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BASQUE RESEARCH  
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[www.azti.es](http://www.azti.es)

# 2023

**AZTI REPORT**

THE ANSWER LIES IN SCIENCE

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Eneko Ibarquengoitia

## FOREWORD



# 1.1. LETTER FROM THE PRESIDENT AND THE CEO OF AZTI

*Bittor Oroz and Rogelio Pozo*

At AZTI, every discovery and breakthrough we make brings along the promise of a more sustainable, healthy, and resilient future. Our work transcends the boundaries of science and technology, making a direct impact on the well-being of people and the preservation of the environment for generations to come.

Our commitment to scientific excellence and technological innovation is the driving force behind our contribution to sustainable development. Through applied research, we work to better understand natural and human systems, seeking solutions that balance economic needs with the protection of natural resources.

At AZTI, we understand that science and technology must serve as tools to strengthen the capacities of societies in the face of current and future challenges. Environmental protection and human health are at the heart of all our activities. We acknowledge that the health of our planet is intrinsically linked to human health and the success of our economies. For this reason, we strive to develop technologies and practices that minimise environmental impact, promote the conservation of

natural resources and provide more efficient processes.

We work in close collaboration with public institutions and private companies, where the value and knowledge generated by our projects provide opportunities for learning and awareness-raising on environmental and scientific issues. This empowers the community to make informed decisions and actively participate in developing policies and strategies for the transformations that society needs.

Our projects generate added value for our clients and institutions, as well as direct and indirect employment. This includes scientific and technical staff, as well as support staff and various collaborating



**Bittor Oroz.** President of AZTI.

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# 1.1. LETTER FROM THE PRESIDENT AND THE CEO OF AZTI

agents. In addition, research and innovation drive economic growth by fostering the creation of new companies and opportunities for new business and resource savings for the private companies with which we collaborate. The impact of AZTI projects goes beyond scientific and technological results. They contribute to sustainable development, community resilience, human health and environmental protection for future generations.

At AZTI, every step we take is imbued within a long-term vision, where the generation of value is not only measured in terms of immediate results, but also by the legacy we leave for tomorrow. Our activity report is a testament to this journey, reflecting not only what we have achieved, but also what we aspire to build: a world where science and technology are allies of human progress in ecological harmony with natural resources. Science does not have answers to all questions, but it does have the best answers available. **The answer lies in science.**



**Rogelio Pozo.** CEO of AZTI.

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## 1.2. AZTI IN FIGURES

# 2023

**289**  
Employees

**58%**  
Women

**65%**  
Of researchers are  
doctors

**226**  
Indirect jobs  
promoted

**23,5M€**  
Income

**284**  
Live projects

**198**  
Clients

**5,5/6**  
Customer satisfaction  
rating

**124**  
Indexed Publications

**6.851**  
Citations

**180**  
Collaboration agreements  
with business partners

**8**  
IP protection

**206**  
AZTInnova partners

**10.828**  
Attendees at our  
events

**2.701**  
Media impact

**850M**  
Social media outreach

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Martín Cabello

**RESILIENCE IN ACTION:**  
AZTI IN A CHANGING WORLD

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The world as we know it is undergoing significant change, driven by major global trends such as demography, climate, food and energy security, and the growing importance of innovation and technology. These challenges, which are complex and intertwined, require comprehensive and impactful responses.

At AZTI, we are committed to addressing these issues by **developing sustainable and healthy solutions** in a number of areas. Our commitment to research and science is for the common good of society as a whole.

**We don't have to save the planet, we have a responsibility to make the world a better, more sustainable and healthier place.**



**RESILIENCE IN ACTION:**  
AZTI IN A CHANGING WORLD

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## 2.1. ADDRESSING GLOBAL DEMOGRAPHIC CHANGES

Factors such as a growing world population, economic growth in developing countries and urbanisation are generating an increasing demand for food. This puts additional pressure on natural resources, posing challenges for ensuring the sustainability and availability of food in the future. In addition, climate change affects the functioning of the planet and brings significant challenges to many sectors of human activity. Alterations in terrestrial and marine ecosystems resulting from climate change may affect water and nutrient cycling and thus the availability of adequate land for food production. All this contributes to the increase in the price of raw materials.

In the context of demographic changes and global trends, AZTI recognises the need to address these challenges in a holistic manner. We propose innovative solutions that focus on personalised nutrition, artificial intelligence in nutrition and a deep understanding of consumer behaviour. Our commitment to sustainable oceans and fish stocks, healthy food and food security reflects our vision of a future where innovation and responsibility are intertwined to improve the lives of people and the planet.

First, we are committed to **personalised nutrition** as the key to addressing population changes. We recognise the diversity of people's nutritional needs and we champion the development of foods that adapt to these individual differences. The application of artificial intelligence in nutrition plays a key

role in analysing massive data to identify patterns and personalised recommendations, thereby improving the health and well-being of consumers.

In addition, we are committed to the research and development of **healthy and health-promoting food solutions**. We work to create products that are not only delicious, but also beneficial to health, thus contributing to addressing the challenges related to an ageing population and growing wellness concerns.

Promoting **sustainable fish stocks** is another cornerstone of our approach. Aware of the pressure on natural resources, we work to contribute to responsible fisheries management that ensures the continued availability of essential ingredients for food



production. We work towards the implementation of circular business models that promote sustainability and reduce the environmental impact of the food supply chain.

In terms of **consumer behaviour**, we recognise that understanding consumer preferences and habits is essential to developing products that fit their

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## 2.1. ADDRESSING GLOBAL DEMOGRAPHIC CHANGES

needs. Using advanced data analytics and cutting-edge technologies, we seek to understand market trends and anticipate changing consumer demands, thereby facilitating the creation of products that align with their expectations.

**Food safety and integrity** are guiding principles in our initiatives. We strive to ensure that every stage of the food chain meets the highest standards of quality and safety. We implement advanced monitoring and traceability technologies to ensure that consumers can trust the provenance and quality of the food they consume.



### SUSTAINABLE FISH STOCKS TO FEED A GROWING POPULATION

The ecosystem approach to fisheries management and the sustainability of fisheries, as well as the conservation and restoration of ecosystems, are fundamental to AZTI's response to the challenges of the Common Fisheries Policy (CFP) and the Marine Strategy Framework Directive (MSFD).

The CFP, oriented towards the environmental, economic and social sustainability of fisheries, is intertwined with the MSFD, which focuses on the protection and good environmental status of the marine environment. The convergence of the two aims to preserve the marine ecosystem and ensure the equitable and sustainable exploitation of fishery



resources.

In this context, marine protein from fishery resources becomes relevant, especially considering its lower environmental impact compared to terrestrial production. Balanced management of marine resources is a crucial challenge to preserve marine ecosystems and the marine environment.

However, fish production in Europe has been declining, proving insufficient to meet internal demand. The need to import from third countries poses challenges in terms of fisheries, environmental and social management.

Some of AZTI's achievements in 2023 are as follows:

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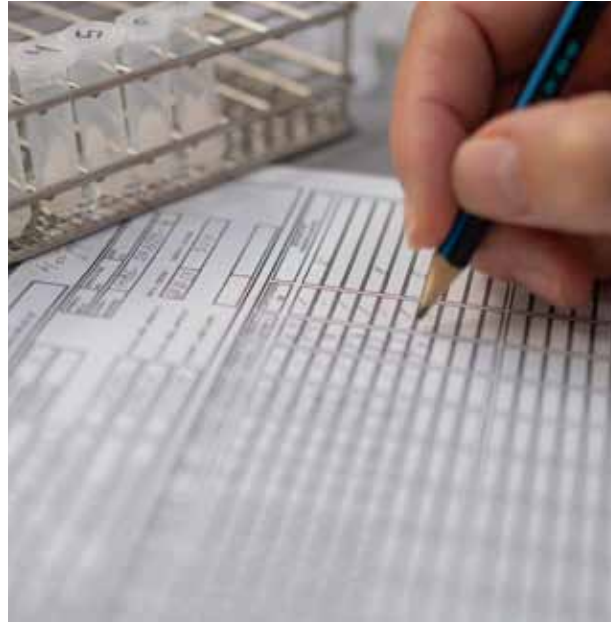
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## 2.1. ADDRESSING GLOBAL DEMOGRAPHIC CHANGES

### Progress in the management of artisanal fisheries in the Basque Country

At a time when the food production system contributes to both carbon emissions and the accelerated loss of biodiversity, preserving and increasing the natural capital of the seas and oceans is essential to ensure the continued provision of valuable ecosystem services. In this context, within the **PLATICAS** project, which is part of the National Knowledge Network promoted by the Spanish Ministry of Agriculture, Fisheries and Food, AZTI has improved the **understanding of small-scale fisheries and their impact on climate change** in the Basque Country. Working closely with fishermen, it has focused on the implementation of innovative systems and awareness-raising, identifying areas for improvement in training, digitalisation and generational change.

Small-scale fisheries are very complex, as they involve a succession of trades throughout the year, with a wide range of gear types, activities and impacts, and often share fishing grounds with other fishing and non-fishing uses. AZTI has coordinated the Interreg Atlantic Arc project **CABFishMan** (Conservation of Atlantic Biodiversity through support for innovative co-Management of small-scale Fisheries) in which different tools have been generated to expand existing knowledge of these fisheries and accurately estimate their environmental, economic and social impact.



### Innovation in biomass estimation, stock identification and delimitation

The implementation of advanced technologies for estimating the biomass of fishery resources, such as those developed by AZTI, comes in response to the compelling need to improve the management and conservation of stocks. In a context where environmental pressures, climate change and human activities directly impact marine ecosystems, innovative approaches are essential. Using techniques

such as **environmental DNA** analysis (traces of marine organisms such as fish suspended in the water column) and the **close relative mark-recapture** (CKMR) technique, AZTI is at the forefront of developing fishery-independent and therefore more accurate indices of abundance.

In addition, the application of population genetics makes it possible to delimit stocks, assign individuals to them and predict adaptations to climate change and human pressures. This approach has enabled, among other things, the study of bluefin tuna connectivity. The **bluefin tuna genetic study**, published in the journal *Molecular Ecology* and featured on its cover, is the most comprehensive to date, revealing **unexpected connections between Mediterranean and Gulf of Mexico populations in a new spawning area off the northeast coast of the United States**. These findings provide crucial information for fisheries management and conservation of the species, highlighting the importance of demographic mixing between reproductively isolated populations. On the other hand, population genetics has allowed the discovery and monitoring of hybridisation between white and black monkfish, with an impact on spawning stock biomass estimates and fleet economics.

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### Fisheries assessment and management advice

The traditional scientific campaigns led by AZTI not only maintain their relevance, but have also gained in value by incorporating, in recent years, an ecosystem approach and new indicators with the aim of studying how natural variability and climate change affect fishery resources. A clear example of this evolution are the **JUVENA and BIOMAN** campaigns, originally designed to estimate anchovy abundance, but which have incorporated measurements of their prey and predators. In addition, during the last few years, information on sardine has been collected and analysed, which has made it

possible to estimate its abundance.

In 2023, the JUVENA and BIOMAN campaigns have confirmed the good state of the species in the Bay of Biscay. This is the result of the continued commitment of the sector, the Basque Government and the scientific community to the sustainable management of this species, which is crucial for the economy and ecosystem of the Basque Country.

AZTI is also leading a project funded by the European Union to **study the behaviour of sharks in the Bay of Biscay**, to prevent unwanted interactions with human activities. This initiative, in collaboration with the fishing sector, demonstrates AZTI's

commitment to the protection and sustainability of the marine ecosystem.

Another contribution of AZTI has been the development of a **tool that facilitates the calculation and visual representation of the economic impact of various Total Allowable Catches (TACs) and quotas**. This tool gives participants in negotiations the ability to anticipate and predictively assess the economic impact of their agreements.

In addition, AZTI has developed a series of sustainability indicators to guide the fishing sector in its management. Of particular note is ICCAT's implementation of the Management Procedure for albacore tuna, which includes a Catch Control Rule, with the outstanding participation of AZTI's tuna team. Prior to this innovative rule, stock assessments were carried out in the traditional manner, revealing that albacore tuna was slightly overfished and showed limited signs of recovery. The adoption of the Management Procedure for albacore tuna has marked a significant milestone. By 2024, its catch quota is expected to increase by 25%, reaching record highs, substantially benefiting the Basque fishing sector.

In this line, seeking to lead sustainability in the tuna sector, AZTI, as technical secretariat, has played a key role in the consolidation and promo-





## 2.1. ADDRESSING GLOBAL DEMOGRAPHIC CHANGES

tion of the **Bermeo Tuna World Capital** Association. This project, in collaboration with various entities, has transformed Bermeo and the Urdaibai region, focusing on the sustainability of tuna fisheries. The **TUNA FORUM**, an international event, witnessed the presentation of the Universal Declaration for Tuna Sustainability and the signing of the Tuna Cities Alliance, consolidating the commitment of its partners to the global sustainability of fisheries.

AZTI has also played a leading role as a local **partner in the ICES Annual Science Conference 2023**, a scientific event promoted by the International Council for the Exploration of the Seas, aimed at drawing strategic lines for the future of the oceans through science. ICES acts as an advisory body to both the European Commission and the International Oceanographic Commission (IOC) and the FAO, issuing annual advice on the fishing opportunities of some 250 fish stocks and other marine resources, many of which are straddling or highly migratory. This important event, which took place at the Euskalduna Palace in Bilbao, brought together more than 800 attendees, highlighting the positioning of the Basque Country in marine sciences and addressing issues in the context of the blue and digital strategy, with an estimated total impact of 1.2 million euros in Bizkaia.

### **Observation and collection of ecosystem-fisheries data**

The revolutionary application of deep learning and artificial vision techniques has completely transformed electronic monitoring by enabling the objective identification of catches in real time. In this

context, AZTI, recognised as a benchmark in the observation of ecosystem-fishery data, has transferred **automatic image recognition algorithms** to fishing technology companies.



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### Assessing and mitigating unwanted impacts of fishing activities

AZTI leads projects aimed at assessing and mitigating the unwanted impact of fishing activity, collaborating at European level to develop more selective fishing gear, a crucial aspect for an effective use of marine resources in accordance with the principle of maximum sustainable yield.

In this sense, the **implementation of Electronic Monitoring Systems (EMS)** in the fishing fleet has marked a turning point in the knowledge of bycatch. These systems allow a significant and efficient increase in monitoring coverage, providing crucial data for a more sustainable management of fisheries.

In addition, the effectiveness of acoustic deterrent devices, known as “pingers”, in **reducing cetacean bycatch in trawl fisheries is highlighted**. These devices, which emit acoustic signals to keep cetaceans away, have proven to be highly effective, reducing the accidental capture of dolphins by trawlers by more than 90%, according to studies carried out by AZTI. The effectiveness of these devices not only represents a significant advance in the preservation of marine life, but also opens the door to their implementation in other fisheries, marking a milestone in responsible fishing.

In parallel, AZTI is working on the implementation of devices to reduce mortality when **releasing vulnerable species and on the development of good practices on board tuna fishing vessels**. This work is carried out in close collaboration with the tuna freezer fleet operating in the Atlantic, Indian and Pacific Oceans, testing pioneering and highly innovative devices.

In addition to these efforts, in the framework of the IMPACPESCA project, **information on the conservation status of benthic habitats** has been obtained in order to assess the effect of bottom contact fishing gear on these benthic habitats.

Finally, in the CetAMBICion project, carried out between 2021 and 2023 in collaboration with the fishing industry and research centres in France, Portugal and Spain, we have established the basis for the coordinated assessment and monitoring of cetacean populations and incidental catches. This project has enabled the joint **adoption of cetacean bycatch mitigation measures in the Bay of Biscay and the Iberian coast**, highlighting AZTI's commitment to the conservation of marine biodiversity and sustainable fishing.



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### PROGRESS TOWARDS BETTER MARINE SPATIAL PLANNING

The marine environment is home to a wide range of human uses and activities that contribute to the economic and social progress of coastal nations. Managing and planning marine space is a challenge, highlighting Maritime Spatial Planning (MSP) as an essential strategic tool to efficiently coordinate human activities in marine areas. With a cross-cutting, integrated and cross-border approach, an optimal use of marine space must be achieved, reducing conflicts and promoting coexistence and synergies between different uses and activities.

In this framework, blue energy, especially offshore wind, is presented as a crucial element for decarbonisation and the achievement of the UN Sustainable Development Goals (SDGs). Although offshore wind is projected to grow exponentially, it faces non-technological barriers related to environmental uncertainty and bureaucratic complexities.

To reach the climate neutrality targets set by the European Union, it is estimated that 240-450 GW of offshore wind energy production capacity will be needed by 2050. The approach must be environmentally sustainable, considering the SDGs and assessing environmental risks from early stages of development.

At AZTI we are involved in marine spatial planning

and management, seeking strategies that allow for a harmonious coexistence between human activity and the preservation of marine resources, for example, through our participation in the European MarinePlan project, in which we are developing **tools for decision-making in marine planning.**

In this context, since 2018 AZTI has coordinated two European projects, WESE and SafeWAVE, aimed at **studying the environmental impacts of wave energy capture technologies and collaborates in related projects**, such as the first wave power plant in the French Basque Country, providing information on the impact of these facilities on marine ecosystems. Similarly, with a focus on the analysis of use and management, assessment scenarios of the social and economic impacts of ocean energy for the selection of sites for ocean energy infrastructure, **specific tools have been developed for the environmental risk analysis of wave energy converters, WEC-ERA** (Wave Energy Converters Ecological Risk Assessment Tool: <https://aztidata.es/wec-era/>) **and WIND-ERA** (Ecological risk assessment of offshore wind turbines: <https://aztidata.es/wind-era/>). Finally, through the **VAPEM tool** (Ecological Assessments and Maritime Spatial Planning tool: <https://aztidata.es/vapem/>), **we make all the information and models developed freely available.**

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## 2.1. ADDRESSING GLOBAL DEMOGRAPHIC CHANGES



Iñaki Oyarzabal

These tools contribute to the Strategy by providing scientific knowledge and technical resources to overcome one of the most important non-technological barriers that could hinder the achievement of the objectives, namely the associated environmental risks.

Under the CABFishMan project, **common data homogenisation methods** have been developed to create high spatial resolution maps showing the spatial fishing patterns and fishing effort of small-scale and coastal fleets. Maps created using this method can reflect nuances such as high gear diversity and seasonal fishing patterns and generate a very accurate picture of small-scale fisheries activity. Although high-resolution data is limited, vessel monitoring is expanding rapidly, making it a valuable tool to support maritime spatial planning by providing evidence of the location and economic value of this fishing activity.

These tools are part of the 'Decision Support Tools' family, designed to facilitate the development of marine renewable energies within the framework of marine spatial planning and management. They aim to support the realisation of the 2050 vision of the European Union's offshore renewable energy

strategy, while ensuring that they do not generate significant harm. In this way, it seeks to ensure that the achievement of the Biodiversity Strategy, the achievement of Good Environmental Status (Marine Strategy Framework Directive) or compliance with nature conservation Directives is not compromised.

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### PERSONALISED NUTRITION TO MEET SOCIETY'S CHANGING NEEDS

Precision nutrition, with the development of nutritional recommendations, solutions and products tailored to the individual characteristics of each person or population group, has become a growing trend. By abandoning generality in favour of personalisation, this approach has established itself as a crucial differentiator in the field of wellness, with precision nutrition standing out as one of its most relevant exponents.

The concept is clear: each person is unique, so the diet that benefits one person may not be effective for another. The importance of knowing the specific characteristics of each individual lies in providing tailored nutritional recommendations with a positive impact on their health. Improvements in biotechnology, together with advances in artificial intelligence and machine learning, have led to its growth, coinciding with an increase in social interest in nutrition.

The main challenge of personalised nutrition, which takes into account biological factors and individual lifestyles, lies in bringing solutions to market. Laboratory biotechnologies are becoming increasingly accurate and cost-effective, and artificial intelligence has become essential to develop viable busi-



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ness models. This technology helps professionals to study the most determinant variables of individuals, providing personalised nutritional recommendations and continuously learning from new data. However, it is necessary to overcome the challenge of social awareness, anticipating lifestyle diseases.

AZTI has led several initiatives to explore the potential of precision nutrition that not only seek to anticipate health problems, but also to improve quality of life in the long term and generate new collaborations and economic opportunities. In 2023, the following stand out:

The SUMA project, in collaboration with Onkologikoa and funded by Asociación contra el Cáncer, aims to design a personalised nutritional strategy based on molecular tools such as lipidomics and nutrigenetics **to improve the nutritional and metabolic status of breast cancer survivors.**

The partnership with the Real Sociedad and the Mugaritz restaurant for the creation of individualised nutrition plans for the staff by applying omics techniques and technologies, such as lipidomics and microbiomics.

**Lipiwell is a personalised nutrition programme based on artificial intelligence,** available via the web and the Lipiwell app on Android and iOS.

Within the framework of the SEAwise project, AZTI

has developed **a personalised guide for selecting the healthiest fish according to individual needs.** This guide, based on algorithms created by AZTI, focuses on the essential micronutrients found in fish such as iodine, selenium, vitamin D, vitamin B12 and Omega-3 fatty acids, categorises the consumption value of different species according to nutritional needs, and suggests fish consumption guidelines adapted to the main fishing regions in Europe.

AZTI coordinates the European CoDiet project, which will develop a customised tool based on artificial intelligence capable of **assessing individual risk of diet-induced non-communicable diseases** and offering personalised nutritional advice.

Research by AZTI in collaboration with the Nutrition and Cancer Unit of the Catalan Institute of Oncology and IDIBELL highlights the **importance of the Mediterranean diet and olive oil in the prevention of obesity-related cancers.** It also points out that these eating habits can modify the composition of the intestinal microbiota, playing a crucial role in the prevention and treatment of obesity-related cancers.



## 2.1. ADDRESSING GLOBAL DEMOGRAPHIC CHANGES



balanced and nutritious diet.

In the field of dairy products, we have reached an important milestone by obtaining a patent for dairy snacks (PCT/ES2023/070755). This innovative creation stands out for its focus on providing delicious and nutritious options to meet consumers' evolving needs.

We have also designed Youlabel, a **specialised software designed to measure the nutritional impact of products in relation to the needs of the population**. This software not only facilitates the development of healthy products, but also enables the evaluation of nutritional marketing positioning strategies. Youlabel represents a comprehensive tool that drives innovation and nutritional awareness.



### HEALTHY AND NUTRITIOUS FOOD SOLUTIONS

At AZTI, we work to develop innovative solutions for healthy and nutritious food. In 2023, we worked closely with 21 food companies on a number of developments that are expected to reach the market in 2024. These collaborations represent our ongoing commitment to push the boundaries of innovation and deliver food solutions that are not only delicious, but also healthy.

One of our key launches was the meat snacks developed in collaboration with Sigma-Campofrio. Transferring the concept of **meat snacks** such as chorizo and ham to Utega, Sigma-Campofrio's manufacturer, has resulted in the successful launch of a new range in 2023.

Another relevant launch was the **Sopa Juliana pasteurised product** developed by AZTI and presented to the market by Itsasur. This product represents a convenient and healthy option for those seeking a

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## CONSUMER BEHAVIOUR

At AZTI, we believe that it is essential to understand, and even anticipate, consumer behaviour trends in order to develop innovative foods and adapt to the changing demands of the market.

For this reason, the AZTI team has carried out a review of the main consumer trends, of what is happening in the field of FoodTech... a review of what is happening and what will inevitably affect the food sector. In **EATrends 2023**, trends have been identified (diversity, sustainability, safety, technology, regeneration...) that are the guiding stars that mark the path of innovation.

We have developed new technologies and methodologies to better understand consumer behaviour in shopping channels. We have focused on **measuring consumer behaviour** through mobile devices and web platforms. This initiative allows us to gain valuable insights into consumer preferences and choices, paving the way for the creation of products that meet their expectations.

In our quest to understand and adapt to consumer behaviour, we have led and participated in significant European projects. One of these, the TITAN (Transparency Solutions for Transforming the Food System) project, has focused on **addressing transparency solutions for transforming the food system**. We have paid particular attention to food

consumption needs and behaviours, especially in families with children. In parallel, we actively participate in EIT Food's Consumer Observatory and Youth Mission projects, where we are engaged in consumer observation and public participation. The focus is on understanding how young people perceive and relate to food, as well as establishing an observatory to measure and analyse consumer behaviour in real time.





## 2.1. ADDRESSING GLOBAL DEMOGRAPHIC CHANGES

### **FOOD SAFETY AND INTEGRITY**

In the field of food safety and integrity, AZTI has driven significant advances through the application of various specialised technologies.

#### **Mass sequencing technologies to identify ingredients in processed foods**

The safety and authenticity of processed foods are critical areas to guarantee the quality of products on the market. AZTI has implemented mass sequencing technologies for the accurate identification of ingredients in processed foods, thus contributing to ensuring the transparency and reliability of the food chain. AZTI, together with the University of Santiago de Compostela, has developed an **innovative genetic chip that guarantees the authenticity of Galician mussels**. This chip is based on a specific genetic study to distinguish the geographical origin of mussels, focusing particularly on the species *Mytilus galloprovincialis*, known as the Galician or Mediterranean mussel. With 17 specific genetic markers, the chip provides an accurate tool for producers and researchers, contributing to the sustainable management of mussel aquaculture, preventing food fraud and ensuring traceability in the value chain.

#### **Tecnologías para el control de enfermedades en acuicultura**

La acuicultura desempeña un papel crucial en la producción alimentaria global, y el control de enfermedades en este sector es esencial para garantizar la productividad. AZTI forma parte de la Red Fishealth, una iniciativa que busca soluciones para

el control de enfermedades infecciosas en la acuicultura. La participación en esta red permite a AZTI contribuir al aumento de la implementación de las tecnologías desarrolladas en el ámbito productivo y optimizar la calidad de los procesos de transferencia, fortaleciendo así los esfuerzos colectivos para mantener la salud y la integridad en la acuicultura.



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### Advances in bacteriophages and their application in the food and fish industry

The research and application of bacteriophages represents a significant advance in improving food safety and integrity in the food and fish industries. AZTI has led initiatives to harness the benefits of bacteriophages, which can specifically target harmful bacteria to help ensure food safety.

In addition, in order to guarantee food safety, AZTI has been **monitoring shellfish production areas on the Basque coast** through the CULTIVOS project, which has regularly measured pollutants, microbiological parameters, toxic phytoplankton and biotoxins since 1990. Information has also been collected for the development of a system for predicting toxic events, which may be useful for the management of production areas.



## 2.2.

# THE CLIMATE CRISIS AND ENVIRONMENTAL PRESSURES AS DRIVERS OF CHANGE

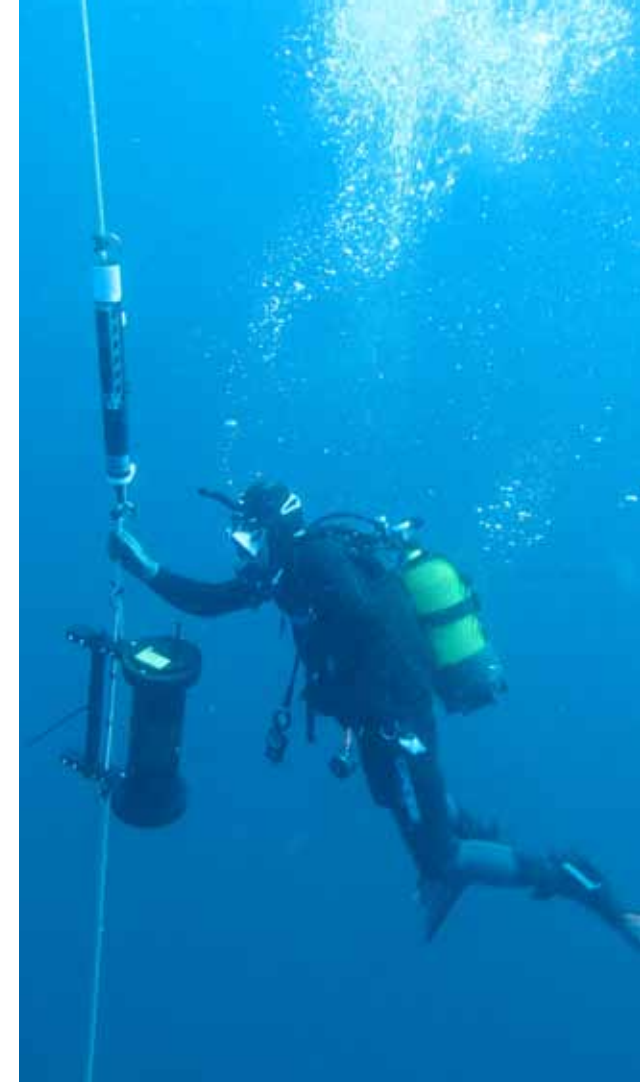
At AZTI, we recognise the urgency of addressing the challenges posed by the climate crisis and environmental pressures, factors that act as drivers of change in the global food chain. We are actively committed to developing innovative solutions to address the challenges of the climate crisis in a holistic manner, contributing to building a more resilient and equitable future.

In the face of the climate crisis and environmental pressures, we have focused our efforts on understanding and mitigating the impact of climate change on marine ecosystems.

In the area of fisheries, we work to develop solutions that not only anticipate the challenges posed by increased competition for marine space, but also promote **sustainable practices and the preservation of biodiversity**. We work closely with fishing fleets to implement mitigation measures that reduce environmental impacts and promote more efficient and equitable exploitation of marine resources.

In addition, **we proactively adapt to climate change in the coastal zone** by, for example, restoring *Zostera noltei* seagrass meadows as nature-based solutions. Through research and implementation of adaptation strategies, we aim to strengthen the resilience of coastal communities and the sustainability of economic activities linked to the sea.

We promote efficiency and sustainability in the food chain. We promote **'circular economy' models** that minimise waste, encourage reuse and reduce the environmental footprint. We work in partnership with key stakeholders in the food value chain to drive **more efficient and sustainable production**, contributing to food security and the integrity of natural resources.





## 2.2. THE CLIMATE CRISIS AND ENVIRONMENTAL PRESSURES AS DRIVERS OF CHANGE



### OBSERVATION AND IMPACTS OF CLIMATE CHANGE ON THE MARINE ECOSYSTEM AND RESOURCES

The ocean is undergoing major changes due to climate change, such as an increase in sea temperature, changes in the stratification of the water column, acidification, oxygen depletion and impacts on the distribution of marine life.

In 2023, AZTI led an international study to **assess the combined effects of climate change and fishing pressure on key commercial species such as tuna and swordfish**. The results show that by 2050, productivity is expected to decline by an average of 36% and the size of some tuna stocks by 15%. These results pose significant challenges for demand, price and profitability of the fishery, and underline the need for comprehensive approaches to address this emerging issue.

As part of the LIFE Urban Climate 2050 project, a study carried out by AZTI on the adaptation **strategies of mackerel and horse mackerel to ocean warming** shows that for each degree increase in sea temperature, mackerel move their spawning grounds northwards by 370 km, while horse mackerel move their spawning grounds forward by about 12 days. This integrated approach, published in the journal *Ecological Indicators*, highlights the importance of understanding the complex interac-



tions resulting from climate change and suggests necessary adjustments to fisheries management strategies.

At the same time, in collaboration with the University of Southampton and the British Antarctic Survey, AZTI has led an **international study on bluefin tuna that warns of the potential challenges posed by the expected rise in temperatures in Mediterranean breeding grounds over the next 50 years**. The analysis, published in *Nature Communications*, highlights the need to adapt fisheries management

to the future distribution and possible relocation of breeding grounds as the Mediterranean warms.

Finally, in an analysis spanning three decades, AZTI has identified **evidence of a decline in anchovy size in the Bay of Biscay**. Published in *Global Change Biology*, the study suggests that this reduction is linked to ocean warming and complex environmental factors, ruling out a significant influence of fishing pressure. This indicator could reflect the response to climate change and ecosystem functioning in the Bay of Biscay.

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## 2.2. THE CLIMATE CRISIS AND ENVIRONMENTAL PRESSURES AS DRIVERS OF CHANGE



### ACTIONS TO MITIGATE IMPACTS ON FISHING FLEETS AND PORTS

The growing economic and environmental crisis resulting from the exponential increase in marine diesel prices has led the European Union to adopt drastic measures in its quest to eliminate greenhouse gases by 2050. In this context, digitalisation and decarbonisation are presented as two fundamental pillars to address energy efficiency in the fishing sector.

AZTI contributes to the sustainability of fishing activity with technologies and research applied to

fuel saving, energy efficiency and decarbonisation of vessels. These efforts aim to promote more sustainable practices in the fishing industry, reducing its environmental impact and promoting the preservation of marine resources for future generations.

#### Digitalisation of inshore fishing: focus on fuel savings

AZTI, as a benchmark in marine research, is at the forefront of the digitalisation of the inshore fishing sector, focusing especially on fuel-saving strategies. Through exhaustive studies, researchers at AZTI have characterised and evaluated the performance of fishing vessels, with an emphasis on energy

consumption. The objective: to propose alternative operations that, while maintaining fishing efficiency, allow fuel consumption and the associated level of gas emissions to be reduced.

AZTI's efforts translate into tangible actions that seek to promote more sustainable practices in the fishing industry, reducing its environmental impact and responding to a problem that today has negative consequences in economic and polluting terms.

An outstanding example of this commitment includes the Digimar project, developed in close collaboration with the Organisation of Fishing Producers of the Port and Estuary of Marin (OPROMAR) and Marine Instruments. The implementation of the "MarineView" system has led to tangible progress in **optimising navigation routes**, resulting in the effective reduction of travel time and energy consumption of fishing fleets. In addition, this initiative has facilitated more selective fishing, thus contributing to reducing the environmental impact associated with fishing activities.

Within the framework of the ENERCOM project, AZTI has examined the consumption of the fleet of the OPROMAR to monitor fishing vessels and analyse performance and consumption patterns in three fishing segments: purse seine, longline and trawling. The results show that measures such as keeping vessel speed below certain values can gen-

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erate significant fuel savings, thus contributing to the decarbonisation of fishing fleets.

Similarly, the **historical analysis of fuel consumption data** has made it possible to propose specific measures, beyond the analysis of specific campaigns affected by variable oceanographic conditions. A specific example is the analysis of 13 tuna inshore campaigns of the Gipuzkoa Producers' Organisation (OPEGUI) fleet between 2015 and 2021, showing a significant improvement in the reduction of the intensity of fuel use in the trolling and live bait fleets in Gipuzkoa. Furthermore, the result suggests that a slight reduction in route speed could lead to fuel savings of more than 30%, thus contributing to the sustainability of the fishing sector and the reduction of the carbon footprint.

Simultaneously, work has been carried out on **catch prediction models, highlighting machine learning with artificial intelligence, massive data and tools to support fishing efficiency**. In the case of the mackerel fishery, two independent models have been developed for handline and purse seine fishing gear, with 72% and 81% accuracy, respectively, in predicting high catches. Given the alteration in the distribution of mackerel due to environmental changes, these models are crucial tools to reduce the searching time and, therefore, the hours at sea and distance travelled, contributing to the knowl-

edge of the environmental impact on commercial pelagic species and strengthening the sustainable management of the stocks, essential elements to guarantee the sustainability of the fishery.

### **Decarbonisation of fleets in the European context within the Green Deal framework**

In a scenario shaped by the exponential increase in the price of marine diesel, decarbonisation emerges as an imperative need to guarantee the survival of the fishing industry. AZTI stands as a leader in the transformation of the fishing sector towards digitalisation and decarbonisation. Its commitment to research, innovation and the implementation of tangible solutions has made the institution a key player in the search for more sustainable and efficient practices in the fishing industry, paving the way towards a greener and more resilient future.

AZTI has played a key role in **sharing its expertise with the European Parliament**, highlighting its crucial role in finding solutions for the fishing and aquaculture industry in line with the 2050 carbon neutrality target set under the Green Deal. They presented more than 20 solutions related to reducing fuel consumption, the use of alternative energies and sustainable fishing for decarbonisation, reflecting AZTI's commitment to sustainability in fisheries and aquaculture in the European context.

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A significant milestone on this path is the **KAINDAR prototype, the first port smart-grid in the Basque Country**. Funded by the Provincial Council of Gipuzkoa, this project uses renewable sources and connectivity technologies to supply bi-directional power to electric vessels. KAINDAR actively contributes to the decarbonisation of docks, thus advancing towards the port electrification targets for 2030. Its focus on the circular economy, through the use of recycled or second-life materials, aligns perfectly with the Blue Growth strategy and the European Union's objectives for sustainable growth.

In tune with the prevailing need to address climate change, AZTI actively addresses the issue of pollution generated by various human activities that affects the marine environment and, ultimately, consumers of seafood products. The **application of circular economy principles in the fishing industry**, promoting on-board recycling and developing low environmental impact technologies, reflects AZTI's commitment to climate change mitigation.



### MITIGATION AND ADAPTATION TO CLIMATE CHANGE IN THE COASTAL AREA

We have developed artificial intelligence tools to assess vulnerability in the coastal area as a consequence of climate change.

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## 2.2. THE CLIMATE CRISIS AND ENVIRONMENTAL PRESSURES AS DRIVERS OF CHANGE



### EFFICIENT AND SUSTAINABLE FOOD SUPPLY CHAIN

In the context of a food chain that seeks personalisation and sustainability, AZTI has developed innovative strategies and technologies that seek to adapt to individual needs while promoting sustainable practices in food production and consumption.

In this sense, AZTI has created **Envirodigital**, an **environmental management software** registered with the intellectual property office. This platform allows companies to assess the environmental impact of their processes and products, standing out for its capacity to carry out efficiency and impact simulation scenarios, contributing to efficiency and sustainability in the food chain.

Furthermore, the **ENVIROSCORE environmental labelling** ([www.enviroscore.eu](http://www.enviroscore.eu)), developed by AZTI in collaboration with European agents to measure the environmental impact of food and beverages, has been scientifically validated and published in the prestigious journal NATURE Science of Food. This environmental labelling system supports informed decision-making by consumers, thus encouraging more conscious and sustainable choices.

Another key initiative is the BIOGEARS project, led by AZTI, which has driven the **development of “bio” ropes made from biodegradable bio-**



**materials for aquaculture.** These ropes have not only demonstrated an 85% increase in yield in the cultivation of mussels suspended in longlines, but also a significant reduction in environmental impact (20%), a 34% reduction in carbon footprint and a 63% reduction in the use of fossil resources, in line with more sustainable aquaculture production. The use of these innovative solutions is not only more eco-efficient, but also proactively addresses the environmental challenges associated with plastic waste management, as these ropes are compostable at the end of their useful life and promote the circularity of materials in new value chains, creating a circular economy. Aquaculture products grown with these ropes, such as mussels, make more sus-

tainable use of natural resources, creating more sustainable food chains, promoting responsible consumption and decarbonising the sector.

Another outstanding method is the DNA-based sexing of sturgeon, which will lead to major savings for the sector by identifying males and females from an early age.

In addition, the introduction of an IoT (Internet of Things) platform integrates management and production data in the maritime and food sectors, enabling faster, more accurate and efficient decision-making. This platform not only streamlines decision-making processes, but also contributes to **more effective resource management and greater**

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### **operational efficiency in the food chain.**

In the search for **efficiency and reduction of waste and dumping**, AZTI has implemented technologies for the recovery of brine in industrial food processes in canning companies.

In terms of circular economy, through the Life-ECOFFEED project, AZTI has innovated in the **use of coffee grounds recovered from the HORECA sector to create a component of animal feed**. This ingredient, integrated into sheep diets, has shown positive benefits in milk production and milk quality, while reducing methane emissions.

In the **fisheries and aquaculture sector**, AZTI has applied **innovative by-product valorisation technologies** in the WaSeaBi project. The extraction of new ingredients and protein products from waste promotes a more sustainable and personalised food chain, opening up new opportunities for the production of high value-added foods.

These collective efforts in which AZTI has participated reflect its leadership in transforming the food chain towards more personalised and sustainable practices, highlighting the importance of adapting food production to individual needs, while addressing the challenge of environmental sustainability and efficiency throughout the food chain, from production to the end consumer.

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## 2.3. INNOVATION AND TECHNOLOGY, A CORNERSTONE OF COMPETITIVENESS

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**Innovation and technology have acquired a key role in competitiveness, especially in an environment of rapid technological change. Rapid technological evolution, including biotechnology and gene technologies, has transformed the competitive dynamics in various industries, from production to marketing. At AZTI, we take a proactive approach to specialisation and innovation, both in technological and market terms, recognising them as crucial elements for the future survival of companies in our sector.**

We understand the importance of integrating information and communication technologies (ICT) into key processes, ranging from production to logistics and marketing. In addition, we explore new frontiers in emerging sectors such as tourism, gastronomy and health. This holistic and future-oriented vision positions us to meet the challenges of an ever-changing world.



## 2.3. INNOVATION AND TECHNOLOGY, A CORNERSTONE OF COMPETITIVENESS



In the face of accelerating technological change, we at AZTI stand out for our comprehensive ecosystem observation initiatives and the digitalisation of the fisheries sector. We innovate in on-board processes and operations, implementing Marine 4.0 technologies to characterise the physical environment and conduct operational oceanography. This adaptability allows us to anticipate and address emerging challenges, ensuring the sustainability and efficiency of our operations.

Changing values in society have led us to re-evalu-

ate our interaction with the marine ecosystem. At AZTI, we respond by developing solutions that go beyond mere technological innovation. We focus on the conservation of marine ecosystems, integrated waste management and the valorisation of marine ecosystem goods and services.

Under the concept of blue economy, that is, placing the value of the seas and oceans as drivers of the economy due to their great potential for innovation and growth, at AZTI we work on an approach that includes environmental impact studies, marine

health assessment and the promotion of the blue circular economy, generating solutions that not only address current challenges, but also contribute to sustainable development.

In terms of shifting economic power, we focus on the development of new sensors and rapid detection systems for chemical and biological markers, as well as on the valorisation of food by-products. These integrated solutions not only respond to market demands, but also contribute to more efficient and sustainable resource management, consolidating our commitment to an equitable and prosperous future.



## 2.3. INNOVATION AND TECHNOLOGY, A CORNERSTONE OF COMPETITIVENESS



### ACCELERATING TECHNOLOGICAL CHANGE

#### Integrated ecosystem and multi-platform observing system

As part of its commitment to technological innovation and sustainable management of the marine area, AZTI has implemented **KostaSystem on the beaches of Arona**, Canary Islands. This pioneering technology, developed by AZTI, uses webcams for the continuous transmission of images in real-time on the beaches of Honda, El Camisón, Las Vistas and Los Cristianos. KostaSystem, in addition to providing spatial referencing, addresses three key areas: bathing safety, beach services and morphological monitoring.

Concerning beach monitoring, this system enables a continuous analysis of the morphological configuration, providing detailed information on sea conditions, wave characteristics and monitoring of coastal processes. In addition, it provides real-time data on the density of beach users. The ability to establish current and wave behaviour patterns not only ensures the safety of bathers, but also facilitates efficient coastal management. It can calculate user density, identify areas of erosion, surface variations and sand accumulation, as well as monitor environmental impact and beach regeneration.

AZTI has also played a key role as a **consultant for**

**EITB in the rowing regattas**. In addition, this year it has introduced an innovative system to quantify the difficulty of offshore regattas, improving the experience for the public and providing detailed information on the oceanographic variables that influence these competitions. The application developed for EITB measures the difficulty index of regattas, offering a useful tool for viewers and enriching the understanding of these sporting events.

In the context of the #ebegi project, AZTI has led the initiative backed by the Basque Government to **strengthen coastal ecosystem observation capacities in the southeast of the Bay of Biscay**.

This project is aligned with the integrated management of marine ecosystems and seeks to advance towards the sustainable transformation of the blue economy. #ebegi provides high quality marine observations and reliable, harmonised and accessible data. The tool enables easy discovery of available marine information and serves as a basis for the development of new solutions to drive care for our coasts in the era of digital twins. The implementation of these technologies reflects AZTI's ongoing commitment to innovation and sustainability in comprehensive coastal and marine ecosystem observation.

In the context of the European Horizon Mission Atlantic project, **a new tool, GAM-NICHE** (<https://gam-niche.azti.es/>), has been developed to **build**

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**Species Distribution Models (SDMs) under the ecological niche theory.** This tool offers a tutorial on GitHub in R language with an application to marine fish. This tool can be used for different applications in species conservation, habitat restoration, management and assessment of climate change impacts.

### **Boosting FoodTech and entrepreneurship in the food value chain**

FoodTech, as a driver of innovation in the food sector, has established itself as an essential pillar for its sustainable development. It not only transforms production, but also fosters cross-border collaborations and generates a significant economic impact. In this context, AZTI leads initiatives that underline the importance of FoodTech as a driver of change and progress in the food value chain.

In 2023, AZTI spearheaded **significant advances in food marking through the innovative use of laser technology.** This technology, which we are using for marking or engraving and for peeling food, is set to revolutionise the food industry in the coming years. Also noteworthy is a patent for the opening of pistachios (application filed at the SPTO).

Likewise, as part of its commitment to innovation, AZTI has developed the specialised **AZPilotManager software, designed specifically for innovation management in pilot plants in food companies.**

This software offers a comprehensive platform that facilitates the planning, execution and supervision of research and development projects in the field of food.

An outstanding collaboration between Itsas Baldegó S.L and AZTI has resulted in a pioneering project proposal: **the first live bluefin tuna fattening facility in submersible cages**, to be located off the coast of Getaria. The initiative will involve the initial capture of the tuna with purse seine gear and its subsequent fattening in submersible cages, avoiding the challenges of winter storms in the

Cantabrian Sea. This initiative promises improvements in sustainability by reducing fuel consumption and increasing safety compared to traditional methods.

AZTI has also provided **support to the Basque Government in the development of the future Bards aquaculture park.** Our contribution includes studies on the design of the facilities, collaboration in the adaptation of the necessary regulations and the identification of national and international projects for implementation in this aquaculture park. Proposals for salmon and sole production



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have been explored, with potential investments that could exceed 100 million euros.

The co-organisation of the 3rd edition of **Food4Future World Summit**, held between 16 and 18 May, stands out as evidence of our presence in key international forums for the food and beverage industry. Prove of the consolidation of this event is the attendance of 8,372 participants from 34 countries, with Japan as the guest country. During the event, a collaboration agreement was signed with SKS Japan and the foundations were laid for Japan's permanent participation in the forum, presenting disruptive food technologies. Food4Future has generated an economic impact of 17 million euros in Bizkaia.

Finally, in collaboration with the Basque-French cheese factory Agour, AZTI has promoted **Inkuba Sarea**, a cross-border network dedicated to promoting start-ups and FoodTech companies. Furthermore, through the TITAN initiative, in which we actively participate, we offer transparency solutions to small consortiums of three start-ups or SMEs, thus contributing to the transformation of the food system.





## 2.3.

# INNOVATION AND TECHNOLOGY, A CORNERSTONE OF COMPETITIVENESS



### CHANGE IN VALUES

AZTI leads initiatives and strategic proposals that seek to change paradigms and promote concrete actions to **boost blue economy**. An action plan has been developed outlining key actions to integrate the principles of the blue economy in various sectors.

An example of this commitment is AZTI's technical leadership in the **Oarsoaldea Blue Economy Pole**, a project that electrifies ports, implements port Smart Grids and promotes marine 4.0 technologies. This initiative not only promotes sustainability in the maritime sector, but also fosters innovation in marine engineering and food production, generating economic opportunities and employment in the region. Furthermore, the inclusion of the Oarsoaldea area in the Preferential Action Zones (ZAP) plan reinforces the Basque Government's commitment to the revitalisation of areas affected by industrial decline, consolidating Pasaia as a benchmark in the development of blue economy.

#### **Marine ecosystem preservation and environmental impact assessment**

AZTI has led crucial research to **understand and mitigate the risks to marine wildlife associated with human activities**. A study published in Nature

Communications highlights the high risk to oceanic seabirds in various regions of the world due to exposure to plastic, underlining the urgency of international cooperation to tackle plastic pollution at a global level.

AZTI has been working for URA, the Basque Water Agency, for 30 years on the recovery of estuarine and coastal ecosystems in the Basque Country, including advice on the restoration of marine habitats, through the network for monitoring the quality status of the coastal zone and estuaries of the Basque coast. This year an article has been published in the journal Science on the **European Nature Restoration Act**.

AZTI has helped to meet European Union requirements in terms of **urban wastewater treatment** by carrying out **Environmental Monitoring Plans** that assess the impact of discharges from different WWTPs on the coasts of Bizkaia and Gipuzkoa. The Galindo WWTP, managed by the Bilbao Bizkaia Water Consortium, is noteworthy for its duration. This initiative has involved monitoring the Abra and the Bilbao estuary for decades, which has enabled the environmental recovery of this estuary ecosystem to be confirmed. This project, "CONSOR", continues today and covers the study of multiple variables of environmental interest (physico-chemistry of the

## 2.3. INNOVATION AND TECHNOLOGY, A CORNERSTONE OF COMPETITIVENESS

water, pollutants in the sediments, their effects on fish, diversity of biological communities, etc.).

In addition, AZTI participates in several European projects (coordinating the GES4SEAS project and leading a work package in OBAMA-NEXT) that are **developing tools to efficiently monitor and assess the marine environment**, in support of the European Marine Strategy Directive and the Habitats Directive.

AZTI keeps contributing to the sustainable management of the marine environment through projects for the assessment of the impact of projects and plans, monitoring programmes and environmental consultancy. Thus, since 2016, we have been monitoring the actions related to the expansion of the port of Bilbao and dredging activities in the ports of the Basque Country in accordance with the legislation in force, as well as providing scientific advice on the project for the electricity interconnection between Spain and France via the Bay of Biscay.



Alex Iturrate



## 2.3.

# INNOVATION AND TECHNOLOGY, A CORNERSTONE OF COMPETITIVENESS



### Assessment of marine ecosystem goods and services

AZTI has made a significant contribution through the DiadES project to **enhancing the cultural and ecological benefits of species such as salmon, eels and sea breams**. This project, funded by the European Union, analyses and assesses in monetary terms the ecosystem services provided by endangered diadromous fish. The research, the first of its kind in Europe for these species, highlights the importance of the cultural services associated with these species, which outweigh traditional monetary values. For example, it has been estimated that the value of some ecosystem services in Gipuzkoa

could be worth at least 25 million euros.

In addition, the photographic exhibition “Metropelagic”, promoted by AZTI, has brought the wonders of the mesopelagic ocean closer to Bilbao metro users, playing **a crucial role in raising awareness of marine biodiversity**. The mesopelagic zone, located between 200 and 1,000 metres deep and commonly known as the twilight zone, is characterised by its inhospitability and difficult access. This area remains one of the least studied and explored, making it one of the most enigmatic and unknown of the ocean. The initiative has not only provided a unique insight into this unexplored marine environment, but has also underlined the importance

of driving further research and exploration in this poorly understood area of our oceans.

The GES4SEAS project has studied the **link between the state of the marine environment, the provision of ecosystem services**, and socio-economic benefits, based on an example in the Bay of Biscay.

In parallel, AZTI has worked on the development of the generation of knowledge of the Profound Ecosystems of the Cantabrian Sea (EPROCAN project). This is a project funded by Fundación Biodiversidad (Ministry of Ecological Transition and Demographic Challenge), within the framework of the Recovery, Transformation and Resilience Plan funded by the European Union - NextGenerationEU.

Deep ecosystems account for 75% of the ocean’s surface area and 95% of its volume and play a crucial role in the functioning of the Earth and the provision of goods and services. But at the same time, thanks to technological advances and the need for resources, more and more activities are taking place in deeper waters. Scientific knowledge of deep-sea ecosystems is very limited and in fact, the UN declared 2021-2030 as the Decade of Ocean Sciences for Sustainable Development, recognising the scarcity of deep-sea biological data. With this in mind, a compilation of existing information, an expert consultation and a workshop have been carried out.



## 2.3. INNOVATION AND TECHNOLOGY, A CORNERSTONE OF COMPETITIVENESS

AZTI's work highlights the need to **advance deep sea exploration and observation for the management**, conservation and restoration of habitats and species, fostering international cooperation and adopting transboundary management measures. These efforts reflect AZTI's commitment to strategic research to understand and protect our marine ecosystems.

With regard to work aimed at marine conservation, AZTI participates in the LIFE IP INTEMARES project, Integrated, Innovative and Participatory Management of the Natura 2000 Network in the Marine Environment. The project aims to **achieve an efficiently managed network of Natura 2000 marine areas**, with the active participation of the sectors involved and research as basic tools for decision-making. The project includes several actions, including the designation of marine protected areas, scientific research and the development of sustainable fishing practices.

AZTI has actively participated in **improving knowledge for the declaration of new marine areas due to their ecological importance**. This study aims to develop a management plan for the Capbreton canyon that takes into account the conservation of biodiversity and the sustainable use of resources. This involves studying the ecology of the canyon, identifying key habitats and species, and assessing human activities that may affect the ecosystem.



Ocean Image Bank Mike Bartick

These results will be used to inform the development of a management plan for the Capbreton canyon system, including the **identification of areas requiring protection and the establishment of fishing regulations that ensure the sustainable use of marine resources**. It will also contribute to a better understanding of the ecological functioning of the canyon and the conservation of its biodiversity.

In the context of the CABFishMan project, the **cultural aspects linked to small-scale fisheries**

**have been identified and their economic value assessed**. This data collection will make it possible to consider the integral value of these fishing activities, incorporating the value of the associated cultural ecosystem services to the already recognised food supply function. This information is also essential for safeguarding cultural heritage and promoting the well-being of coastal communities.

AZTI has also studied how marine blue spaces, through the cultural services they provide, contrib-

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ute to human wellbeing and health. This blue well-being has been analysed in the BideURDIN project, where a **characterisation of marine recreational activities on the coast of Gipuzkoa and their contribution to mental health** has been carried out.

Thus, the environmental conditions on which these activities depend and how they can impact the marine environment were analysed. Their spatial distribution and the compatibility between them was studied in order to detect possible conflicts between users. Finally, an analysis was made of the feelings and emotions generated by the practice of the different marine recreational activities, and their effect on mental restoration.

The RESONATE project, which started this year, will explore **how therapies in nature can contribute to human physical and mental health in different natural spaces**, such as the coast. Finally, AZTI has participated in the book “Oceans and Human Health” published by Elsevier, leading a chapter in which it summarises how contact with marine blue spaces benefits human health and well-being.

### **Advances in marine health assessment**

The MER-CLUB project, led by AZTI, stands out for its innovative approach to the decontamination of mercury in marine sediments. This project, co-funded by the European Maritime and Fisheries Fund, has established a database and a collection

of bacterial cultures (MERCC) from contaminated sediments from different regions. **A highly efficient bacterial isolate, capable of removing 75% of the mercury in the liquid medium within 24 hours, has been identified.**

The project has also worked on characterising and optimising the conditions for this strain to carry

out the detoxification process in contaminated sediments, including its growth in bioreactors and immobilisation in synthetic matrices for bioremediation applications. **A pilot plant for the decontamination of marine sediments has been designed** in collaboration with AFESA.





**INTERNATIONAL BENCHMARK:**  
SCIENTIFIC EXCELLENCE

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Scientific excellence, backed by the practical application of our research results, is the basis that establishes our team as an international benchmark.

This recognition translates into our outstanding participation as leading speakers in international forums and a consolidated presence in the main scientific committees linked to our fields of research, especially those key to the sustainable management of fishery resources of the main species of interest to the Basque fishing sector.

**This presence underlines the transcendence and significant influence of our work in the scientific community worldwide.**



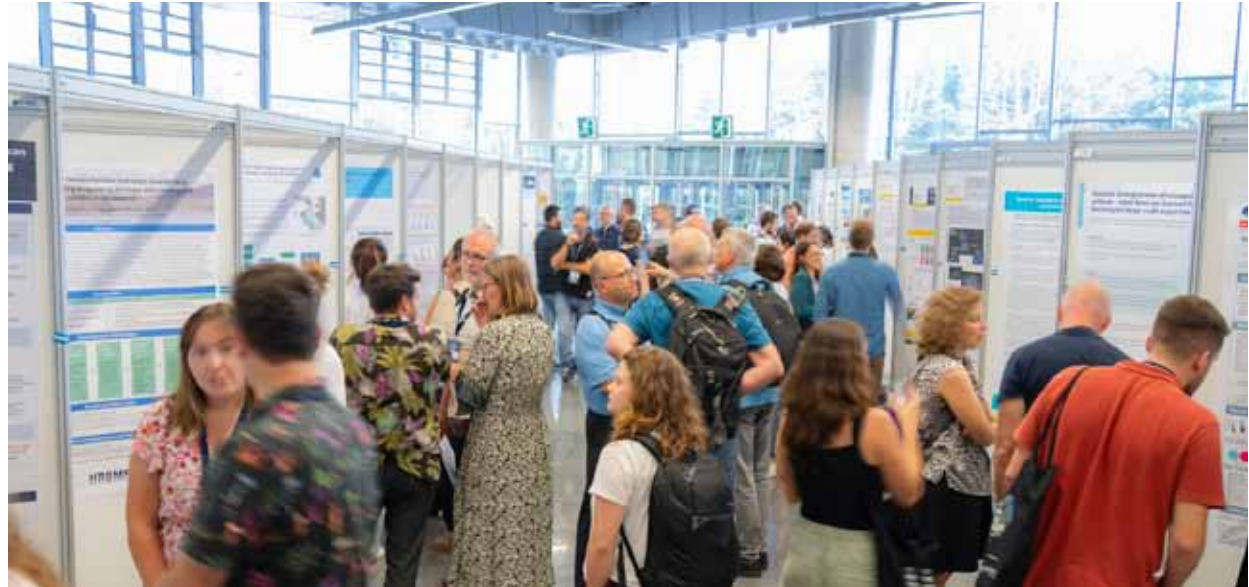
## INTERNATIONAL BENCHMARK:

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## 3.1. HIGH IMPACT SCIENTIFIC PUBLICATIONS

AZTI is recognised in the SCIMAGO index, which evaluates excellence at a global level through its contribution to Research, Innovation and social impact.



### 124 INDEXED PUBLICATIONS IN 2023

The number of scientific publications remains at around 120 indexed publications per year (>75% in first quartile journals), with **more than 6000 citations to AZTI work this year**. In terms of impact, the number of citations is increasing steadily, exceeding 30 citations per publication.

### 11 ARTICLES IN HIGH-IMPACT JOURNALS IN 2023

In 2023, AZTI research staff published 11 articles in high-impact journals (with an impact factor (IF) above 10), including: Reviews in Aquaculture; Nature Communications; Seminars in Cancer Biology; Environment international; Earth-Science Reviews; Critical Reviews in Food Science and Nutrition; Allergy; Journal of hazardous materials; Global Change Biology.

### SCIENTIFIC INFLUENCE

AZTI is recognised in the SCIMAGO index, which evaluates excellence at a global level through its contribution to Research, Innovation and social impact. Only 23% of institutions worldwide in our areas of knowledge match or exceed our results. To be **included in the SCIMAGO index**, an institution must exceed, during the last year, **a minimum threshold of production equivalent to twice the percentage that represents that area in the world**, as measured by Scopus and/or SciVal.

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## 3.2. CONSOLIDATED PRESENCE IN MAJOR SCIENTIFIC COMMITTEES



AZTI continues to coordinate and actively participate in several working groups of European scientific institutions:

- **Guillermo Boyra** has been appointed chair of the International Council for the Exploration of the Seas (ICES) Working Group on Acoustic and Egg Surveys for Small Pelagic Fishes in the Northeast Atlantic (WGACEGG). Coordinated by Guillermo, the group will ensure the supply and quality of the data provided to the ICES advisory groups in charge of assessing species of interest to our fleet such as anchovy, sardine, blue whiting, mackerel and horse mackerel in the Northeast Atlantic.
- **Josean Fernandes** has been appointed as chair for the next 3 years in the Artificial Intelligence working group (WGMLEARN) of the International Council for the Exploration of the Sea (ICES). This presidency strengthens AZTI's position as an expert in AI (Artificial Intelligence) applied to fisheries, as a tool to help the fishing sector face the challenges associated with its sustainability.
- **Naiara Rodríguez-Ezpeleta** has been re-elected chair of the Working Group on the Application of Genetics for Fisheries and Aquaculture (WGAGFA) of the International Council for the Exploration of the Seas (ICES) for the next 3

years. This re-election strengthens AZTI's position as an expert in the application of genetic techniques to improve fisheries management.

- **Estanis Mugerza** will complete his three-year term as chair of the ICES WGRFS Working Group on Recreational Fisheries Studies of the International Council for the Exploration of the Sea (ICES) in 2024.
- **Lucía Zarauz** has been chair of the governance group overseeing the current Regional Database (RDB) and the new Regional Database and Estimation System (RDBES) of the International Council for the Exploration of the Seas (ICES). She has also been chair of the ISSG intersessional group on RDB catch, effort and sampling overviews.
- **Leire Ibaibarriga** has this year completed his three-year term as chair of the International Council for the Exploration of the Seas (ICES) Working Group on Horse Mackerel, Anchovy and Southern Sardine (WGHANSA).
- **Anna Rubio** becomes a member of the Scientific Council of the French National Coastal and Littoral Research Infrastructure ILICO, an organisation created in 2016 to observe and understand coastal and littoral environments and ecosystems as a whole. Anna's participation in this scientific council strengthens AZTI's



## 3.2. CONSOLIDATED PRESENCE IN MAJOR SCIENTIFIC COMMITTEES

position as a centre of expertise in operational oceanography research.

- **Iñigo Martínez de Marañón**, AZTI's Technology Director, has been appointed Advisor to the Scientific Advisory Committee of the Basque Council for Science, Technology and Innovation. The Scientific Advisory Committee is set up as a consultative body to advise and make proposals on the Basque science, technology, research and innovation system. It is made up of ten professionals of recognised prestige in these fields, appointed by the Lehendakari.
- **Leire Ibaibarriaga, Raúl Prellezo y Andrés Uriarte** are part of the Scientific, Technical and Economic Committee for Fisheries (STECF). This committee directly advises the European Union and is made up of highly qualified scientists, especially in marine biology, marine ecology, fisheries science, fishing technology and fisheries economics. Eight percent of this group is made up of AZTI scientists, which has made us the research centre in Europe with the largest representation on such an important Committee. Moreover, since 2022, Raúl has been vice-president of this body.
- **Dorleta García** continues as vice-chair of the Advisory Committee of the International Coun-



cil for the Exploration of the Sea (ICES). This is the committee that gives fishing recommendations to the European Commission for all fish stocks.

- **Gorka Merino** has been appointed Vice-Chairman of the Scientific Committee of the Indian Ocean Tuna Commission (IOTC) and continues to serve as European Scientific Coordinator to the IOTC as well as Chairman of the Tropical Tuna Working Group.
- **Haritz Arrizabalaga** has been appointed in

2023 as European scientific coordinator to the International Commission for the Conservation of Atlantic Tunas (ICCAT) and continues as chairman of the Commission's Albacore Working Group.

- **Josu Santiago** has been re-elected chairman of the FADs Working Group of the Inter-American Tuna Tuna Commission (IATTC) for the next two years and continues to serve as European scientific coordinator to this commission.

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## 3.2. CONSOLIDATED PRESENCE IN MAJOR SCIENTIFIC COMMITTEES

- **Raúl Prellezo**, is the chairman of the European Commission's Economic Committee for Fisheries (ECA).
- **Ángel Borja** is a member of the Advisory Board of MARE (Portugal's equivalent of CSIC) and of the Scientific Board of SustainMare (German marine research alliance).
- **Naiara Rodríguez-Ezpeleta** has been elected Chair of the Bluefin Tuna technical subgroup on CKMR of the International Commission for the Conservation of Atlantic Tunas (ICCAT).

In addition, AZTI's scientific staff participate in or lead various scientific committees, including the **Board of Directors of the Scientific Association of Economists** in the Economics of Natural and Environmental Resources (AERNA), the **Vice-presidency of the Iberian Society of Ichthyology (SIBIC)** in the European Society of Sensory Sciences and in the European Association for Food Safety, as well as holding **relevant positions in the scientific committees of regional environmental and fisheries management bodies**, especially those dealing with the most important fisheries for the Basque fleets..

- **Jaime Zufia and David San Martin** continue as members of the European Food Losses and Food Waste Platform for the next five years 2022-2026. We are one of 7 European research

institutes that are part of this platform. Promoted by the European Commission, it provides food waste prevention recommendations and sets targets to be included in the binding regulatory framework to reduce food waste in the EU.

- AZTI is part of **EITFood's 2023-2025 Consumer Observatory**, which includes the involvement of 4 countries. We lead the Identification of Trends at European level from Spain.
- AZTI is member of the **Food 4 Life Spain** management committee and we participate in 5 operational groups.

- **Angel Borja** is the Editor-in-Chief of a new journal, launched in 2023, called **Frontiers in Ocean Sustainability**, in which several AZTI researchers participate as associate editors.
- AZTI has participated as technical secretariat in the preparation and monitoring of the **Strategic Aquaculture Plan**, Euskal Akuikultura 2030.



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### 3.3.

## SPEAKERS IN INTERNATIONAL FORUMS

2023 has been a significant year in terms of the participation of our experts in various international fora and specialised committees, highlighting their contribution to the promotion of sustainability, innovation and science in the fisheries and aquaculture sector.

This participation not only reflects the relevance of our team in the international scientific community, but also underlines the importance of their knowledge and experience in shaping policies and strategies at a global level.

- **Oihane Cabezas and Gorka Gabiña** have been invited to present the report commissioned by the European Parliament itself to the European Parliament's Fisheries Committee on the decarbonisation and circular economy aspects of fisheries. This outstanding presentation is part of a series of workshops organised by the EU legislative body to address the challenges and opportunities of the European Green Deal for the fishing industry and aquaculture.
- **Carlos Bald** participated as speaker in the committee on the EU Protein Strategy.
- **Carolina Najar** has been invited to participate in the SKS Japan Global Foodtech Summit, where she was part of the European Innovation panel and was a member of the jury of the Kyoto Foodtech start-ups.
- **Marina Santurtún** has been a guest speaker at the 11th edition of the Conxemar-FAO International Congress.
- **Oihane Cabezas and Irantzu Zubiaur** have been speakers at the XXVII Jornadas de la Pesca de Celeiro, a dean and reference event in the fishing, administrative and scientific fields.
- **Raúl Prellezo** was invited by the Permanent Representation of Spain in Brussels to be a speaker on improving decision-making on the allocation of TACs and Quotas, incorporating socio-economic aspects of fisheries before the European Commission and the Ministry of Agriculture and Fisheries, in the framework of Spain's Presidency of Europe.
- **David San Martín**, in the framework of the "EU Platform on Food Losses and Food Waste", has transmitted the results of the case of the diagnosis of Food Waste in the Basque Country.
- **Ángel Borja** was the opening guest speaker at the «International Council for the Exploration of the Sea (ICES) Annual Science Conference» in Bilbao. He was also the closing guest speaker at the conference «Bringing marine nature back to our lives - the role of science», organised by VELMU (The Finnish Inventory



Programme for Underwater Marine Diversity), in Helsinki.

- **Leire Arantzamendi** was guest speaker at the 1st BlueMissionMed Stakeholder Forum - in the context of the high-level event of the European Commission EU Mission "Restoring our oceans and waters by 2030" - The Mediterranean Lighthouse action in Palermo, 30 May 2023, to convey the results of the BIOGEARS project as a case study.
- **Andrés Uriarte and Marga Andrés** were invited as key speakers at SIMERPE 2 (Second Iberian Symposium on Modelling and Evaluation of Fishery Resources).
- **Naiara Rodriguez-Ezpeleta** was invited as a keynote speaker at the FisBase Symposium in Stockholm.



## 3.4. AWARDS AND ACKNOWLEDGEMENTS



AZTI has been awarded several distinctions in 2023:

- **AWARD FOR SCIENTIFIC EXCELLENCE** granted by Radio Bilbao- Cadena Ser.
- **AWARD FOR THE CONTRIBUTION TO SUSTAINABLE FISHING** granted by MSC (Marine Stewardship Council).
- **AWARD FOR RESEARCH EXCELLENCE, INTERNATIONAL PRESENCE AND SUPPORT TO THE SECTOR** to achieve sustainable fishing granted by the Marine Industries Association (FINE).
- **SECOND PRIZE IN THE SUSTAINABILITY CATEGORY OF THE SUN & BLUE CONGRESS** for the developments carried out in the framework of the BideURDIN project where a characterization of marine recreational activities on the coast of Gipuzkoa and their contribution to mental health has been carried out.

## 3.5. DOCTORAL THESES AND INTERNATIONAL POSTGRADUATE MASTER'S DEGREES

2023 has witnessed important academic contributions in the field of food, marine and environmental research at AZTI.

The **doctoral theses** presented in 2023 are:

- *Development of new applications for smart sensors coupled with chemometrics for ensuring the quality and authenticity of food products within the framework of Industry 4.0.* Sonia Nieto Ortega. 2023
- *Development of new analytical tools for verifying the geographical origin of farmed Mediterranean mussels (*Mytilus galloprovincialis*).* Ane del Rio Lavín. 2023
- *Solving Fishing Routing Problems with Meta-heuristics.* Igor Granado Domínguez. 2023



In addition to doctoral theses, the year 2023 has been fruitful in terms of the completion of **international master's degrees** in areas related to marine resources and environmental management:

- **Lydia Rincón:** "*Analysis of pico and nano-plankton communities in coastal waters of the Basque Country: seasonality and climate change effects*", Master of Marine Resources of the University Côte d'Azur, France. Successfully presented on August 3, 2023.

- **Dorcas Essel (2023).** *Ocean acidification in the Bay of Biscay.* Master Marine Environment and Resources, University of Basque Country. Supervised by G. Chust and J. Larreta, and E. Villarino. Defended on 6/09/2023. TFM
- **Angélica Bas Gómez, 2023.** *Improving the effectiveness of the Marine Protected Area network in the Bay of Biscay.* Advisors: Ibon Galparsoro Iza, Dr. Isabel García Barón, Dr. University of Akureyri Faculty of Business and

- Science. University Centre of the Westfjords. Master of Resource Management: Coastal and Marine Management. Ísafjörður. TFM
- **Yeregui, R. 2023.** *Assessing the impact of the Climate Change and its associated uncertainty on the Bay of Biscay marine ecosystem.* Master Thesis, Universidad de Alicante.
- **Christian Gostout,** Master program Biodeversidad, EHU/UPV: "*Leveraging estuary sediment*

## 3.5. TESIS DOCTORALES & MÁSTERS INTERNACIONALES DE POSTGRADO

*metagenomes in designing a new digital PCR (dPCR) assay for the detection of functional indicator genes". Presented 27 sep 2023. TFM*

- **Gotzon Mandiola.** Master's Degree in Environmental Engineering and Management. Academic year 2022 - 2023. International University of Valencia
- **Oksana Avendaño.** Characterization of main tuna and tuna-like species and major fishing fleets in the Tropical Atlantic Ecoregion of the International Commission for the Conservation of Atlantic Tunas. Master's Thesis. Master's Degree in Assessment and Environmental Monitoring of Marine and Coastal Ecosystems. Universitat Politècnica de València.
- **Louis Bidard.** Evaluation of the ecoregions as a tool for developing ecosystem advice-products to inform the implementation of the Ecosystem Approach to Fisheries Management in International Commission for the Conservation of Atlantic Tunas. Internship Report. As part of the M.Sc. Environmental Management - Sustainable Production and Exploitation of Aquatic Bioresources. Université de Montpellier
- **Wael M. Gheith.** From Sea to Sale: Investigating the Factors Driving Anchovy Fishery Prices in Basque Country. Master en gestión pesquera sostenible. Universidad de Alicante.







**REVITALISATION OF THE INDUSTRIAL AND SOCIAL FABRIC:  
BOOSTING INNOVATIVE PROJECTS AND PROMOTING ECONOMIC ACTIVITY**

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At AZTI, we contribute to innovation, value creation and the promotion of competitiveness in the public and private sectors.

To this end, we transform knowledge into business opportunities and we strongly believe in collaboration with companies as the main way to transfer the results to the industrial fabric.

**We achieve this through licensing and the creation of new companies based on technologies developed as part of our research activities.**



**REVITALISATION OF THE INDUSTRIAL AND SOCIAL FABRIC:  
BOOSTING INNOVATIVE PROJECTS AND PROMOTING ECONOMIC ACTIVITY**

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# 4.1. INNOVATION PROJECTS



We highlight the number of innovation projects we are undertaking to generate new knowledge, products and services in areas such as the fight against the climate crisis, ecosystemic management of fisheries, personalized nutrition, sustainability of the food chain, etc.

Some evidence to back this up are:

- **Economic and social impact of AZTI's investment in R&D:** on society is very significant in terms of generating economic activity and new jobs. For every euro invested by AZTI, between €7 and €15 of new economic activity is generated, depending on the type of industry
- **Fostering the creation of new technology-based companies:** AZTI supports innovators and start-ups in the food value chain, such as the creation of bio-refineries for the valorization of vegetable by-products of vegetable origin and the wine sector, which will involve an investment of around 32 M€. In addition, we continued to support the consolidation of recently created companies such as Saretu, Itsas Balfego and Datafish, which are expected to invest around €6 M in the medium term.
- **Leadership in public funding:** AZTI tops the list of Spanish entities with the highest level of state and European competitive public funding

in fisheries and aquaculture projects in the last two decades. It leads both in total budget granted and average funding per project.

- **Outstanding recruitment in EU programs.** In the first Horizon Europe WP2021-2022 work program, AZTI obtained 12 projects (3 coordinated), exceeding 7.36 million euros. In the 2023 call, 5 new projects were obtained, with a contracting of 1.97 million euros.
- **Outstanding participation in the Transmissions Program:** AZTI leads the “Biotegania” project within the new Transmissions program in 2023, with a total funding of 1.43 million euros of a project amounting to 7.67 million euros.
- **Collaboration with the General Secretariat of Fisheries:** Through an agreement financed with Next Generation funds (PRTR - National Plan for Recovery, Transformation and Resilience) for 3 million euros, 17 projects related to the sustainable management of fisheries have been developed, highlighting the applicability of the results in the strategy for the implementation of fisheries policies.
- **Significant contracts:** AZTI has been awarded relevant contracts in public tenders with the Regional Government of Andalusia and the EFSA (European Food Safety Agency). In addition, in 2023, the Port of Bilbao and Pasaia Port

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## 4.1. PROYECTOS DE INNOVACIÓN

Authority has consolidated its commitment to AZTI as a reference center in its technical assistance for all environmental monitoring derived from the actions of the ports as poles of economic activity in the north of Spain through multiannual contracts. Altogether, these contracts have exceeded 3 million euros.

- **Strategic collaborations:** AZTI has established 180 collaboration agreements with various business agents.
- **Intellectual Property Protection:** AZTI has 8 intellectual property protections, including 3 European patents, 3 European trademarks, 1 microorganism registration and the extension of a patent to the United States, modifying its scope. In addition, the concept and mode of operation of the Envirodigital platform are registered in the intellectual property registry office.
- **AZTIInnova:** The collaborative and technological innovation community, has added 76 new members in 2023, reaching a total of 206 members (8 foreign). It has promoted the business innovation community with 40 participating companies, held 4 webinars with 255 companies, and was present at F4F2023, showing the innovation showcase of the product launches of partner companies.



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## 4.2. COMMITMENT TO ECONOMIC AND SOCIAL DEVELOPMENT

In a world that is increasingly interconnected and dependent on sustainable and innovative solutions, our commitment to economic and social development has been strongly manifested in the Basque Country.

Throughout the year, we have witnessed and participated in a number of initiatives and projects that have not only had a significant economic impact on the region, but have also reinforced our commitment to sustainability, innovation and collaboration.

### € ECONOMIC IMPACT ON THE BASQUE COUNTRY

- The **organisation of international events**, such as the Food4Future World Summit, the ICES Annual Science Conference and the Tuna Forum, has generated a significant economic impact in the Basque Country, reaching 18.5 million euros.

### 📈 INVESTMENT ATTRACTION

- The **creation of a biorefinery to promote the circular economy in the Basque Country** has been carried out in collaboration with local companies (UVA and MCC), with a planned investment of 32 million euros.

- The **attraction of investment for the development of the Basordas Aquaculture Park**, which is in the process of allocating industrial plots to projects, will exceed 100 million euros.
- Newly created **industrial projects, such as Saretu, DataFish and Itsasbalfegó**, will see investments of around 5 million euros in 2024.
- The **promotion of 6 new companies** specialising in ship electrification, autonomous vessels, marine platforms, marine bio-products and V-range products, within the Oarsoaldea Blue Economy HUB, involves an investment of over 10 million euros.



### COMMUNITY BUILDING

- AZTI plays the role of **technical secretariat of Bermeo Tuna World Capital**, an association that brings together 44 companies from the entire tuna value chain. In 2023, the association has promoted the Universal Declaration for the Sustainability of Tuna and has finalised the Tuna Cities Alliance.
- The **AZTIInnova collaborative open innovation community** currently has a total of 205 member companies, with 75 new ones joining in 2023.



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## 4.3.

# SOCIALISATION OF SCIENTIFIC KNOWLEDGE

At the very core of AZTI lies an undeniable commitment to the socialisation of scientific knowledge. From its very foundations, AZTI has embraced the conviction that the real and positive impact of research only becomes a reality when it is shared with society and with the industry and sectors of interest that make up the vital fabric of our work.

- **Outstanding participation in international events**

In 2023, AZTI has carried out numerous knowledge communication activities, with the co-organisation of the **Food4Future World Summit** and the **ICES Annual Science Conference 2023** being particularly noteworthy, attracting more than 10,500 attendees from 34 countries. AZTI also formed part of the organising committee of EUROFISHING, an international fishing congress within the framework of World Maritime Week, which was held at the BEC in March 2023.

- **Commitment to education and dissemination**

AZTI's contribution to the dissemination and promotion of science remains strong. Since 2016, more than 12 AZTI mentors have participated in the Inspira STEAM project, encouraging the interest of young people, especially girls, in science and technology. In 2023, the 19th edition of AZTI's international summer school, this year in collaboration with five Eu-



ropean projects, was held, and was attended by 60 people from 19 countries.

AZTI played a prominent role in the **Basque Environment and Ocean Week**, held in Bilbao in June 2023, with the delivery of 8 talks and the dynamisation of the session dedicated to the oceans.

- **Creation of dissemination materials:**

Efforts have been made to produce scientific dissemination materials, including videos and infographics, as well as participation in dissemination actions in different formats, such as radio and television programmes, workshops for families and conferences for the general public.

The materials include an infographic on fishing gear in the Basque Country and four infographics for the identification of common species in the Cantabrian coast. In addition, the **“Metropelagic” exhibition**, present in several Bilbao metro stations, has reached more than 800,000 people, offering a photographic look at the species that inhabit the deep ocean.

- **Participation in academic teaching activities**

AZTI continues to participate in teaching and mentoring students in several international postgraduate Master's programmes at the University of the Basque Country. More than



## 4.3.

# SOCIALIZACIÓN DEL CONOCIMIENTO CIENTÍFICO

30 AZTI researchers participate in these activities.

- **Relevant presence on social networks**

With more than **40,000 followers**, our social networks focus on disseminating scientific content in an accessible way. The podcast series “The answer lies in science” presents scientific and customer voices addressing issues related to our activity.

- **A reference for the media**

In line with our philosophy of not only generating knowledge, but also disseminating it, we at AZTI continue to work towards giving society a deeper and more scientific understanding of the subjects in which we specialise. We have established ourselves as a **scientific source of reference for various media**, and thanks to this collaboration and the various actions undertaken, we have managed to **exceed 2,700 media hits** in 2023.



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*One more year at the service of a healthier and more sustainable society... because today, more than ever,*  
***the answer lies in science.***

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Maria Lavilla

AZTi

MEMBER OF  
BASQUE RESEARCH  
& TECHNOLOGY ALLIANCE

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