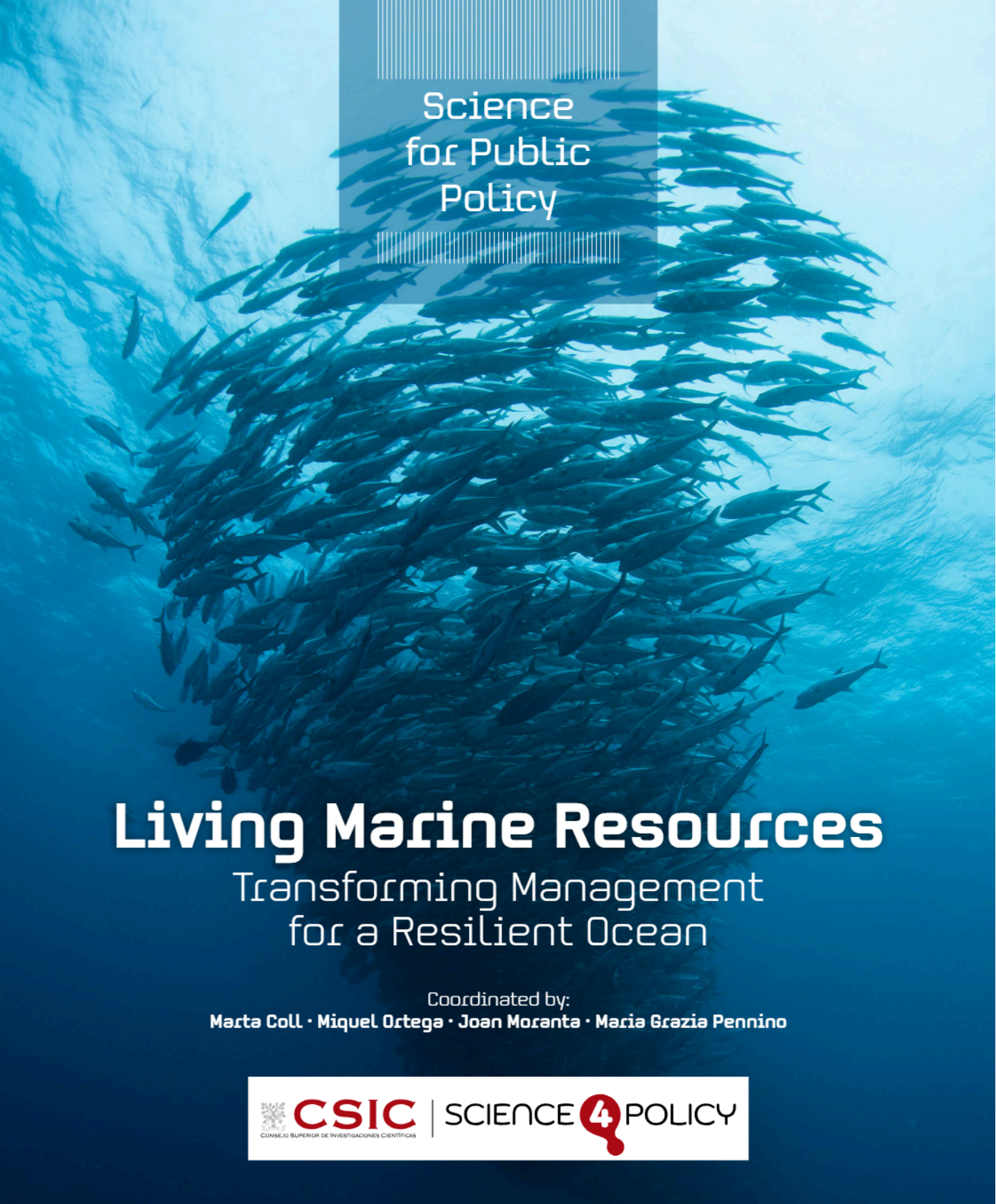




Science
for Public
Policy

Living Marine Resources

Transforming Management
for a Resilient Ocean

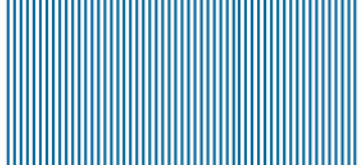
Coordinated by:

Marta Coll • Miquel Ortega • Joan Moranta • Maria Grazia Pennino



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Science for Public Policy



Knowledge Transfer
Report



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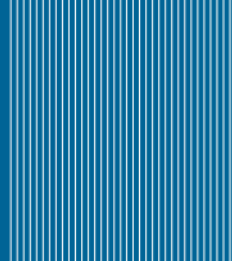
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ONE of the CSIC's functions is to inform, assist and advise public and private entities on science and technology, as stated in article 5 of its Articles of Association. As part of this function, the report *Living Marine Resources. Transforming Management for a Resilient Ocean*, from the Science for Public Policy collection, is presented as a document aimed at public administrations and society in general. It sets out the major challenges for seafood provision which should contribute to healthy, affordable and efficient diet, while ensuring the conservation of harvested resources and the health of the socio-ecological system. This system must maximise its contribution to the Sustainable Development Goals and recognise that it is part of a food system embedded within planetary boundaries. This requires transforming seafood management and integrating it resiliently into a changing ecosystem, promoting food chains and habits compatible with ecological limits and environmental conditions, and favouring a fair distribution of the benefits and income generated throughout the seafood value chain. This report highlights results achieved and necessary scientific developments, emphasising the role that the CSIC plays in this great challenge.

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MARIA GRAZIA PENNINO

one



The Marine Food System

1.1.

Introduction: the importance of marine ecosystems for society

MARINE ecosystems are key to the functioning of the Earth system. Their uses are the basis for the growing blue economy and form a central element of our societies.

In spite of their vast size, marine ecosystems are greatly affected by human activities and natural phenomena of anthropogenic origin. The increase in pollutant emissions, especially those that accelerate climate change; the dumping of synthetic components into the soils, atmosphere, and water; changes in the management of land and marine spaces; land urbanisation processes; the transformation of the coastline; overexploitation and the alteration of biogeochemical cycles (such as the carbon and nitrogen cycle); among many other aspects, have generated multiple impacts on the entire planet, a process known as global change.

The impact of this global change on the marine environment translates into loss of biodiversity; changes in the distribution, abundance, production, and physiology of species; destruction of the ecosystems that protect the coast; and increased levels of water pollution, among other phenomena. These transformations inevitably imply economic, social, and cultural consequences.

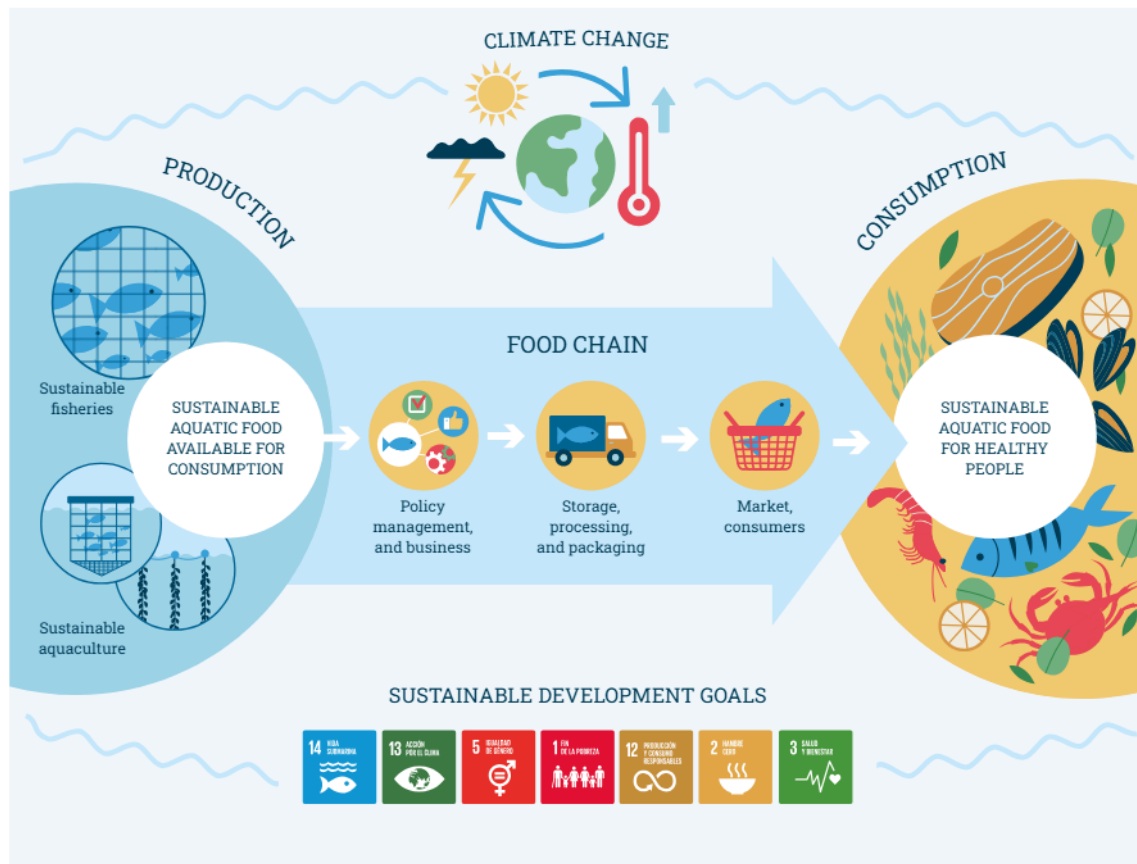
It is therefore necessary to urgently promote improvements in policies linked to the exploitation, conservation, and recovery of resources on a global scale and, in particular, in the marine environment. These improvements must be able to guarantee a good environmental status and the present and future supply of the multiple benefits that marine ecosystems provide.

One of the main environmental services provided by marine ecosystems is the provision of food through the activity of the fisheries sector (which includes fishing and aquaculture). Fishing refers to the capture of aquatic organisms in their natural environment (mainly fish, molluscs, and crustaceans) through the use of various techniques. Aquaculture focuses on the breeding, cultivation, and harvesting of aquatic organisms under controlled or semi-controlled conditions (mainly fish, molluscs, crustaceans, and aquatic plants). For this purpose, ponds, cages, tanks, and other similar systems are used, both in the marine and inland areas. This activity not only provides us with food, but also brings many other social benefits: it stabilises the coastal population, generates employment and wealth throughout the production and consumption chain, and is the basis of a great cultural and identity-related wealth.

However, like any other economic activity, it must be developed in an appropriate manner. The United Nations, within the framework of the 2030 Agenda, stresses the importance of ensuring that the food system is based on sustainable production, i.e., that it makes efficient use of resources, helps to maintain ecosystems in good condition and adapts to climate change. Furthermore, it must be carried out without discrimination of any kind—particularly on the basis of gender—and through quality employment. Finally, the ultimate aim of the food system must be to achieve healthy, nutritious, sufficient, and affordable food. To achieve these objectives, among other mechanisms proposed, it emphasises the need to eradicate practices that contribute to overexploitation and waste, climate change and other adverse environmental impacts.

In the field of fisheries and aquaculture, these recommendations imply maintaining the level of production and fishing within a context of good health of the fishery resource and the ecosystem in which commercial species live. This requires fair socio-economic exploitation to ensure year-round access to healthy and culturally appropriate seafood for all.

Figure 1 Conceptual overview of future aquatic food systems and their contribution to key SDGs (PREPARED BY THE UNITED NATIONS OCEAN DECADE PROJECT, CLIMEFOOD)

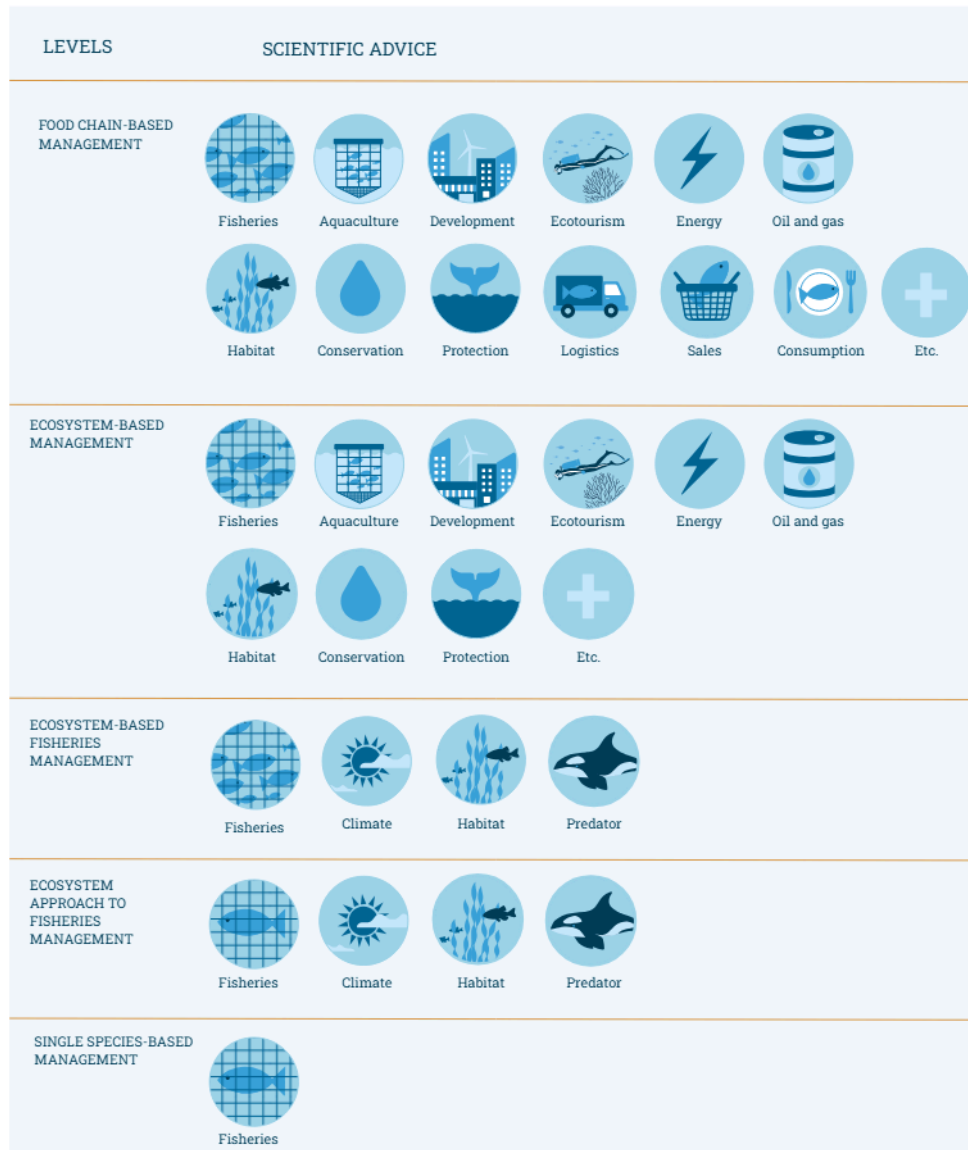


Source: <https://unesdoc.unesco.org/ark:/48223/pf0000390117>

However, the current state of the fisheries system is far from this idea. There is therefore broad agreement on the need for a blue transition based on a *One Health* approach. That is, changes need to be made in human activities associated with the provision of seafood in order to ensure human and environmental health together, on the premise that one is not separate from the other. This approach, applied to food production, requires simultaneously achieving healthier food patterns, reducing the environmental impacts associated with food provision, adapting food provision to climate change, and providing a fair distribution of the income and wealth generated.

But how much and what kind of aquatic products should be consumed? How should fishing, aquaculture, and the distribution of seafood be done to ensure planetary health and the fair distribution of the resources generated? What practices should be promoted and which should be avoided? These are necessary questions to solve the environment-health-society trilemma, the answer to which is still largely unknown and needs more research, more public debate and more political attention.

In view of the great challenges facing the supply of aquatic food-stuffs, it is urgent to broaden the focus to consider a more sustainable activity in comprehensive terms that takes into account the ecosystem in which it is developed. In this sense, management bodies such as the Food and Agriculture Organisation of the United Nations (FAO) speak of fisheries management based on an ecosystem context that includes commercial species and their physical, ecological, and socio-economic environment. This management represents an important step forward compared to the original concept of management of marine fishery resources, which focused solely on exploited species.

Figure 2 Methods for marine ecosystem analysis and management

Source: adapted from NOAA Fisheries.

Sustainable fisheries and aquaculture management requires the implementation of effective regulations, the adoption of responsible practices and the integration of ecosystem approaches to minimise negative impacts and ensure the long-term viability of the activity and the societies that depend on it. This, in turn, requires development of the food chain elements. The food chain includes the set of activities and processes that transform marine resources, such as fish, shellfish, and seaweed, from extraction to final consumption. It is composed of multiple stages: capture or farming (aquaculture), processing, distribution, marketing, and consumption. Each stage adds value to the product through improvements in quality, presentation, food safety, and compliance with standards and regulations. In addition, the food chain may involve ancillary services such as transport, storage, and logistics, as well as research and development activities to innovate and improve the sustainability and efficiency of production, distribution, and marketing. Efficient and sustainable management of this food chain is crucial to maximise the economic, social, and environmental benefits derived from marine resources and to improve their distribution. Finally, this management must also account for elements that affect what is consumed as well as focusing on understanding what is produced. All of this is necessary to move towards resilient oceans and thus guarantee food safety and nutritional quality in the face of climate and global change.



In this context, basic and applied sciences are fundamental as a driving force for the generation of knowledge. Science must generate the necessary information, on a multi-disciplinary and interdisciplinary basis, on the dynamics of marine resources and the ecosystems where these resources are found, and on the effects and impacts of the changes to which they are subject, as well as on the socio-economic implications derived from possible management scenarios. Science also plays an essential role as a source of reliable information to develop sustainable management strategies based on solutions that take into account all stakeholders. This scientific knowledge is vital to improve the management of the exploitation and use of marine resources: management based on scientific evidence that takes into account the complexity of the marine socio-ecological system and its intrinsic and extrinsic characteristics.

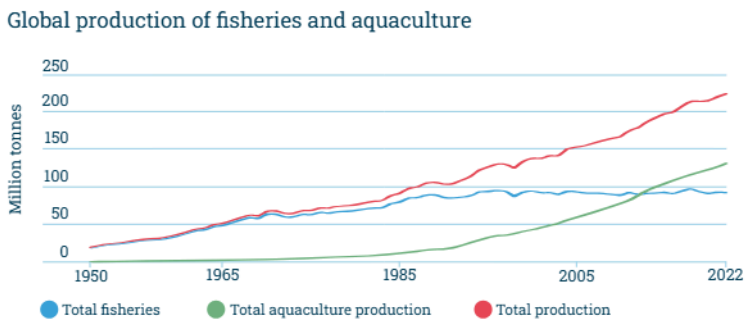
This report seeks to answer three interconnected questions that focus on understanding the necessary elements and existing constraints to achieve sustainable management of the supply of living or renewable marine resources. These three questions are structured around three fundamental issues related to an environmentally sustainable and socio-economically equitable production, food chain, and consumption of marine products.

1.2.

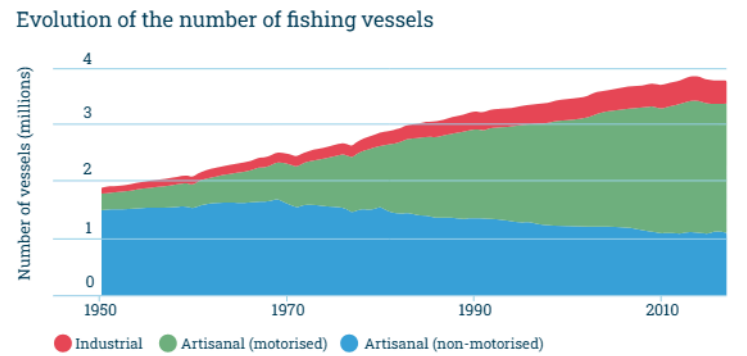
Fishery extraction and production: How much and how?

IN 2022, a total of 223.2 million tonnes of seafood was extracted or produced, of which 185.4 million tonnes were animal products and 37.8 million tonnes were seaweed. Of the total, 89% was for human consumption.

Figure 3 Global state of fisheries and aquaculture



Source: FAO 2024



Source: Rousseau et al., 2024

Source: FAO 2024

Own creation based on MAPA data

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In parallel, aquaculture has experienced significant and continued growth globally, becoming a crucial source of food and livelihoods. In 2022, aquaculture surpassed marine animal harvesting in global terms for the first time.

However, aquaculture also faces significant environmental and management challenges, including degradation of aquatic habitats, pollution from waste and chemicals, the spread of diseases to wild organisms, and pressure on other marine species (e.g., small pelagic fish such as sardines and anchovies) for feed production. As in fisheries, efforts are being actively pursued to reduce these problems by, among other measures, incorporating aquaculture into integrated production systems, improving diets to reduce the intensity in the use of animal feed and a reduction in the use of pharmaceuticals, water eutrophication (i.e., excessive increase in nutrients) or carbon footprint.



ADOBE STOCK

In the case of Spain, the total amount of marine product obtained, with small fluctuations, has remained stable over the last twenty years, with a clearly predominant role of fishing over aquaculture.

Fishing in Spain is highly dependent on external resources. Access to fishing quotas in third countries, i.e., in waters outside Spanish jurisdiction, is achieved through a large international fleet and a complex web of different types of agreements.

Current fisheries management is based, in most cases, on a combination of regulations and approaches that aim to ensure the sustainability of exploited stocks and to guarantee that the fishing catch is around the maximum sustainable yield.



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The actions most frequently carried out include setting technical measures on fishing gear, imposing catch quotas and controlling fishing effort, establishing minimum sizes of commercialised species, implementing time-area fishing bans and, to a lesser extent, creating fishing restriction zones. This management, mostly based on the status of target or commercial species, is based on assessments of individual species and has been effective in several cases, but has failed in many others. Among the latter are the cases of North Atlantic cod, of the Peruvian anchoveta or the sardine of northern Benguela. The negative ecological effects of the depletion of these three cases were very noticeable: the populations of these species suffered an exponential decline in the face of the proliferation of other organisms with less commercial value. The socio-economic effects were also intense. The causes of depletion include excessive fishing intensity combined with abrupt environmental and ecological changes.

Figure 4 Origin of catches by Spanish vessels and aquaculture production

CATCH AREAS AND AQUACULTURE PRODUCTION IN SPAIN	CATCH TYPOLOGY AND PRODUCTION				
	 Algae and aquatic plants	 Molluscs	 Crustaceans	 Fish	 Others
AQUACULTURE PRODUCTION	23	227,975	378	73,370	
NORTH-EASTERN ATLANTIC	3,016	28,013	4,330	222,291	
WESTERN INDIAN				153,958	
SOUTH-WEST ATLANTIC				114,855	
CENTRAL-EASTERN ATLANTIC		938	4,558	85,458	
MEDITERRANEAN		4,487	5,627	51,211	12
SOUTH-EAST ATLANTIC		29,612	1,586	17,835	
EASTERN-CENTRAL PACIFIC				26,529	
SOUTH-EASTERN PACIFIC				19,172	
NORTH-WESTERN ATLANTIC		1		18,653	
SOUTH-WEST PACIFIC				8,284	

Weight in tonnes. Data for 2022.

Own creation based on MAPA data.

From an ecological point of view, there are internal and external factors that are central to the successful management of fishery resources. These include environmental factors, the distribution and dynamics of essential habitats, and the trophic interactions between the species inhabiting an ecosystem (and that integrate complex ecological networks).

Ecosystem-based fisheries management has become popular as a necessary evolution in the process of managing renewable marine resources. This approach is based on several key principles. First, it considers the dynamics of multiple species and their relationships within the ecosystem, rather than focusing solely on a single species. It also takes into account ecological interactions, including predation, competition, and the effects of non-target species, as well as abiotic factors such as temperature, water quality and habitat. This approach seeks to maintain the health and resilience of marine ecosystems as a whole, promoting the long-term sustainability of both fisheries and the ecosystems that support them.

It also advocates the use of a precautionary approach to manage uncertainty and reduce risks to ecosystems. In addition, it recognises and takes into account the impacts of human activities, both fishing and other non-fishing interventions, and proposes the use of an adaptive approach that allows for adjustments in management strategies based on continuous monitoring and new scientific information.

Implementing ecosystem-based fisheries management includes conducting assessments that integrate data on multiple species, their habitats and human impacts on them, and applying ecological modelling and spatial analysis to simulate and predict the effects of different management strategies on the ecosystem. Implementation requires the creation and management of marine protected areas to safeguard key habitats and high-biodiversity areas (such as vulnerable marine ecosystems), which provide refuges for sensitive species, such as coral communities or macroalgal forests. It also involves developing measures



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to reduce by-catch and discards, thereby protecting non-target species, and provides for the establishment of robust monitoring systems to assess the state of ecosystems and the effectiveness of management measures.

Finally, it requires the involvement of fishermen, local communities, scientists and other stakeholders in the decision-making process to ensure acceptance of and compliance with management measures, as well as the implementation of an adequate governance system that includes information, monitoring, adaptation, and control, and acceptable benefit-sharing by the entire fishing community.

The main benefit of ecosystem-based fisheries management is an improvement in the long-term sustainability of fisheries and marine ecosystems, ensuring that fishery resources are available for future generations. Another advantage of this management model is that it minimises the negative impacts of fishing activities on non-target species and marine habitats, helping to protect and conserve biodiversity, and maximising the contribution to the Sustainable Development Goals.



MIGUEL POZO



The principles of ecosystem-based fisheries management are the basis of the agendas of international reference initiatives such as the Food and Agriculture Organisation of the United Nations (FAO) and regional bodies. In general, this strategy is progressively being adopted at a global level, with a number of countries and international bodies acknowledging its importance. In regions such as North America, Europe, and Oceania, significant progress has been made by including ecosystem assessments in fisheries management plans and using advanced tools such as ecosystem modelling. For example, the United States and Canada have implemented some of these principles in their fisheries policies, while the European Union has included them in its Common Fisheries Policy. Australia and New Zealand are also notable for their efforts in this area.

However, the implementation of ecosystem-based fisheries management faces several challenges. The lack of resources and capacity in many countries, coupled with the need for comprehensive data on marine ecosystems and the complexity of ecological interactions, make effective implementation difficult. In addition, coordination between multiple sectors and governments is essential, but is often complicated due to institutional fragmentation and disconnection between different levels of management. This is compounded by the difficulty of any change with different rates of implementation in a globalised context.



In Spain, ecosystem-based fisheries management has evolved in line with EU regulations and policies. Principles of environmental and economic sustainability have been adopted in the management of the fishing industry, reflecting a growing commitment to the conservation of marine ecosystems and the rational use of resources. This approach has resulted in the implementation of stricter regulatory measures. However, the development of management strategies, accepted by the different parties involved, that take into account not only the target fish stocks, but also ecological interactions and environmental impacts, is still very limited. In many fisheries, important challenges remain, such as effective control and enforcement of fishing regulations, reduction of non-selective fishing, and adaptation to climate change. In the Mediterranean region, especially, the situation is very delicate, with a very high percentage of overexploited commercial species or with very low biomass compared to historical references. This precarious environmental state has a strong impact on the current socio-economic system.

13.

Marketing and processing: stakeholders, policies, and good practices to promote the fair distribution of resources

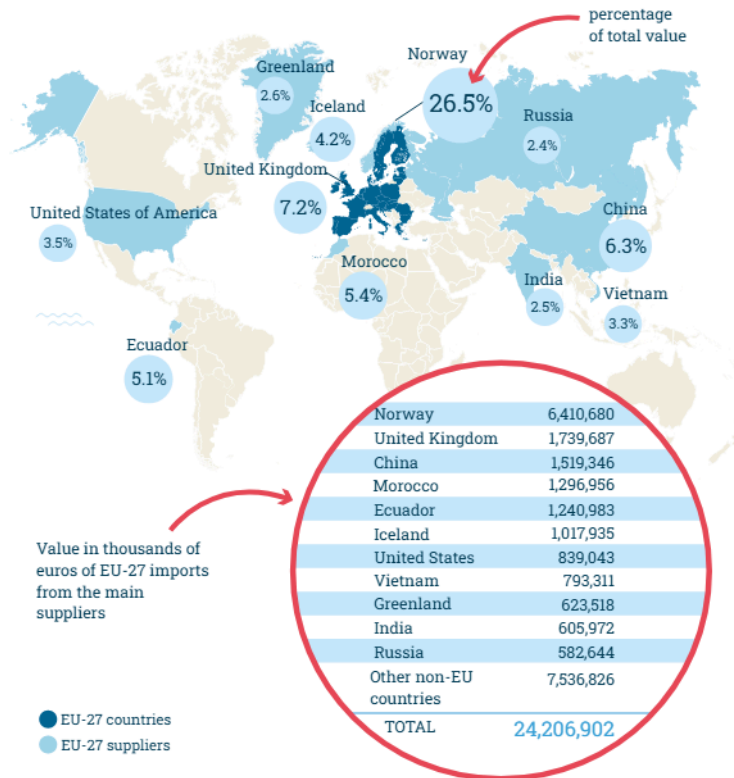
ALTHOUGH we are not always fully aware of it, marine products are among the most globalised food products, which influences consumption, extraction, aquaculture production, processing, and marketing systems.

International trade in seafood products has been growing steadily in both volume and value over the last 50 years. Today, 36% of global seafood production is traded internationally, including some 230 countries or territories. More than 6,800 tonnes of seafood products cross borders every hour, mainly from low- and middle-income countries (mostly in Asia) to high-income countries.

In 2022, trade related to all aquatic products combined generated an all-time high of \$195 billion, 19% more than in 2019, before the global COVID-19 pandemic. At \$45 billion, net trade in aquatic commodities from low- and middle-income countries exceeded that of all other agricultural commodities combined.

In this global trade, the European Union plays a key role. The EU is the world's largest trader of fisheries and aquaculture products in terms of value. European trade (i.e., imports and exports) has increased in recent years, reaching €31.2 billion in 2020. This political community is a net importer of fishery and aquaculture products, mainly frozen, fresh, and chilled. Spain, Sweden, Denmark, and the Netherlands are the main importing Member States. Norway, the UK, China, Morocco, and Ecuador are the main suppliers to the EU. In 2020, exports to non-EU countries increased to €6.96 billion. Denmark, the Netherlands, and Spain are the main exporting Member States, while the United Kingdom, the United States, China, Norway, and Switzerland are the main customers.

Figure 5 Value of EU-27 imports from main suppliers (percentage of total value and value in thousands of euros)



Source: European Commission: Directorate-General for Maritime Affairs and Fisheries, (2022). *Facts and figures on the common fisheries policy: basic statistical data: 2022*, Publications Office of the European Union. <https://data.europa.eu/doi/10.2771/737237>

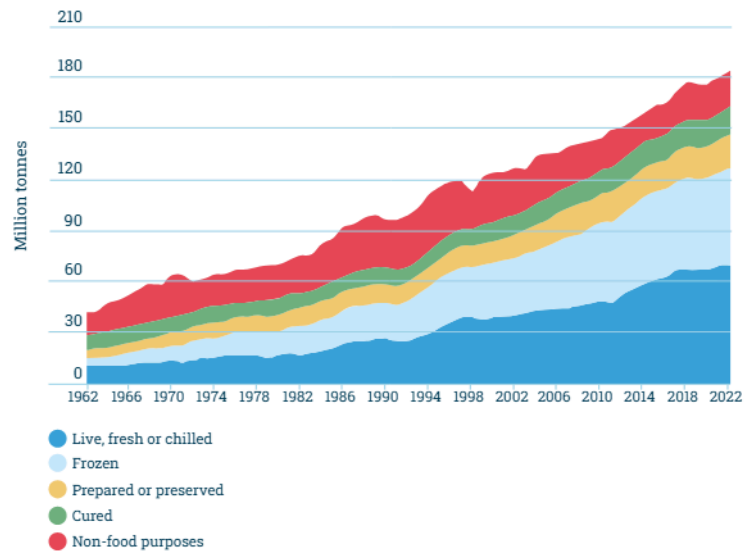
In this context, the EU is a global organisation with a strong interest in effective international marine and trade governance, so as to ensure the supply for consumption and the processing and marketing of goods within the Union. It is therefore a proactive stakeholder in global marine foreign policy. This includes, among many other mechanisms, a decisive intervention in international governance fora, both in the management of access to marine resources and in the management of the EU's own resources and

global environmental management as well as in international trade, policies linked to control, subsidies, and governance in international waters, and payment for access of the European fleet to third country waters.

The importance of processing procedures is also sometimes overlooked in the design of public policies. Currently, on a global scale, only a third of all marine products are consumed fresh, compared to frozen as the most dominant form of processing. Spain, in turn, plays an important role in this international trade, both in terms of volume and value.

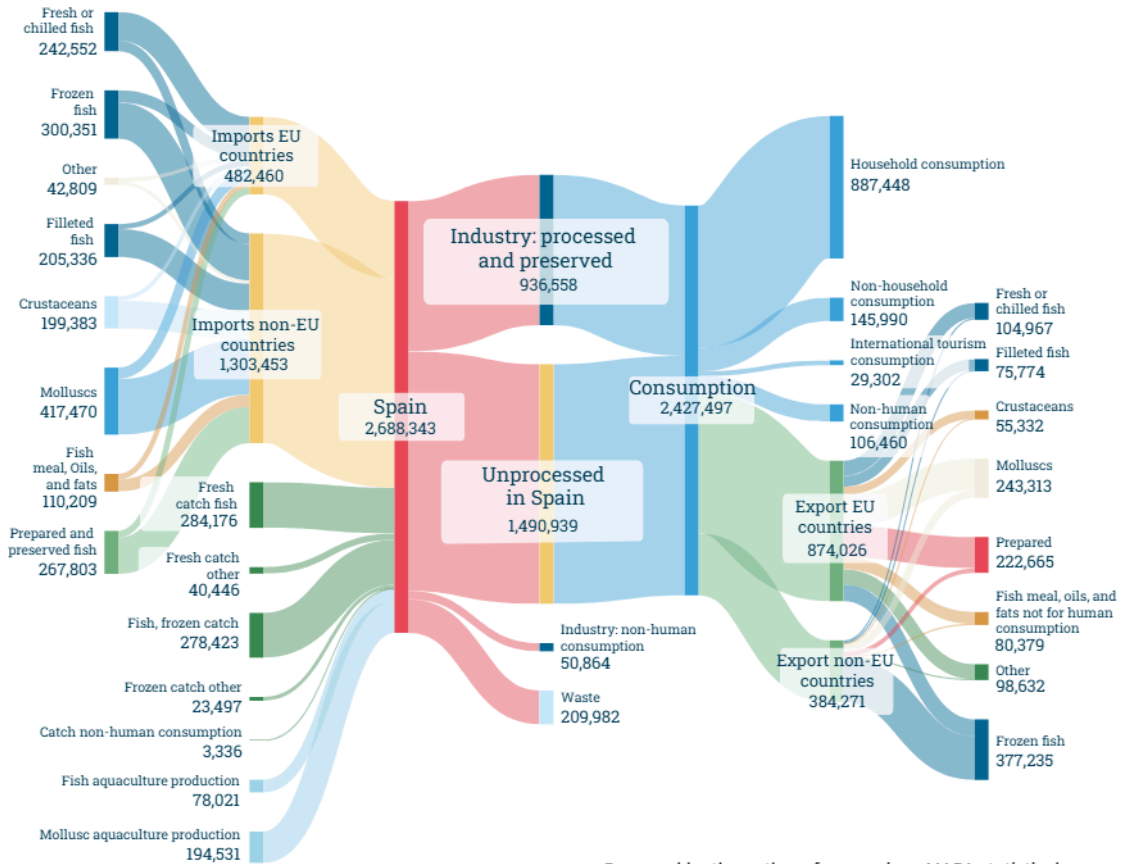
Figure 6 World fishery and aquaculture production of aquatic animals by type of presentation (1962-2022)

Utilisation of world fisheries and aquaculture production of aquatic animals



Source: FAO, 2022

Figure 7 Estimated main flows of the Spanish fishing system for the year 2022 [tonnes]



Prepared by the authors from various MAPA statistical sources.

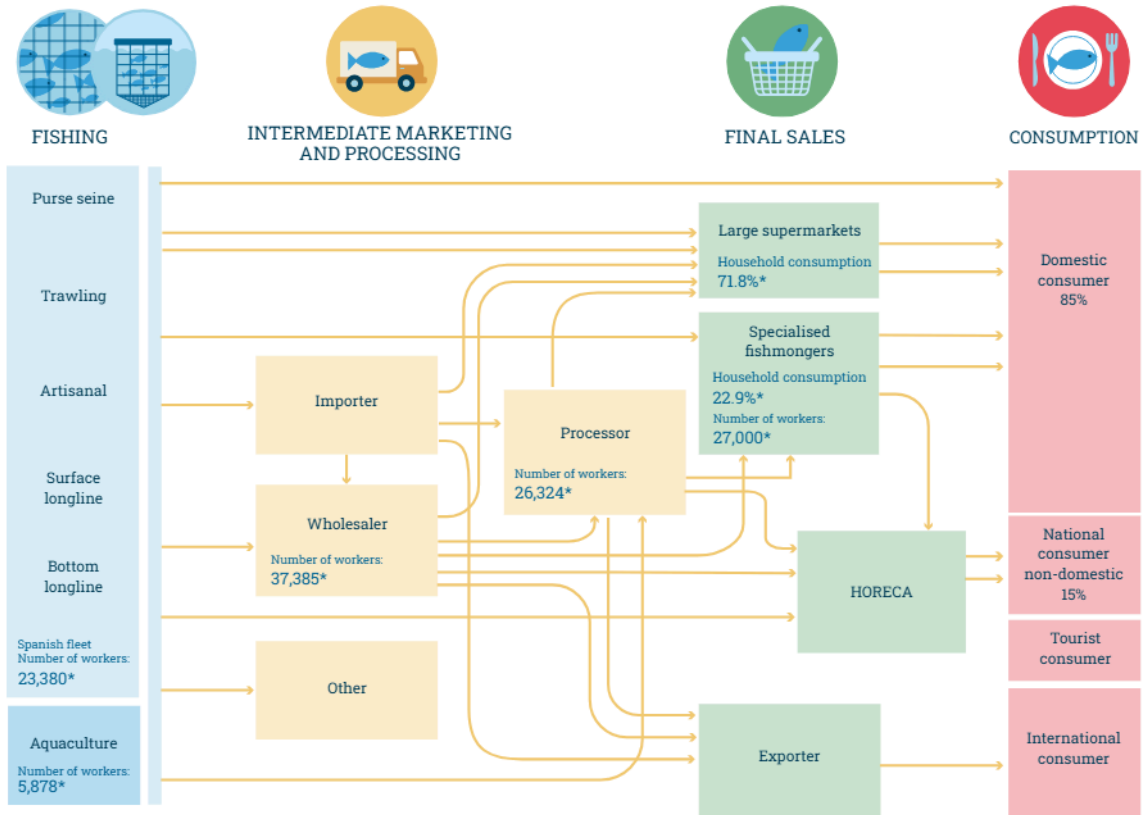
In terms of volume, for example, imports (partly channelled through joint ventures in which Spanish players have a stake) exceed the total catches of the Spanish fleet and aquaculture production combined, and account for 65% of the inputs to the fishing system. Moreover, as a significant part of the Spanish fishing fleets' catches are outside European waters, more than 87% of the product that constitutes the material basis of the Spanish fishing system comes from non-Mediterranean and Atlantic European waters.

Exports are also very important, although in this case they are centred on European countries. Their volume is as significant as the total consumption in Spain. It is therefore a very open and globalised system whose future—and also that of the activities carried out in Spain—is greatly influenced not only by the internal management of resources, the fleet and the Spanish market, but also to a large extent by what happens abroad. It is therefore essential to understand both the conservation and management of resources and the international trade regulations that affect imports and exports, and to understand the agreements for the marine exploitation of non-Spanish resources and the health, labour, and environmental regulations that limit international trade, among other aspects. The implication of these international regulations and dynamics transcends the issue of marine food production, and has impacts on a globalised socio-economic level, such as the impoverishment of local communities in less favoured areas of the Global South and the establishment of migratory flows towards areas with higher economic income.

At the root of many of the problems and constraints in the contemporary marine resource supply sector is the lack of a common international playing field. This is true both in terms of fisheries management and in terms of environmental, labour, and health conditions, subsidies, and other support to the sector, and in the limitations of international governance.

Another essential aspect is the complexity associated with the seafood supply system, which articulates the entire food chain in three blocks: production (which includes both extractive fishing and aquaculture), the processing industry and marketing (which includes wholesalers, specialised retailers, general distribution chains and importers and exporters). Sometimes a fourth factor is added, formed by companies supplying products and support services to the above.

Figure 8 Examples of the relationships between the main stakeholders in the Spanish fisheries production-marketing chains



* Data for 2022 in Spain

OWN CREATION



MARTA COLL

It is important to note that each of these categories in turn includes a great deal of internal diversity (e.g., of fleets or types of aquaculture production), that not all production and consumption chains involve the same stakeholders, and that there is real competition between the various fishing, processing, supply, and food chains. In general, short chains are considered to be those in which there is no more than one intermediary between the fisherman and the end consumer, whether it is a direct sale or a short supply chain (consisting of a single intermediary), regardless of the distance travelled between the catch and its consumption.

In some cases, to emphasise the geographical proximity between those who produce and those who consume, the term *Short Food Supply Chain (SFSC)* is used to refer to this type of supply chain. Generally speaking, short food supply chains offer fishermen the possibility of higher profits and closer relationships with consumers. However, they are still a minority model in Spain, and the dominant players in fish distribution are still wholesalers and large supermarkets.

The diversity of stakeholders involved in the provision of seafood is a key factor when it comes to analysing the benefits generated by the sector's activity, since, from a comprehensive point of view that includes environmental, social, and wealth-sharing factors, there is no magic formula. This is why it is necessary to hold a democratic and informed discussion before making decisions on fisheries and food policies. This debate must involve all the organisations associated with the food chain (fishermen's associations, producers' organisations, professional associations, etc.), as well as other stakeholders (NGOs, consumer organisations, etc.) and the public administration, and must be supported by the scientific community. The various forms of participation in management represent another of the challenges posed by the new fisheries management, especially because it is essential for it to be able to adapt to changes in the ecosystem and to be as democratic as possible.

At present, this process is still in its early stages and is expected to evolve significantly in the coming years.

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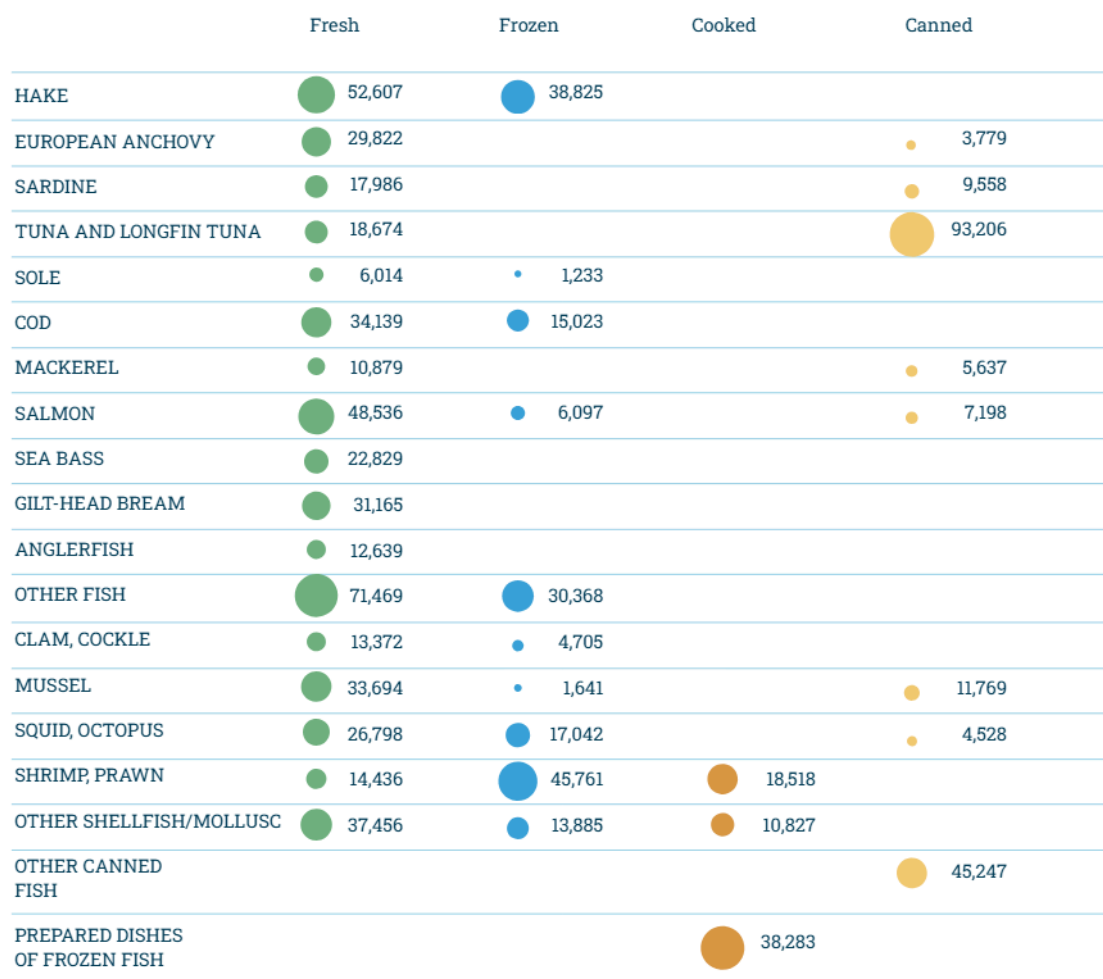
How can the consumption of marine resources contribute to a healthy, nutritious, and waste-free diet?

AQUATIC food includes both animals and plants. These include fish, crustaceans, shellfish (such as crabs and shrimps), cephalopods (octopus and squid), other molluscs (mussels and clams), aquatic plants, seaweeds, and other aquatic animals (including birds, reptiles, and marine mammals). These can be farmed or wild-caught. They come from inland, coastal, and marine waters and offer a wide range of choices at different times of the year and in different geographical regions. This group of fresh foods is complemented by a whole series of processed products, mainly frozen and canned. In Spain, seafood consumption is dominated by tuna and long-fin tuna (mainly canned), various fish (including hake and, increasingly, salmon) fresh or frozen, shrimps and prawns, frozen or cooked.

Seafood is an important part of many human diets and contributes to a healthy, nutritious, and adequate diet. It is a potential source of key elements, such as essential micronutrients or omega-3 fatty acids, as well as animal protein. Currently, they account for 17% of animal protein production for human consumption, although it exceeds 50% in some countries in Africa and Asia.

Despite these benefits, the consumption of seafood products involves two main risks. Firstly, the presence of contaminants or parasites in the food chain can sometimes pose health hazards to some human groups if not properly managed. In order to reduce these threats, health authorities regularly issue health recommendations and establish health control mechanisms.

Figure 9 Household consumption in Spain. Main species and preparations
[thousands of kilograms in 2022]



Source: Household food consumption survey in Spain, 2022.

Secondly, the market trend favours an extraction, production, and marketing that generates higher profits for those involved in the value chain, and in particular for those who control the different elements of this chain. However, this approach does not encourage the production of as much food as possible with the lowest environmental impact, but could lead to a decreased availability of fish for the people who need it, especially in countries with serious malnutrition problems. Moreover, it is often in conflict with the optimal use of resources from an ecological and social point of view, and favours the concentration of all fishing activity on a few species. On the other hand, the prioritisation of excessive profit encourages the overexploitation of these species, while indirectly favouring discards and eliminating the possible use of other species with food potential, which is a major problem in some non-selective fishing methods, such as demersal trawling.

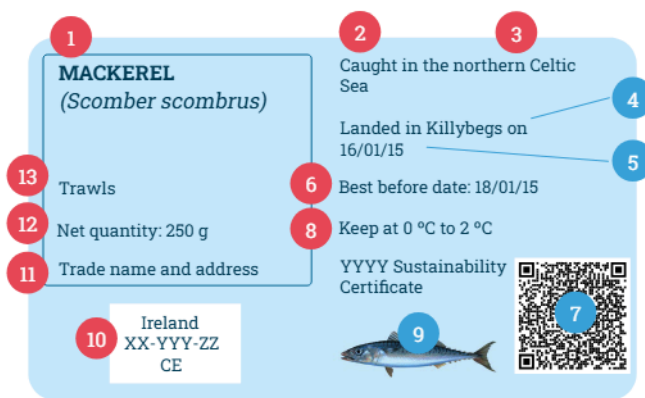
Some short distribution channels and communication campaigns promoted by the public administrations are attempting to diversify the consumption of seafood products. This would favour a better use of resources and adaptation to natural seasonality, but so far, the overall practice of these activities has not managed to halt the growing consumption centred in just a few species.

Furthermore, the environmental, social, and economic implications vary greatly depending on how and where the seafood is caught and marketed. This has consequences on socially relevant aspects such as the generation of employment or the contribution to climate change, and it is not always possible to maximise all these parameters in a positive way.

There are some mandatory labelling indications on seafood products that provide important and basic information for consumers. However, some aspects of this information are still considered insufficient and difficult to understand in order to make informed choices.

This basic mandatory information can be supplemented on a voluntary basis by information provided by the fishing fleet or the relevant distribution channel. Such voluntary data can be significantly enhanced thanks to the important advances in traceability processes that the digitisation of information linked to catching, processing, and marketing currently allows.

Figure 10 Example of a label for a fresh, unprocessed, packaged product



- | | |
|-------------------------------------|--------------------------|
| 1 ● Trade and scientific name | 8 ● Storage conditions |
| 2 ● Method of production | 9 ● Certification label |
| 3 ● Catch area | 10 ● Identification mark |
| 4 ● Landing port | 11 ● Food operator |
| 5 ● Date of shipment | 12 ● Net weight |
| 6 ● "Use by date" / "Best before" / | 13 ● Gear category |
| 7 ● Quick response code | |
-
- | | | | |
|--------------|-------------|--|--|
| ● Compulsory | ● Voluntary | ● Regulation on the common market organisation | ● Regulation on the provision of food information to consumers |
|--------------|-------------|--|--|

Source: adapted from WWF

However, it is important to note that, despite these improvements, there are still breaches of labelling regulations, mainly at the final point of sale. Good labelling, proper control and the provision of information to the end consumer are essential in the fight against illegal, unreported, and unregulated fishing, prevalent in international and national markets. This type of fishing is not only a problem for the ecosystem and fishery managers, but also a risk for consumers, as it bypasses existing health control systems. Improvements in fish traceability and the fight against illegal fishing are relevant aspects of current fisheries research and management, as well as their regulatory implications.

Occasionally, short food supply chains and catches in specific coastal areas are accompanied by different labels, normally promoted by local public administrations in collaboration with the fishing sector. An example of this case is the local sale (*venta de proximidad*) labelling in Catalonia or the brands Mil-lorquín from Mallorca and Peix Nostrum from Ibiza. For some specific seafood products, beyond the length of the chain or the point of capture, trademarks or product designations of origin are also being promoted in order to gain visibility. Examples are the designations of origin for mussels from Galicia or mackerel and frigate tuna from Andalusia. Finally, various international organisations also provide consumer recommendations (for example, organisations such as WWF or Ecologistas en Acción) or private certification systems informing consumers of certain fisheries and supply chains with specific characteristics (environmental, social, etc.) which go beyond the established legal minimums. The best known and most comprehensive bodies are the Marine Stewardship Council (MSC) for fisheries and Farmed Responsibly ASC for aquaculture, although there are many others that address specific aspects relevant to some fisheries, such as, for example, those relating to *dolphin-safe*, which seeks to avoid the accidental capture and death of dolphins.



MARIA GRAZIA PENNINO

Consumers are currently faced with a wide variety of types of voluntary labelling with different quality levels (in terms of the elements that they guarantee, their level of rigour and their control systems), which is sometimes a problem. Clarifying the information aimed at consumers is a relevant aspect and an active area of work for both research and public administrations.

On the other hand, from a consumption perspective, the characteristics of marine products compared to other food alternatives (whether animal, such as meat production, or vegetable-based) are extremely difficult to assess. They depend to a large extent on the environmental or social variables being evaluated, or on the product being compared, and are subject to great internal variability, due to the diversity of production and extraction systems, and the characteristics of the species themselves.

It is also worth noting that the projected world population growth by 2050 is approximately 9.7 million people, according to the United Nations. Consequently, the global demand for food is also expected to increase considerably. According to the FAO, approximately 70% more food, measured in calories, will need to be produced to meet global demand, if current distribution and use is maintained. However, there are serious doubts as to whether food supply can be increased in a sustainable way and, in particular, the contribution of seafood without, in addition to improving existing technologies, significant changes in current policies in terms of distribution and efficient use of resources.

The difficulty of supporting, with an extent of reliance, an increased supply capacity of marine products able to satisfy the medium-term demand forecast without exceeding the ecological capacity of the ecosystem, imply that the production and consumption systems and the diet need to transition towards a significantly different scenario to the current one. This situation is very complex from the point of view of both scientific knowledge and management.



MARTA COLL

two



How the CSIC Contributes to the Management of Marine Resources and Ecosystems

SPAIN has demonstrated a strong commitment to scientific research and regional and international collaboration in seafood provision.

In this context, the CSIC carries out a wide range of basic and applied scientific work necessary for the management of marine resources and their ecosystems. These studies cover multiple disciplines, from physical oceanography, fisheries biology and marine ecology to mathematics and statistics, socioeconomics and geography.

Applied science covers a wide range of aspects, such as the study of population dynamics of commercially valuable species, the distribution of vulnerable species and the reduction of fisheries discards, the effect of climate change, the direct and indirect impact of extractive activities, marine spatial planning and spatial management, and the cumulative effect of human activities, including marine pollution.

21.

Contributions to sustainable fishing and fishery production

Basic information about the marine ecosystem

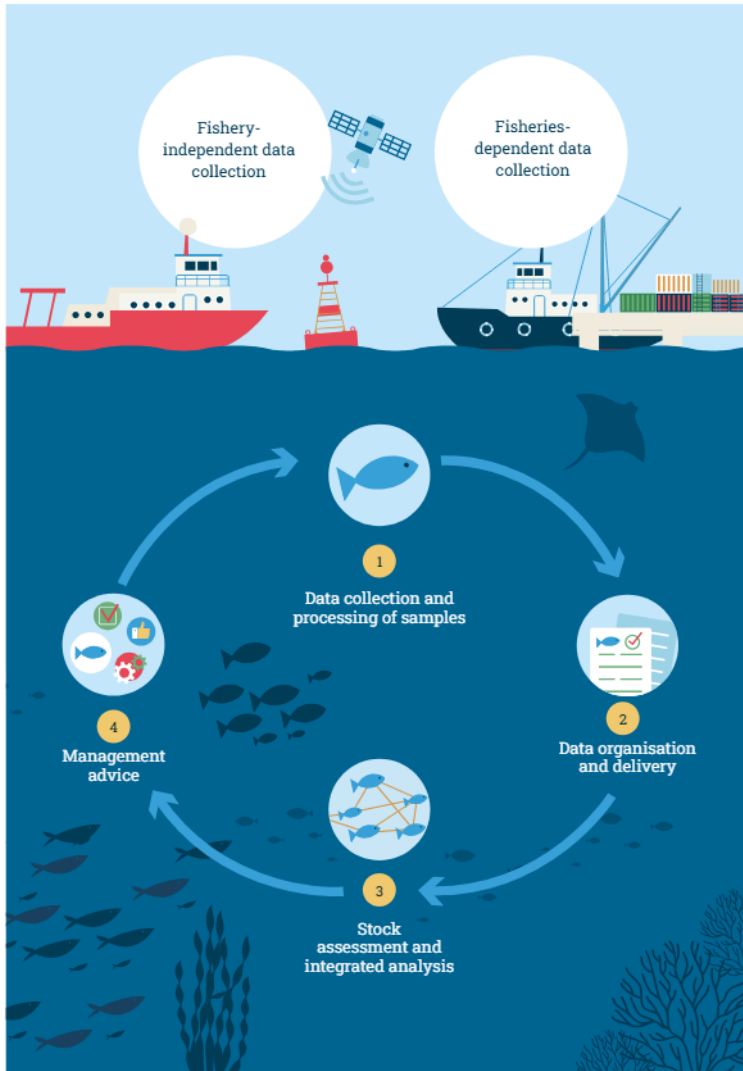
A fundamental task in managing the marine environment is to obtain basic information on the organisms that inhabit it and the physical, biological, and ecological processes that take place within it. In this regard, the CSIC plays a crucial role in the research and management of fisheries (both extractive and aquaculture), at national and international level.

CSIC scientists collaborate closely with several regional fisheries management organisations, such as the International Commission for the Conservation of Atlantic Tunas (ICCAT), the Indian Ocean Tuna Commission (IOTC), the Northwest Atlantic Fisheries Organisation (NAFO), the International Council for the Exploration of the Sea (ICES), the General Fisheries Commission for the Mediterranean (GFCM) and the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). These organisations are responsible for the sustainable management of fisheries and the conservation of marine resources in their respective regions, and the CSIC's work is based on data collection and analysis, the use of mathematical models for the assessment of fish stocks and the provision of scientific and technical advice.

In this context, the first step to obtain complete information on the marine environment is the collection of essential data. For this purpose, there are different types of sampling, although those carried out in fish markets, on board fishing vessels and in oceanographic campaigns are fundamental tools. During the collection of samples, researchers use a number of methods to capture marine species, which are identified, measured and weighed. In addition, some parts of marine organisms, such as otoliths (bones of the inner ear) and muscle tissue, are extracted and used for further studies in the laboratory. These biological samples make it possible, for example, to determine the age of the fish and to assess their physical condition and diet, providing a detailed picture of the health and dynamics of the populations. These campaigns also include the collection of oceanographic and environmental data. Researchers measure parameters such as water temperature, salinity, dissolved

oxygen concentration, and the marine currents using specialised probes and sensors. This information is essential for understanding habitat conditions and how they affect fish stocks.

Figure 11 Shedding light on sustainable fisheries management



Source: adapted from www.cefas.co.uk/icoe/fisheries

Fish market sampling takes place at fishing ports where vessels unload their catches. At the fish market, scientists select representative specimens from the catch to ensure that a diverse range of species, sizes, and stages of development are reflected. Fish and other commercial organisms are individually measured and weighed, and biological data similar to those collected during oceanographic surveys are recorded. In parallel, trained professional observers embark on fishing vessels to collect information on fishing activities for both target and non-target species (by-catch). This includes counting and identifying the species caught, as well as measuring the length and weight of specimens. In addition, on-board observers document the fishing effort, including the number of hauls, the duration of each haul, the geographical location and characteristics of the fishing gear used, as well as information on the catch of vulnerable species and the resulting discards.

Sustainable management of exploited stocks

The data collected on commercial species are analysed using different mathematical models that provide information on catch limits, temporal or spatial bans and technical restrictions to ensure the sustainability of fisheries. The results of these mathematical models are used to provide scientific-technical advice, fundamental in fisheries management decision-making.

In particular, the analysis of the state of exploitation of the different species is first carried out using mechanistic models, called *stock assessment models*. These models combine biological and fishery data in order to interpret the history of an exploited stock, quantify factors of importance for its management, determine its current state, estimate short- and medium-term measures that will bring it to a pre-defined desired level, and predict possible long-term effects of management actions.



MARTA COLL

One of the most important outputs of stock assessment models is the estimation of the biomass of the fish stock. Biomass is the total amount of fish present in a stock at a given time and is crucial for determining the health and resilience of the stock. Models also provide estimates of the relative quantities of fish stocks. This measure indicates the number of fish compared to a reference standard or baseline period. Relative abundance is useful for assessing trends over time and comparing quantities between different geographical areas or time periods. Data-rich stock assessment models also allow estimation of the age structure of the fish stock, i.e., its distribution into different age classes and the growth rate of each class. This parameter is crucial because it determines the vulnerability of the stock to fishing and its reproductive capacity. Stock mortality rates, both natural and from fishing, are another key factor, as they are used to assess the impact of fishing on the stock and to set sustainable catch limits that do not exceed their natural replenishment rates. Stock assessment models provide estimates of the maximum sustainable catch, which is the level of catch that can be sustained without depleting the stock, and allow future projections to be made under different management scenarios.

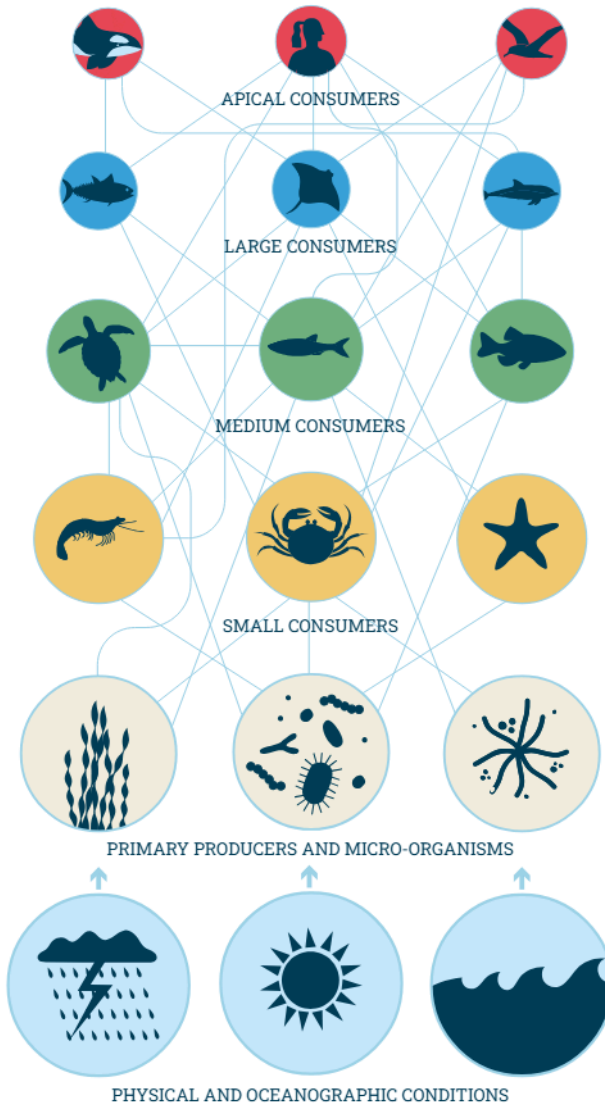
Integrated models as a tool for holistic management

The CSIC is also developing other integrated approaches that draw on data from different sources (satellite data, data recorded in scientific campaigns, data provided by observers in markets and on fishing boats, and data on climate change) and stock assessment models to analyse the dynamics of marine resources from a more inclusive perspective that takes into account ecosystem context.

For example, spatial models, such as species distribution models, that integrate geographic and environmental data are implemented to understand the location of fish stocks and their variability. Recently, bio-economic models that combine biological and economic data are also being applied to assess the performance of fisheries and propose balanced management measures.

In addition, there are a number of advanced tools and technologies, such as mechanistic marine ecosystem models or environmental and risk assessments, which consider multiple environmental ecological and socio-economic factors at the same time, necessary to inform ecosystem-based decision-making. These analyses, which may be spatial-temporal, take into account the particular characteristics of commercial and non-commercial species, the effect of environmental factors and human activities. These models contribute to understanding how these ecosystems are structured and function, the ecological role of species, and the effects of fishing and climate change on the ecosystem, as well as of management strategies, including the establishment of marine protected areas. For example, climate velocity studies can predict the rate and direction at which isotherms are moving and where species can be expected to move to remain at a preferred temperature.

Figure 12 Basic principles of marine ecosystem models that A) include several organisms of different sizes, and B) take into account the ecological relationships between marine species



Source: adapted from Blanchard & Novaglio, 2024. FishMIP; Piroddi et al.

The results of these models are being used to strategically assess the effect of fisheries and climate change on the distribution, biomass and biodiversity of marine ecosystems, and to inform UN regional and global assessments. Examples are the assessments carried out by FAO and the Fisheries and Marine Ecosystem Model Intercomparison Project (FishMIP) or the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) or the Intergovernmental Panel on Climate Change (IPCC).

On the other hand, the availability of more and more real-time data and more powerful computational technology is allowing the development of tools that can progressively bring us closer to a management model that is more adapted to ecosystems and updated in real time. Several CSIC groups are participating in initiatives such as the Digital Twins of the Ocean, promoted by the European Commission, which seeks to exploit these advances.

Also noteworthy is the CSIC's growing interest in studies associated with extreme events (such as marine heat waves or the intensification of storms) or combined phenomena associated with global change, whose effects are difficult to study using traditional modelling methods. This is why assessment methodologies are also increasingly based on risk assessments, combining quantitative elements with qualitative and semi-qualitative elements, based on expert knowledge and the specific knowledge of those involved in the food chain.



MIQUEL ORTEGA

Improving the conservation and restoration of marine biodiversity

Food production is one of the activities with the greatest impact on biodiversity loss, including marine ecosystems. The CSIC is working to improve fishing extraction strategies, combined with measures for the conservation and restoration of biodiversity. To this end, it contributes from multiple perspectives, including, among others:

- The design, creation, and monitoring of marine protected areas and marine area networks, as well as other maritime planning figures.
- The design of multiannual recovery plans for the protection of endangered species, or management plans for more regularly exploited species, as well as the development of overfishing reduction and risk assessment strategies.
- Introducing selectivity improvements through temporal or spatial-temporal management strategies, the redesign of fishing techniques, etc.
- Reducing the impact of fishing techniques on benthic ecosystems (e.g., through the use of raised footrope trawls) and other areas of the marine ecosystem (e.g., reducing the unwanted catch of non-target species and waste from ghost fishing).
- Implementing strategies in projects for the recovery of marine ecosystems and developing nature-based solutions.
- Developing measures to save energy, reduce emissions that accelerate climate change and reduce waste linked to maritime activities.

Improving aquaculture production

In the current context, where aquaculture plays an increasingly important role in the marine food system, the CSIC contributes to its improvement from various perspectives with the main, although not exclusive, goal of developing technology for the production of high-quality aquatic proteins for human consumption. To this end, it promotes high-performance seafood production under optimal sustainability and animal welfare conditions.

This research addresses fundamental aspects of each specimen, the mechanisms of action of its organs and systems, as well as the response in relation with coexistence in groups and populations. From the perspective of endocrinology, physiology, reproduction, epigenetics, embryology, ontogeny, nutrition, pathology or welfare, the productive cycle is comprehensively approached from the sexual maturation of adults to the fully developed juveniles, passing through the egg, embryo, and larva stages. Other CSIC research focuses on the development of an innovative strategy in European aquaculture, known as *Integrated Multi-Trophic Aquaculture*, which manages to reproduce the food chain by raising species at various trophic levels in a shared water system, thus favouring the transformation of the by-products generated by some into habitat and food for others. The presence of algae in all combinations of multi-trophic farming guarantees bio-mitigation effects and reduces eutrophication.

The CSIC is also working on improving feeds, the growth and immune responses of farmed species, and understanding the impact of climate change on aquaculture target-species at physiological, genetic, and epigenetic levels.

22.

Participating in the development of efficient, fair, and participatory food chains, and mainstreaming multidisciplinary studies

THE CSIC is actively involved in promoting food chains that favour the circular economy, local development, and the launch of new marine products, and that the resources generated are distributed as fairly as possible with the lowest environmental impact.

For example, its research supports the drafting of the Food Waste and Loss Prevention Act, enabling the reuse of discards, by-products or waste from the processing industry. Different research teams are proposing to optimise industrial processes and encourage the development of new products using what was previously considered loss or waste as raw materials. With the same idea and with the aim of promoting a more efficient use of resources, but from another perspective, the CSIC is also carrying out studies to promote the use of food products that are currently out of demand and often discarded.

The development of efficient and fair food chains also involves improving environmental cradle-to-grave assessment, i.e., along the whole chain, in line with the European Farm to Fork strategy. To this end, the carbon footprint of the main seafood products is measured along the entire food chain and strategies for reducing it are suggested. Studies are also being carried out on the adjustment of marine ecosystems and the food chain in order to jointly assess the ecological impact of fisheries management of the marine environment and its consequences on the whole chain.

The CSIC also contributes to the better functioning of the food chain through studies on the distribution of wealth and jobs generated in the fisheries sector, and through analysis for the promotion of short supply chains or those linked to agro-ecology. This research focuses on distributive elements and generates rigorous data for the effective development of the future law on measures to improve the functioning of the food supply chain.

In the food sector, there are also projects that promote new value chains through the innovation of processed products, adapted to the demands of both private consumption and the hotel and catering industry.

Traceability and food safety

The CSIC takes part in the technological development and innovation of advanced traceability systems, thus making it possible to have a safe and reliable system that guarantees the accuracy and reliability of the information associated with food safety and the sustainability of fishery products.

It is noteworthy that, beyond the strictly food-related domain, in the framework of the blue economy development, there are research projects on other value chains linked to marine products and animals. Some examples are the development of new potential biotechnological applications of marine products in animal and human health, and the benefits and impacts derived from recreational fishing, a very important activity, especially in some areas of the Mediterranean.

The role of social sciences in the study of the maritime environment

The CSIC is increasingly developing research projects that combine different areas of knowledge, such as sociology, anthropology, history, and other fields of social studies. This interdisciplinarity serves to increase knowledge of socio-ecological systems and to incorporate local and traditional ecological knowledge. It further supports better decision-making based on more holistic and implementable ideas. It also helps the co-development of adaptive management measures and promotes better definition of feasibility studies and scenarios, and improved risk assessments, among other aspects.

At another level, there are also numerous participatory science activities that are carried out. The CSIC actively promotes collaborative science projects in the maritime domain, where citizens share information (e.g., through photographs, videos, etc.) that is subsequently incorporated into the scientific knowledge chain. Also, through agreements with private stakeholders (fishermen, fishmongers, industrial operators, and restaurants), public-private collaboration projects are carried out in which the design, collection and analysis of data is conducted jointly.

Although still in its early stages, the CSIC is also beginning to carry out work on maritime culture, through co-creation processes in which the knowledge generated in its research is interwoven with diverse cultural expressions, particularly artistic ones.

Importantly, in order to enable effective participation in decision-making affecting the marine environment, all those involved in the food chain—and, in general, the public—need to have the best possible information at their disposal. For this reason, the CSIC carries out numerous initiatives to transfer and promote maritime culture, an aspect considered key to guaranteeing the proper social use of the scientific knowledge acquired.



JOAN MORANTA

2.3.

Encouraging and promoting responsible and healthy consumption

PROMOTING more sustainable fishing practices with low impact on the marine environment and designing appropriate food chains is as necessary as encouraging responsible and moderate consumption of seafood. Thus, to strengthen the environmental resilience of the food system, guarantee food safety and promote healthy and balanced diets, consumption and market systems need to be redirected towards local development with a low environmental impact, integrating socio-cultural aspects and adapting to contemporary consumption trends.

As explained in detail in the report *Sustainable and Healthy Nutrition* in this collection, the CSIC works in various fields to promote responsible nutrition and consumption. In the marine context, CSIC groups, through basic and applied science, foster the diversification of demand so that the food product can be offered not only fresh, but also processed according to quality standards, while including consumption patterns based on traditional knowledge and the cultural diversity coexisting in today's society. In this way, the aim is to optimise the use of fish and increase the food biodiversity of fish products.

Seafood products are essential for a healthy diet due to their high nutritional quality, including protein, polyunsaturated fatty acids (especially omega-3) and essential micronutrients. Fish consumption is associated with reduced risks of cardiovascular disease, type 2 diabetes, cognitive and nervous system developmental disorders in the foetus and during childhood. However, the nutritional quality of seafood products varies according to their production, processing, preparation, and consumption. Factors such as species, origin, time of year, and post-harvest handling techniques affect their nutritional value.

CSIC research highlights the nutritional benefits of seafood products, studies the positive effects of these components on human health, including the prevention of cardiovascular, inflammatory, and metabolic diseases, and develops methodologies to ensure optimal seafood management from a nutritional point of view.

In relation to food safety, the CSIC focuses on the quality and safety of fishery products, especially on the design and development of strategies to reduce the risk of exposure to *Anisakis* larvae. It investigates how insufficient treatments may not inactivate larvae adequately, or how intensive treatments may increase exposure to allergens or negatively alter the characteristics of fish muscle. In addition, the resistance of *Anisakis* allergens and parasite material to gastrointestinal digestion and their transport through the intestinal epithelium is being studied. CSIC scientists are also working on the development of spectroscopic methods to authenticate treatments applied to fish, with a special focus on freezing and frozen storage. They are also looking into the mechanisms that cause changes in fish muscle, which can diminish its organoleptic and techno-functional quality.

Likewise, the CSIC is actively researching the processes of incorporation of contaminants, such as plastics or heavy metals, into marine products, and the implications for animal life and circulation in food chains. Through the research carried out, monitoring is improved, risk reduction measures are proposed from the point of view of the end consumer, and strategies are designed for the reduction of pollutant sources, thus guaranteeing a bottom-up approach to the problem.

2.4.

Fisheries management adapted to global change

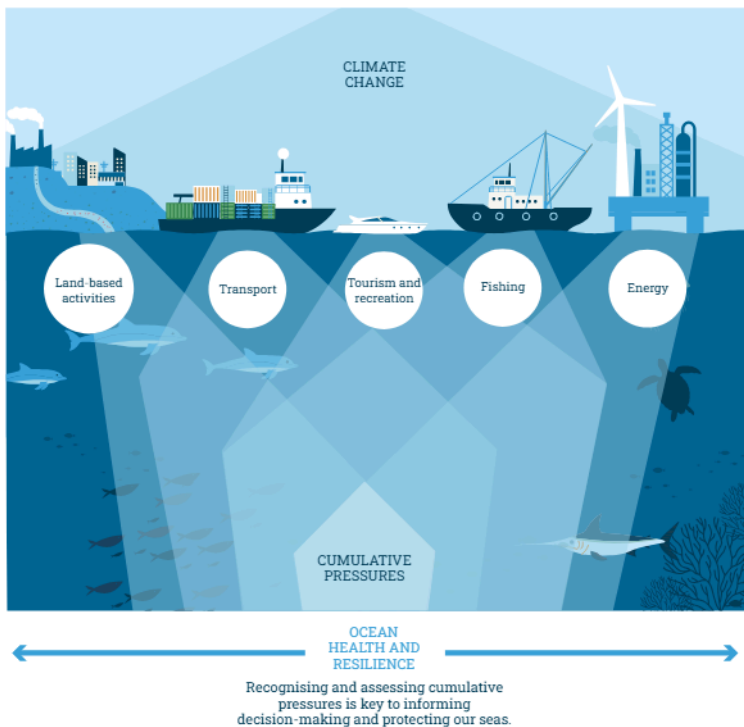
FROM a research perspective, in order to facilitate the transition described above, holistic studies, bringing together different areas of knowledge, and assessing the socio-economic and environmental consequences of the management of different economic sectors, social groups, and territories are needed. For example, a basic objective is to generate accessible information that combines ecological, social and economic factors, so that it can be used in decision-making.

The CSIC is currently working on the generation of new integrated panels, with indicators more adjusted to social, environmental, and economic factors that support, for example, "One Health" policies, follow the Sustainable Development Goals and avoid exceeding planetary boundaries.

There is also a need to improve the joint assessment of the potential consequences on the marine environment and its ecosystem services of economic activities and global change (especially climate change). The CSIC, through numerous projects, is actively working in this field through the development and application of novel methods for the study of cumulative and compound impacts.

Of particular importance is the research being carried out to better understand the implications of climate change in the maritime context, both from a strictly ecological point of view (changes in species and their production, in communities and ecosystems) and from a socio-ecological point of view (changes in fishing, in food, etc.). To this end, multiple methodological tools are used, ranging from animal experimentation to ecosystem modelling and semi-qualitative risk assessments, among others. Many of these methodologies seek to assess the health of marine ecosystems in order to design management strategies that ensure human benefits, such as the provision of nutritious food.

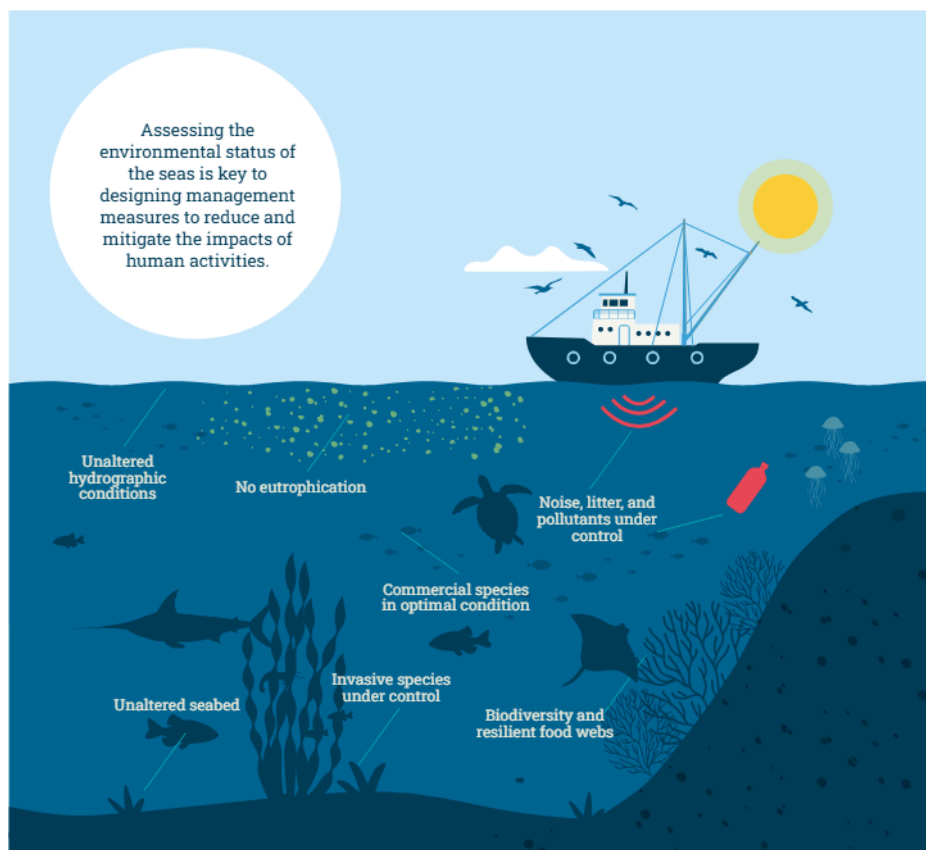
Figure 13 Example of what is meant by cumulative impact



Source: adapted from the European GES4SEAS project

Lastly, it is worth highlighting research related to disruptive events and extreme events (the latter specifically addressed in another book in this series). In recent years, the CSIC has carried out various research projects that analyse the impacts of unexpected events such as the COVID-19 crisis on the socio-ecological fishing system. Currently, it is actively working on the analysis of potential risks and impacts of disruptive elements, such as extreme marine heat waves and the possible crossing of climate tipping points.

Figure 14 Components required for the good environmental condition of a marine ecosystem



Source: adapted from the European GES4SEAS project

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Conclusions and Recommendations

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In recent decades, consumption has continued to increase on a global scale, although levels continue to vary widely from one country to another. At the same time, and particularly in Northern countries, consumption is increasingly concentrated on a few species due to new eating habits, which indirectly promotes over-exploitation, inefficient use of resources, and increasingly processed products. On the other hand, information on the possibilities and implications of consumption is growing, although not always sufficiently or reliably, which hinders responsible alternatives.

Recommendations

As in other public policy areas or sectors (see the *Science for Policy* framework report in the 2023 collection), in the case of the exploitation and management of marine resources, an in-depth understanding of the particular characteristics of our multilevel-governance and decentralised decision-making territorial model (the so-called *autonomous state*) is needed. This will allow us to develop systems characterised by an active, effective, fair, and relevant participation of all stakeholders and interested parties.

For public management:



Firstly, decision-making in this public policy sector must be based on scientific evidence and the best and most reliable information available. It is therefore necessary to continue investing in human capital and funding programmes that increase and push the boundaries of knowledge of marine ecosystems and the organisms that inhabit them, as well as in the development of useful tools for integrated management (management that takes into account not only the dynamics of commercial species, but also non-commercial species, environmental, ecological, and socio-economic factors).



Another key element is to strengthen the consistency and coordination of the different policies and management measures relevant to seafood production, the associated food chain and consumption. The stakeholders, bodies, and institutions in charge of this coordination (including their leadership or possible hierarchy) at governmental level (State, Autonomous Communities, sub-national governments, etc.) should be identified. This can help to convey a clear vision of priority environmental, social, and economic objectives, and ensure their sustained pursuit in the medium and long term, as well as their practical implementation. In the food system there are difficult-to-avoid dilemmas between these objectives, and greater clarity and transparency would support the further consistent and efficient development of more sectoral policies and measures.

From this perspective, the existing governance mechanisms need to be reviewed, striving to guarantee the active participation of all stakeholders (co-management) and, in particular, of those whose participation has so far been a minority, as a key measure for a better management of resources in an adaptive context and a fairer distribution of the benefits generated.

In terms of political-administrative organisation, the adoption of strategies, measures, and management plans must change to progressively adopt schemes based on the ecosystem itself, including the evolution of commercial species, their environmental and ecological setting and the socio-economic reality associated with their exploitation, as well as the implications of climate and global change.

In existing adaptive co-management systems, improvements in governance, and information transfer processes are key. New technologies and lessons learned from existing participatory science processes provide examples of how to improve existing processes. For example, the “One Health” approach is only possible if management, technological, political, and economic measures are accompanied by changes in food habits and demand to bring them in line with ecological carrying capacity. In addition, there is a need to move away from promoting indiscriminate increases in fish consumption towards a much more selective orientation related to dietary and ecological recommendations, nutritional properties and toxicological characteristics of products, and product diversification.

Multi-annual plans for co-management of fisheries need to be developed and made adaptive, while allowing for the establishment of short, medium, and long-term objectives, as well as continuity in management processes to allow for better private planning.

Adequate and sufficient access to information on the environmental and social implications of consumption, as well as on the state of the marine environment, must be ensured for consumers and the general public, and maritime culture must be promoted.

A clear commitment to the integration of environmental, fisheries, trade, and health policies is needed. In other words, it is essential to improve consistency in policy-making through inclusive strategies that bring together multiple players to negotiate, deliberate, and agree on actions to be taken, as well as the combination of services from different sectoral policies to make public policies more efficient. In this regard, the use of incentives (e.g., by promoting fisheries with lower environmental impact and higher social return, by introducing environmental and social criteria in the distribution of fishing quotas and fishing effort, or by promoting short supply chains with better sharing of the benefits generated) should be combined with the elimination of what is known within the OECD framework as *perverse incentives*, i.e., mechanisms that encourage certain behaviours that go against the original objectives and hinder the emergence of high-social-interest alternatives. In particular, it is necessary to work actively on taxation and regulation, and to attempt to avoid inconsistencies in decision-making between different policies, which damage the credibility of the overall measures developed.

The Spanish fishing system is highly globalised and depends on the product obtained in non-domestic waters. It is therefore necessary to continue improving fisheries and environmental management in territorial waters in order to recover the good condition of national waters, promote fairer, and more efficient food chains in Europe, and consumption that is more adapted to ecosystem capacities. At the same time, it is essential to act in parallel and decisively in global discussions and regulatory frameworks, promoting the highest possible standards in health, environmental, trade, and fair taxation aspects.

For the private sector/industry:



The private sector/industry needs to adopt a pro-active and forward-thinking approach to the transition process determined by the public administration, which is the guarantor of collective priorities. This is particularly relevant for the official statements of the sector's associative entities, as they influence the productive fabric as a whole.



Through the adoption of the best available technologies and management systems, industry has a very important role to play in the innovation processes necessary for the transition of the food system. In order to realise its full potential, it must be able to dialogue effectively with the government and the scientific community to ensure that food industry policies are implemented in a way that works for the collective benefit.



The involvement of the private sector in marine research and in particular in the seafood environment needs to be enhanced, both through transfer agreements by research institutions and through the active participation of the private sector/industry in research projects.

For the scientific community:



Data collection, management, and processing need to be further improved, as they are essential for both basic and applied research. In parallel, policies of maximum transparency and easy access to the data generated should be promoted, with the aim of optimising the associated costs, increasing efficiency, and multiplying results. In a context in which the availability of data is the cornerstone for harnessing the growing digital computing power that exists, open data access policies are central to seafood research.



There is a need to continue to promote the knowledge needed to facilitate the adoption of ecosystem-based fisheries management that is able to incorporate the effects of ongoing climate change and the accumulation of impacts on the marine environment. In this context, scientific and technological innovation is key to advancing the development and application of analyses and operational models capable of integrating complementary data from disparate sources.



The capacity for analysis must be improved in order to be able to assess the objectives and results in a more integrated and holistic way, and to be able to develop future scenarios. To this end, fisheries management measures must be analysed together with the implications for the food chain as a whole, while at the same time improving the evaluation parameters by adopting a broad perspective of the management implications.



In terms of economic factors, there is a need to integrate the ramifications of policies throughout the food chain and to internalise externalities. On the social dimension, it is necessary to define more robust methodologies, collect information more regularly and link it to food needs, in particular the need for the seafood system to contribute to healthy, nutritious, sufficient, affordable, and efficient food.

For society:



Both through their capacity to consume and, more particularly, in their role as citizens/players with the capacity to participate in decision-making and to influence public policies, citizens must take advantage of existing information to encourage food chain stakeholders and political representatives to act decisively in the necessary blue transformation processes.



Citizens can participate in existing citizen science processes and help raise awareness of the need to care for the marine environment and to ensure that the marine food system is within planetary boundaries.

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List of Centres

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CENTRE	WEB PAGE	E-MAIL
Centro de Estudios Avanzados de Blanes [CEAB, CSIC]	www.ceab.csic.es	direccion.ceab@csic.es
Centro Oceanográfico de A Coruña [COAC-IEO, CSIC]	www.ieo.es/coruna	ieo.coruna@ieo.csic.es
Centro Oceanográfico de Cádiz [COMA-IEO, CSIC]	www.ieo.es/cadiz	contacto.cadiz@ieo.es
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Further Information



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Alimenta: Think tank for the food transition



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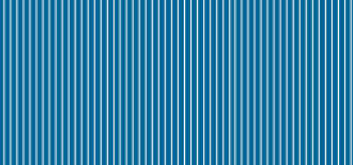
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