest in sustainable, healthy, and novel seafood products influences producers, manufacturers, and retailers. Their feedback also shapes future innovations by indicating which products succeed or fail in meeting their expectations.
- Restaurants and food service providers introduce innovative seafood dishes to consumers, influencing trends and preferences. Restaurants and food service providers create demand for innovative seafood products by incorporating them into their menus and promoting them to customers.
- Investors and financial institutions provide funding and support for research, development, and commercialization of innovative seafood products. Their investments enable the growth of businesses engaged in seafood innovation, driving advancements in the industry.
- Environmental and conservation groups advocate for sustainable practices in seafood production. They influence stakeholders to adopt eco-friendly methods, reduce overfishing, promote responsible sourcing, and support conservation efforts in the seafood industry.

Collaboration among these stakeholders is beneficial for the successful development, promotion, and adoption of innovative seafood products while ensuring sustainability, quality, and consumer satisfaction within the ecosystem.

2.4. Defining the INNOAQUA end user

End-users of innovative seafood products may include:

- **Individual Consumers** - group comprises everyday consumers who purchase seafood products for personal consumption. They can vary widely in their preferences, tastes, dietary restrictions, and cultural backgrounds.

- **Families and Households** - families and households represent a significant consumer segment for seafood products. They often seek convenient, healthy, and appealing options, that cater to different family members' tastes and nutritional needs.
- **Restaurants and Food Service Establishments** - chefs, foodservice professionals, and restaurant owners utilize innovative seafood products to create diverse menus, offering unique dishes and experiences to their customers.
- **Catering Services** - companies providing catering services for events, parties, and gatherings may utilize innovative seafood products to offer distinct and memorable culinary experiences.
- **Health-Conscious Consumers** - individuals focused on health and wellness who seek seafood products for their nutritional benefits, such as omega-3 fatty acids and lean protein, prefer innovative products that align with their dietary goals.
- **Ethical and Sustainable Consumers** - those concerned about ethical sourcing, sustainability, and environmental impact are inclined to choose innovative seafood products that support responsible fishing practices, sustainable aquaculture, and reduced environmental footprint.
- **Specialty Food Enthusiasts** - consumers interested in unique or specialty food items often seek out innovative seafood products for their exotic flavors, premium quality, or unconventional characteristics.
- **Food Industry Professionals** - professionals in the food industry, including chefs, nutritionists, food bloggers, and influencers, may explore and promote innovative seafood products to their audiences, influencing trends and consumer preferences.

Understanding the diverse needs, preferences, and motivations of these end-users is crucial for seafood producers, marketers, and retailers to develop and market innovative seafood products effectively, ensuring they meet the demands of their target consumer segments.

3. Gap analysis through the optics of an end user

The purpose of this section is to provide an overview and qualitative analysis of some of the relevant literature that can inform the development of other aspects of Work Package 1 in the INNOAQUA project. The process and criteria for selecting the articles that have been reviewed is as follows. First, we used ChatGPT to find, summarize, and tentatively rank the relevance of articles. At this stage, we utilized several broad criteria. We then modified a spreadsheet that divided articles into narrower categories. However, we still had too many articles to include. We further delimited the list of articles by excluding those that were not related to Europe, not related to a protein source, and not related to a relevant consumer action such as accepting, buying, or liking new foods. Finally, after carefully reading the remaining articles, and exploring their bibliographies, we took a snowball approach to find additional articles that we may have missed. This led us to further exclude articles that were non-empirical or involved novel non-algae protein sources (such as insects).

We identified 29 articles that explicitly include empirical studies related to the acceptance, liking, or purchasing of novel algae or seaweed products by European consumers. Because research in this field is relatively new it is not surprising that there is no standard way to study these issues. We found that the 29 remaining articles were quite diverse and did not lend themselves to any obvious analytical categorization. In a separate work, we are coding these articles and will provide a quantitative analysis of their contents. The purpose of the literature review below is to provide a more qualitative description of these key articles. Because one of our reasons for this review within the wider strategy of INNOAQUA is to inform our own mixed methodology, we decided to organize our discussion of these articles around their methodological approaches. Broadly speaking, there are two types of methodological approach for data collection: questionnaire only (20 articles) and in-person mixed methodologies that sometimes include questionnaires (9 articles). These are the two main

headings below. Within these headings, there are a wide variety of analytical tools used to make sense of the data collected. These distinctions will be discussed as we go along. A concluding section will summarize some of the main themes that emerged from the literature review, with special attention paid to issues related to consumer motivation in relation to novel algae food sources.

3.1. Studies using only online or mail questionnaire methodologies for data collection

This section describes the methodologies and basic results of those studies that collected data only through the use of online or mail questionnaires. Sample size and representativeness varied greatly, as did theoretical framework and types of methods used to analyze the survey data. Most studies involved only one country, while a few included multiple European countries. In what follows, the studies are treated (approximately) in the order of methodological complexity beginning with those that used only descriptive statistics in their analysis and moving toward those that used more advanced analytical tools such as van Westendorp's Price Sensitivity Meter analysis, exploratory or confirmatory factor analysis, and structural equation modeling.

The oldest article in our sample was on "Motivational differences in food orientation and the choice of snacks made from lentils, locusts, seaweed or 'hybrid' meat" (De Boer et al., 2013), in which the authors utilized the "food choice motives" (FCM) questionnaire that they had developed in earlier work (De Boer et al., 2007). They surveyed 1,083 consumers in the Netherlands in order to discover correlations between motivational differences and snack choices related to the options listed in the title of their article. Their approach was based on a theoretical distinction between a promotion orientation and a prevention orientation which led to two components in the FCMs questionnaire: one that differentiates consumers in relation to their focus on varied or adventurous taste vs. preferring ordinary meals, and a second component that distinguishes consumers on the basis of their focus and reflection on wider issues related to food choice such as health, naturalness, ethics. Multinomial logistic

regression findings include the fact that adventurous taste and wider reflection orientation were associated with an increase in the chance of a consumer choosing a seaweed snack compared to hybrid meat. Fish consumers (but not meat consumers) were more likely to choose the seaweed-based snack. Higher level of education and living in an urban area also predicted choice of the seaweed snack.

A survey of 3,084 Spanish consumers was the basis of an article on "Consumer knowledge and attitudes towards microalgae as food: the case of Spain" (Lafarga et al., 2021). Their questionnaire aimed to assess knowledge and attitudes toward microalgae as a food source. The authors found a low level of knowledge in general in their sample, suggesting that it is relatively unknown to the majority of Spanish population. However, they also found that a large percentage of their sample considered the food source sustainable and environmentally friendly, nutritious and healthy, and safe. Reasons given for not consuming such products were primarily lack of available information and lack of habit. The study design included an "intervention" of sorts in which participants read a text that summarized positive elements of microalgae after providing their initial answers about their attitudes, and then were then asked to provide their answers again. Reading this text increased willingness to eat such products from 42.7% to 84.5%. After reading the text, willingness to pay an extra 30% for the product doubled and willingness to pay an extra 50% tripled.

The statistical analysis reported in "Attitudes of consumers toward Spirulina and acai and their use as a food ingredient" (B. F. Lucas et al., 2023) was based on a survey of 442 Swiss consumers. The questionnaire first asked about participants' knowledge of the microalga Spirulina. They were then provided with information about its sustainability, health benefits and sensory properties. Next, participants were asked whether this information would lead them to eat this kind of food regularly. Several types of products were then presented, along with questions about how likely it would be that they would make these products part of their regular menu. Sociographic data was collected at the end of the survey. Statistical analysis suggested that the information about the health and sustainability attributes of Spirulina had a greater influence on intention to consume than information about its sensory attributes. No significant difference between women and men was found in this study.

120 Swedish consumers composed the sample for the data analyzed in “Seaweed as food – attitudes and preferences among Swedish consumers. A pilot study” (Wendin & Undeland, 2020). Based on an online survey of these consumers, the authors found that most respondents were familiar with the possibility of seaweed being used in food and would consider eating seaweed. A majority also indicated that their reasons for intending to consume such foods included that it was “good for the environment,” or “tasty” and “healthy.” Statistical analysis found that young men were more positive than women to the idea of seaweed being included in snack products and fast food. Participants preferred that seaweed-based products be purchased in a food store but valued eating them at home or at a restaurant equally. Overall, the most preferred forms of seaweed-based foods were snacks, breads, and as ingredients in various dishes.

The authors of “A multi-national comparison of meat eaters’ attitudes and expectations for burgers containing beef, pea or algae protein” (Michel et al., 2021) used linear regression to analyze the results of their online survey of consumers from three countries: Germany (567), France (605), and the UK (562). Their main concern was to identify (and find correlations between) respondent’s opinions of algae burgers compared to beef burgers in relation to taste, health, and environmental friendliness as well as the role of factors such as meat commitment, neophobia, and attitude toward vegetarians and vegans. The biggest challenges to positive attitudes and expectations related to pea or algae-based products were negative taste expectations and negative attitudes toward meat-free diets. Overall, however, pea and algae-based burgers were seen as more favorable in relation both to personal health and to sustainability in the environment.

The only longitudinal sample in this literature review is found in a study on “Positive emotions explain increased intention to consume five types of alternative proteins” (Onwezen et al., 2022), based on two surveys in the Netherlands. This led to cross-sectional samples of those who answered the survey either in 2015 (n=2461) or 2019 (n=2000), and a longitudinal sample comprised of those who answered both (n=500). The survey measured personal norms, neophobia, innovativeness, food-choice motives, emotions, intention, and self-reported consumption. The most relevant driver for intention to consume was positive emotion (joy, contentment, pride). It appears that, for most respondents, focusing on the consumption of

alternative proteins feels good. The longitudinal sample revealed an increase in intention to consume seaweed among the participants. Statistical analysis showed that neophobia is significantly associated with the intention to consume seaweed, a finding that surprised the authors.

The only article in our sample that attended to adverse events and negative side effects eating seaweed-based foods was "Microalgal food supplements from the perspective of Polish consumers: patterns of use, adverse events, and beneficial effects" (Rzymski & Jaśkiewicz, 2017). This study focused on the characteristics and behavior of a group (n=150) of Polish consumers. Data was gathered using an online survey. The use of microalgal supplements (such as Spirulina) was most popular among those who were vegetarian or vegan and the reasons given for consuming such foods were mostly related to nutrition, immunity boosting, and detoxifying.

So far, the articles reviewed here have primarily used relatively simple descriptive statistical tools in their analysis. The remaining articles incorporate more complex analytical tools that attempt to tease out correlations among factors influencing consumer attitudes, motivations, perceptions, and behaviors related to novel algae foods.

In "Pasta goes green: consumer preferences for spirulina-enriched pasta in Italy" (Fantechi et al., 2023), the authors used an online survey of (n=362) Italian consumers to identify and differentiate among segments. The survey design included a discrete choice experiment, which enabled them to profile consumers using a chi-squared automatic interaction detection (CHAID) analysis. A large consumer segment was interested in and willing to pay more for spirulina-based pasta. The segment is characterized by younger, active, well-educated men open to trying new foods and eating healthily. Their analysis also revealed two latent classes, which they profiled in relation to factors such as gender, age, education level, neophobia, and type of diet.

A convenience sample (n=278) of Austrian consumers were the source of data for "Eating algae? Consumer perception of algae-based food in Austria" (Meixner et al., 2023). Like Fantechi, et al. (above), this online questionnaire utilized a discrete choice experiment as part of the survey design. In this case, however, they used Choice Based Conjoint Analysis (CBCA)

in order to discover the weighting of product attributes such as price, flavor, packaging, and production method. The most important attribute influencing consumer perception and willingness to pay for algae crackers was “production method,” followed by price, origin, packaging, and taste. Socio-demographic data was also gathered. Overall, respondents in this sample expressed more willingness to accept such products if they are produced regionally and organically, in which case they would be willing to pay a price premium.

Choice Based Conjoint Analysis was also used in “Preference and willingness to pay for meat substitutes based on micro-algae” (Weinrich & Elshiewy, 2019) to analyze the data from an online questionnaire filled out by respondents in three countries: Germany (315), the Netherlands (310) and France (315). This analysis showed that, across all three countries, acceptance of microalgae-based substitutes for meat products was driven primarily by consumer attitudes related to the unhealthy nature of meat consumption and the unethical nature of meat production. Consumers reported a preference for organic and local preparation of micro-algae substitutes. The authors also used exploratory factor analysis, which revealed seven latent factors (such as “dislike meat” and “meat habit”) describing consumer’s attitudes (positive and negative) toward meat and meat substitutes.

The study with the greatest number of European countries in this literature review (the Netherlands, Germany, Hungary, Spain and Italy) was “Consumers’ willingness-to-buy pasta with microalgae proteins – which label can promote sales?” (Van Der Stricht et al., 2023), with a total n=2880. The online survey reported in this article also utilized a discrete choice experiment. The questionnaire gathered information on respondents’ general health interest, food neophobia, environmental concern, and demographic factors. Participants indicated willingness to pay the most for pasta products with microalgae proteins if they had front-of-pack labels that indicated the product as organic, followed by labels that included a “Nutri-Score,” followed by labels that noted the product was vegan. These estimations were based on a random parameter logit model.

An online survey of Italian consumers (n=257) provided the data for the study reported in “The potential of edible seaweed within the western diet. A segmentation of Italian consumers” (Palmieri & Forleo, 2020). Using principal component analysis, the authors aimed

to identify and find correlations in their sample's attitudes toward, perceptions of, and willingness to consume edible seaweed. Participants were profiled in clusters based on various characteristics, which led to groups such as those emphasizing health and environmental aspects, those emphasizing sensory or other perceptions, and neophobia. Consumers consistently emphasized the health characteristics of edible seaweed, but its characteristics and availability were also important drivers for attitudes toward this novel food source. The authors concluded that information about the health and organoleptic characteristics of edible seaweed is particularly important in marketing strategies.

The same authors used factor analysis and binary logistic regression models analysis on the survey data from the sample of Italian consumers in "An exploratory study of key factors driving Italian consumers' willingness to eat edible seaweed" (Palmieri & Forleo, 2022). Their questionnaire had helped to identify consumers' (1) personal values and food choice traits, (2) perceptions of and attributes influencing willingness to eat seaweed, and (3) sociodemographic information. Their most general finding was that acceptance of edible seaweed seems primarily driven by the provision of more information about seaweed's organoleptic (sensory) and nutritional characteristics, as well as by its environmental impact and opportunities to access and eat it. Based on their factor analysis, the authors offer several concrete suggestions for strategies for marketing and promoting seaweed production and consumption.

Exploratory factor analysis was also used in "Consumers' attitudes towards sustainable protein sources: comparing seaweed, insects and jellyfish in Italy" (Palmieri et al., 2023), which utilized an online questionnaire of Italian consumers (n=1,043). Respondents were queried on topics related to willingness to try (WTT) these products, willingness to introduce them into their diet (WTD), perception of their impact on health and environment, attitude toward consumption in various gastronomic modalities, personality traits and socio-demographic characteristics. The study found that there was no significant gender effect for trying seaweed or including it in one's diet. However, 18–45 year olds were significantly more willing to try seaweed than 46-80 year olds.

The authors of "Beyond classical van Westendorp: Assessing price sensitivity for variants of algae-based meat substitutes" (Weinrich & Gassler, 2021) used a modified Price Sensitivity Meter (PSM) approach to estimate the price preferences for product innovations among a representative sample of German consumers (n=1,175). Offering choices among a wide variety of product concepts in an online questionnaire, the study found few differences in average price preferences. Product base (milk, pea, or egg) or share of algae in the product did not seem to be strong positive drivers of price perceptions. Similar to Weinrich and Elshiewy (2019), they found that it does not matter how much algae is in the product once consumers are already interested in accepting micro-algae into their diet. Males and younger respondents were more likely to purchase the various products presented in the survey.

Although several of the articles just reviewed hint at causal explanations of consumer preferences and motivations related to novel algae-based foods, they do not adopt complex analytical methods explicitly designed to gain insights that can lead to plausible claims about causality. Structural equation modeling (SEM) is one of the most well-known methodologies with this orientation. All of the remaining articles in this section include SEM as one of the tools in their mixed methodological approaches.

One of the few other representative samples in this literature appears in "Algae production technology: effect of framing on German consumer acceptance" (Weickert et al., 2021), which utilized an online survey to of German consumers (n=1,213) in order to study how consumers evaluate microalgae cultivation systems in light of various types of information such as the sustainable use of resources or environmental benefits. How does such framing influence consumer's acceptance of such technologies. The authors found that respondents showed no preference between "open" and "closed" cultivation systems, and providing information about the relevant technology did not affect acceptance. In addition to statistical analysis, the authors also developed a structural equation model (SEM) that revealed (among other things) that education, income, and sex had a significant influence on attitude toward algae as a food product. The main conclusion was that if consumers understand the process of food production, they are less likely to reject novel seaweed-based foods.

An online study of UK consumers (n=476) was the source of data for "Edible seaweeds as an alternative to animal-based proteins in the UK – identifying product beliefs and consumer

traits as drivers of consumer acceptability for macroalgae" (Embling et al., 2022). Participants were presented with a description of edible seaweed and a description of seaweed-based food products. They were also asked to rate their beliefs about attributes and report their acceptance in terms of liking, willingness to try, willingness to buy, and readiness to adopt such products as a meat alternative. Structural equation modeling confirmed the authors' hypothesis that positive beliefs about such products would be significantly associated with these aspects of acceptance. Food neophobia had a negative effect on consumer acceptance and this was mediated by perceiving foods to be tasty and familiar. Unlike some other studies, this analysis found that product beliefs related to cost, health, and sustainability of such products were poor predictors of acceptance.

The authors of "Exploration of seaweed consumption in Norway using the norm activation model: the moderator role of food innovativeness" (Govaerts & Olsen, 2022) utilized confirmatory factor analysis and structural equation modeling to test a series of hypothesized relationships about variables that would predict seaweed consumption. The study was based on data gathered in an online survey of Norwegian consumers (n=426). Their analysis was based on theoretical developments in the "norm activation framework," which assumes that intention and behavior are triggered by activation of a personal norm. The confirmatory factor analysis validated the reliability of the measurements and the SEM revealed that intention and food innovativeness were the strongest predictors of consumption of seaweed. The relation between intention and consumption was positively moderated by consumer food innovativeness. Moreover, both awareness of health consequences, and ascription of responsibility, were positively related to consumers' intention to eat edible seaweed.

Using the same representative sample of Norwegian consumers as the previous article, the same authors developed new hypotheses, tested in their more recent article on "Consumers' values, attitudes and behaviors towards consuming seaweed food products: the effects of perceived naturalness, uniqueness, and behavioral control" (Govaerts & Ottar Olsen, 2023). As in the previous article, the authors used confirmatory factor analysis and SEM to analyze their data. In this case, however, the hypotheses were framed in light of the value-attitude-behavior approach, which posits a hierarchical influence from abstract cognitions (values) to mid-range beliefs and attitudes and then to specific behaviors. Their main findings were that

attitude significantly affects seaweed product consumption and that "biospheric" values and beliefs related to the healthiness and naturalness of such products are the strongest predictors of positive attitudes toward consuming edible seaweed among Norwegian consumers.

A different Norwegian consumer panel (n=1,011) was used in "Microalgae-based food: purchase intentions and willingness to pay" (Maehle & Skjeret, 2022). Data was gathered using an online survey and analyzed using confirmatory factor analysis and SEM in order to find the determinants for consumers' behavior for microalgae-based food (bread and beer). Positive consumer attitude and purchase intension related to these foods was predicted by environmental concern and subjective norms (social norms related to the food). Willingness to pay for microalgae-based foods was highly significantly impacted by purchase intention, attitudes towards innovation in food, and subjective norms. The opinions of others played an important role in the acceptance of microalgae-based food. Unsurprisingly, the authors found that such foods appeal especially to environmentally concerned and innovative consumers. Surprisingly, however, they found that neophobia *positively* influences the attitude of consumers in this sample toward the food and indirectly influences purchase intentions.

3.2. Studies using in-person mixed methodologies for data collection

This section reviews the nine articles in our sample that utilize methodologies that include some sort of in-person (or, in one case, interactive "Zoom") engagement during the process of gathering data. The first five articles used relatively human-interaction methods (e.g., interviews, focus groups). These are described in order from least interactive with consumers to most interactive with consumers. The last four articles used methodologies that also included the actual consumption of novel algae- or seaweed-based foods. These are described in order from least to most complex methodology of data collection.

Sensory profiling and interviews with experts were used to gather data for an article on "Consumer-oriented product development: the conceptualization of novel food products based on Spirulina and resulting consumer expectations" (Grahl et al., 2018). Here the authors were interesting in measuring and analyzing consumer interest, liking, expectation, and

willingness to try Spirulina-based food products in a representative sample (n=1035) of consumers from Germany (348), France (337) and the Netherlands (350). The in-depth interviews with culinary experts (n=4) were used to inform the development of the online questionnaire, which presented respondents with an image of food products and queried their expectations about and willingness to try spirulina-based foods. The basic finding was that spirulina-based pasta was the most acceptable novel food in these countries (compared to sushi and jerky).

Qualitative methodologies extracting insights from experts were also used to inform an online survey design in "The determinants of the adoption intention of eco-friendly functional food in different market segments" (Moons et al., 2018). First, the authors conducted a workshop with experts (n=10) to determine lifestyle and behavior profiles of consumer segments that might be early adoptees of Spirulina-enhanced food and to identify their motives for adaptation. The discussion led to the identification of three target segments: sporting individuals, vegetarians, and foodies (who like the latest trends). An online survey of Belgian consumers (n=1325) was then developed to corroborate the findings of the workshop. Confirmatory factor analysis, a structural model, and multi-group analysis were used to study variations and significant differences in motivational structure. In all consumer segments, health consciousness and willingness to compromise on taste were positive and significant drivers of adoption intention.

These first two articles only personally engaged experts. Other studies, however, have also engaged consumers directly. The methodology behind "Seaweed consumption and label preferences in France" (Lucas et al., 2019) began with an online pre-survey (n=123) to determine first impression on seaweed consumption and in-person interviews with professionals in the seaweed sector to inform development of a broader survey. That survey involved in-person interviews with consumers in seven major French cities (n=825), which aimed to identify consumer diet patterns, level of current edible seaweed consumption, knowledge about seaweed, perception of seaweed attributes, label preference, and sociodemographic information. The authors used a multinomial probit model to analyze the determinants of attitudes toward, preferences for, and willingness to consume seaweed-based foods. Insights from the findings include younger people are more willing to consume Japanese seaweed products, having peers who consume seaweed influenced those willing to consume all kinds of seaweed products, and label preferences differed widely across consumer segments.

The authors of “A cross-country analysis of how food-related lifestyles impact consumers’ attitudes towards microalgae consumption” (Weinrich & Elshiewy, 2023), used focus group interviews in the three countries to develop items for an online survey that measured attitudes of representative samples of consumers (n=938) towards microalgae as food (Germany n=315, Netherlands n=308, France n=315). In addition to attitude toward microalgae, the questionnaire also measured food-related lifestyle and sociodemographic information. Using linear regression analysis, the authors discuss a wide variety of correlations and predictions related to factors such as lifestyle dimensions, attitudes toward advertising, interest in cooking, perception of women’s tasks, social relationships, age, gender, and education level. Most factors varied across the three countries, but in all of these Western European countries preference for organic food appears to be a general driver for positive attitudes toward microalgae as a novel food.

A different kind of focus group methodology was used in “Consumer knowledge and acceptance of ‘algae’ as a protein alternative: a UK-based qualitative study” (Mellor et al., 2022). In this case, the authors set up six focus groups using Zoom video technology to discuss consumer’s knowledge and level of acceptance of high-protein algae as a novel food. For consistency, the same group facilitator led each group. The sessions were semi-structured, first using warm-up questions, then discussing topics such as appeal of algae-based food, willingness to try and purchase, and opinions on product development and marketing. Next researchers used inductive theme analysis and coding to analyze the data from the Zoom group interviews and classify themes and sub-themes. The main themes that emerged were pre-existing ideas about algae, product attributes that influence acceptance, and interest in potential food products. Subthemes included novelty, edibility, healthiness, sustainability, and affordability. The overall conclusion of the authors was that this sample of UK consumers have relatively little knowledge about these novel foods and that providing more information about their health and sustainability benefits would be an important step in overcoming concerns about (expected) taste, processing methods, and lack of familiarity.

In none of the articles reviewed so far were consumers asked to actually *taste* novel algae-based or seaweed food products. The last four articles in our review utilize some strategy within their mixed methodologies that includes consumers (not just experts or chefs) tasting

and directly reporting on their levels of acceptance, preferences, and willingness to try or purchase such novel foods.

The authors of "Food or fad – challenges and opportunities for including seaweeds in a Nordic diet" (Chapman et al., 2015) took a four-step approach in their attempt to understand consumer perceptions related to the inclusion of seaweed in fish cakes. First, they executed a flavor descriptive analysis using a sensory panel of 15 judges recruited from project partners. Next, a panel of chefs (n=7), who were gathered for a seaweed cooking workshop, provided a quality control test based on the findings of the first panel. Third, the same chefs who made up the second panel held a later cooking workshop in which they prepared several dishes that included ingredients from different seaweed species, which were tested and awarded by a panel of 17 volunteers. Finally, the authors conducted a consumer test in which participants were asked to compare two fish cakes, one with and one without seaweed as an ingredient. Respondents then completed a questionnaire about their tasting experience. Descriptive analytical tools and principal component analyses were used to understand the data. One of the main conclusions was that the primary reasons for *not* adopting seaweed-based food in Norway is prejudice against changing traditional Nordic cuisines.

A multi-stage approach was also used in "Consumer perception and acceptability of microalgae based breadstick" (García-Segovia et al., 2020). In this case, the authors first developed a novel breadstick product that included microalgae as an ingredient. Then they set up a preliminary session of trained assessors (n=12) to generate a vocabulary about the sensory and emotional attributes of breadsticks with four levels of algae concentration. Finally, clients of a restaurant in Spain (n=85) voluntarily participated in a taste test of the breadsticks, responded to a CATA survey (with terms developed by the assessors) indicating their descriptions, sensations, and expectations related to this novel food, and finally filled out a food neophobia scale questionnaire. Cluster analysis, non-parametric Friedman analysis, Cochran's Q test, and penalty lift analysis were used to study the data. Over 75% of the consumers either maintained or increased their overall liking scores of the algae-based breadsticks after they ate them.

A similar procedure characterized the study reported in “Alternative protein sources in western diets: food product development and consumer acceptance of spirulina-filled pasta” (Grahl et al., 2020). The authors began by producing new forms of spirulina-filled pasta and developing a variety of taste mixtures. They conducted conventional sensory profiling using trained panelists (n=12), with the goal of selecting a descriptive vocabulary. A consumer test was then conducted to determine preferences for pasta-filling flavor and extrudate content among participants from Germany (n=139), the Netherlands (n=137) and France (n=144). Statistical analysis and linear mixed effects regression models were used to analyze the data. Across all countries, a lemon-basil flavor was more liked that a tomato and beet-ginger flavor. Neither gender nor age had a significant effect on liking, but age had a positive influence on expectation. In line with much other research, food neophobia had a negative effect on liking and familiarity had a positive effect on liking spirulina-based pasta.

Attendees at a cooking workshop in Spain that participated in a tasting experiment (n=50) were the source of the data for the analysis reported in “Neophobia and seaweed consumption: effects on consumer attitude and willingness to consume seaweed” (Losada-Lopez et al., 2021). Participants filled out a survey and sampled seaweed-based foods prepared by chefs. The experiment was designed to discover levels of confidence among participants in the healthiness of algae, influence of the credibility of chefs, and satisfaction with and willingness to purchase seaweed-based foods. Younger consumers and regular workshop attendees expressed more satisfaction with the dishes and more willingness to consume such products. Neophobia discouraged behaviors among consumers toward novel seaweed products, but did not significantly affect cognitive assessments (e.g., confidence about seaweed attributes and signaling credibility of chefs when offering seaweed products. The authors called for an approach that focused on less neophobic consumers when marketing highly innovative seaweed products, suggesting that more neophobic consumer segments would come along in time.

4. Gap analysis through the optics of value chain

The following work on the innovative seafood development presents a needed advancement of cross-sectoral value chains, which are destined for eventual integration within broader value networks.

4.1. Main barriers, value chains stakeholders concerned by the identified barriers and factors

PEDAL developed a structured document for the Gap Analysis through the optic of value chains which serves to:

1) present the relevant literature records;
2) identify barriers (gaps);
3) define value chains stakeholder concerned by the identified barriers;
4) describe the relation of the barriers to the factor such as: cultural, economic, environmental, governance, structural, technical or others factors.

Title	Source (publisher)	Link	Short Overview	Document Type	Year	Barrier name	Value chains stakeholder concerned by the mentioned barrier	Factor	Abstracts from the text about the barrier, value chains, stakeholders, and improvements related to the value chain

Figure 1 Structure of the document for the Gap Analysis through the optics of value chain

The cultivation of novel cross-sectoral, seafood value chains needs a collaborative and synergistic approach encompassing multiple sectors. This cooperative effort spans both within and across the value chains, uniting diverse stakeholders and mobilizing innovative endeavours, to stimulate market momentum through the introduction of cutting-edge products. However, the convergence of processes and stakeholders from previously disparate sectors poses a range of barriers that, in numerous instances, serve as impediments to the evolution of fresh value chains and the establishment of sustainable seafood business models.

The following list of barriers (Table 2) was selected as navigation for the literature review and were identified in the reviewed literature:

No	Barrier Name	Importance based on number of the appearances in the reviewed literature records (1 - Most frequently mentioned, 5 - less frequently mentioned)
1	Collaboration, networking, and knowledge exchange	1
2	Awareness and knowledge	1
3	Labelling, standards and certification	1
4	Knowledge about algae industry	2
5	Creation of supply chains	2
6	Knowledge, demand and trust	2
7	Cost	2
8	Communication and promotion	2
9	Strategies to support the algae industry in different countries	2
10	Quality of feedstock	2
11	Feedstock availability and sustainability	2
12	Acceptance and trust (safety and performance)	3
14	Legislation stability and harmonization	3
15	Funding, incentives and investments	3
16	Support to small industries	4
17	New business model	4
18	Functionality and performance	4

19	Processability	4
20	Prices	4
21	Innovation transfer	5
22	Life circle assessment	5
23	Motivation drivers	5
24	IP and Patent issues	5
25	Participation to the aquaculture agenda	5
26	Skilled work-force	5

Table 2 The list of barriers

These barriers can be systematically classified into distinct categories (Table 3) by value chains stakeholder concerned by the barrier and encompassing the following:

No	The value chains stakeholder concerned by the barrier	Importance based on number of the appearances in the reviewed literature records (1 - Most frequently mentioned, 5 - less frequently mentioned)
1	Industry and Clusters	1
2	Policy	1
3	Market (brand owners & retailers)	2
4	Feedstock Suppliers	2
5	Consumers (end users)	3

Table 3 The value chains stakeholder concerned by the barrier

Furthermore, within the intricate web of the value chain, each stakeholder category may simultaneously function as both a supplier and a client, thus confronting unique and context-specific barriers within each specific scenario and value chains stakeholder concerned by each specific barrier. The visualisation of this process is presented on the following figure:

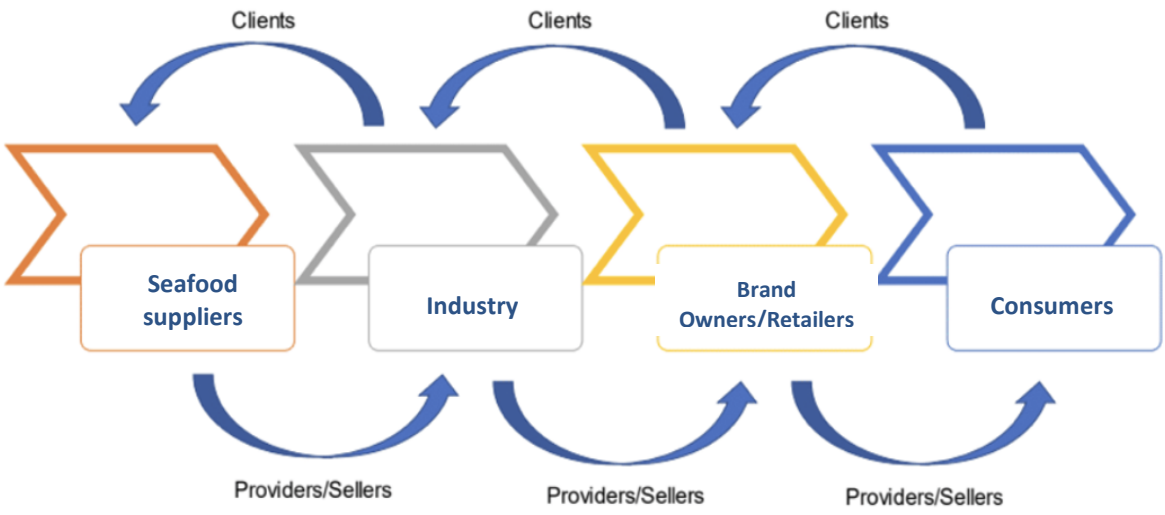


Figure 2 Value chain

During the literature review the identified barriers pointed us on the following external factors that may impact the value chain:

No	Factors	Importance based on number of the appearances in the reviewed literature records (1 - Most frequently mentioned, 5 - less frequently mentioned)
1	Governance	1
2	Environmental	1
3	Economic	1
4	Structural	2
5	Cultural	2
6	Technical	3

Table 4 External factors

4.2. Overview of the identified barriers and suggestions on enhancing collaboration

Further, we briefly present the key barriers that exist in the interaction between industry stakeholders, suppliers, brand owners and retailers from the cluster's point of view.

The intricate interplay among stakeholders within the value chain, compounded by a range of industry and market impediments, significantly influences the uptake of innovative seafood products and practices. This dynamic can also lead to the transfer of pre-existing barriers from

one segment of the chain to another. Given that each stakeholder occupies a dual role within the chain — both as a provider to subsequent actors and as a client to preceding ones — the barriers encountered are shaped by their initial identity (industry, brand owner, retailer) and their specific contextual position in the chain (provider or client).

INNOAQUA, as its central aim, strives to cultivate collaborative alliances spanning Seafood Industries, Brand Owners, and Consumer Representatives, with the primary objective of enhancing the market viability of sustainable seafood products. In pursuit of this goal, the project has chiefly pinpointed key barriers that appear to be common among all stakeholders in their intermediary interactions.

The following table enumerates the barriers confronted by each stakeholder type during their engagements with both subsequent and preceding actors within the value chain. These barriers have been identified through a comprehensive review of pertinent literature, analyses of reports, findings from relevant EU initiatives.

Stakeholder 1	Barrier	Indicative Recommendations
Industry and clusters	Barriers in collaboration with innovative seafood product suppliers: ● Collaboration, networking, and knowledge exchange; ● Creation of supply chains; ● Quality of feedstock; ● Feedstock availability and sustainability; ● Differences in prices per quantity per region ● High Transferability costs; ● Differences in the level of innovative seafood product sector development in EU;	● Optimize infrastructure for innovative seafood product manufacturing, storage and transportation; ● Training/Information activities in order to raise awareness of innovative seafood product, especially micro-algae and innovative seafood practices ● Financial incentives ● Update regulations ● Uniform standardization ● Clarification regards labelling and certification system

	• Lack of knowledge about innovative seafood product practices; • Lack of skilled work-force; • Difficulties in networking with relevant suppliers; • Lack of standardized labelling and certifications	
Industry and clusters	Barriers in collaboration with brands: • Lack of knowledge and trust; • Cost; • High prices; • Low market demand; • Lack of support to small industries; • IP and patent issues.	• Networking activities, events, working groups and development of digital platforms/tools/applications; • Co-creation activities and stakeholders' engagement to build new value chains; • Introduce financial incentives for the use of innovative seafood products and practices; • Apply innovative seafood product oriented; • Legislation measures and regulations; • Promotion of healthy protein and it consists products.
Stakeholder 2	**Barrier**	**Indicative Recommendations**
Market (brand owners&retailers)	Barriers in collaboration with industry: • Lack of standardized labelling and certifications; • Functionality and performance of innovative seafood product; • Connection with industry stakeholders.	• Improve innovative seafood product functionality, performance and characteristics; • Address existing barriers to meet the businesses and end user needs; • Open database of innovative seafood product and micro-algae, new

		protein, novel solutions and products which them can replace. ● Collaboration with industry to develop innovative seafood product; ● Uniform standardization, labelling and certifications.
	Barriers in interaction with consumers: ● Enhance acceptance of innovative seafood product; ● Communication of micro-algae safety, quality and benefits for the consumers and their health; ● High cost; ● Low demand.	● Develop the dissemination and provide updated information through the different communication channels and force innovative seafood product awareness with help of the most efficient marketing strategies; ● Develop a labeling system. ● Adjust the certification process.
Stakeholder 3	**Barrier**	**Indicative Recommendations**
Consumer	Barriers in interaction with brands: ● Lack of standardized labeling and certifications; ● Level of acceptance of innovative seafood product (micro algae) in terms of safety functionality, performance and characteristics; ● Lack of targeted promotion of innovative seafood product and its benefits.	● Develop a labeling and certification system; ● Provision of financial incentives or apply environmental regulations; ● Reinforce the dissemination and communication around the micro-algae; ● Promote innovative seafood product from the business point of view and how beneficial it is for end-users.

Table 5 The barriers confronted by each stakeholder type and recommendations

A roughly categorization of the actors that need to be involved:

Policy makers

Lack of standardized labeling and certifications, high transferability costs, differences in prices per quantity per region, IP and Patent issues, lack of knowledge about the innovative seafood products (products and practices, especially about micro algae) among potential suppliers, part of industry and businesses–differences in the level of innovative seafood sector development among EU Member States can be addressed through the involvement of policy makers.

There is a list of suggestions to be take: uniform standardization, labeling and certification system, apply innovative seafood products oriented legislation measures and regulations, optimize infrastructure for algae manufacturing, storage, transportation and decentralization, provision of financial incentives.

Collaboration among industry brand owners and retailers

Innovative seafood product functionality, performance and characteristics, difficulties in networking with other key stakeholders of the value chain, and absence of well targeted communication to consumers, can be addressed through the involvement of industry brand owners and retailers.

There is a list of relevant actions to be take: working groups, networking activities, events, focus groups, development of digital platforms, tools and applications, update communication and marketing strategies, improve innovative seafood products functionality, performance and characteristics by addressing existing technological barriers to meet the businesses' and end user needs.

5. Preliminary conclusions

5.1. Current state of innovative seafood products

The European algae industry is still at an early phase, lagging behind the overall increase seen at a global level, mostly driven by Asia.

It is worth considering that defined barriers requiring high level support to be addressed could be additionally approached by creating strong networks or communities of the interested parties aiming to cluster and having their interests represented in policy makers' decisions.

Moreover, the literature analysis shows that stakeholders from industry and business sector have allowed us to draw some assumptions as far as their preferences in terms of collaboration are concerned. The majority of the industry stakeholders need to improve collaboration and networking with brand owners and policy makers. Furthermore, the literature review led to the finding of information on the preferences of the representatives of brand owners and retailers, who would rather cooperate mostly with industry, research and end users, in order to elaborate on the development of innovative seafood product that will meet consumers' needs.

5.2. Desired state of innovative seafood products

The Farm to Fork Strategy of the European Green Deal has acknowledged the potential of algae to become an important source of alternative low-carbon footprint protein and contribute to improve the sustainability and competitiveness of the aquaculture sector.

The desired state of innovative seafood products could reflect following changes:

- Innovative seafood products sector is growing
- Digitally enhanced integrated fish and algae cultivation systems at a pre-commercial level
- Optimised processing techniques for future pilot projects
- Formulated high added value of innovative seafood products
- Optimized and increased economic and sustainability performance within waste minimisation and valorisation strategy
- Better understanding how consumer perceptions and social norms influence the consumption of innovative seafood products
- More engaged end users in co-creation of the innovative seafood products

- Increased knowledge and data base on how to adopt the existing innovative seafood products to the market with the high level of innovation acceptance
- Developed new markets and their acceptance of innovative seafood products
- Efficient international cooperation, networking and synergy for the knowledge transfer
- Increased level of awareness and knowledge about innovative seafood products (micro algae)
- Developed a labeling and certification system
- More funding and investments are attracted
- Clear environmental regulations
- Reinforced the dissemination and communication
- Formed new supply chains
- Higher demand and trust to the innovative seafood products from different stakeholders
- Well-functioned enabling ecosystem that allows to proceed with effective deployment of innovations and projects outcomes

5.3. Existing gaps in innovative seafood products and preliminary proposals to mitigate them

All findings in the literature stimulated the insights regarding existing gaps and allow at once to provide initial recommendations to mitigate these gaps.

In this respect, preliminarily identified topics that are relevant to all stakeholders and could form the content base of the foreseen project activities are:

- Labeling and certifications, IP and patent issues;
- Functionality, performance and characteristics of innovative seafood products;
- Networking and close cooperation with all the stakeholders in the value chain for the development of new value chains and innovative seafood products;

- Raising awareness and provide incentives to consumers, industry and business sector.

6. From Product To Market Co-Creation Methodology

6.1 Introduction

This guide is dedicated for practitioners developing novel, sustainable food products, and describes the From Product To Market Co-Creation (FPTM CC) methodology.

From Product To Market means that the guide focuses on a broad set of research activities that help novel food producers from developing the concept of the product, all the way to simulating the introduction of that product in a given market.

Co-Creation means that the proposed approach boosts stakeholder engagement, so that the final novel food products are developed according to and together with consumers. Involving end-users in the process of novel food development aims to tailor the foods to customer needs, which increases the probability of product acceptance, and eventually positively impacts the market share. Citizen, civil society, and end-user engagement is also one of the backbones of open science, and co-creation activities (alongside co-development and co-assessment) are important means to through which open science can be realized (see also FAIR in the box below). Co-creation here is understood as involving citizens or end-users directly in the development of new knowledge, often through user-led innovation.

Methodology means that the approach proposed here is grounded in scientific research. It is a set of individual methods implemented in a specific sequence, that feed information into one another. Figure 3 shows graphically what methods compose the FPTM CC methodology.

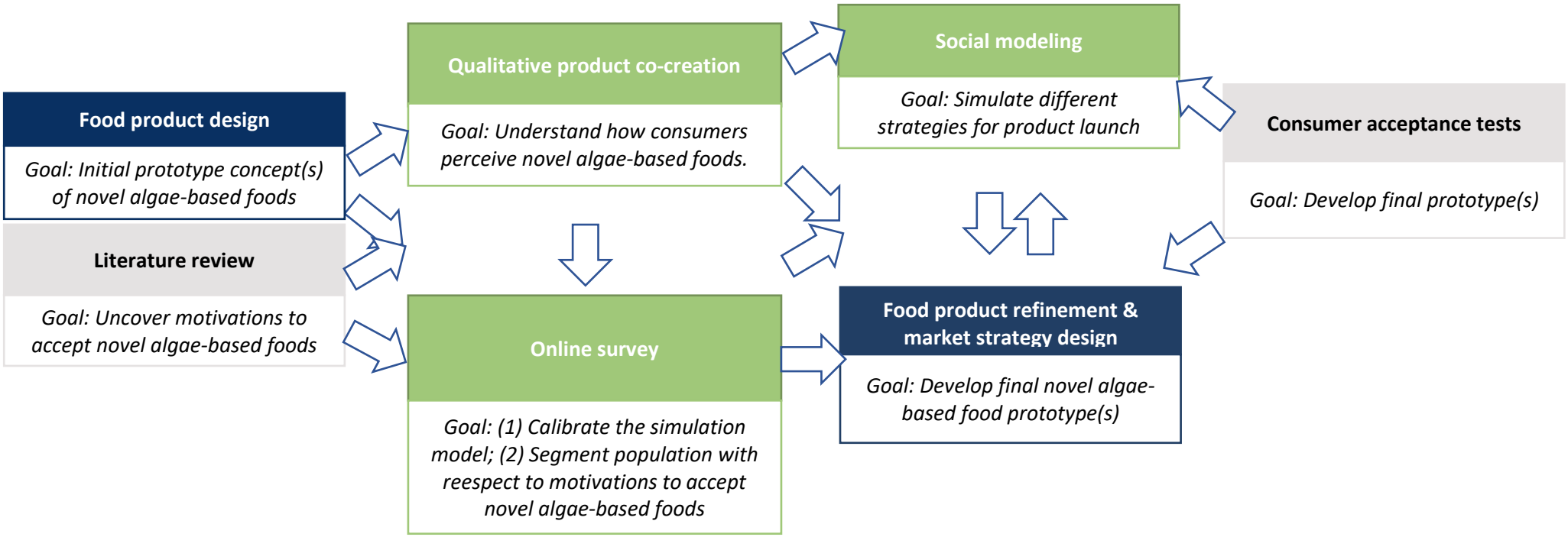
INNOAQUA project carried out an extensive, systematic literature review (left side of Figure 3) to identify motivations that drive and inhibit acceptance of novel algae-based food products. The results of the review will be openly published for anyone who would like to gain more understanding of drivers and barriers to make use of that knowledge. This was an

important investigation that allows us to develop further studies, but it does not have to be conducted every time the methodology is implemented. It is however advised to carry it out if the novel food product is not algae-based and there is a reasonable expectation that different motivations can significantly impact consumer decisions. What is necessary however, is the initial prototype food concept that can be further developed and refined throughout the process.

The main methods comprising the core of the FPTM CC methodological mix are: qualitative product co-creation (either individual in-depth or focus group interviews), a survey and social simulation. Each of these methods are further described with general information, goals of the study, typical process, resources required to implement the study, typical results and helpful literature in subsequent sections below. Additional consumer acceptance tests can (but do not have to) accompany the main methodological core.

It is important to highlight that, even though we will eventually provide the audience with all research tools used in this project to facilitate the ease of re-implementing FPTM CC, we strongly advise collaborating with experienced scientists that will help conduct the individual studies. It is especially important to make sure all future implementations adhere to ethical and data protection standard.

Figure 3: From Product To Market Co-Creation methodology.



Dark green field: initial prototype food concept is a mandatory prerequisite for the FPTM CC methodology. Grey field: additional empirical studies carried out in INNOAQUA, which does not have to be re-implemented every time the methodology is used. Light green fields: empirical studies of the FPTM C-C that inform the main outputs (blue field): the final algae-based food prototypes and the market strategy

INNOAQUA takes special attention to assure that science is open. This means that data produced in the project is as open as possible, and as closed as necessary and follows the FAIR guiding principles:

Findable:

- (Meta)data are assigned a globally unique and persistent identifier
- Data are described with rich metadata (defined by Reusable below)
- Metadata clearly and explicitly include the identifier of the data they describe
- (Meta)data are registered or indexed in a searchable resource

Accessible

- (Meta)data are retrievable by their identifier using a standardised communications protocol
  - The protocol is open, free, and universally implementable
  - The protocol allows for an authentication and authorisation procedure, where necessary
- Metadata are accessible, even when the data are no longer available

Interoperable

- data can be compared and combined with data from different sources by both humans and machines
- stored in a non-proprietary file format and described with a standard vocabulary (if available) – guidelines from the trusted repository

Reusable

- FAI + appropriate additional documentation

Source: https://www.go-fair.org/fair-principles/

6.2 Qualitative product co-creation

General information

The first part of the text describes what qualitative methods are in general. Subsequently, it will look closer into more specific approaches, specifically in-depth interviews and focus group interviews, as well as the Kelly repertory grid.

Qualitative methods typically consist of three major components: *data, coding* (conceptualizing, reducing, elaborating, and relating data), and *reporting* (Strauss & Corbin, 1998). These methods are often used to explore substantive areas about which little is known or about which much is known to gain novel understandings They can be used to investigate peoples' experience, perspectives, behaviors, emotions, and cultural phenomena. Qualitative methods differ from quantitative methods significantly, as researchers use the former to understand why or how certain phenomena take place. For example, why people are prone or reluctant to try novel algae-based foods, analyzing data wishes to discover and organize relationships and concepts (Strauss & Corbin, 1998). The strength of qualitative research, compared to quantitative research, is the ability to get more nuanced and detailed information about what people are doing and thinking (Strauss & Corbin, 1998). Even though qualitative data can be quantified, it is relatively rare. A good example of performing a quantitative analysis of qualitative data is a word cloud, where the size of a word reflects how often it was mentioned by study participants.

<u>In-depth Interviews</u>

When we talk about in-depth interviews (IDIs) we usually talk about *semi-structured interviews* (Bryman, 2016), where the researcher uses an **IDI protocol** (also called a guide): a list of topics and/or questions keeping the conversation between the interviewer and the interviewee to the point. The interviewee can ask follow-up questions that are not in the protocol and answer questions in a different order than planned. This differentiates semi-structured interviews from fully-structured interviews, (where question order or content deviations from the protocol are strongly discouraged) and from unstructured interviews (which do not have a strict protocol, or even a protocol at all). Importantly, in semi-structured

interviews all questions from the protocol (with the same wording to all participants) should be asked at one point of the conversation (Bryman, 2016).

When choosing between the different forms of in-depth interviews, it is good to keep in mind their different strengths. Semi-structured interviews ensure a higher degree of comparability between interviews with different participants and addressing all research questions of interest (Bryman, 2016). On the other hand, allowing a freer discussion gives a better chance of accessing what participants perceive as interesting or important (Bryman, 2016). Regardless of the form, IDIs should be recorded to enable subsequent coding and analyzing data.

Focus group interviews

In focus group interviews (FGIs, also called focus group discussions (FGDs)), a group of participants converse about relevant open-ended questions. FGIs often can take place in workshop settings, where interviewees are given specific tasks to do and comment on their experiences. Depending on the purpose and context of the study, FGIs can be carried out in several groups. For example, one FGI can be implemented with younger participants, another one with a middle-aged group, and the last one with older interviewees. Similarly to IDIs, the discussion can range from little to full structure, with more structured approaches popular if content from different groups is later compared. For analysis, FGIs should also be recorded and transcribed. In contrast to IDIs, FGIs allow for a joint production of meaning among participants (Bryman, 2016).

Kelly repertory grid

The Kelly repertory grid is one of the structured techniques to collect data during an interview (usually in-depth but focus group is also possible). It uses participant's own language to identify meaningful constructs and record them in the form of a grid. The constructs can give food producers useful insight to better understand how consumers perceive products, to

further help tailoring food products and marketing strategies to the targeted market's needs and desires (Van Kleef et al., 2005).

Goal

The goal of using qualitative interviews that include the structured Kelly repertory grid in the From Product To Market Co-Creation methodology is to understand how consumers perceive concepts of novel algae-based foods.

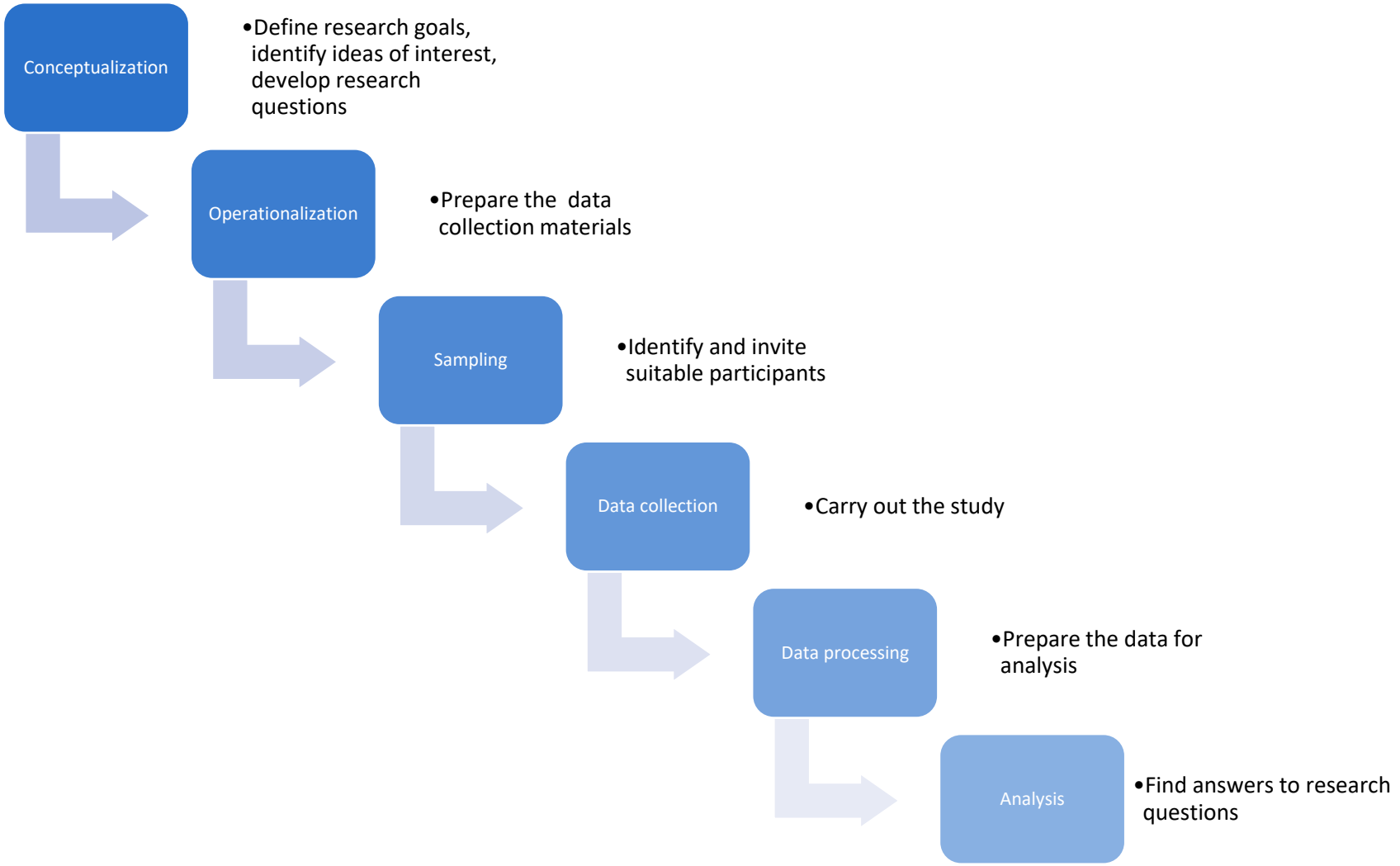
Examples of research questions:

- How do interviewees perceive novel algae-based food products?
- What are the important dimensions with respect to which algae-based foods differ from non-algae-based foods?
- What motives, opportunities, and abilities affect consumers' willingness to buy novel algae-based food products?
- (If the study is implemented in multiple groups/countries) Do motives opportunities and abilities differ among participants coming from different countries/representing different cultural backgrounds?
- What motivation profiles are present among the respondents/participants?
- (If the study is implemented in multiple groups/countries) Do motivational profiles differ among participants coming from different countries/representing different cultural backgrounds?

Typical process

Different aspects of a typical process of carrying out an IDI/FGI is described below, highlighting elements common to IDIs and FGIs. The description follows typical phases of a research process in social scientific studies (Figure 4).

Figure 4 Phases of a research process in social scientific studies



Good and detailed conceptualization of a study determines decisions that are made later in the implementations process. For FPTM CC, the goals for each method, and consequently the role of that method in the broader research design, are pre-defined and outlined in this document. Conceptualization will also influence how many and what type of (groups of) participants will be needed to answer the research questions.

Conceptualization is followed by operationalization, which for IDIs/FGIs means developing the interview protocols and any other data collection materials that will be needed during the interaction with participants. It is important to be aware on how flexible the interview should be regarding follow-up questions, and how the questions can guide the participants answers, eventually affecting the data from the interviews.

Good advice is to:

- **avoid preconceptions** (avoid guiding the participants' answers) and **keep questions open**.
- **plan the order of topics** in a logical manner, so the interview is closer to a natural conversation and flows well.
- **Formulate individual within the topics** with the research questions in mind. The structure of the interview should revolve around your research goals (Bryman, 2016).
- Use natural language that is easy to understand by the participants and **avoid asking leading** questions.

When identifying who to invite to participate in the study it is a good practice to keep metadata about the participant, which can be useful to contextualize the answers they give and can subsequently be used in analysis (e.g., name, age, gender, position in company, years of experience etc.; Bryman, 2016). Consider **the number of participants**. The number of participants can depend on when theoretical saturation is reached - a situation where each new participant does not provide any more information. In IDIs, this can typically be anywhere between 10 and 30 interviewees. In FGIs, typically four to ten groups with between 4-8 participants in each group. Having too many groups can limit the research by taking too much time both in the interviewing process and the analysis. It is also important to consider **the selection of participants**, who are the appropriate to include in your research. When sending

the invitation to participants, it is a god practice to introduce them to the goals of the study and inform them about their role as interviewees.

At the stage of actual data collection, it is important to introduce yourself, repeat the goal of the study, and collect consent from participants to record the interview. The transcription of the recording will serve as the material for analysis. At the end of the interview, thank the participants again and explain what will happen to the data (Bryman, 2016). Remember to collect metadata about the interview: who conducted it, when/where it took place, how long it lasted, what was the source of funding.

Data preparation precedes analysis. Keep in mind that data should be anonymized to prevent identification of participants. Data is fully prepared for analysis after is had been coded, for which various computer-assisted qualitative data analysis pieces of software (CAQDA) can be used. Typically, the coding structure follows the interview protocol, however other coding structures and analytical methods that fit the research questions can be used to uncover information.

Resources needed to carry out the study

Uninterrupted, neutral space to conduct IDIs/FGIs that allows for recording the interviews.

- Recording device (+ extra one for safety)
- IDI/FGI protocol
- Triads of food products
- Empty grid to record
- Pen and paper and other materials needed for the Kelly repertory grid

Typically, 1-2 hours

IDI:

- Typically, 10-30 (can be more depending on research question)

FGI:

- 4-10 groups of 4-8 participants

Typical results

From the in-depth- and focus group interviews typical results will be noted down thoughts and impressions from the interviewer, audio recordings, and transcriptions of these recordings. Dependent on how you analyze these data you can end up with different results with qualitative or quantitative analysis; results from qualitative research often presenting data with words, and quantitative research often presenting data with numbers (Bryman, 2016). Strauss and Corbin (1998) also point out that even though we might get new insights and answers to our questions, we can also discover how complex the world actually is, thereby ending up with even more questions (Strauss & Corbin, 1998).

The Kelly repertory grid typically produces constructs depicting how consumers perceive and conceptually organize food products. The strength of the approach is having the consumers' self-articulated descriptions (Busse & Siebert, 2018), which can help in marketing of these food products by referring to consumer needs and values (Van Kleef et al., 2005).

Additional resources:

Qualitative methods:

Strauss, A. L., & Corbin, J. M. (1998). Basics of qualitative research: Techniques and procedures for developing grounded theory (2nd ed). Sage Publications.

Bryman, A. (2016). Social Research Methods. Oxford University Press.

Kelly repertory grid:

Bech-Larsen, T., & Nielsen, N. A. (1999). A comparison of ®ve elicitation techniques for elicitation of attributes of low involvement products. Journal of Economic Psychology.

Busse, M., & Siebert, R. (2018). The role of consumers in food innovation processes. European Journal of Innovation Management, 21(1), 20–43. https://doi.org/10.1108/EJIM-03-2017-0023

Pires, M. A., Rodrigues, I., Barros, J. C., & Trindade, M. A. (2021). Kelly's repertory grid method applied to develop sensory terms for consumer characterization (check-all-that-

apply) of omega-3 enriched bologna sausages with reduced sodium content. European Food Research and Technology, 247(1), 285–293. https://doi.org/10.1007/s00217-020-03598-6

Thomson, D. M. H., & McEwan, J. A. (1988). An application of the repertory grid method to investigate consumer perceptions of foods. Appetite, 10(3), 181–193. https://doi.org/10.1016/0195-6663(88)90011-6

Van Kleef, E., Van Trijp, H. C. M., & Luning, P. (2005). Consumer research in the early stages of new product development: A critical review of methods and techniques. Food Quality and Preference, 16(3), 181–201. https://doi.org/10.1016/j.foodqual.2004.05.012

6.3 Online survey

General information

A survey is a quantitative interview aiming to collect data on a specific topic from a defined group of people. Depending on the specific type of collecting data, surveys can take different forms, for example a Pen-and-Paper Personal Interview (PAPI), Computer-Assisted Personal Interview (CAPI), Computer-Assisted Telephone Interview (CAWI) or an auditorium survey (where you collect information from multiple respondents simultaneously). Computer-assisted web interviewing (CAWI) is one method involving the distribution of a link to an online survey via email or other platforms. This method eliminates the need for an interviewer, making it efficient and cost-effective. The advantage of in-person or telephone-based methods is that the interviewer can provide better explanations, leading to a more robust agreement on the interpretation of questions. However, this approach necessitates a trained interviewer. The advantage of computer-based methods to pen-and-paper interviews (PAPI) is that all results are quickly ready for statistical analysis, ensuring thoroughness and validity. Through a **statistically representative** survey, researchers can collect data from a randomly selected sample of respondents and infer properties of the entire population with a certain degree of precision.

While online surveys offer many advantages, they also present challenges. A general challenge for all online surveys is statistical representativeness. In many surveys a link is either present on a website or sent by email, which leads to a selection bias, as only certain, non-randomly selected respondents, can come across the survey link. The online distribution platform also systematically and unproportionally excludes individuals without access to the Internet. On top, due to a high number of surveys and a high degree of respondent fatigue, research results can be significantly skewed by a self-selection bias - certain groups of respondents are underrepresented as an effect of participating in filling in the surveys. If the sample is randomly selected, self-selection bias can be mitigated analytically through weighing. To make this possible, survey questions must include relevant socio-demographic characteristics.

Goal

In the FPTM CC methodology, the online survey is crucial for calibrating social modeling and segmenting a population of interest based on their motivations for accepting novel algae-based foods. The survey is not merely a quantitative tool for data collection, but rather a method to quantify insights from previous research (summarized in the literature review) and qualitative product co-creation (IDIs/FGIs).

Examples of research questions:

- How important are various motives for accepting/not-accepting novel algae-based foods in a population of interest?
- What segments of consumers can be distinguished based on their motivational profiles?
- How are motivational profiles related to socio-demographic characteristics of consumers?
- (if survey carried out in multiple countries) How do the above differ in national markets of interest?

Typical process

The process of conducting online surveys follows a specific sequence. At the conceptualization stage research goals are formulated, ideas of interest of interest are defined and research questions are developed. In the case of FPTM CC, motives from the literature review and qualitative co-creation feed into the survey questionnaire developed at the stage of operationalization. Likewise, the aim of the agent-based model should be precise, as the survey data provides input to the social simulations. Additionally, the novel algae-based food product concepts are the core thematic focus of the questionnaire. The survey questions are crafted by experts in the field, ensuring validity and reliability of the indicators. It is a good practice to pre-test the survey on a small sample and develop a data analysis plan.

When choosing a suitable sample, it is worth considering collaborating with an expert organization that is responsible for data collection. Various enterprises have established online panels that represent the target population and can be used for random selection of the final sample. When determining the sample size, it is important to consider how precise

the population estimations should be (more precise estimations require larger sample sizes) and what is a typical response rate (what is the percentage of respondents that will complete the survey).

The fieldwork company typically is also responsible for creating the survey in an online form, sending the survey link to respondents, and following up with respondents to maximize response rates. It is also a good practice that a pilot study on a small sample is carried out to assure the quality of the online survey implementation.

Preparing data for analyses requires a careful check of data quality, typically assuring logical consistency between answers, identifying unusual response profiles, assuring appropriate coding of responses and analytical weighting. A dataset can be prepared either in a non-proprietary file format (e.g., *.csv) or a format dedicated to a specific analytical software. The data is subsequently analyzed following the analytical plan developed earlier.

Resources needed to carry out the study

- sampling frame
- online platform hosting the survey
- population data providing reference values for weights

- survey questionnaire

- filling in a survey typically takes max. 15 minutes

- experienced researcher developing the study
- (optional) enterprise responsible for fieldwork
- experienced quantitative data analyst
- analytical software

Typical results

In a representative study, results from survey use inferential statistics either to estimate the value of an indicator in a population based on the survey answers from a studied sample or test a hypothesis about the research population.

In the first instance, results typically include descriptive statistics that summarize the collected data and answer simple research questions, including suitable central tendency measures (e.g., mean, median, mode) and dispersion measures (e.g., range, standard deviation, variance). For example, what is the mean acceptance level of a novel algae-based food product in the German population? Distributions of answers for individual survey questions are also often provided.

In the second instance, various data analysis techniques are used to test the existence of statistically significant relationships between various indicators, answering questions such as: what socio-demographic characteristics influence the acceptance level of novel algae-food products? What segments of algae-based foods consumers can be distinguished depending on their motivational profiles? The results are often visualized in the forms of diagrams or tables.

Additional resources

Norman M. Bradburn, B., Seymour Sudman, S., & Brian Wansink, W. (2015). Asking questions: the definitive guide to questionnaire design - for market research, political polls, and social and health questionnaires (Rev. ed.). Jossey-Bass.

Lohr, S. L. (2021). *Sampling: design and analysis*. Chapman and Hall/CRC

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gesis.org. (2024). Gesis EU-SILC Metadata. Retrieved May 6, 2024, from https://www.gesis.org/ 247en/missy/metadata/EU-SILC/

6.4 Social modeling

General information

Agent-based modeling (ABM) is a computational social modeling technique used in a variety of disciplines to simulate the behavior of individual agents within a system and observe the emergent properties that arise from their interactions. In such models, “agents” can be any kind of autonomous entity with predefined behaviors, rules, and decision-making processes. When ABM is used in social science, these agents usually represent individuals, organizations, or other entities within a social (or socio-ecological) system.

The participatory approach to ABM typically involves actively engaging stakeholders or participants in the development and use of such models. Unlike traditional modeling approaches where researchers develop models based on their own understanding of a social system, participatory ABM modeling invites stakeholders and change agents to contribute their knowledge, perspectives, and insights to co-create and validate the model. This approach is often used in fields such as community planning, natural resource management, and public policy.

Goal

The goal of an ABM in the INNOAQUA project is to represent a realistic population of consumers and to simulate a launch of a novel algae-based food product with the ultimate goal of finding strategies that would maximize the uptake. This will enable stakeholders to check how different segments of the market will accept the novel food under different what-if scenarios.

The inputs for the INNOAQUA model will be:

- Input from the online survey: calibrating models to cases of countries (e.g. a different structure of the population with respect to how important are various motives to accept novel algae-based foods, and how attractive these are as a source of nutrition).
- Input from interviews and other qualitative methods as described in the previous section.

- Input from qualitative product co-creation workshops to inform rules for actions/decisions of agents under various what-if scenarios (e.g., what if a food was cheaper).

The outputs of the model are intended to inform the development of a final product concept. The dependent variable for the model is likely to be something like "positive consumer attitudes," and the goal is to discover which other agent variables (e.g., gender, personality, age, etc.) and interactions (e.g., learning from someone else about algae-based foods, trying such foods, etc.) that are driving positive consumer attitudes (or behaviors) up or down.

Examples of research questions:

Here is an example of the sort of research question that might guide the development of the INNOAQUA agent-based model: Under what conditions – and by what mechanisms – do positive attitudes toward trying and purchasing novel algae-based foods increase or decrease in a population?

Typical process

Ideally, stakeholders (who may include policymakers, community members, experts, and other relevant parties) should be involved from the start of the modeling process. Their input is solicited to identify the key issues, goals, and factors influencing the real-world social system being modeled. Collaboration may involve workshops, interviews, focus groups, or other participatory methods to elicit stakeholders' knowledge about the system, define agent behaviors, specify rules, and design scenarios. The participation of stakeholders in validating the model helps to ensure its accuracy, relevance, and credibility. The iterative process of reviewing the model structure, assumptions, and parameters and providing feedback on its performance helps refine the model and increases stakeholders' confidence in its results.

Once the model is developed and validated, stakeholders can use it to explore various scenarios and policy options, simulating the effects of different interventions, strategies, or decisions on the social system and assessing their potential impacts. In this way, the ABM model serves as a decision support tool for stakeholders, helping them make informed decisions and understand the complexities of the system. The participatory approach to ABM promotes transparency, inclusivity, and empowerment by involving stakeholders in all stages

of the modeling process. It enhances the relevance and applicability of such models to real-world problems and fosters collaboration between researchers and stakeholders. Moreover, it can lead to more effective solutions and policies that are grounded in local knowledge and context.

Resources needed to carry out the study

An ideal starting point for participatory modeling is a face-to-face workshop involving stakeholders and computer modelers. Our tentative plan is to have such a workshop with a core team at the June meeting of the INNOAQUA teams. In addition to a general introduction, this workshop will discuss relevant agents (e.g., buyers, sellers, developers), variables (e.g., attitudes, personality factors, gender), and parameters (e.g., economic stress, price, social norm shifts). The computer scientists will provide agent-based modeling skills. The other participants are subject-matter experts so only need to come with an open attitude and a willingness to have their knowledge extracted by the moderator of the workshop. Later workshops can be on Zoom, and will be focused on clarifying the agent variables and causal architecture, proposing simulation experiments that can inform product development, and eventually discussing the implications of simulation experiments.

Unrestricted physical space (e.g., a meeting room) of at least 30 m^2

- workshop protocol
- whiteboard
- set of colorful markers

1.5 hours

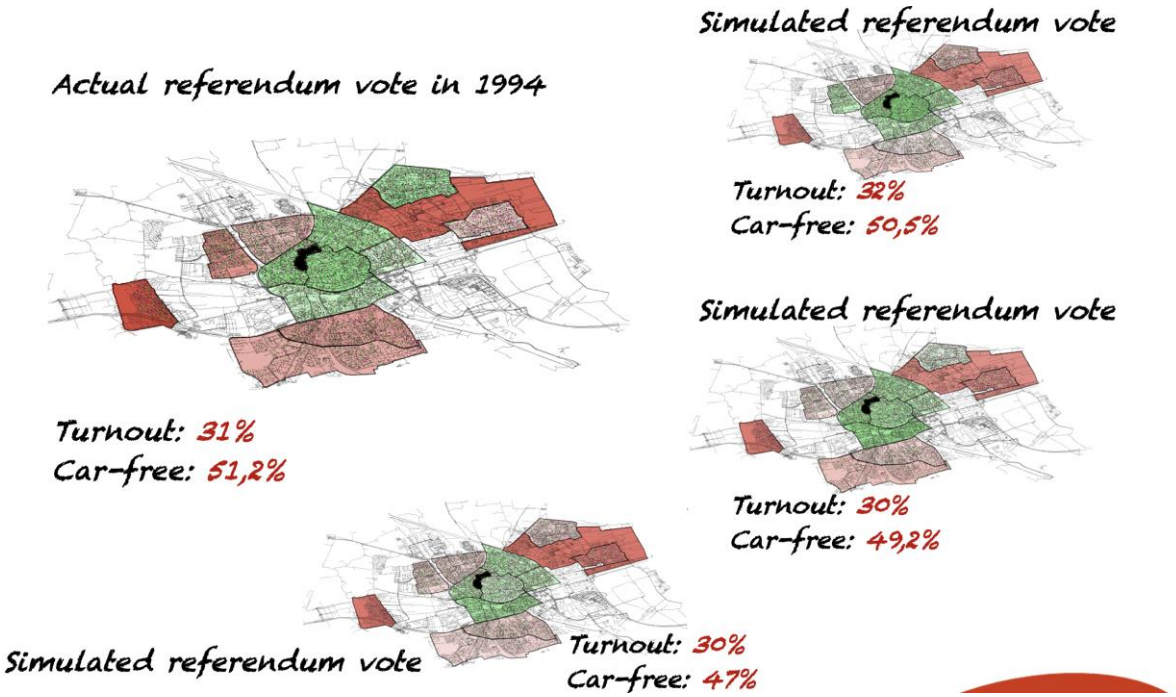
+ 20 minutes room preparation

moderator + 4-8 participants

Typical results

After the production of an ABM, stakeholders can expect outputs that illustrate the outcomes of various simulations run on the model. Because there is stochasticity in each model run, large scale simulations are needed to validate the model and see how sensitive it is to changes

in main assumptions and parameter values. Below is an example of an output from an ABM that was used to study the factors at work in a referendum in the town of Groningen, The Netherlands, on acceptance of a car-free park near the center of the city.



It is not yet clear what the results will look like for the INNOAQUA model. This will emerge out of the conversations among stakeholders during the various workshops.

Additional resources

Ahrweiler, P. (2017). Agent-based simulation for science, technology, and innovation policy. *Scientometrics*, *110*(1), 391–415. https://doi.org/10.1007/s11192-016-2105-0

Epstein, J. (2006). *Generative Social Science: Studies in Agent-Based Computational Modeling*. Princeton University Press.

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- Small-scale fisheries markets: value chain, promotion and labelling, European Parliament - Directorate-General for internal policies - Policy Department B: Structural and cohesion policies - Fisheries - Research for PECH Committee

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- All presentations from the workshop on food 2030. Research and innovation tomorrows nutrition and food systems, 2016: https://research-and-innovation.ec.europa.eu/events/upcoming-events/food-2030-research-and-innovation-tomorrows-nutrition-and-food-systems-2016-10-12_en
- Deliverable: D7.1 inventory of the Stakeholders and Stakeholders' needs, European Commission. SUCCESS project: Strategic Use of Competitiveness towards Consolidating the Economic Sustainability of the European Seafood sector: https://cordis.europa.eu/project/id/635188/results
- Fishery Value Chain. United Nations Development Programme: https://www.undp.org/yemen/erry-jp/publications/fishery-value-chain
- The Philippines' Seafood Sector - A Value Chain Analysis. Arie Pieter van Duijn, Rik Beukers, Willem van der Pijl: https://www.fao.org/sustainable-food-value-chains/library/details/en/c/270941/

- BLOCKCHAIN APPLICATION IN SEAFOOD VALUE CHAINS FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS: https://www.fao.org/3/ca8751en/ca8751en.pdf
- Value chain of fish and fishery products: origin, functions and application in developed and developing country markets, De Silva, D.: www.fao.org/fileadmin/user_upload/fisheries/docs/De_Silva_report_with_summary_.doc
- Processed seafood and mariculture value chain analysis and upgrading strategy International Labour Organisation, Myanmar http://ilo.ch/wcmsp5/groups/public/---ed_emp/---emp_ent/documents/publication/wcms_553135.pdf
- Developing sustainable value chains for aquatic products. Food and Agriculture Organization of the United Nations: https://www.fao.org/fileadmin/user_upload/FISH4ACP/documents/FISH4ACP_VCAD_Methodological_Brief_vSept2021.pdf
- Resilience of Agricultural Value Chains in Developing Country Contexts: A Framework and Assessment Approach. Marketlinks Team: https://www.marketlinks.org/resources/resilience-agricultural-value-chains-developing-country-contexts-framework-and-assessment
- Assessment of the Commercial Seafood Chain in Lebanon. Dario Pinello and Samir Majdalani:http://www.agriculture.gov.lb/getattachment/3446e66a-1147-457b-a75f-08a5ca6b97a3/Assessment-of-the-Commercial-Seafood-Chain-in-Lebanon
- Blue Economy Promoting resource-efficient and circular production practices in Morocco's fish processing value chain. European Commission: http://switch-blue.ma/en/home/
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- Recent developments in the production and utilization of photosynthetic microorganisms for food applications, Heliyon: https://www.sciencedirect.com/science/article/pii/S2405844023019151
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Annex 1 Literature list for the Gap analysis through the optic of value chain

Instruction: Please, fill in all the relevant information about innovative seafood industry that can be applicable for further work on INNOAQUA project. Resources may include the following information: literature, past and ongoing projects which you work on or you know relevant partners who work on it, recent surveys, trends reviews or any other relevant information.

Resource No	Title	Source/Author	Short overview: short description and key words	Who added information (Name and organisation)	Contact	Link to the resourse	Is it relevant?
1	The SUCCESS project	H2020-EU.3.2. - SOCIETAL CHALLENGES - Foo	SUCCESS is bringing together an integrated t	PEDAL	Yuliya Kharchenko	https://cordis.europa.eu/project/id/635188	Not relevant
2	Deliverable: D2.2Results on consumer prefer	H2020-EU.3.2. - SOCIETAL CHALLENGES - Foo	Form other food products we know that cons	PEDAL	Yuliya Kharchenko	https://cordis.europa.eu/project/id/635188	Not relevant
3	Deliverable: D7.1Inventory of the Stakeholde	H2020-EU.3.2. - SOCIETAL CHALLENGES - Foo	The objective of this report is to present the	PEDAL	Yuliya Kharchenko	https://cordis.europa.eu/project/id/635188	Not relevant
4	EU research and innovation drivingsustainab	European Commission	A thematic collection of innovative EU-funde	PEDAL	Yuliya Kharchenko	http://publications.europa.eu/resource/cella	Not relevant
5	FOOD 2030:Innovative EU research ensures f	European Commission	Overview of Horizon 2020 research program	PEDAL	Yuliya Kharchenko	http://publications.europa.eu/resource/cella	Not relevant
6	Deliverable: D9.3Reports on preferred sustai	European Commission. SUCCESS project: Stra	The outcomes from the various stakeholder c	PEDAL	Yuliya Kharchenko	https://cordis.europa.eu/project/id/635188/	Value chain
7	Small-scale fisheries markets: value chain, p	Josupeit, H. (2016).	AbstractThe revised Common Market Organi	PEDAL	Yuliya Kharchenko	https://www.europarl.europa.eu/RegData/et	Value chain
8	Aquatic food products and new marine value	European Commission	the principal objective of the workshop was t	PEDAL	Yuliya Kharchenko	https://research-and-innovation.ec.europa.e	Value chain
9	Deliverable: D7.1Inventory of the Stakeholde	European Commission. SUCCESS project: Stra	As part of the Dissemination activity (WP7),	PEDAL	Yuliya Kharchenko	https://cordis.europa.eu/project/id/635188/	Value chain
10	Value Chain Analysis in the Fisheries Sector	Erik Hempel	The Trade Working Group ofthe Partnership	PEDAL	Yuliya Kharchenko	https://studylib.net/doc/7796537/value-cha	Value chain
11	The Fishery Value Chain Analysis in Taiwan	Center for Marine Affairs Studies, National K	Keywords: fishery; industrial value chain; inp	PEDAL	Yuliya Kharchenko	https://www.mdpi.com/2410-3888/7/3/114	Value chain
12	Fishery Value Chain	United Nations Development Programme	A market study with potential COVID-19 imp	PEDAL	Yuliya Kharchenko	https://www.undp.org/yemen/eny-jp/public	Value chain
13	The Philippines' Seafood Sector - A Value Cha	Arie Pieter van Duijn, Rik Beukers, Willem va	This research explores the Philippines' seafo	PEDAL	Yuliya Kharchenko	https://www.fao.org/sustainable-food-value-	Value chain
14	BLOCKCHAIN APPLICATION IN SEAFOOD VAL	FOOD AND AGRICULTURE ORGANIZATION O	This publication will contribute to equipping	PEDAL	Yuliya Kharchenko	https://www.fao.org/3/ca8751en/ca8751en.	Value chain
15	Value chain of fish and fishery products: orig	De Silva, D.	Value chain analysis describes the activities	PEDAL	Yuliya Kharchenko	www.fao.org/fileadmin/user_upload/fisherie	Value chain
16	Processed seafood and mariculture value ch	International Labour Organisation, Myanmar	In November 2016, a value chain analysis tea	PEDAL	Yuliya Kharchenko	http://ilo.ch/wcmsp5/groups/public/---ed_e	Value chain
17	Developing sustainable value chains for aqu	Food and Agriculture Organization of the Uni	A methodological brief for analysis and desig	PEDAL	Yuliya Kharchenko	https://www.fao.org/fileadmin/user_upload/	Value chain
18	Resilience of Agricultural Value Chains in De	Marketlinks Team	This paper synthesizes knowledge from the s	PEDAL	Yuliya Kharchenko	https://www.marketlinks.org/resources/resil	Value chain
19	Assessment of the Commercial Seafood Cha	Dario Pinello and Samir Majdalani	This report includes s a number of recommen	PEDAL	Yuliya Kharchenko	http://www.agriculture.gov.lb/getattachment	Value chain
20	Blue EconomyPromoting resource-efficient a	European Commission, SWITCHMED	Under the SwitchMed Blue Economy compon	PEDAL	Yuliya Kharchenko	http://switch-blue.ma/en/home/	Value chain
21	Project PROFUTURE	European Commission. PROFUTURE	ProFuture is a European-funded research pro	PEDAL	Yuliya Kharchenko	https://pro-future.eu	Not relevant
22	Project iFishIENCI	European Commission. iFishIENCI	iFishIENCI is an EU Horizon 2020 project brin	PEDAL	Yuliya Kharchenko	https://ifishienci.eu	Not relevant
	From value chains to food webs: The quest fo	Trends in Food Science & Technology, Knorr, D., Augustin, M.A.		PEDAL	Yuliya Kharchenko	https://www.sciencedirect.com/science/arti	Value chain
	Recent developments in the production and u	Heliyon		PEDAL	Yuliya Kharchenko	https://www.sciencedirect.com/science/arti	Value chain

Annex 2 INNOAQUA value chain collaboration challenges model