

EUROFISH MAGAZINE

Türkiye

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GUEST PAGES: Dr Kate Larkin, Head of the EMODnet Secretariat

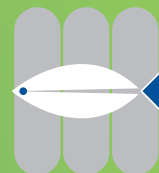
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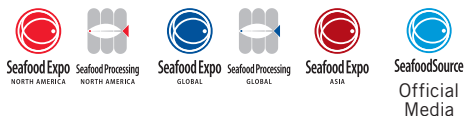


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Sustainable exploitation reflected in legislation



Over the years Türkiye has introduced legislation that seeks to strike a balance between economic, social, and environmental interests. Restrictions on the fleet have been implemented, softened, and then tightened again. More recently support to compensate for vessel decommissioning has led to a reduction in capacity. Control and inspection is used systematically to ensure compliance with the rules. Sustainable exploitation of stocks will go hand in hand with measures to safeguard resources, promises Turgay Türkyilmaz, recently appointed director in the General Directorate of Fisheries and Aquaculture. Read more on [page 23](#)



The Turkish aquaculture sector had another bumper year in 2023 with significant increases in production volumes of almost all key species compared with 2022. The government is keen to increase production value by encouraging producers to add more value to their products. To this end it offers support for training programmes and for compliance with international standards. Moreover, there is strong interest in ensuring the sustainability of aquaculture. Read more on [page 25](#)



Globally, pond fish farming is responsible for almost two thirds of the fish produced from aquaculture. Ponds provide a habitat for fish to grow, but they also offer a range of ecosystem services including flood mitigation and biodiversity, as well as recreational opportunities. They are also a source of historical and cultural value with traditions that go back centuries. Despite the ancient roots of pond farming, this form of cultivation has moved with the times. Read Dr Manfred Klinkhardt's article on [page 11](#)



The use of light in fish cultivation is a topic of growing interest among both practitioners and academics. Certain wavelengths and exposure times have been shown to have a positive impact on the sexual maturation, feeding behaviour, and growth of some species. However, light can also have malign influences and therefore there is need for more study on what light can and cannot achieve. Read more on [page 15](#)



Among the challenges faced by the European fishing industry is the gradual increase in the average age of those working in it. Getting young people to join the sector is important to maintain and renew fishing as an occupation. However, like any other profession today, fishing too demands skills that are best learned in a formal setting. An education that can equip a young person to become a fisher while providing a stepping stone to something else may help attracting young people to the sector. Read more on [page 17](#)



The project, SEAGLOW, attempts to increase the environmental friendliness of the small-scale fishing fleet in the North Sea and the Baltic Sea by reducing its dependence on fossil fuels. This not only benefits the environment but should also reduce costs for the fisher as the project is also developing tools that will enable greater efficiencies when fishing. Read more on [page 19](#)



Another project, FishEUTrust, seeks to increase food safety of and consumer confidence in European aquaculture products. The project which is in its second of three years has released several tools including one to determine the origins of a fish which can be used to combat IUU fishing. Two sensors, one to calculate freshness and the other to detect biotoxins in mussels are among the other outputs from the project. Read more on [page 21](#)



Oil and gas are best known for their contribution to greenhouse gas emissions, but the platforms which are used to extract them from beneath the sea could have a more positive environmental impact. Researchers from the National Institute of Aquatic Resources at the Technical University of Denmark studied offshore platforms in the North Sea and discovered that fish abundance, biodiversity, and fish size were all higher closer to the platforms than further away leading to ideas to use them as artificial reefs. Read more on [page 42](#)



Reducing the threat to marine ecosystems from environmental damage was the focus of a recent conference at Roskilde University in Denmark. Among the points highlighted was that mitigating negative environmental changes in something as complex as a marine ecosystem demands a pathway that integrates economic, social, and ecological considerations. In addition, all stakeholders, scientists, policymakers, industries, and local communities, need to be involved to create a durable solution. Read more on [page 45](#)



Frozen fish has several advantages compared with fresh product including its shelf life, and the relative ease of handling. Storing and transporting frozen fish is far easier than moving fresh fish which helps explain that the global trade in frozen fish and seafood is set to touch USD400bn by 2028. Freezing is a powerful preservation method as it slows down oxidative and enzymatic activities and bacterial growth. Industrial freezing is rapid which helps preserve product texture, nutrients, and freshness. There are a variety of freezing techniques for a company to consider before deciding. Read more on [page 51](#)

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Front cover picture courtesy Ministry of Agriculture and Forestry, Türkiye

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Belgium: EU expands seafood trade with Iceland, Norway

After several years of negotiations, the European Commission has agreed and implemented tariff quotas covering imports of certain fish and shellfish and their products from Iceland and Norway, a move that is expected to reduce import costs and expand EU trade with these Nordic nations. The two sets of tariff quotas on the countries' trade are effective 1 January through 4 April of each year from 2025 through 2028. They apply to eight subheadings for Iceland and 12 for Norway in the EU tariff schedule, covering dozens of individual products, including certain fresh, frozen, cured, and otherwise prepared species of fish and shellfish, both wild-caught and farm-raised.

A tariff quota is a tool of trade policy that applies tariff-free treatment during a specified period to imports whose volume is below a set amount (the quota). Additional imports above the quota are then charged the normal tariff. For example, for a product whose normal tariff is 10%, a tariff quota of 1,000 tonnes allows up to 1,000 tonnes to enter



Fishing vessels in Reykjavik harbour

tariff-free, and when the quota is filled, additional imports are subject to the 10% tariff. For supply or demand reasons, in many cases the quota in a particular year is not filled, and the product effectively becomes tariff-free; the tariff remains on the books and provides market stabilisation and economic security in case there is an unexpected surge in imports, filling and exceeding the quota.

The products affected by the two recent agreements include fresh whole sole, turbot and other flatfish, frozen whole herring and

blue whiting, fresh redfish fillets, cured herring in brine, frozen Norway lobsters, prepared or preserved frozen shrimps and prawn, smoked salmon, smoked trout, and frozen *Pandalidae* shrimps, among many others. Because the negotiations took so long, the quota years are retroactive back to 2021. The agreed quotas for the period from 2021 to the actual opening of quotas on 1 January 2025 will be distributed over the remaining period through 30 April 2028. Quotas in years now ended that were not filled, and unfilled quotas in current and

future years through 2028, can be carried over for up to two years, making 2030 the effective ending year of the agreements. The agreements can also be extended at their expiry.

The two agreements by the EU along with an annex describing each product, its quota and its over-quota tariff rate, are available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L_202403165 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ%3AL_202403164&qid=1734591840629

Denmark: New CO₂ tax has long-term benefits to society but near-term costs to fishers

Starting this year, Danish fishermen are paying a tax on every litre of fuel to offset costs associated with CO₂ production. The tax is significant at DKK 2.25 (EUR 0.30) per litre—but it seems huge for a sector of the fish industry that is already operating on a slender margin. Fishermen and their representatives are starting to protest against what they view is an unfairly large burden on them to switch to production processes that will someday benefit society but that don't exist yet. As part of

Denmark's—and all of Europe's—long-term climate strategy, a shift away from fossil fuels toward alternative energy sources that pollute less is vital. The status quo is causing the planet to heat up, and the resulting warmer waters are already shifting fish migration patterns, individual fish growth, and disrupting commercial fisheries. This is but a part of the broader economic and social impacts caused by global climate change. Society as a whole must share the burden of adopting new



The CO₂ tax will make the Danish fishing fleet less competitive globally, particularly against non-taxed or lower-taxed fleets. Smaller operators and coastal fisheries are likely to struggle.

technologies, if it as a whole is to share the benefits of slower climate change.

The problem for fishermen is that there are currently no practical alternative energy sources to power Denmark's fishing fleet. Therefore, the fuel tax is "fixed" in a sense and must be paid despite the fact that no conversion to an alternative power source is possible in the near term. The tax will someday help finance the development of new

energy sources, but fishermen's groups wonder when that someday will be. The Danish CO₂ tax—the first tax of its kind to be passed by any EU member state—could force fishermen to land their catch in neighbouring countries, depriving the Danish supply chain with necessary raw material. Production and employment in this chain could suffer. Added to that, Danish fishermen say, are the needs of the aquaculture industry which uses feed processed from industrial fish

species that make up a large part of the Danish catch. In value terms, the Danish industrial fish catch amounted to one billion Danish kroner (EUR 130 million) in 2023. At the same time that aquaculture is growing, the raw material caught by Danish fishermen will decline, partly because of the CO₂ tax.

Commercial fishing is typically carried out by small enterprises unable to finance new technology by themselves. Without the

large sums needed for research and development, fishermen need government, universities, and other large organisations to come up with these new technologies. To turn the argument around and require the financing to come directly from a CO₂ tax on fishermen that already operate on slim profit margins is, according to fishermen's representatives, to force near-term costs directly on fishermen to pay for uncertain long-term gains to society.

Spain: Basque government to promote rules on packaging use

At year-end 2022, legislation entered into force regarding new rules about package labels and packaging waste disposal in the Basque Country, the autonomous region in northern Spain. The new rules govern information that labels must contain, and how packaging waste must be recycled or otherwise disposed of. All packaging, including that for fish and seafood products, is covered by packaging rules and regulations. The new rules aim to reduce the vast quantities of waste that non-recycled packaging creates.

To more effectively implement the new rules, the Basque government has enlisted the Hazi Foundation, a body supported by the Department of Food, Rural Development, Agriculture and Fisheries, to carry out a series of educational programmes regarding responsible use of packaging targeted at

product manufacturers, distributors, and consumers. The foundation has set up online training modules with the goal of educating producers and users of packaging—including anyone in the flow of packaged products from originator to final buyer—about allowable packaging materials, recycling of packaging in whole or in part, and proper disposal methods for packaging materials that cannot be recycled. The expected results include, in addition to compliance with the legal requirement to recycle, the reduction of garbage that is costly as well as unsightly, and perhaps the joining of stakeholders in community groups or organisations that focus on recycling as part of environmental protection. Package labels will remind package makers and users of the requirement to recycle, along with tips on which materials are recycled and how to do it.



In 2021, the EU generated approximately 84 million tonnes of packaging waste, averaging 188.7 kg per person. This marked an increase of 10.8 kg per person from 2020, representing the most significant rise in a decade.

The government of the Basque Country emphasises that the new rules are different from the plastic tax already in place, which is intended to dissuade packaging manufacturers from using certain

types of non-reusable plastic in their processes. The recent set of rules is not a tax but more of an educational effort designed to promote environmentally effective recycling behaviour.

Spain: Galicia introduces new management plans for some seafood

Several local fisheries are operating under new management plans for 2025-2027 as Galician authorities strive to protect the environmental health of the resources and increase their economic value, the region's minister for the sea announced recently. *Percebes*, (gooseneck barnacle) is just one of

several Galician marine resources in Galicia that, along with solenids, echinoderms, sieve, algae, anemones, and polychaetes, are now subject to a set of improved fishery management plans, according to the regional government. These fisheries face environmental pressures even as their popularity

grows, posing biological and economic problems for the local industry and fishery managers. In many cases these Galician fisheries are the embodiment of small scale, with some resources harvested by hand along the water's edge. The management plans have a three-pronged purpose. One is

biological, relating to sustainable harvest levels that can be achieved by restricting commercial harvests that will allow long-run stability. A second is ecological, improving biodiversity of the ecosystem in which percebes and other species form a part. The third purpose is economic, bringing all the goals



Percebes (*Pollicipes pollicipes*) are a rare and highly priced seafood delicacy found clinging to wave-battered rocks along the coasts of Spain and Portugal.

together to maximise sustainable production that maintains long-run employment, volume of production, and income to the fishermen and the communities where they live.

The plans and their associated quotas apply mostly to fishermen's guilds for the specific species, while a few go to individual firms that process the harvests. Of the total of 153 plans, 148 cover the operations of the guilds and five apply to companies. The management plans form a network of natural areas intended to provide an array of ecosystem services that protect biodiversity. In the

percebes plans, extraction areas are reserved for the planting of mussels. For 2025-27, 14 *percebes* plans managed by 12 guilds are approved. This measure regulating shellfish activity aims to protect and conserve the *percebes* in specific areas within the scope of the management plan, guaranteeing the compatibility of the extraction of barnacle and mussel seed and that both activities are developed harmoniously, explained a government spokesman. Within the overall plan, there may be areas in which *percebes* and mussel seed can be extracted, and other areas in which only *percebes* can be extracted.

EU: Commission imagines seafood-related life in 2050 under different scenarios

The European Commission has made available a report on "Fishers of the Future," an ambitious analysis undertaken during 2024 and culminating in a public presentation on 14 January 2025. The report evaluates the possible life an EU fisher could face by the year 2050 under four possible scenarios regarding two broad forces at work during the next 25 years: climate and biodiversity changes in marine ecosystems, and consumer demand within market dynamics. The four scenarios examined for the study compare positive or negative developments attributable to these two forces. One is climate and diversity changes that leave fish stocks in EU waters relatively unscathed versus changes that drive fish stocks out of fishers' reach. The other is consumer demand that increasingly favours EU-caught fish versus demand that increasingly finds EU-caught fish too costly or otherwise undesirable.

One way to visualise the four resulting scenarios is with a 2 by 2 box, with "good, good" and "bad, bad" scenarios in opposing corners and

two "good, bad" and "bad, good" scenarios in the other opposing corners. For example, the "good, bad" scenario is where a response to climate change has little effect on fish stocks (good) but consumers turn away from EU-landed fish (bad); by the year 2050, fishermen will find plenty of fish to harvest but no market for their catch. In the "bad, good" scenario, by 2050 consumer demand for EU fish is still strong but climate change has severely weakened EU fish stocks and there are few fish to catch. The report's conclusions suggest that all scenarios are currently possible, but with the right policy adjustments the "bad" outcomes are avoidable. The authors prescribe policies that fund research into technological and green transition by the fish industry, policies that strengthen fish industry competitiveness by promoting local markets and fish traceability to differentiate EU-caught fish and their products, policies that encourage workforce renewal through improved working conditions and gender inclusivity, and policies that expand aquaculture as an alternative to traditional fisheries.



The Fishers of the Future foresight study is a Europe-wide participatory initiative launched by the European Commission to explore the future role of fishers in society up to 2050.

In all these ways, the authors say, a "good, good" scenario by 2050 becomes more likely.

The document can be read here: https://oceans-and-fisheries.ec.europa.eu/fishers-future_en

Faroe Islands: New tax regime for offshore salmon farms should stabilise market

The Faroe Islands government has instituted a new tax regime for salmon farmers that everyone hopes will reduce year-to-year volatility in tax bills on salmon farm operations. The new tax system reduces one calculated tax that companies found hard to predict and adds a new tax that is easier to predict, helping to stabilise the overall tax bill. It applies only to offshore operations, not smolt production nor land-based farms. The old tax of 20% on revenue is reduced to 7.5%, and a new corporate tax of 12% is added to the existing 18% corporate tax. The fluctuations arose in the calculation of the revenue tax. Previously, the revenue tax was based on an estimate of gross revenue (price) using the FishPool index and average production cost based on a volume-weighted calculation. Now, price is calculated using the SISALMONI index and cost is a simple average of data

across the three Faroese salmon farming companies.

The volatility in revenue tax led Faroese farmers including Bakkafrøst to shy away from long-term contracts. Such contracts are an important element in many channels of the salmon supply chain, from farm to retail. The new tax is based on easier calculation methods and is a smaller part of overall taxes. However, the price estimate it is based on is still an index of foreign prices (albeit a different index), but some industry members see this drawback as acceptable if it means the tax's volatility is reduced. Others in the industry are concerned that the tax change applies only to offshore operations (only Bakkafrøst farms its salmon entirely offshore) and may give advantages to some companies over others. A tax only on offshore



Faroese salmon is a premium product, exported primarily to Denmark, the EU, the US, and Asia. In 2023, salmon exports reached almost 67,000 tonnes.

producers is defended by the Faroese government as a way to charge for using public property. What companies are paying for is a vast exclusive right to use the fjords, the ocean, and

the water in the Faroes. We think that it is correct that they pay for each kilo of salmon that they produce, says Høgni Hoydal, Faroese Business and Foreign Relations Minister.

Netherlands: EABA and DLG Benelux strengthen collaboration

During the AlgaEurope 2024 conference, that took place in Athens from 10-13 December, the organisers, the European Algae Biomass Association (EABA) and DLG Benelux signed an agreement to strengthen collaboration for the Seagriculture EU Conference, taking place annually in rotating locations in Europe. Both companies have been successfully organising the AlgaEurope Conference together since 2015, attracting some 425 delegates. The general objective of the European Algae Biomass Association (EABA) is to promote mutual interchange and cooperation in the field of algae biomass production and uses in all thinkable applications.

EABA aims at creating, developing and maintaining solidarity and links between its members and at defending their interests at European and international level. It acts as a catalyst for fostering synergies among scientists, industrialists and decision makers to promote the development of research, technology and industrial capacities in the field of algae. DLG Benelux has been organizing Seagriculture for over 14 years and each year the conference gathers top speakers, sharing their know-how within seaweed for feed, food, offshore cultivation, biorefinery of seaweed, and much more. The Seagriculture conference has built up a solid



Team photo of DLG Benelux and EABA

reputation as the leading conference for the seaweed industry, and in Europe has been successfully organized since

2012. The next edition is scheduled for 17-19 June 2025 and will take place in Rotterdam, the Netherlands.

AlgaEurope Conference, 10-13 December 2024, Athens

Driving innovation in the algae biomass sector

AlgaEurope 2024, one of the leading annual conferences dedicated to advancements and trends in the algae biomass sector, concluded successfully, bringing together an impressive 424 delegates from 43 countries and 256 organizations. Jointly organized by the European Algae Biomass Association (EABA) and DLG Benelux, over four enriching days, the conference served as a global platform for science, technology, and business collaboration in the algae industry.

This year's AlgaEurope has set a new benchmark once again," stated Carlos Unamunzaga, President of EABA. "With over 400 participants and nearly 300 abstract submissions, this year's conference has reinforced its role as a key event in the algae sector".

A program designed for impact

Under the supervision of the chairman, Jean-Paul Cadoret, AlgaEurope 2024 featured a comprehensive program with over 20 plenary sessions and presentations from 110 expert speakers. Attendees gained insights into critical topics, including algae physiology, biorefinery, food and feed applications, wastewater management, high-value products, and more. Keynote speakers such as Dr. Kengo Suzuki (Japan), Hélène Marfaing (France), Susan Løvstad Holdt (Denmark), and Lieve Laurens (USA) inspired audiences with their expertise and vision for the future of algae biomass. Attendees could also explore 154 poster contributions, offering opportunities for meaningful discussions and collaboration.

Once again, the conference featured an award evening, recognizing achievements with the Poster Presentation Award, Personality Award, and Loyalty Award. After

the ceremony, delegates had the chance to connect with fellow delegates and sample algae-based products generously provided by GreenCoLab.

Connecting science, technology, and industry

AlgaEurope is renowned for fostering collaboration across the algae value chain. The event combined scientific discourse with practical industry engagement. In addition to industry presentations, delegates explored a dynamic trade show featuring 20 exhibitors, showcasing the latest products, technologies, and services driving the sector forward. Additionally, site visits to Solmeyer and Plankton First offered attendees firsthand insights into innovative algae production processes.

"AlgaEurope 2024 demonstrated the strong momentum within the algae sector," noted Kuno Jacobs, Managing Director of DLG Benelux. "With 424 participants, 20 exhibitors, 110 speakers, and 154 poster presentations it was a great opportunity to connect science and industry."

Networking and cultural highlights

Beyond the formal sessions, AlgaEurope 2024 offered attendees unique opportunities to network



Attendees at the AlgaEurope Conference applaud with enthusiasm, reflecting their active participation and shared excitement for advancements in the algae industry.

and experience Greek culture. A highlight was the conference dinner held at the Markou Wine Museum, complete with a wine tasting. Enhanced connectivity through the AlgaEurope app further supported interactions among participants, enabling meaningful collaborations to emerge.

Looking ahead

The success of AlgaEurope 2024 underscores the growing

importance of the algae biomass sector in addressing global challenges such as sustainability, food security, and renewable energy. The event's success was made possible by the support of sponsors, including A4F, Beckman Coulter Life Sciences, SCHOTT, GreenCoLab, and Brightwave.

The next AlgaEurope conference will take place in Riga, Latvia, from 9 - 12 December 2025.

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Innovation and tradition in **pond farming**

Ponds are the foundation of global aquaculture

Aquaculture is often viewed critically, even though it makes an indispensable contribution to the food supply. However, many accusations are unfounded, because the sector is changing very dynamically, and some criticisms have long since become irrelevant. This is particularly true for pond farms around the world. They provide the bulk of production and, as valuable cultural landscapes, also serve to protect the climate, nature, and recreation.

In the public perception, off-shore floating net pens, such as those used for salmon farming in Norway, tend to dominate the image of aquaculture. While this is not fundamentally wrong, it is quite unrealistic, because the majority of global

aquaculture production is generated by pond farms of all forms. Of the global aquaculture production of 94.4 million tonnes (live weight equivalent, excluding algae and aquatic plants) in 2022, with a total value of USD 295.7 billion, 59.1 million

tonnes, or almost two-thirds, were produced in land-based production facilities. Fish account for almost 90% of global inland aquaculture production (89.7%), followed by crustaceans, mainly shrimp (8.7%). Inland aquaculture uses a wide range of

methods and technologies, varying significantly in intensity and often combined with other economic activities. Although there are no reliable surveys and clear statements on the share of traditional pond farming, it is generally assumed that man-made



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Ponds are an economically, ecologically and socially important component of the cultural landscape, which has often developed over time, in many parts of Central Europe.

ponds are still the most widespread production method.

This is also supported by a Chinese study by Zhihua Wang and other researchers in the *International Journal of Applied Earth Observation and Geoinformation* (Vol. 115, 2022), which analysed the global distribution of land-based aquaculture ponds based on the 10-m Sentinel-2 time-series images from Google Earth Engine. According to this, 89.12% of the world's land-based aquaculture is located in Asia. Three-quarters of pond facilities (75.57%) were concentrated in a 30 km wide coastal strip. This result is broadly consistent with the FAO aquaculture statistics and underlines the enormous economic, ecological, and social importance of pond farming for the respective regions and beyond. They make a significant contribution to closing the existing gap between supply and demand for aquaculture food. They create jobs and generate income, thus making an important contribution to the

fight against poverty in emerging markets. This effect is further reinforced by the fact that many ponds contain fish species that feed at low trophic level and can be produced extensively without supplementary feeding. For example, in 2022, more than half of global aquaculture production (51.5%) was accounted for by Indian and Asian carp (31.788 million tonnes combined) and catfish species (10.8%; 6.628 million tonnes). The ponds also provide exportable products that are in high demand in other parts of the world. Just think of catfish species such as pangasius or tilapia and other cichlids (10.6%, 6.549 million tonnes). Shrimp and other crustaceans are mainly produced in brackish or seawater ponds.

Ponds have been successfully utilised for centuries

Pond cultures are the most common aquaculture systems in the world. Ponds are usually filled with fresh water, but sometimes with

brackish or salt water. They range from small, purely gravity-fed systems to large-scale facilities with sophisticated water management. In the simplest cases, they use irrigated rice fields or dammed natural water bodies. However, the majority of earth ponds are located on dry land and are created by excavating soil or building dams or embankments. The reservoirs constructed in this way are often lined with concrete or tarpaulins to retain river,

rain, ground, or well water. Extensively managed ponds are particularly environmentally friendly as a cultural landscape because they provide shelter for numerous animal and plant species. Ponds have been used for food production for thousands of years. The Chinese are believed to have built their first ponds as early as 4,000 years ago. From there, the technology expanded to the Mediterranean through Mesopotamia and rapidly spread across the Roman Empire. The idea was taken up primarily by the monasteries of Central Europe, which then mainly contributed to the domestication of the carp.

However, despite its centuries-old history, pond farming is by no means outdated or outmoded, as it has proven to be highly successful and offers compelling advantages. The construction of a pond is relatively easy and inexpensive, and maintaining it does not require a great deal of effort. This is especially true for extensively managed ponds, which are sometimes even self-sustaining. With their almost closed material and energy cycles, they resemble natural ecosystems, allowing the fish species to feed on what grows there. However, as this natural food source is usually limited, the productivity of such



In large, semi-intensive or intensive ponds, fish feed is usually distributed over the surface with specially equipped boats.

extensive systems is correspondingly low. Low input, low output. This principle works wherever sufficient pond area is available or production is only for regional demand. If there is a higher demand for fish, pond productivity can be increased by intensifying management, which usually involves adding external feed to the pond system. This input enables a correspondingly higher output.

Although ponds are relatively easy to maintain compared to other aquaculture systems, pond farmers cannot avoid some cleaning and maintenance tasks. This mainly involves removing the sludge that settles to the bottom over time as a result of dying plankton and aquatic plants, feed residues, and fish excrement. In extensive, near-natural ponds, this waste is almost completely broken down by micro-organisms and returned to the system's internal nutrient cycle. However, in more intensively managed facilities, these 'service providers' find it increasingly difficult to cope with this task, so people have to intervene and remove the sludge. Otherwise, the ponds run the risk of losing depth, becoming overgrown, and silting up. This is the fate of earth ponds that are

not regularly maintained. However, the silting of ponds results not only in the loss of reservoirs for fish production but also in the disappearance of biologically important refuges and habitats for many animal and plant species. Ponds make a valuable contribution to practical nature conservation! This is just a warning to those 'conservationists' who think that they can preserve these habitats by renouncing the use of pond landscapes.

Production-oriented, yet close to nature

Earthen ponds are, so to speak, man-made natural spaces. However, this also means that, as open systems, they are exposed to numerous external factors that are either entirely or partially beyond the control of the pond farmer. Examples include environmental factors such as temperature and precipitation, as well as oxygen content in the water, or fish losses due to predators ranging from cormorants to otters. Technical aids such as aeration systems or net covers can be used to prevent this, but they are costly and often limited by the size of the ponds. Classic pond cultures generally do not



In many areas of Central Europe, carp farming has been a centuries-old tradition. Fishing often takes place during regular festivals.

have any special water treatment methods. However, this is often not the case with new and modern pond systems, as the equipment is frequently a requirement for obtaining a permit. Regulatory requirements for pond permits have been significantly tightened, both in Europe and elsewhere in the world. Environmental and water regulations play a much more important role today than just a few years ago. Due to the increased requirements, older existing facilities are also often modernised and retrofitted.

Technical innovation in pond aquaculture production proves beneficial wherever it contributes to improving production efficiency and reducing environmental impacts. Until a few years ago, environmental aspects hardly played a significant role in Chinese aquaculture. This has now changed dramatically. In many Chinese provinces, canal systems have been constructed in pond landscapes to collect nutrient-rich runoff water and direct it to artificial wetlands for treatment, following the principle of settling ponds. This idea has also been taken up and implemented in other countries, including Vietnam, Colombia, Mexico, Uzbekistan, Bangladesh,

and Egypt. In some cases, such integrated systems have even given rise to fish-farming clusters or aqua parks, in which the water is not only shared and purified, but where pond farmers and other businesses involved work together. Typically, the management team then takes over the coordination and monitoring of production processes, which helps to reduce costs, create synergies, and facilitate investment in sustainable infrastructure for a more environmentally-friendly aquaculture in inland areas. Asian pond farms are by no means all primitive old-fashioned systems, but are gradually being developed into state-of-the-art solutions for fish and shrimp farming.

The politically-driven concept of 'greening' aquaculture also fits in with the locally coordinated remediation plans, which are slowly evolving into an internationally significant trend. One aspect of this colourful mosaic is the stricter regulation of access to pond farming licenses, which are now granted based on sustainability assessments of water bodies, a shift from previous practices. Potential investors are suddenly realising that environmental and nature conservation concerns are being taken just as seriously as



In coastal villages in India, mud crabs and other crustaceans are often raised in brackish water ponds alongside shrimp.



Ponds are oases of nature conservation, serving as habitats for diverse flora and fauna, offering both protection and nourishment.

economic interests. This inevitably leads to considerations of how aquaculture activities can be better integrated into local structures in a more environmentally and socially responsible way.

Modern pond farming methods

In some respects, pond farms have a much better chance of social acceptance in Asia than in Europe. On the one hand, people there have long been familiar with pond farms and appreciate their value for food production. On the other hand, ponds are often closely linked to other activities, particularly in agriculture, so their benefits for food supply are obvious to everyone and need no further explanation.

Integrated Agro-Aquaculture Production Systems (IAA) are proof of this. They combine different aquaculture and agricultural activities, which can take place simultaneously or successively. For example, IAA can include pig, duck, and fish farming, or fish and shrimp farming in rice fields. IAA have existed in East Asia for centuries, but in the 1960s they also spread to Latin America and Africa. Typically,

these systems are operated extensively or semi-intensively. In the latter case, the livestock are usually kept directly above the pond in barns with slatted floors, so that the waste ends up in the water and, as fertiliser, promotes the growth of phyto- and zooplankton. This means that more food is available for the fish and the productivity of the ponds increases. While in this case the combination of agriculture and aquaculture is primarily aimed at improving fish growth, the opposite is true in wet rice fields, where the focus is on rice production. Produced fish is a very welcome by-product that improves farmers' diets by providing high-quality animal protein. There is no need to feed the fish, as they can find enough mosquito larvae in the water of the rice fields, which, in this farming system, function almost like ponds. This also has the welcome side effect of at least somewhat reducing the annoying mosquito population in the area.

Another modern variant of pond farming involves systems where ponds are integrated with agricultural production, utilizing nutrient-rich runoff water from

commercially grown crops. This principle is similar to aquaponic systems, which, despite their advantages, have not yet gained widespread adoption in the Western world. One of the main advantages of such coupled production systems is the meaningful use of water resources, including the nutrients dissolved in the water, which would otherwise be lost in pond runoff and contribute to eutrophication of downstream waters. Efficient use of available resources and better environmental protection are the driving forces behind this forward-looking pond farming practice.



More than half of Asia's inland aquaculture production comes from small and large ponds, from rice fields to professional facilities.

Nature conservation is often more important than fish production

In Asia, Africa, and Latin America, aquaculture is generally highly valued for its contribution to both the regional economy and the food supply for the population. In many places, ponds form part of the cultural landscape, and local fresh food markets sell fish and other pond products. Of course, the industry is not completely free of problems there either, but it is generally accepted and welcomed by the population. In Europe, on the other hand, the situation varies from region to region. While pond farms in the east and south of the continent, or in landlocked areas, generally enjoy a certain degree of acceptance, elsewhere they often face increasing difficulties and sometimes even hostility. The source of many of the problems is rarely the local people who have lived in and benefited from the pond landscape for centuries, but rather self-appointed conservationists and, unfortunately, often the responsible authorities, who view fishing activities only from a purely economic perspective and therefore suspect pond farming of being in opposition to nature conservation.

In their efforts to protect nature and the environment, they are constantly devising new requirements and regulations, which are increasingly perceived as a threat by the pond farmers concerned because they make the core business of the companies more difficult. In addition, there is a feeling of deeply unjust treatment, because pond farmers are already active conservationists who, by maintaining their ponds, make an extremely valuable contribution to the preservation of aquatic and adjacent ecosystems and their biodiversity. Ponds provide much more than healthy, sustainably produced fish products for our nutrition. They retain large amounts of water in the landscape like a sponge and, due to the specific heat capacity of water, act as natural air conditioners that moderate extreme

temperatures. The cooling effect of evaporating water is particularly appreciated in hot summers and gives pond landscapes a high recreational value. Unfortunately, the public is often unaware that ponds also serve as natural water purification systems. The solid particles settle and accumulate on the bottom as sludge, which is removed at regular intervals. Dissolved substances, primarily nutrients, enhance the biological productivity of the water, as evidenced by the growth of aquatic plants and reed beds along the banks. They provide food and habitat for a wide range of insects, amphibians, birds, and many other species.

On the one hand, politicians and public authorities recognise the contribution that pond farms make to our food supply and to



The 'pond-in-pond' method is used to create additional, confined habitats in ponds in order to keep and feed fish at higher densities.

nature conservation. Subsidies are available for pond maintenance, as well as compensation for economic losses incurred by pond farms due to environmental regulations. On the other hand, the same authorities are making the work of pond farmers

increasingly difficult by imposing more regulations and reporting obligations on the operations, as well as bureaucratically hindering them. The political will to reduce this demotivating regulatory burden is not even remotely evident at present. *Manfred Klinkhardt*

The impact of **light** on **fish cultivation** deserves more attention

Light has positive and negative effects on aquaculture

Aquaculture, one of the fastest-growing segments in food production, constantly seeks innovative strategies to improve the efficiency, health, and sustainability of aquatic farming systems. One promising avenue is understanding the role of light—an often overlooked yet significant factor in influencing the physiology, behaviour, and growth of aquatic organisms.

Two workshops entitled “Light and Fish” and “Light and Other Aquatic Organisms” at last year’s AQUA2024 conference in Copenhagen brought together experts to explore the multifaceted effects of light in aquaculture.

The impact of light is a growing field of study

The AQUA24 workshops, jointly organised by Eurofish (Denmark)

and MATE (Hungary), were a continuation of the discussions initiated at the European Aquaculture Society (EAS) 2023 in Vienna. Building on the positive feedback and insights gained previously, the workshops expanded the focus from fish alone to include other aquatic organisms, providing a broader exploration of light’s influence on aquaculture. The sessions were divided into two main themes covering the impact of light on fish and

on other aquatic organisms, and both addressed how various light parameters—such as wavelength, intensity, and photoperiod—affect the physiology, growth, reproductive biology, and health of different species. The sessions featured ten expert-led presentations showcasing advancements in lighting technologies and scientific findings with the potential to transform light use in aquaculture. Key innovations in lighting systems

and machine vision were presented, emphasising their role in boosting farming efficiency. Discussions highlighted how specific wavelengths, and light intensities could positively influence fish physiology, impacting feeding behaviours and metabolic rates, with the potential to lower production costs and improve fish welfare.

A major topic centred around light’s role in controlling sexual



Lights with specific characteristics are being tested in hatcheries to study their positive and negative impacts on the fish.

maturation in aquaculture species. Researchers presented findings showing that targeted light manipulation could suppress melatonin production, delay sexual maturation, and enhance growth rates. Studies demonstrated that continuous light exposure in sea-cage environments led to better growth with further potential for sex-specific light strategies to optimize production. Additionally, the presentations explored emerging LED and supplemental lighting technologies. While these advances offer benefits such as energy efficiency, enhanced production, and parasite management, their long-term effects on fish biology remain only partially understood. Narrow-band lighting, for instance, can impact biological processes beyond growth, potentially leading to

outcomes such as stress, premature maturation, or deformities. As light plays a key role in regulating diurnal and seasonal rhythms, developmental stages, and behaviours, careful consideration of light intensity and spectral composition is essential to ensure the well-being of farmed fish.

Some results seem to depend on the wavelength of light

Other sessions focused on the interaction between light, photosynthesis, and oxygen levels, particularly in carp pond systems, where optimised light exposure was shown to improve water quality, boost fish health, and support growth through enhanced photosynthetic activity. Discussions also addressed the effects of light on plankton

dynamics, with light enrichment benefiting plankton and oxygen production initially but posing risks to fish health if not balanced correctly. Specific wavelengths also demonstrated promising results in certain species; for example, blue LED light was found to increase growth rates in Malabar grouper, suggesting the potential to enhance growth and reduce feed costs through targeted light use. Moreover, light management strategies were emphasized for improving welfare, especially in smolt and pikeperch farming. Research showed that a 16-hour light and 8-hour dark photoperiod optimized growth and survival in pikeperch larvae, while well-regulated light conditions supported improved feed conversion ratios and growth in fish larvae within recirculating aquaculture systems.

The presentations highlighted a consensus on several key points. Firstly, light is a critical yet underutilised factor in aquaculture production. Despite its proven effects on growth, welfare, and health, the use of light in aquaculture remains in its early stages. The technology is available, but more research is needed to refine how different species respond to varying light conditions, including intensity, duration, and wavelength. Participants agreed to try and reorganise these discussions as sessions at the upcoming EAS 2025 in Valencia. By integrating these workshops into a larger platform, the organisers hope to further the discourse, facilitate collaboration, and ultimately develop comprehensive guidelines for light management in aquaculture.

When combined with other modern technologies, light shows even more promise

By integrating advanced technologies like AI and machine vision, as well as drawing on natural processes such as photosynthesis, the aquaculture industry stands at the cusp of a new era where light becomes a cornerstone of sustainable and efficient fish production. As the field progresses, workshops like those at AQUA24 will be instrumental in shedding light on the complex interplay between light and life in aquatic environments—paving the way for innovations that benefit both producers and the environment.

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Faculty of Livestock Raising and Water Bioresources, **Ukraine**

Dragging the nets?! Nope - driving the industry!

It is no secret that around the globe the average age of people employed in the fisheries and aquaculture sector is climbing. Attracting young professionals is by far the most important task to maintain the industry's dynamism. To achieve this, education is crucial. Eurofish spoke to Ruslan Kononenko, Dean of the Faculty of Livestock Raising and Water Bioresources at the National University of Life and Environmental Sciences of Ukraine (NUBiP).

This is the first in a series of articles in Eurofish Magazine about education in fisheries and aquaculture.

Ukraine is rich in water resources, and qualified specialists for the fisheries and aquaculture sector have always been in high demand. With over 120 years of history, Kyiv-based NUBiP, one of the country's oldest universities, plays an important role in supplying the industry with a competent workforce.

What will my child become

The parents of applicants often ask me, says Mr Kononenko, what will my child do after graduation—drag a fishing net for the rest of their days?! I explain that our graduates will become leaders of the sector: they will become

business managers, implement new technologies, promote innovations, expand production, work in exports and imports, influence the economy of their companies, and more broadly, the economy of their country. Those who do not see themselves in business, can continue their education, get a degree, become researchers, developers of new technologies, or discover new species to farm. Our graduates work in the national administration and other authorities; they have a perfect background to apply for a job abroad—many of our alumni work in Europe, America, and beyond.

The Faculty of Livestock Raising and Water Bioresources offers a

Water Bioresources and Aquaculture Programme to students who decide to get a professional education in the area. The programme annually absorbs up to 75 students of which 50 get the education for free after passing admission tests, while the rest pay fees. Getting a bachelor's degree takes four years for students who graduated from high school, and three years for college graduates. The faculty also offers both master's and PhD degrees.

The faculty operates 15 modern laboratories for research and education, an earthen pond, and a RAS system with six reservoirs of 16.6 cubic m each for different stages of the fish farming process, including one for broodstock and one for quarantine, for farming of 11 fish species in total. It also has 30 aquariums from 30 to 500 litres each and one of 1,000 litres; these contain ornamental fish, sturgeons, African catfish, tilapia, *Macrobrachium* shrimp, and Louisiana crawfish (*Procambarus clarkii*). All these facilities combine to teach students of the Water Bioresources and Aquaculture Programme both theory and practice, and give them a professional grip on their chosen career.



Ruslan Kononenko, the Dean of the faculty of Livestock Raising and Water Bioresources at the National University of Life and Environmental Sciences of Ukraine (NUBiP)

Joint efforts lead to a better catch... and release

Mr Kononenko himself graduated from NUBiP with a diploma with honours, has a master's degree in veterinary sciences, became an associate professor, and three years ago was appointed as a dean of the faculty. Sharing his observations of the students now and then, he says that today's students seem to be more motivated, their choice of future profession has



Genetic research by faculty scientists in the genomics and transcriptomics research laboratory.



Postgraduate students, together with a specialist in ornamental aquaculture, inspect newly created ornamental aqua systems

become more conscious, and their confidence that they are making the right choice is growing.

All this would not be possible if NUBiP had been trying to keep the students in an ivory tower. Instead, the university works in close contact with the State Agency of Ukraine for the Development of Melioration, Fisheries and Food Programs, national institutions, and private businesses. Webinars, round tables, seminars, arranged by national institutions expose students to the real world and help them build networks. Internships provided by businesses give young people an in-depth understanding of what their future job might be. It happens, explains Mr Kononenko, when a potential employer puts four students in the car, drives them to the facility and two of them return—with job offers!

About 70% of the faculty's alumni remain devoted to the fisheries and aquaculture sector. Even low-scorers, who often choose a different occupation after graduation, may sometimes return to their roots because the knowledge and skills planted by experienced and caring lecturers finally grows on them.

COVID-19 challenges were just the beginning

The university offers the students not only high-class lecturers—it

offers modern laboratories and other professional settings designed to familiarise students with the working conditions they will encounter in their careers. Most importantly from a long-term perspective, the academic standards which the university upholds are the same as those currently required by the EU. These standards will not only ease Ukraine's eventual entry as an EU member state, but also the students that the university now produces already meet EU standards of education and qualification, Mr Kononenko says.

However, without the physical presence of students, these qualifications are weakened. The COVID-19 pandemic was the first strike that badly affected student's lives. Online lectures were in place, but eye-level contact with teachers and fellow students, as well as physical, educational, and social activities were put on hold. Such things are crucial for a young person who is not only studying the necessary discipline but also learning how to interact with peers and staff, socialise on different levels, and fit into society—both professionally and socially.

Another problem was with the applicants—the challenge and excitement of an in-person admission had been mitigated as

everything became remote. The general fear was that the youngsters would become discouraged and postpone admission till better times. However, NUBiP developed special programmes for remote learning, which later, when things returned to normal, were followed by studies in practice. As a result, during the pandemic the university did not experienced a significant rate of dropouts, though the situation required additional efforts to ensure the smoothness of the educational process.

Half of the workforce is gone—what is next?

The war has added more challenges. For the first two months of the war part of the Kyiv region was under Russian occupation and the future of the country's capital was uncertain. The learning process has been affected by shelling, disrupted logistics and transportation, a lack of food supplies, and simply by human fear. However, the students expressed the desire for in-person studies, the desire to be part of the group; and two months after hostilities began, they returned to their classrooms. For students in fisheries and aquaculture, this part of their education—on-site and in and around farming facilities—is particularly important, as it is here they learn to get their hands dirty.

Luckily, NUBiP has a shelter dating back to World War II and during the sirens, the lecturers and the students go there to hide. In the beginning, chuckles Mr Kononenko, some senior students would avoid going down to the shelter and go “for a cup of coffee”. But later, when the shelter was refurbished and made fit for studies, they had no excuse.

Getting new students during wartime is becoming harder: most potential applicants aged between 16-18 years old have fled abroad. Some colleges and high schools that were among the major suppliers of students to the university either stopped operating because of the hostilities or have low numbers of students. These days the students still come mainly from high schools, but the numbers are still low. Before the war, the number of people employed in fisheries was about 3,000, and now about 50% of them have been drafted. This created 1,500 workplaces, which have to be filled up, but without fresh blood it is a daunting task.

Advertising is the driver of progress

Mr Kononenko is convinced that the promotion of fisheries and aquaculture is crucial to attracting young people to the profession: Those employed in the sector have



RAS facility for growing sturgeon in the faculty's laboratory



Earthen pond and laboratory. The facility hosts field laboratory training for senior students, studies of farming practices, and All-Ukrainian student competitions.

the chance to produce high-quality products, products that make the population healthier. We must make fish and seafood popular. People's mentality must change, they need to care about a healthy lifestyle and healthy food—and it must be done at the national level.

Private businesses as potential employers shall be more involved in the educational process. This is not about coming and getting a ready-made employee, this is about coming to the classroom and telling young people about the business, the work, the

salaries, and social benefits. The faculty also works with school children, by inviting them to the fish production and processing facilities. Children are shown around the facilities and are informed about raising a fish from an egg to an adult, about work in fisheries and aquaculture, and its benefits.

Care for people and country motivates students and teachers

One day the war will come to an end, a lot of young men and women will come back from the front, and many of them will need rehabilitation. None of the state institutions will be able to handle it alone, therefore every institution must do its share. NUBiP has a virtual reality laboratory that has developed new

tactile programs, so even if a soldier comes back without both arms, it will be possible to study, using modern technology.

However, for now the war continues, and the students and their teachers are rushing to and from the shelters. But, explains Mr Kononenko, we try to perceive it as today's life. We must come to terms with it, we have a job to do, and so we "ignore" the war. We perceive it, it is around us, we cannot get away from it. But we must work and do our jobs well—not just 100%, but 200%. Because the future of the country depends on it—you cannot let down your country, your university, and the students who came to learn from you.

*Aleksandra Petersen
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[PROJECTS]

The **SEAGLOW** Project tests solutions that benefit fishers and the environment

Pioneering greater sustainability in small-scale fishing

In the face of pressing environmental challenges, the maritime sector is exploring innovative solutions to reduce its carbon footprint. Among these efforts, the SEAGLOW project, an initiative funded by the European Union under its Horizon Europe programme, attempts to transform the Baltic and North Sea small-scale fishing fleet, traditionally reliant on fossil fuels, into a model of sustainability and efficiency.

At its core, SEAGLOW, short for "Sustainable Energy Applications for Green and Low-Impact Operation of Small-Scale Fishing Boats," seeks to address the environmental challenges posed by small-scale fishing

vessels. According to Hanne Bregendahl Pihl, Acting Director at the North Denmark EU-Office (NDEU), which is leading the project, the initiative is about much more than reducing emissions; it aims to redefine operational practices for small-scale

fishers while ensuring their economic viability.

Greater fuel efficiency is in everyone's interest

Small-scale fishing boats make up a substantial portion of

the European fleet. Their fuel dependency not only contributes to high operational costs but also to the impact on marine ecosystems. SEAGLOW is determined to change this, Ms Bregendahl Pihl explains. By adopting alternative energy sources and integrating

energy-efficient technologies, SEAGLOW aims to help fishing communities transition towards sustainable practices and achieve commission targets of a 15% reduction in fossil fuel intensity (litres/kg of landed product) by 2030 with the goal of being carbon neutral by 2050.

One of the standout features of SEAGLOW is its diverse and multidisciplinary consortium from the EU, Norway, and Thailand. Bringing together research institutions, industry representatives, NGOs, energy technology providers, and four participating vessels, the project embodies multinational, cross-disciplinary collaboration. Ms Bregendahl Pihl emphasises the significance of this collaborative framework. The team combines technical expertise in marine engineering, energy-efficient technologies, policy, and fishing industry operations with an understanding of industry needs. Fishermen are not just participants but critical contributors, investing their time and energy by allowing their vessels to serve as test platforms, she says. The involvement of multiple stakeholders ensures the project's approach is both holistic and practical. The fishermen's direct engagement provides real-world insights, enabling technologies to be fine-tuned for the unique challenges of small-scale fishing operations.

Project to test multiple technological solutions

SEAGLOW is testing a range of cutting-edge technologies across the four fishing vessels situated in Denmark, Norway, Estonia, and Sweden. These case study boats serve as experimental platforms, offering valuable data on the performance and adaptability of different solutions under diverse environmental conditions.

Key innovations include:

1. Hybrid methanol/electric engines: These engines represent a dual advantage of reducing greenhouse gas emissions while maintaining operational efficiency.
2. Low-drag hull coatings: By minimising friction in water, these coatings reduce fuel consumption and improve overall vessel performance.
3. Low-cost monitoring systems: These systems provide fishers with real-time data on fuel usage and operational efficiency, enabling informed decision-making and promoting energy conservation.

These technologies are not just about reducing carbon emissions; they also aim to bring economic benefits to fishers, Ms Bregendahl Pihl notes. By cutting fuel costs, SEAGLOW ensures that these solutions are both environmentally and economically sustainable.

Involvement of all stakeholders ensures practical relevance of solutions

Recognising the importance of stakeholder involvement, SEAGLOW places a strong emphasis on co-creation workshops, community-based trials, and policy advocacy. Ms Bregendahl Pihl elaborates on the project's inclusive approach saying that NDEU has made a concerted effort to involve fishers, industry players, and policymakers throughout the project lifecycle. This collaboration ensures the technologies developed are practical, scalable, and meet the needs of local communities.

For fishers, SEAGLOW offers hands-on opportunities to explore the technologies through demonstrations and trials. In Sweden, for instance, demonstrations



Hanne Bregendahl Pihl, Acting Director, North Denmark EU-Office, and leader of the SEAGLOW consortium

allow fishers to test new solutions under real-world conditions, witnessing firsthand the potential savings and efficiencies these innovations can offer. In November 2024 scientists from AZTI, a research institution in Spain that is one of the project partners, installed a system on the Estonian fishing vessel that would monitor operational and engine parameters such as vessel speed, distance covered, and fuel consumption. This information will be analysed to determine energy consumption and operational patterns; and to later carry out a comparative analysis of different engines' energy consumption. Moreover, stakeholder workshops provide a platform for fishers to contribute to policy recommendations submitted to the EU Commission, shaping the future of sustainable fishing practices.

Creating a model that can be replicated across Europe

One of SEAGLOW's primary goals is to balance environmental sustainability with economic feasibility. Small-scale fishers often operate on tight margins, making it crucial that sustainable solutions do not impose undue financial burdens. By introducing

renewable technologies like hybrid engines and low-cost monitoring tools, the project addresses both operational efficiency and long-term environmental impact. Ms Bregendahl Pihl also highlights the broader environmental benefits, stating that reducing emissions not only supports marine biodiversity but also ensures the longevity of the fishing industry. SEAGLOW is committed to creating a symbiotic relationship between economic viability and environmental stewardship, she says.

While SEAGLOW has made commendable progress, challenges remain. Transitioning from traditional fuel systems to alternative energy sources requires significant investment and behavioural changes. Furthermore, the diverse regulatory landscapes across the Baltic and North Sea basins can complicate the implementation of standardised solutions. Ms Bregendahl Pihl remains optimistic, however, viewing these challenges as opportunities for growth and innovation. Through continuous dialogue with stakeholders and adaptive project strategies, SEAGLOW is poised to navigate these challenges. Our goal, she says, is to create a replicable model that can be scaled-up across Europe.

Reinventing the small-scale fishing sector to face 21st century challenges

As the SEAGLOW project continues to make waves in sustainable maritime practices, its impact extends beyond the immediate outcomes. The initiative serves

as a blueprint for integrating green energy solutions into traditional industries, paving the way for broader adoption across sectors. For Ms Bregendahl Pihl, the project is deeply personal. Her role as leader of the SEAGLOW project and her broader work at the North Denmark EU-Office reflect a commitment to

fostering innovation and collaboration. SEAGLOW is more than a project; it's a testament to what's possible when diverse stakeholders come together with a shared vision for sustainability, she concludes.

With its focus on reducing fuel dependency, cutting emissions,

and enhancing economic viability, SEAGLOW is not just transforming small-scale fishing—it's redefining the relationship between humans and the ocean, ensuring that future generations inherit a more sustainable and equitable maritime legacy.

FishEUTrust seeks to increase traceability and food safety of European aquaculture

The first sensor innovations have been tested

Following the successful conclusion of its second general assembly meeting in Olhão, Portugal, Eurofish brings a 2nd year update on the achievements and future initiatives of FishEUTrust, a project supported under the Horizon Europe framework. The project aims to improve European consumers' trust in seafood products from European (and other) aquaculture producers through innovative technologies and services.

Aquaculture is widespread in Europe, and research besides the industry's development has mainly concentrated on technical aspects of production. Although product quality is high in the EU, scientists and policymakers agree that product traceability and microbiological safety methods are limited in some areas and must be substantially improved to increase consumer confidence and thus raise the uptake of aquaculture products.

Increasing quality with innovative devices and services

These challenges are what the Horizon Europe funded FishEUTrust project seeks to address through—among others—innovative sensor and traceability service solutions, to further increase and secure food safety and consumer confidence in European aquaculture products for the EU market. To this

end, new technologies and services are being developed in the FishEUTrust project to enhance both the food safety of aquaculture products and the information to the seafood end-consumers on the aquaculture product they are about to buy. These important areas were also the main topic at the project's second general assembly meeting, where the first prototypes were presented to industry stakeholders.

It is important to note that the technology being developed in the project in many cases is based on already existing technologies. The innovation can lie, for instance, in scaling down a technology to an easily used handheld version with an easy-to-follow interface that both industry professionals and private end-consumers can utilise—compared to a large and expensive laboratory robot that will need trained personnel to extract data, that often takes days to obtain.



A handheld sensor developed by UNIFI and UMF together with the company Micrux Technologies. The sensor is able to detect the remaining shelf life, the biotoxins, and bacterial contamination in seafood products.

Advanced suite of tools for seafood traceability, three sensor innovations, and one digital platform technology

The project has already generated several outputs as outlined below.

- *Advanced suite of tools for the determination of fish origins based on metagenomics, DNA profile, and stable isotope approach* (Università di Firenze

(UNIFI), Università di Padova (UNIPD), and Jožef Stefan Institute (JSI)): By extracting DNA samples from the fish's gills and matching it with stable isotope data, the approach can determine with a 95-99 % accuracy the origin of the fish. Here, the isotope data is derived from the IsoFoodTrack database, which is another innovation developed in the project during 2023. The developed tool

will be of value for importers, producers, and wholesalers as the origin of the fish can be validated. In addition, the tool can play a vital role in increasing the safeguards against food fraud from IUU (Illegal, Unreported, and Unregulated) fishing or mislabelling. The first data has already been produced and is being tested by the industry to increase the accuracy—ideally towards 100%.

- *A sensor for determining freshness and remaining shelf life* (Brandenburgische Technische Universität (BTU), and Universitatea de Medicină și Farmacie “Iuliu Hațieganu” (UMF)): By scraping the fish's skin for slime and adding it to a methanol mixture, the sensor can determine freshness and remaining shelf life by measuring the headspace of the fish sample by electrochemical chemotransistor exploiting the novel principle of a virtual sensor array. The measured sensor signals are then analysed, and the extracted descriptors are matched against the database obtained during the sensor calibration to determine the freshness and the remaining shelf life of the given fish species. This tool is expected to be of primary value for fish-mongers and end-consumers as they can control the freshness of the fish, but it will also be of value for producers who can validate the freshness claim of their inbound goods. The first laboratory prototype has been developed, and the fabrication of a portable device is in progress. The main challenge that must be addressed for this specific sensor, is a possible variation in the calibration data for different types of fishes, different fish parts, and preparation conditions, and a corresponding necessity



The project participants of the FishEUTrust project at the FishEUTrust demonstration day in Olhão, Portugal, 2024.

to extend the database of the calibration data for these particular cases.

- *A sensor for detection of harmful biotoxins in mussels* (UNIFI): This sensor is geared towards detecting the occurrence of the biotoxins, okadaic acid and saxitoxin, in mussels. This sensor is expected to be of primary value for mussel producers who can increase their capability to test the health of the mussels on-site. It is also expected to have great value for the HoReCa sector and end-consumers who can test for these biotoxins before, for example, preparing a meal. The first prototypes are being produced and are expected to be tested by the industry during 2025.
- *A FishEUTrust digital platform for complete digital traceability* (BELIT and JSI): The platform aims to deliver an immutable digital “product passport” service that guarantees full digitised traceability and data integration in the seafood supply chain. In addition, a feature of the platform will be the capability of integrating data from sensor technologies already in use within the seafood supply chain to further enhance the traceability and transparency level in the digital product passport. A trial-based platform is expected to be ready in late May 2025 and will be followed by testing from industry project partners and private end-consumers.

However, given that no standard policy for data reporting currently exists in the European aquaculture sector, there are concerns amongst industry partners that such a platform will have a limited impact unless a clear standard policy on data reporting is delivered alongside the digital platform. This is one of the main bottlenecks facing this innovation's impact currently, which will be addressed during the remaining project period.

Future perspectives as the project approaches its conclusion

So, what lies ahead for the FishEUTrust project towards 2026?

The next major milestone for the project will be the demonstration of the project's innovations in relevant real-world applications with participants from the aquaculture industry and private end-consumers. Here, the aim will be to validate the innovations at a technology readiness level of 6 and 7 to showcase the readiness of the prototypes for further scale-up to a “flight-proven” system. Of equal importance, therefore, is the preparation for the transfer of knowledge to the aquaculture industry and academia of these new innovations, so the further development and scale-up of the project's results can be initiated. This will be organised through a

series of open-trade-days organised by the co-creation living labs that are in Croatia, Denmark, Malta, Portugal, and Spain—and with awareness campaigns in each project country, to ensure that different stakeholder groups and policymakers are made aware of the innovations and results of the project.

The FishEUTrust project is not just about achieving milestones; it is about reshaping the seafood industry to ensure its sustainability and future resilience. By integrating advanced technologies, sustainable practices, and consumer-centric strategies, we are creating a transparent, efficient, and trustworthy seafood supply chain that directly addresses the needs of industry stakeholders. The outcomes of this project will empower businesses with innovative tools and models to enhance their operations, comply with evolving regulations, and gain a competitive edge in the market. At the same time, consumers will benefit from increased confidence and knowledge to make informed choices. As we continue to advance, FishEUTrust is setting new benchmarks for sustainability, innovation, and collaboration that will redefine the seafood industry's standards and practices, says Prof. dr. Nives Ogrinc, Jožef Stefan Institute, project coordinator of the FishEUTrust project.

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Legislation reflects the importance of conserving resources for future generations

Fisheries regulations and practices in Türkiye

Turgay Türkyilmaz, recently appointed director in the General Directorate of Fisheries and Aquaculture of the Turkish Ministry of Agriculture and Forestry, is committed to the sustainable exploitation of Turkish fisheries resources. Here he summarises how fisheries management has evolved over the years to focus on the balance between environmental, economic, and social security.

Fishing regulations in Türkiye date back to the Ottoman Empire, when already in the second half of the 19th century regulations governing the trade in shellfish and the administration of wholesale fish markets in Istanbul were introduced. At that time too these rules sought to restrict the use of publicly available natural resources in favour of the state. These regulations had articles like those in today's fisheries law; they legalised the obligation of vessels and fishers to obtain a license, and stipulated sanctions such as the confiscation of fishing gear of vessels caught fishing during closed seasons, and the imposition of administrative fines.

Conservation became a priority from the mid-80s

Post-Republic legislative regulations show that the first important steps in the field of fisheries in Türkiye were taken in the 1950s—the first Fisheries Congress was organized in 1951—when several decisions were made to develop fisheries. In the 1970s, there were important developments in Turkish fisheries including the restructuring of existing legislation. In 1971, Fisheries Law No. 1380 was enacted which was last revised in 2020 when it took its current form. From the 1950s to the mid-80s, fisheries policy was designed

primarily to effectively exploit the seas; the fleet was modernised and expanded to increase fishing capacity. As it became clear that the resources in the seas were not inexhaustible, the amendments of 1986 to the Fisheries Law No. 1380, the fisheries regulation prepared in accordance with the amended law, circulars, and subsequent communiqués introduced measures aimed at the protection of resources. In the 1990s, Türkiye implemented a capacity control strategy for the fishing fleet and in 1991 ceased issuing licenses for new fishing vessels. However, the easing of this regulation in 1991, 1994, and 2001 led to a new increase in Türkiye's fishing capacity. In 2002, the issuance of licenses for new fishing vessels at sea was completely stopped. Between 2013 and 2018, support was implemented to reduce fishing capacity. A total of 1,264 fishing vessels were removed from the fleet and approximately 165 million Turkish lira (~EUR46m) was paid in support to the affected fishers.

All stakeholders contribute to shaping fisheries regulations

It is the authority and responsibility of the General Directorate of Fisheries and Aquaculture in the Ministry of Agriculture and



Turgay Türkyilmaz, Director, General Directorate of Fisheries and Aquaculture, Ministry of Agriculture and Forestry, Türkiye

Forestry to develop policies for sustainable fisheries and aquaculture in Türkiye and to implement these policies. The Fisheries Law No. 1380 and the Fisheries Regulation prepared within the scope of this law are the umbrella legislation for the protection of marine resources, sustainable use, and preservation of stocks. Prohibitions, limitations, and responsibilities regarding fisheries in seas and inland waters in terms of species, size, time, place, and fishing gear are described in the Communiqués on the Regulation of Commercial and Amateur Fishing. While preparing these communiqués, the health of natural resources, the status of the fisheries and aquaculture sector, as well as Türkiye's fishing dynamics are taken into consideration. During the preparation process, the opinions and suggestions of all

stakeholders such as public institutions and organisations, universities, research institutes, civil society organisations, and private sector representatives are collected and evaluated. Following this process, the opinions and suggestions are evaluated by the Aquatic Products Advisory Board, and the Fisheries and Aquatic Products Scientific and Technical Advisory Board, before the communiqués are finalised and put into effect.

Türkiye is a member of regional fisheries management organisations such as the General Fisheries Commission for the Mediterranean (GFCM), whose main objective is to ensure the good use, rational management, protection, and development of marine resources in the commission's area of responsibility, as

well as the sustainable development of fisheries products, and the International Commission for the Conservation of Atlantic Tunas (ICCAT), which determines protection and management measures aimed at shielding tuna and tuna-like fish species in the Atlantic Ocean and connected seas, as well as sharks and other marine organisms that may be harmed as bycatch or incidental catch. The decisions of regional fisheries management organisations and other international organisations are implemented in Turkish legislation according to our own fisheries dynamics. When these decisions are implemented in the legislation, a detailed comparison is made with Türkiye's current regulations and the decision that offers the resource most protection is implemented.

Production planning and management plans in fisheries and aquaculture

To ensure the sustainability of stocks and to secure the food supply, the balance between the protection and the use of species of ecological and economic importance has been taken into consideration. As of 2024, fisheries and aquaculture production planning takes into account production, export, import, catchable stock status, scientific studies, environmental and socio-economic factors, development plans, strategic plan and international obligations and statistical data. Under the production plans implemented by the Ministry of Agriculture and Forestry, anchovy, bluefin tuna, pearl mullet, eel, medical leech, white sand mussel, and sea cucumber have been included in the plan for fisheries and aquaculture. To ensure the sustainable use of resources, quotas of the species included in the



Fisheries control and inspection is necessary to ensure compliance with legislation. Here, inspectors check a vessel, the catch, and the documentation to ascertain their legitimacy.

production plan have been determined and management plans have been prepared.

For example, Türkiye has adopted a new model for the management of anchovy, a major species that constitutes approximately 65% of the total fishing volume, by taking into account its own fishing dynamics. With the new management model, which came into effect on 1 September 2024, the total amount that can be caught has been determined and allocated to each fishing vessel based on the vessel length, the characteristics of the fishing gear used and their fishing potential. This management model is quite different from the models applied in the past. With this model, fishermen hold the right to catch anchovy throughout the season. The volume that can be caught corresponds to the quota allocated to the fishing vessel, and catches are recorded with electronic monitoring systems at landing points, fish markets and factories, in addition to on-site control and inspections.

This is a big step for the sustainable fishing of anchovy.

Control and inspection activities ensure compliance

While the establishment of fishing legislation and management plans is important, if the rules are not enforced, they become meaningless. Legislative efforts can only achieve their goals through effective inspection and control activities. The ministry routinely, and also after evaluating notifications and complaints within a certain fisheries programme, organises inspection and control activities. In addition, in provinces where fishing activities are high, personnel working in different provincial directorates are assigned and simultaneous cross-inspections are carried out in teams. To combat illegal, unreported, and unregulated fishing, deterrent sanctions such as administrative fines, fishing licence cancellations, fishing bans, and imprisonment are applied. Control and inspection of fisheries plays a role in ensuring effective traceability

and is carried out in seas and inland waters, on fishing vessels, at landing points, retail outlets, cold storages, and on transportation routes. The effectiveness of control and inspection activities is constantly being improved as the institutional infrastructure is developed and today remote monitoring systems that record fishing data digitally are being used effectively.

Although Turkish fisheries management has come a long way, it is still evolving. The status of commercially valuable stocks in the Black Sea and the Mediterranean is improving but much remains to be done. Moreover, stock management regimes need take into account new challenges, such as the impacts of global warming, that affect the sector. Türkiye will continue to develop measures that safeguard fisheries resources while allowing their sustainable exploitation.

Turgay Türkyilmaz, Director, General Directorate of Fisheries and Aquaculture, Ministry of Agriculture and Forestry, Türkiye

Turkish government assists aquaculture sector adapt to climate change

Securing the future of fish farming

The government in Türkiye is contributing to efforts by the aquaculture industry to adapt to climate change. The cultivation of fish and shellfish has implications for food security and is also a source of livelihoods in many parts of the country.

Aquaculture production in Türkiye has been going from strength to strength. In 2023 production increased year on year by 8% to 556 thousand tonnes, a figure that represents a 137% increase over the last decade. The main species continue to be freshwater raised trout, and marine farmed seabream and seabass, volumes of each of which hovered around 155 thousand tonnes in 2023. In addition, sea-cage-raised rainbow trout has shown explosive growth—from less than 5,000 tonnes in 2014 to 66,000 tonnes in 2023. Other species with significant volumes in 2023 include mussels (9,000 t), meagre (6,000 t) and bluefin tuna (4,000 t).

Increasing both production and unit value

Tanju Özdemirden, the head of the aquaculture department in the General Directorate for Fisheries and Aquaculture is broadly responsible for keeping growth in the aquaculture on track. The goal, he says, is not only to increase sustainable production but also to encourage the addition of greater value to aquaculture products. The government therefore offers support to increase the efficiency of producers in the sector, create product diversity, and strengthen export potential. The production of high-value-added products supports local economic development while also increasing Türkiye's competitiveness in the aquaculture market. The ministry

supports projects to develop new technologies and production methods that will increase added value of products from the aquaculture sector. These projects are focused on areas such as fish processing, preservation, packaging, and the development of innovative products (e.g. frozen or processed products) and sustainable production methods. Support is available for efforts to increase sustainability anywhere along the value chain, from the vessels, to storage, transport, and processing.

Training farmers is also considered part of the value adding process and is thus eligible for support. Farmers learn about fish processing, branding, product diversification, marketing and new product development. As part of branding and marketing efforts, labels such as organic aquaculture certificates provide producers an edge when promoting their products at local and international food fairs. Support is also available both for the establishment of new facilities and the implementation of technologies that increase the efficiency of existing facilities. Low-interest loans and grants from the government encourage producers to invest in the production of high value-added products. In addition, small-scale enterprises engaged in aquaculture in rural areas are offered financial support for the modernisation of their facilities and the development of new products. Farming companies



Tanju Özdemirden, Head of Aquaculture, General Directorate for Fisheries and Aquaculture, Ministry of Agriculture and Forestry, Türkiye

are encouraged to comply with international standards such as Global.G.A.P., ASC, ISO, and BAP among others, while for processing facilities relevant standards include IFS, BRC, and ISO. Turkish exports of farmed fish have climbed steadily in the four years to 2022, according to the latest available data from FAO. They currently amount to a tiny fraction of total Turkish exports, and the ministry sees significant potential to increase this. Supporting company efforts to comply with global health, safety, and quality standards thus aligns with government priorities to boost exports from the sector.

Deployment of more recirculation systems will increase sector resilience

The government's strategic plans for aquaculture seek to

strike a balance between environmental, social, and economic priorities. Environmental Impact Assessment (EIA) processes are required to minimise the negative impacts of aquaculture facilities on the environment. By adopting ecosystem-based management approaches, efforts are made to prevent production activities from disrupting the ecological balance. Detailed planning of potential aquaculture sites reduces the potential of environmental impacts in the form of nutrient build-ups and habitat degradation. Protected areas or those with high biodiversity levels are generally off-limits for aquaculture production. Closed-circuit aquaculture systems reduce water consumption and have limited impact on the external environment. The government also compels companies to establish

Aquaculture production in Türkiye

(Tonnes)

	2019	2020	2021	2022	2023
Aquaculture products					
Total	3,73,356	4,21,411	4,71,686	5,14,805	5,56,287 ^(r)
Inland water					
Trout (Rainbow trout)	1,13,678	1,26,101	1,34,174	1,44,347	1,54,991 ^(r)
Trout (Salmo sp.)	2,375	1,804	1,558	1,302	1,440
Carp	203	173	171	293	216
Sturgeon	-	14	-	1	1
Tilapia	6	13	6	-	-
European catfish ⁽¹⁾	121	92	84	95	79
Frog	43	39	49	25	31
Marine water					
Trout (Rainbow trout)	9,411	18,182	31,509	45,454	66,055
Trout (Salmo sp.)	281	507	45	-	-
Seabream	99,730	1,09,749	1,33,476	1,52,469	1,54,011
Seabass	1,37,419	1,48,907	1,55,151	1,56,602	1,60,802
Common seabream	5	1	4	28	59
Bluespotted seabream ⁽¹⁾	74	-	-	-	-
Redbanded seabream ⁽¹⁾	-	-	-	-	-
Corb	47	26	2	18	-
Meagre	3,375	7,428	5,913	4,771	6,149
Dentex	27	-	-	-	-
Sharpsnout seabream	-	-	-	-	-
Bluespotted bream	66	-	3	5	-
White grouper ⁽²⁾	-	-	-	1	-
Bluefin tuna	2,327	4,338	4,952	3,879	3,674
Mussel	4,168	4,037	4,585	5,469	8,738
Whiteleg shrimp	-	-	4	19	18
Truncate donax ⁽²⁾	-	-	-	25	21
Blue crab ⁽³⁾	-	-	-	-	1
Spirulina nei ⁽²⁾	-	-	-	2	1

Source: Ministry of Agriculture and Forestry, Türkiye

Compiled since (1) 2017; (2) 2022; (3) 2023

(r) data revised

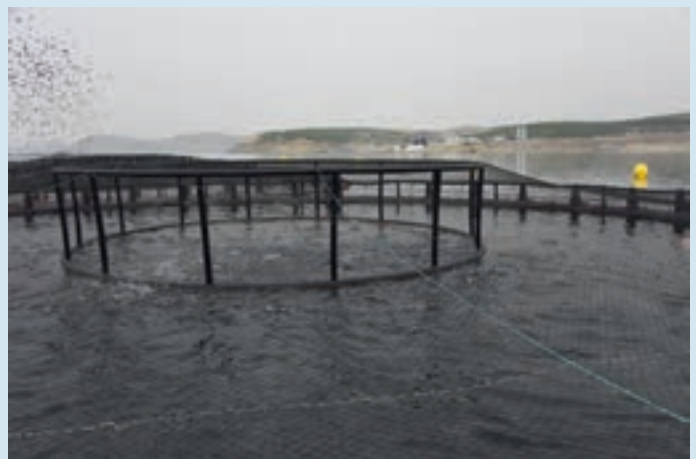
water purification systems and to ensure the environmentally appropriate disposal of waste generated by these systems. Licences to farm fish in dam lakes take into account the carrying capacity of the lake while, in the sea, production is sited far from sensitive ecosystems, says Mr Özdemir.

Moreover, the water is regularly sampled for nutrient concentrations and oxygen levels, and the status and diversity of natural populations in the region are monitored. In addition, studies have been initiated to monitor the activities of the facilities remotely and to identify the risk of habitat degradation. International

certification programmes that focus on the environment together with technological innovations and digitalisation are also expected to play a role in making the sector more environmentally friendly, for example, by monitoring water quality, improving waste management, and tracking diseases. Providing information about the availability of technology and training farmers in how to deploy it are also among the government's plans. Increasing consumption on the domestic market by organising campaigns to raise public awareness of the quality of Turkish farmed fish and the benefits of consuming it is also a strategic priority as is supporting women entrepreneurs and young people in the aquaculture sector, creating a more gender-balanced sector, and creating employment opportunities especially in rural areas. The ministry is also keen to widen and deepen collaboration between the administration, the research establishment, and the industry. As these plans are implemented over the next years the hope is that they will lead to increased production and exports, while reducing environmental impact, and fulfilling social priorities.

Range of state measures boost sustainability

Mr Özdemir is aware that for expansion in the aquaculture sector to continue, growth needs to be sustainable. At the same time aquaculture plays a role in Turkish food security as a source of nutritious and healthful fish and seafood that contribute to consumers' protein requirements and increase food diversity. Apart from support to aquaculture companies that encourages environmentally friendly, efficient production systems, the government monitors the quality of water in aquaculture regions, ensures that the species cultivated are compatible with the local ecosystem and do not harm natural habitats, protects natural fish populations with sustainable catching policies, and ensures that feeds and other compounds used by farmers, such as vaccines or drugs, do not harm nature. In addition, joint studies especially in the fields of genetics and biotechnology are carried out with universities, research institutes, and the private sector, and new solutions to increase the sustainability of fish and shellfish farming are developed, tested, and deployed. The impacts of climate change



The impacts of climate change threaten the aquaculture industry across the Mediterranean. The Turkish government is taking measures to enhance resilience in the sector.

are also among the focal points of government-supported research. Scientists are encouraged to study how endemic species can be protected as well as to identify new species that can adapt to different climate conditions and ecosystems and show potential as species that can be farmed. Both the government and researchers are aware that potential new species for the aquaculture industry may not exhibit invasive characteristics, such as highly predatory behaviour, destruction of habitats, or unconstrained spreading in Turkish waters.

Among the challenges the industry is facing is the increase in

water temperatures. This has affected mussel producers in particular causing mass mortalities in stocks. In addition, producers worry that the high temperature will trigger another mucilage event as was the case in 2024.

Identifying new species to farm while making existing species more resistant

While the potential of new species as candidates for aquaculture is being explored, Mr Özdemir adds that other efforts to adapt to the impacts of global warming are also being made to increase the resilience

of existing farmed species. Strains are being selected and hybridised for their resistance to high temperatures, increased acidity levels, and lower oxygen content in the water. Moreover, he says, satellite data and modelling studies are being used to detect changes in sea temperatures and potential extreme weather events in advance. Early warning systems give growers a better chance to adapt to adverse conditions. Recirculation aquaculture systems (RAS) are also attracting growing attention as they can isolate the fish from the natural environment and allow all the parameters (temperature, pH, oxygen levels etc.) inside the

system to be controlled. Feeds too are being adapted to water with lower oxygen levels and feeding techniques and regimes are being modified to use fewer resources.

The numerous measures the government is taking to reduce the impact of climate change on the aquaculture industry reflect the importance of the sector and the fact that the Mediterranean is one of the most climate-stressed regions on the planet. While these efforts will not shield the sector completely, they will certainly contribute to a more climate-resilient fish farming industry.

AyFish contributes to the restoration of sturgeon stocks

Ambitious caviar production plans

At sites in Dalaman, Gaziantep, and Elazig, AyFish produces Turkish salmon as well as four varieties of sturgeon for restocking, meat, and caviar, for domestic and international markets.

Between 2017 and 2023 aquaculture production in Türkiye has doubled to almost 560 thousand tonnes of seafood. Over 70 percent of this production comes from marine waters. A variety of finfish species is farmed, but three dominate the production, seabass, seabream, and rainbow trout which together account for 97% of the total. Of the non-fish species farmed, the most noteworthy is Mediterranean mussel, production of which has grown over 18-fold to 8,700 tonnes since 2017. Among the many finfish species produced are meagre, bluefin tuna, carp, catfish, and sturgeon.



Abdulla Hajiyeve (left), the CFO, and Mikaeil Hosseinzadeh, the COO, with a fine specimen of *Huso huso* (beluga sturgeon), the species that dominates production at AyFish.

Farmed sturgeon production has seen rapid growth over the last two decades

The latter are among the world's most ancient species dating back 250 million years and are represented by two families and 27 species in waters in the northern hemisphere. Wild stocks have suffered from grievous overfishing, habitat loss, and illegal trade over the last decades and today some 20 species of sturgeon are listed in the CITES appendix I (species threatened with extinction, trade in specimens of which is permitted only in exceptional circumstances) and II (species not necessarily threatened with extinction, but in which trade must be controlled to avoid utilisation incompatible with their survival). Production of sturgeons from aquaculture dates back to the 19th century, but it was in the 1980s that it started to increase first slowly and then rapidly from the early 2000s onwards, when sturgeon catches in the Caspian Sea and the Black Sea were banned. The increased interest in sturgeon farming stemmed both from a desire to restock natural waters with the fish, but also from the high price sturgeon caviar commanded. However, among many sturgeon species the females take 8-10 years to reach maturity. In this period the main product from the production is the meat of the male fish. This continues to be an important product even after the females are mature enough to start producing caviar.

In Türkiye, the company AyFish produces sturgeon in cages in the river Firat, as the Euphrates is known locally. Founded in 2018, AyFish farms both Turkish salmon (sea-raised rainbow trout) and sturgeon. The former is produced at a site in Gaziantep near the Syrian border where conditions enable the fish to be grown



At the Elazığ site the company has 150 cages of 30 m diameter and 40 cages of 20 m diameter making it one of the biggest sturgeon farming sites in the world, according to Mr Hajiyeve.

all the year around and in Keban near Elazığ, where sturgeon is also farmed. Abdulla Hajiyeve, the CFO, spent several years studying in the UK before coming to Türkiye upon graduating in 2020 to manage the business together with Mikail Hosseinzadeh, the co-owner of the company. While Mr Hajiyeve takes care of the accounts, sales, and marketing, Mr Hosseinzadeh is responsible for the production. In 2020 when Mr Hajiyeve arrived, sales of Turkish salmon were just starting, but at the end of the year and in 2021 the first sturgeons started to arrive from sturgeon farms in the Caspian Sea area, first to Gaziantep and a little later to the Keban site, where the water conditions are better for sturgeons in terms of the temperature, minerals, and oxygen levels. The main species currently being produced are *Huso huso* (Beluga), *Acipenser gueldenstaedtii* (Russian sturgeon), *Acipenser persicus* (Persian sturgeon), and *Acipenser ruthenus* (sterlet). The area and conditions in the Firat river by the Keban dam, says Mr Hajiyeve, have enabled us to build one of the biggest sturgeon farms in the world. The sturgeons

are grown here all around the year, and between October and May we also produce rainbow trout.

Restocking sturgeons is one of the main objectives

While the high price of caviar is the main incentive to produce sturgeon, AyFish is also interested in the conservation of sturgeon and the rebuilding of wild stocks. To this end the company intends to release millions of young fish into the wild to give them a chance to repopulate the Black Sea and the rivers that drain into it. Mr Hajiyeve envisages producing enough caviar in the future to influence the market price on the domestic market. This in turn should make it more accessible and may thus reduce some of the pressure on wild stocks from poaching. While selling the caviar may not be an issue, sales of sturgeon meat on the local market may be more challenging. Per capita fish consumption in Türkiye was estimated at about 8 kg in 2023 according to the OECD, well below the level for meat, and

sturgeon is a relatively unknown species on the market. Building a market for a new fish species from scratch in a country that is not a prolific consumer of seafood is a long-term commitment. Turkish salmon on the other hand is an established product that Turkish companies have been growing in the Black Sea for the last couple of decades and exporting to Japan and Russia. At AyFish the production process is very similar; young salmon trout are grown to 400-800 g in fresh water and then introduced into cages in the Firat river in October. The fish stay in the cages until about May when the water starts to get too warm for the fish. During this period growth is very rapid and the fish can reach 4-5 kg before they are harvested. At the Gaziantep site the water is cooler and fish can be grown all through the year. However, Mr Hosseinzadeh points out, these advantages are offset by some drawbacks. Because it is further downstream, the water quality in Gaziantep is not as high as it is in Keban, besides production in Gaziantep had reached the maximum permitted capacity

prompting the establishment of the Keban site.

At the Keban site AyFish has 150 cages 30 m in diameter and 40 cages of 20 m diameter which house the smaller fish. The site has cages both for Turkish salmon and for sturgeon. Young salmon are raised at a hatchery in Dalaman 1,200 km to the west on Türkiye's Ionian coast. The eggs are imported from France or Iran and are genetically selected for rapid growth, good shape, meat quality, and robustness. They are also triploid, so the fish do not mature sexually. In addition to preventing them from interbreeding with local fish, triploids put all their energy into growth rather than into gamete development. Currently the Turkish salmon is sold fresh on ice, but the company plans to open a processing facility in 2027 for value-added products. Here the Turkish salmon will be processed into fillets and steaks as well as hot and cold-smoked

products. The facility will also process the sturgeon, removing the caviar and adding value to the meat. AyFish has Turkish partners who handle the processing now before the new facility is realised. The salmon is then exported, mainly to Russia (fresh on ice) and Japan (frozen headed and gutted), but consignments have also been sent to the EU, US, Middle East, Canada, and China.

Healthy stocks are less likely to succumb to climate change impacts

Working in a region, the Mediterranean, that is among the world's worst-affected by the impacts of climate change, Mr Hajiyeve is all too aware of the threat this poses to the business. In the five or six years since he started, he has noted greater unpredictability, for example, in the supply of water from the mountains where it originates to the hatchery in Dalaman, and in the temperature and oxygen

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Co-owners: Fikrat Hajiyeve, Mikael
Hosseinzadeh (COO), Abdulla
Hajiyeve (CFO)

Sites: Dalaman (hatchery),
Gaziantep and Sanliurfa (cages),
Elazig and Tunceli (cages)
Species: Turkish salmon (large
rainbow trout), sturgeons
(Beluga, Russian, Persian)
Products: Turkish salmon, sturgeon
meat, caviar (from 2030)
Product forms: Fresh on ice, frozen;
value added products from 2027
Annual volumes: 10,000 tonnes
(Turkish salmon), 3,000 tonnes
(sturgeon meat)

content of the water at all the sites. The sturgeons are hardy fish and better able to adapt to changing conditions, but the Turkish salmon can suffer. Mr Hosseinzadeh says the company is taking precautionary measures, for example, by reducing the density of fish in the cages. This translates into better welfare for the fish and makes them more resilient when faced with changes caused by climate.

At the same time such measures improve the quality of the final product. While little can be done by the individual fish farmer to influence climate change, they can adapt their production processes to avoid the worst impacts and to make the fish as resistant as possible. Healthy stocks whether farmed or wild are the best remedy against the stresses caused by the effects of global warming.

Mullet, seabass, seabream, and eel are among the species caught by a cooperative

Exploiting the natural migration of fish

A cooperative of fishermen near Dalaman in western Türkiye uses a system of weirs to catch mullet as the fish migrate between a lake and the sea. Apart from selling the fish, the roe is also extracted and commands a good price.

The Dalko fishermen's cooperative in Dalyan close to the Ionian sea has existed for almost 50 years and today has about 750 members. As one of the oldest fishing cooperatives in Türkiye it is a model for other cooperatives who often send representatives to learn how Dalko operates and how it addresses the issues of its members. The

cooperative focuses on catching fish from a channel that connects the lake Köyceğiz with the Ionian sea. Oğuz Burak Sünger, who is loosely tied to the cooperative, explains that there are 12 varieties of fish inhabiting the lake, but the main species targeted are only two, called the summer mullet and the winter mullet. The two exhibit some physical differences,

for instance, the head of the summer mullet is larger while the nose of the winter mullet is more pointed, but perhaps the biggest difference is the catching season.

Small fish are allowed to escape

The fish migrate from the lake to the sea via the channel which

forks at a point with the left fork going to the sea and the right going to the cooperative's cages. The left fork is guarded by a barrier that can be opened or closed. When catching the fish the barrier is closed diverting the fish towards the cages. A weir allows the large fish to enter the cages but prevents them from leaving again, however, small fish can

escape and make their way down to the sea where they can spawn. Mr Sünger clarifies that even if the fish are small, it does not mean they are not carrying gametes. Instead of 20m eggs, they might have only 10m. The saltwater helps the eggs mature which is why the fish instinctively head for the sea when they are ready to spawn. These small spawners are monitored in the lake and the sea 24/7 by the cooperative with staff working three eight-hour shifts. A speedboat and drones are used to ensure that fishers do not catch them before they have spawned. We know when the fish are going to spawn and that is when we monitor them closely, says Mr Sünger, as we have to secure future generations of the fish because the cooperative depends on it and for environmental reasons.

Production of winter mullet amounts to 500 to 750 tonnes a year and dominates the annual catches. The season for summer mullet begins in June or July and catches amount to about 150 tonnes annually. Once the fish have spawned in the sea, the



M. Ali Demirhan (left) and Emre Dön (right) from the Muğla Provincial Directorate of Agriculture and Forestry, and Oğuz Burak Sünger (centre) from the Dalko Dalyan Fishermen's Cooperative.

eggs hatch, and the young fish migrate to the lake where they grow and mature, and the cycle repeats itself. The mullet is followed by seabream which are also trapped in the cages. The fish are harvested on a daily basis and distributed around Türkiye in the cooperative's fleet of vehicles. The local market cannot absorb all the fish we produce, says Mr Sünger, so we must sell in other parts of the country. Commercial buyers can also come to the cooperative

to purchase fish for onward sales to retailers. The cooperative runs a network of five shops in the region, where the fish is sold. Apart from the fish itself, the other main product is the roe. The cooperative has a processing area where women remove the roe and dry it. Self-sufficiency is one of the cooperative's principles as it helps reduce costs. The cages, for example, are fabricated by workers who bend roles of steel wire into cages and also create sections of steel wire to repair cages in case they are damaged. These sections are then attached to the damaged cages by divers. Making cages this way reduces the cost by half compared to the price of a prefabricated cage especially as the raw material is purchased directly from the factory and not through a dealer. The oxygen cylinders used by the divers are also filled using machinery the cooperative owns rather than outsourcing this task.

The cooperative has several functions

In addition to generating an income for the fishers and protecting the stocks, the cooperative

also maintains the environment in the channel. Arif Yalili, chairman of the board of directors of the cooperative (and Mr Sünger's uncle) is committed to maintaining the channel and sends the cooperative's divers to monitor the channel bed and remove rubbish that may be present. Dalyan is a resort area and in the season it is visited by up to 10,000 tourists a day many of whom also sail along the canal to sightsee. While contributing to the local economy they also generate garbage, some of which ends up in the channel. The workers do these jobs during the low season when there is no fish to harvest. This way they can be kept on the payroll all year round.

Membership of the cooperative is determined by where the member lives, since a prerequisite for membership is to live by the lake. Living anywhere else disqualifies one from membership. Membership is also only available to those in possession of a fisher's licence. Membership confers certain benefits in the form of free rations of fish of up to 50 kg a year and 1 kg of caviar. The fishers, however, do not carry out any of the work of



The Dalko Dalyan Fishermen's Cooperative has a fifty-year history and with approximately 750 members it serves as a model for other cooperatives in Türkiye.



A system of weirs is used to trap fish, mainly mullet, seabass, seabream, and eel, as they migrate from the Köyceğiz lake to the Ionian sea and back.



The channel connecting the Köyceğiz lake and the Ionian sea bifurcates with one fork going to the sea and the other leading the fish to the cages. Blocking and unblocking the fork to the sea allows the fishers to control the catch.

the cooperative; that is done by the cooperative's roughly 90 employees. They take care of the harvesting, the monitoring functions of the stocks and the channel, the caviar extraction, marketing, and sales. The cooperative's processing facility is ISO certified and has cold storage rooms, shock freezing and storing chambers, and ice machines so the fish can be stored properly after being harvested. In the low season, other species such as blue crab, seabass, seabream, and eel are also caught and stored for sale. The mullet caviar is an important product for the cooperative because of its high value. Once the caviar is extracted from the fish,

it is cleaned, salted, and dried. The first quality dried product is also dipped in wax to prolong its shelf life. When it is to be used the wax coating can easily be broken off. Because demand for the product on the local market exceeds supply, the roe is not exported, although there is demand for it in Italy and other countries.

Dryer seasons threaten the fish directly and indirectly

The cooperative has also experienced periods when rain is scarce and when this happens aerators are used to move and aerate the

water in the cages so that the fish do not suffer from a lack of oxygen. Another manifestation of climate change is the increased flow of saltwater into the lake as the freshwater that normally feeds the lake becomes more intermittent. It usually rains here in winter, but in the last two or three years winters are more like summers, says Mr Sünger, and instead of four distinct seasons we seem to really have only two, summer and winter. The higher salt content has an impact on the reeds in the lake which cannot tolerate salt. As they die, the fish and other organisms that use the reeds as hatcheries, nurseries, and for feed are negatively affected. Mr Sünger expects that

in the future the freshwater delta will be replaced with seawater. The cooperative must also contend with vast numbers of cormorants that eat the fish voraciously. Scaring them away with shots or explosives draws protests from activists so the cooperative must determine other ways of dealing with them. Initial attempts have been made to diversify into value-added products, such as fillets which are being sold to hotels. Another initiative is a fish and chips shop that offers a competitively priced, healthful, and tasty meal made from fresh fish. These and other developments will surely enable the cooperative to continue its activities for at least the next fifty years.



Mullet roe is dried on screens. The finished product is a delicacy and sells for a high price.

S.S. Dalko Dalyan Su Ürünleri Kooperatifi (Dalko Dalyan Fishermen's Cooperative)

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Muğla
Türkiye

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dalko.com.tr

Volumes: 505 tonnes/year (total weight of all species combined), 2 tonnes (mullet roe)

Markets: Türkiye

Value-added products: Fillets, fish and chips, dried mullet roe

Members: 750

Species: Mullet, seabass, seabream, blue crab, eel, carp, grouper

Photos courtesy Muğla Provincial Directorate, Turkish Ministry of Agriculture and Forestry

Wellness products based on natural ingredients extracted inhouse

Enzymes from leech saliva for extra benefits

The company Hirudo based in Kayseri uses extracts from a variety of aromatic herbs, other plants, and leech saliva to create products that it claims improve wellbeing. All the product ingredients are extracted at the company's processing facility, so it exercises full control over the quality of the final product.

Leech therapy, scientifically known as hirudotherapy, has blended traditional medical practices with modern therapeutic applications for centuries. While often associated with ancient medicine, the use of leeches has seen a resurgence in recent decades, driven by advances in biomedical research and a deeper understanding of the biological mechanisms underlying their effectiveness.

Leech saliva contains a number of potent components

The cornerstone of leech therapy lies in the saliva of the medicinal leech (*Hirudo medicinalis*), a small aquatic parasite, known for its anticoagulant,



Ahmet Ekren (centre) with his son (left) and the company manager.

anti-inflammatory, and vasodilatory properties. Leech saliva contains a complex cocktail of bioactive compounds, including hirudin, which prevents blood clotting; calin, which inhibits platelet aggregation; and hyaluronidase, which enhances tissue

penetration. These substances not only facilitate blood flow but also promote healing, reduce swelling, and alleviate pain, making leeches valuable in certain medical scenarios.

Today, leech therapy is recognized as an effective treatment in various medical fields, particularly in reconstructive surgery and microsurgery. Surgeons often use leeches to alleviate venous congestion, a common complication that arises when veins are unable to remove blood efficiently from reattached or transplanted tissues. By restoring circulation, leeches play a critical role in ensuring the survival of delicate grafts and reattached body parts, such as fingers, ears, and skin flaps. Beyond surgery, leech therapy has shown promise in managing conditions like osteoarthritis, chronic venous

diseases, and even certain cardiovascular disorders.

Breeding leeches for medical treatments as well as for saliva extraction

In Kayseri, a city in central Türkiye, Ahmet Ekren farms leeches for medicinal purposes. While there are some 650 species of leeches, the variety used by Mr Ekren is *Hirudo verbana*. This species can be easily found in Türkiye and, compared to other species that were tested, also gave the best results. The animals are used both for live leech therapy and as a source of components from leech saliva that Mr Ekren combines with other ingredients to create a range of wellness products, which he sells under the brand name, Hirudo. According to Mr Ekren, unlike other producers of these



The company's processing facility where the extraction of the various ingredients used in the healthcare products is carried out. The active ingredients in a product are all extracted at this plant.

ingredients, Hirudo does not sacrifice the leech when extracting the leech saliva. The system uses a combination of pressure and temperature, but at levels that do not harm the leeches. The extracted saliva is filtered and purified and then processed in the company laboratory to extract the enzymes of which leech saliva has over 100. However, isolating each individual enzyme has proved difficult as some of them are present only in small proportions, so only a few enzymes are extracted and used, of which hirudin, a powerful anti-coagulant, is the most important. But, Mr Ekren says, he knows the properties and the functions of each of these different enzymes, and when more of them can be extracted, the company will develop new products that include them.

At the facility, other essences such as lavender are also extracted using the same system. The lavender is grown on the farm where the leeches are produced, and in the season it is harvested and brought to the processing facility. Here, the lavender is processed in a series of machines to extract the essence which is then used as one of the raw materials in the wellness products. These products are made almost entirely of natural



The company Hirudo breeds leeches of the species *Hirudo verbena* for use in leech therapy and to extract enzymes from leech saliva.

ingredients extracted from different herbs and other plants including oregano, mint, ginger, and turmeric, besides lavender. He emphasises that none of the ingredients in his products are obtained from external suppliers. They are all extracted at the Hirudo processing facility.

Collaboration with universities improves knowledge and products

New product creation is done by the research and development team which develops and tests product formulas. The scientists have been working with leeches and on plant science for many

years, researching the active ingredients, participating in scientific programmes, and conducting experiments to identify the mechanisms through which the products work. The company also collaborates with the relevant departments and laboratories in three institutions, Erciyes University, Firat University, and Ege University. In the last two decades, over one thousand experiments have been conducted, based on which the company has developed over twenty products. The company is regulated by the government, specifically by the Ministries of Health, which regulates 90% of the products, and of Agriculture, which regulates the remaining 10%, which

ensures the products meet certain standards and are safe for consumers. Regulatory bodies also monitor that no wild claims are made about the products' benefits. The product components are all ingredients extracted from natural sources, synthetic chemical copies are not used at all, Mr Ekren says. The range of products includes many for the care of the skin and of the hair, while others are taken orally and are intended to strengthen the immune system, treat infections, and combat fatigue. The skin- and hair-care products take the form of creams, moisturisers, and oils among others, while the supplements are usually liquids, a few drops of which are taken one to two times a day. The dosage is determined by the researchers, but the company recommends that small amounts be tried first in case the user cannot tolerate the product.

New possibilities with leech saliva are still being uncovered

Leech saliva holds a unique position in the broader context of complementary and integrative medicine. Its popularity reflects an interest in exploring natural and holistic treatments that



Health-boosting products manufactured by the company Hirudo feature extracts from aromatic and other plants as well as enzymes from leech saliva among their ingredients.

harness the therapeutic potential of biological organisms. Moreover, ongoing research continues to uncover new possibilities for the medicinal use of leeches. Leeches produced at the Hirudo leech farm are supplied to medical practitioners in Türkiye and the company also organises seminars and workshops where scientists, industry representatives, and medical practitioners can exchange ideas, knowledge, and experience regarding leech therapy. These events serve

to validate the efficacy of this therapy, cementing its role in managing conditions ranging from arthritis to post-surgical recovery. Türkiye's dedication to preserving and refining this ancient practice demonstrates the enduring value of traditional knowledge in addressing modern health challenges. With its blend of tradition, innovation, and hospitality, Türkiye remains a destination for those seeking the benefits of leech therapy.

Hirudo

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Products: Healthcare products for skin, hair, etc.,

Special features: Use of natural ingredients exclusively

Raw materials: Extracts from aromatic and other plants, and from leech saliva

Other activities: Breeding of leeches for medical purposes and for saliva extraction

Facilities: Processing plant, farm for growing leeches and some of the plants.

Sür-Koop, the Central Union of Fishery Cooperatives

The bridge between fishers and the state

The cooperative movement in Turkey has a history that dates to the 12th century, according to some experts. However, its modern development began with the establishment of the Turkish Republic in 1923. Today, among its other functions, the Central Union of Fishery Cooperatives represents fishers and their concerns to the government.

Sür-Koop, the Central Union of Fishery Cooperatives, was formed in 2004 by seven unions of fisheries cooperatives (Eastern Black Sea, İstanbul, Çanakkale, Balıkesir, İzmir, Mersin, and Mugla) and is the largest such organisation in Turkey. It forms the top-most layer of the cooperatives' structure representing 17 regional unions of cooperatives comprising 232 cooperatives and around 14,300 members.

Cooperatives help to iron out bureaucratic wrinkles

These cooperatives oversee fishing activities, organise marketing and storage, and conduct training for members. They also act as intermediaries between

fishermen and the Ministry of Agriculture and Forestry, helping to streamline bureaucratic processes. Sür-Koop conducts workshops on the challenges facing fisheries and proposes solutions. These events have become a tradition and are now organised every year. They provide an opportunity for fishers from all over the country to convey the issues they are facing to the authorities. The reports from these workshops form the basis for Sür-Koop to make legislative proposals to the ministry. These proposals consider the interests of the fishers, as well as those of the fish stocks, and of the environment. This partnership between the ministry and Sür-Koop when drafting legislation has proven valuable, especially as the new fisheries law is

set to take effect in 2025. Sür-Koop also participates in a range of projects typically funded by FAO or the Global Environment Facility. These include projects on discards, data collection, women in fisheries, wild shrimp, and young people. At the institutional level, Sür-Koop has since 2014 a membership agreement with the International Cooperative Fisheries Organization (ICFO). Under the terms of this agreement eight students from Türkiye have received full scholarships to take postgraduate degrees at Pukyong National University in South Korea.

The chairman of the board of directors of Sür-Koop is Mr Ramazan Özkaya and the former head of aquaculture in the General Directorate of Fisheries

and Aquaculture, Turkish Ministry of Agriculture and Forestry, Mr Özerdem Maltas, is the president. Mr Özkaya notes the importance of the organisation's wide representation across the fishing sector, from small boats to large trawlers operating in the Mediterranean, Black Sea, Sea of Marmara, and Aegean Sea. The activities of Sür-Koop vary by region. In the Aegean, the cooperative is actively involved in fish marketing and sales. In contrast, fishers in the other seas primarily sell directly to wholesalers. Mr Maltas attributes this to the cooperatives' financial limitations for purchasing, storing, and selling fish and the wholesalers' strong control over the trade. This situation mirrors challenges in other markets for other agricultural



Ramazan Özkaya, Chairman, Central Union of Fishery Cooperatives (Sür-Koop)

produce, according to Gülser Fidancı from the Ministry of Agriculture and Forestry, and is difficult to reform due to the involvement of multiple ministries, including finance and transport.

Support for fishers to bring issues to the attention of the government

Membership of a cooperative facilitates access to a port where fishers can discharge their fish. Individual fishers can also approach the cooperative if they have economic problems and need, for example, support for fishing gear or even a vessel. More generally, if there is an issue with the fishery that is experienced by a number of fishers, they can approach the cooperative who can take it up with the government. For example, small scale fishers, who make up the majority of the cooperatives' members, find that their catch volumes are declining. They can also experience difficulties selling the catch

as individuals and so go through the cooperatives. Cooperatives have not always been influential, says Mr Özkaya, who worked for many years at the Güllük (a town in Mugla province on the west coast) Fisheries Cooperative before taking over his current position. Ten or fifteen years ago fishers wondered how they would benefit from membership of a cooperative. But that has since changed as cooperatives have become an established part of the way fisheries are organised. Some cooperatives sell freshly caught fish from their members directly to consumers at a reasonable price creating a positive awareness about cooperatives and their activities. For fishers, this trade is an incentive to join a cooperative because it eliminates middlemen and so fetches the producers a better price. Sometimes the sales price at the cooperative is at a level where it becomes worthwhile for a trader to buy fish from the cooperative and sell it to a supermarket, says Mr Özkaya.



Özerdem Maltas, President, Central Union of Fishery Cooperatives (Sür-Koop)

Contribution to drafting of legislation

Among the functions of the cooperatives is to give fishers some say in the drafting of laws that relate to their activities. In this role, Sür-Koop has successfully influenced several provisions in the fisheries law. Mr Maltas highlights a significant improvement: cooperatives will now coordinate with a single ministry instead of three, reducing bureaucracy and simplifying negotiations. Another achievement is the introduction of regional fisheries management. Previously, nationwide regulations applied uniformly, but now seasonal restrictions and species-targeting rules will vary by sea basin, a change Sür-Koop has long supported. The law also addresses conflicts between commercial and recreational fishers, a longstanding issue in Turkey as in many other countries. Recreational fishers, though prohibited from selling their catch, have often bypassed this rule due to weak enforcement. The

new regulations impose stricter fines on violators, a measure Mr Özkaya believes will significantly ease pressure on fish stocks. With millions of recreational fishers in Turkey, this could have a notable impact on fisheries sustainability. More recently Sür-Koop was involved in consultations regarding the government's plan to manage the fisheries of certain species using quotas allocated to vessels. The idea is to limit the volume of fish, such as anchovies, that can be caught by the big fishing vessels—the small-scale fisheries are outside the quota system.

The system of fishers' cooperatives has developed over the years and is still evolving. It plays an important role in supporting fishers and advancing their causes. Cooperatives' functions as interlocutor for the fishers in their interaction with the authorities and as a social partner for the government contribute to ensuring that priorities such as the sustainability of fisheries and visions for rural development are implemented.



Polish fisheries sector's involvement in events in 2024

Knowledge exchange and promotion of capabilities

Representatives from the Polish fisheries industry attended various national and international events during 2024. Some of these were intended to promote products, skills, and services that the sector has honed over the years, while others were of a more technical nature. A brief overview of three of them is presented here.

Data collection for fisheries management purposes in 2022-2024

At the end of the strategic operation, data collection for fisheries management purposes in 2022-2024 financed by the European Maritime, Fisheries and Aquaculture Fund, on 30 December 2024, an information and promotional event was held in the National Marine Fisheries Research Institute's Gdynia Aquarium building. During the event, institute experts presented the assumptions behind the strategic operation, the actions taken, and the results. During the official part, interested parties could learn about European Funds from the perspective of the managing institution (Ministry of Agriculture and Rural Development) and the paying agency (Agency for Restructuring and Modernisation of Agriculture), the scope and importance of the multi-annual programme for the collection of fisheries data, as well as the collection of data on diadromous fish, including socio-economic data related to sea fishing, fish processing, and aquaculture. After listening to the speakers and the discussion, there was a tour of the aquarium. The event attracted many residents of the region, with over 600 people visiting the aquarium that day.



Various branches of the Polish fish processing industry offering products and services for the domestic and international markets were represented at POLFISH 2024.

Polish and international fish industry well represented at POLFISH 2024

From 11 to 13 September 2024, the Amberexpo Congress and Exhibition Center in Gdańsk, Poland was a hub for the exchange of knowledge and experience among representatives of the domestic and international fish and food industries. The event gathered some 2,000 participants attending either as exhibitors or visitors. Among the participants were leading Polish producers

and importers of fish, seafood, and fish products. Representatives of the packaging, machinery, and equipment sectors were also present, including those specializing in processing plants, gastronomy, and retail solutions. Exhibitors showcased innovative solutions such as drainage systems and hygiene maintenance technologies.

POLFISH 2024 was packed with accompanying events, including debates, presentations, and interviews addressing current issues in the fish industry. Special attention

was given to topics such as sustainable fishing and the future challenges and opportunities for this rapidly evolving sector. The traditional Mercurius Gedanensis Competition also took place during the fair, honouring the best products and technologies in the fish industry. The Grand Prix in the "Fish Product" category was awarded to EvraFish Sp. z o.o. from Brus for their EvraFish High Protein—Asian Protein Salad. Two joint medals were awarded to Suempol Sp. z o.o. from Bielsk Podlaski for their Salmon Nuggets and GRAAL SA from Wejherowo



for their SUPERFISH Atlantic Salmon – Roasted.

In the technology category, the winner was the National Marine Fisheries Research Institute which, in collaboration with the Koszalin University of Technology, had designed and built a fresh and frozen fillet slicer. The Minister of Agriculture and Rural Development's Cup was awarded to Herring Brygida Stachniuk from Wielka Nieszawka for their outstanding contribution to the fish processing sector, exemplifying the effective use of national and EU support funds. The next edition

of the event is scheduled for 9-11 September 2026.

Polish finalist at 2024 Seafood Excellence Global Awards in Barcelona

The Polish fish processing industry was represented by 22 companies at the world's largest seafood trade fair, Seafood Expo Global, in Barcelona in April 2024. This year's event marked the 30th edition of the fair. The Polish pavilion was officially inaugurated by Ms Ilona Kałdońska, Consul General of Poland in Barcelona, Ms Małgorzata Pawliszak,

President, Polish Association of Fish Processors, and Mr Miroslaw Purzycki, President, Organization of Sturgeon Fish Producers. As in previous years the pavilion featured a cook who prepared samples for the participants as well as for visitors to the pavilion.

A Polish company, Suempol, was among the finalists for the 2024 Seafood Excellence Global Awards illustrating the sophistication of Polish processed fish products. Forty finalists were selected from a total of 85 entries competing for six awards. This year, the Polish Association of Fish Processors, together with the Sturgeon Fish

Producers Organisation, organised the Polish national pavilion, where 22 companies from the processing sector were showcased: Abramczyk, Graal, Evra Fish, Barkas, Freezco, Antonius Caviar, Mik-Food, Mirko, Polski Karp, Dalekomorska Organizacja Producentów Ryb, Przetwórstwo Rybne Łosoś, Rybhand, Seamor International Ltd, Seko, Stanpol, Tahami Fish, Thai Union Global, Dega, Contimax Trade, CPF Culinar, and the Sturgeon Fish Producers Organisation. Participation in the trade fair was made possible thanks to support from the European Maritime, Fisheries and Aquaculture Fund 2021-2027.

Eleventh **Polish Fish Congress**, 1-2 April 2025, Sopot

Event for the entire fisheries sector

The 11th edition of the Fish Congress, the largest event for Polish fish processors, farmers, fishers, technology suppliers, scientists, and the administration will take place on 1-2 April 2025, at the Sheraton Hotel in Sopot, a seaside resort near Gdańsk.

The congress will cover a diverse array of topics, including market trends, economics, marketing strategies, raw materials, and technological advancements in the fisheries sector. One of the featured presentations, *The Role of Packaging in Shaping Brand Image in the Food Sector: Trends in Food Packaging and Labelling*, will be delivered by Maciej Konopka, a professor at the Academy of Fine Arts in Warsaw. Drawing from 15 years of experience leading the Packaging and Brand Design Studio at the Faculty of Design, Mr Konopka will highlight how innovative packaging can enhance brand perception.

Herring is a critical species for Polish processors

Another keynote speaker, Jacek Suryń of Pelagia, a Norwegian



In her intervention, Dr Joanna Krupska, Faculty of Economics, University of Gdansk, will analyse the efficiency of the Polish fish processing industry.

company, will present *Variability in Quality and Quantity of Herring from the Northeast Atlantic and Its Impact on the Processing Industry*. Mr Suryń will examine the challenges of processing fish from 54 diverse Atlantic herring populations, emphasising differences

in spawning, fat content, and meeting client specifications. Dr Joanna Krupska from the Faculty of Economics at the University of Gdansk will analyse the efficiency of the Polish fish processing industry. Her presentation will segment companies by

size and type of production to provide a detailed economic assessment. Tomasz Kulikowski, editor-in-chief of Fish Industry Magazine for 27 years and a researcher at the National Marine Fisheries Research Institute, will examine consumer ambivalence in the



fish and seafood market, focusing on expectations regarding price, convenience, and product quality attributes.

Attendees can look forward to cutting-edge discussions, such as modern cooling techniques

by Prof. Mariusz Szymczak from the West Pomeranian University of Technology and the recovery of active ingredients from fish processing by-products by Prof. Joanna Szlinder-Richert from the National Marine Fisheries Research Institute.

An indication of what the future has in store for the fish industry

With around 250 delegates and 20 expert lectures scheduled, the Fish Congress promises to deliver valuable insights into

the challenges and opportunities facing the fisheries industry. Organised by *Fish Industry Magazine*, Poland's leading publication for the sector, the event continues to serve as a vital platform for knowledge sharing and networking.

XXVI Conference of the Polish Association of Fish Processors, 13-14 June 2024, Dźwirzyno

Innovation and cooperation define the Polish fish market

The XXVI Conference of the Polish Association of Fish Processors (PSPR) was held on 13-14 June 2024 in Dźwirzyno and focused on the prospects and threats to the Polish fish market in the current economic situation in Poland and in the world. The event was organised under the patronage of the Minister of Agriculture and Rural Development, Czesław Siekierski.

The conference gathered a wide group of experts from the fish industry, representatives of science, administration and companies, who discussed the key challenges, development opportunities and threats facing the fish sector in Poland and in the world.

The conference opened with remarks from Małgorzata Pawliszak, president of PSPR, who welcomed participants and emphasised the importance of fish processing for both the Polish and global economy. A ceremony followed to honour individuals with the "Meritorious Service to Agriculture" distinctions, recognizing their contributions to the development and promotion of the Polish fisheries sector. The first panel focused on key aspects of supporting and advancing the fish processing sector. Discussions highlighted the roles of veterinary inspection and food safety in ensuring product quality, as well as financial aid

programmes like the European Maritime, Fisheries and Aquaculture Fund 2021-27, aimed at fostering innovation and competitiveness in the industry. Presentations also reviewed past funding programs, shared experiences from the new financial frameworks, and detailed opportunities available under the National Recovery and Resilience Plan. These initiatives were framed as essential tools for promoting modernisation and sustainable growth in fish processing. A highlight of the day was a presentation by Guus Pastoor, president of AIPCE, who discussed strategies for effective communication at the EU level and the role of AIPCE in advocating for fish processors.

Comprehensive list of topics covers many aspects of fish value chain

The second day of the conference began with the panel on scientific reports. The session featured presentations on various aspects



Małgorzata Pawliszak, president of PSPR welcoming participants in her address that highlighted the importance of fish processing for the Polish economy.

of fish processing, bioactive substances, and their applications, as well as the use of fish as functional food. Later in the day, the focus shifted to food safety and logistics, with topics covering safe packaging, the role of logistics operators in the fish market, and potential threats in fish and seafood processing. The day concluded with a discussion on consumer trends and a summary of the conference provided by the organisers.

The 26th PSPR Conference showed that the Polish fish processing sector is ready for dynamic changes, investing in innovation and cooperation at the national and international level. The discussions and the rich substantive programme emphasised the need for further cooperation between science, industry and administration to ensure the development of the fish sector in Poland and worldwide.



Coldstore Gdańsk's commitment to society

Building bridges between fisheries, sports, and charity

Fisheries are not only about the economic dimensions of harvesting and processing of fish stocks but, equally importantly, about the social impact of this activity. This may sound like a truism, but especially nowadays, it is never too often to reinforce this message and approach.

One Polish company specialising in providing comprehensive storage services at the Port of Gdańsk has taken this commitment seriously. Under the initiative Human2Ocean (H2O), the company Coldstore Gdańsk (CSG) engages in various activities focused on cultural, sport, educational, and charitable initiatives aimed at supporting vulnerable communities.

Initiatives support activities and communities in need

Coldstore Gdańsk decided to establish a partnership with the Polish athlete Paweł Tarnowski, a member of the Polish Olympic windsurfing team for Paris 2024, current world vice-champion and European champion in the iQFOiL windsurfing class. Moreover, the company also cooperates with local Gdańsk junior and senior volleyball teams as well as a senior handball team. As part of the company's commitment to aiding charities working with people with disabilities, one of our key activities is our long-lasting relationship with a nursing home care facility for male orphans living with complex disabilities, run by Saint Dominic Nuns. This cooperation is not limited to financial contributions but aims to provide more



Coldstore Gdansk supports several causes, cultural, social, educational, and charitable, in the community in which it is based.

comprehensive support. Another action supported by the company was the donation of dozens of sports trunks from famous volleyball players to a fundraising auction for a regional hospice for children.

The scholarship exchange program called PISCES, established in cooperation with universities in Gdańsk and Akureyri (Iceland), was an example of the company's forward-looking endeavours. This initiative aimed to attract graduates and introduce them to the best opportunities that the blue economy had to offer after their studies. Another example

of CSG's cultural engagement, which also aligns with their charitable approach, is their consistent financial support for an event called Jazz4Rare. Organized by a local charity, Jazz4Rare is a jazz concert that raises awareness about the needs of people living with rare diseases as part of the Rare Disease Day celebrations.

The role of a businesses in its community is not limited to economics

Fisheries are not just about economic gain but also about making a meaningful social impact, a responsibility Coldstore Gdańsk

takes seriously through its H2O initiative. By supporting vulnerable communities, fostering education, and promoting culture and sports, CSG highlights the essential role businesses can play in creating positive change. Such initiatives emphasise the importance of integrating social responsibility into business strategies, showcasing a model for sustainable and impactful growth. Social initiatives in the fisheries sector are more than a trend; they are a catalyst for positive change. By embracing social responsibility, the industry can become more appealing to employees, customers, and investors.



How Polish fisheries address the **global food security crisis**

Fishing for stability

As geopolitical instability, armed conflicts, and climate change disrupt food systems worldwide, one of the industries that plays a key role in combating hunger and fostering global stability is fisheries. By providing a healthful, sustainable source of protein, the fishing industry is becoming essential in addressing the growing global food security crisis.



The Polish long-distance fishing fleet supplies healthful fish to African countries helping to avert food crises.

Food is no longer just a basic necessity—it has become a tool of global politics. Disrupted supply chains, rising prices, and restricted food access are increasingly being used as leverage to pressure vulnerable regions. The consequences are severe: worsening famines and forced migration, all of which contribute to destabilising fragile areas.

In the face of this crisis, sustainable fisheries are proving essential. By securing the ability to supply high-quality fish—a vital source of protein—to regions facing food shortages, the fishing sector is crucial in preventing

food from being weaponised in international power struggles. Packed with high-quality protein, essential vitamins, and minerals, fish provides affordable food, particularly in regions where other animal proteins are limited or expensive. For many food-insecure nations, especially in Africa, fish remains one of the most reliable sources of nutrition. Polish long-distance fisheries play a vital role in supplying this protein, with Polish long-distance ship operators—members of the High Seas Fish Producers Organization—exporting enough fish to provide approximately 300 million meals annually to African nations.

Polish fish contributes to resilience in food supply chains in distressed areas

As a member of the European Union and currently holding the EU Council Presidency under the motto “Security, Europe,” Poland is emphasising the importance of food security in fostering stability. Polish fisheries, operating as part of the EU’s broader commitment to sustainable fishing, are implementing responsible and eco-friendly practices that contribute to European and global food security and stability. By exporting high-quality fish to regions in need, Poland is demonstrating how fishing can help

feed the world in an environmentally sustainable and future-focused way. Fish has a lower carbon footprint and requires fewer resources compared to other forms of protein production, making it a smart and sustainable solution for feeding a growing global population.

Polish fisheries are contributing to improved food security in countries where a stable food supply cannot be guaranteed. They are helping reduce social and political tensions, prevent conflict, and alleviate migration pressures. These efforts align with the priorities of the Polish EU Presidency, which highlights the critical connection between security, stability, and access to food.



Recruitment for the pilot **“Our Trout for HoReCa”** Partnership Programme has begun

Promoting locally farmed trout to restaurants

The Polish Trout Breeders Association (PTBA) has launched recruitment for the pilot Partnership Programme aimed at the HoReCa sector. Its goal is to invite dining establishments to cooperate by serving trout from local farms certified with the “Nasz Pstrąg (Our Trout)” label in their menus.

The “Our Trout” campaign includes educational and promotional efforts to raise awareness about sustainable aquaculture and to promote the consumption of trout. The campaign was initiated and organised by the Polish Trout Breeders Association, which currently brings together approximately 60 fish farms across Poland. Promoting the consumption of certified aquaculture products, particularly trout, is one of the main objectives of the next phase of the educational campaign “Our Trout,” co-financed by the European Maritime, Fisheries and Aquaculture Fund for 2021–2027. Communication efforts by the association aim to promote fish from local, certified farms.

“We aim to encourage consumers to make informed choices by selecting certified aquaculture products. Trout from local fish farms—low-emission and resource-efficient operations—meet the highest environmental standards and strict veterinary and food safety regulations. Thanks to these farmers, we have access to fresh, local fish that haven’t travelled thousands of kilometres to reach our tables. This is why we created the Partnership Program for dining establishments. More and more people are paying attention to

the origin and certification of products, and local food is gaining importance and popularity. We want serving certified ‘Our Trout’ trout to become the norm, so consumers can enjoy it in their favourite restaurants,” explains Daniel Krysiński, President of the Polish Trout Breeders Association.

Certification guarantees responsible production

Since 2019, the association has awarded the “Our Trout” certification to fish farms that operate sustainably and responsibly. The certification guarantees that the entity using it offers consumers trout bred in full compliance with Polish law, European standards, and respect for the environment. To obtain the “Our Trout” certification, farms must meet a number of requirements, including providing comprehensive documentation reporting farming conditions. After thoroughly reviewing the documentation and issuing a positive opinion, the certification is granted for one year. Farmers wishing to extend its validity must submit complete reporting documentation confirming the continuous adherence to high farming standards, adds the Association President.

The pilot “Our Trout for HoReCa” Partnership Program



The Polish Trout Breeders Association is running a campaign to encourage restaurants to source responsibly farmed trout from its members.

will run until December 31, 2025. Every restaurant that joins the program will receive a set of promotional materials and merchandise. Applications are

accepted via email at kontakt@naszpstrag.pl, and the program regulations are available on the website: <https://www.naszpstrag.pl/>, in the HoReCa section.

Do oil and gas platforms affect commercial fish species and biodiversity?

Life below water in the North Sea

The North Sea, home to many different species including the threatened Atlantic cod, remains one of the most important fishing grounds in the world, but it is also a hotbed for oil and gas exploration. Numerous oil and gas platforms are reaching the end of their lifespan in the North Sea and are expected to be decommissioned and removed from the seabed. However, increasing evidence suggests that offshore platforms may function as artificial reefs and even benefit marine biodiversity.

In this article, the authors summarise findings from two separate studies conducted in 2021 and 2023. The first was a broad assessment of several platforms, while the second was a detailed assessment of a single platform. Both studies revealed increased fish abundance and elevated biodiversity of various fish species near the platforms. In addition, fish were often larger near the platforms. These findings suggest that removal of offshore platform foundations from the seabed may affect marine life negatively. Policymakers, NGOs, and other relevant stakeholders are encouraged to consider the potential negative outcomes for marine life caused by the upcoming decommissioning of offshore platform foundations in the North Sea.

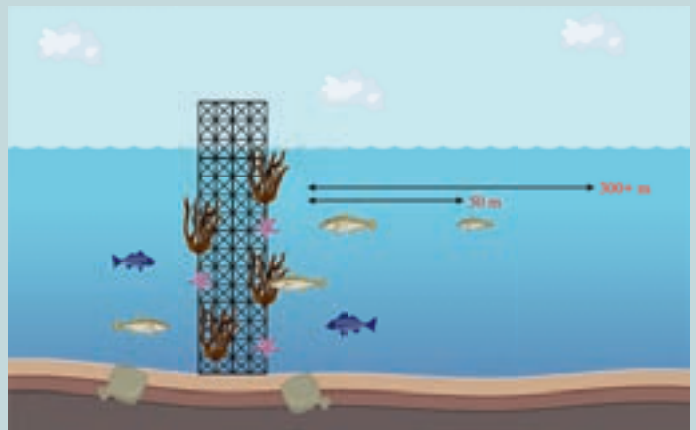
Offshore platform installations started in the mid-1900s in the North Sea

Since the mid-1900s, the North Sea has been a hotbed for offshore oil and gas (O&G) extraction. Currently, about 50 platforms are extracting fossil fuel in several O&G fields in the Danish part of the North Sea. Increasing evidence suggests that the platform foundations support fish abundance and may benefit marine biodiversity. The submerged hard structure provided by the foundations allows various marine

organisms such as invertebrates and algae to attach and grow. This may create a diverse marine ecosystem, hosting many small mobile species. As a result, larger species are attracted, because of the developing foraging opportunities. In popular terms, this scenario is known as a reef effect. When offshore platforms are operational, they are typically surrounded by a 500 m no-fishing zone. The no-fishing zone creates an area that resembles a marine protected area. Combined with the reef effects, the no-fishing zone allows a platform foundation to act as an offshore habitat for several—potentially overfished—species. Near the platform foundation, numerous species may grow in both abundance and body size. Some of the species hosted by platforms are Atlantic cod (*Gadus morhua*), mackerel (*Scomber scombrus*) and dab (*Limanda limanda*).

Elevated fish abundance near several platforms

We examined the impact of offshore platform foundations on fish abundance, fish body size, and species richness during the summer of 2021. The study was completed in the central North Sea, about 200 km from the nearest coast. The platforms had been operational for decades and were each surrounded by a 500 m no-fishing zone. Researchers sampled fish abundance and



Species richness, fish abundance, and fish body size are often elevated near platform foundations in the North Sea.

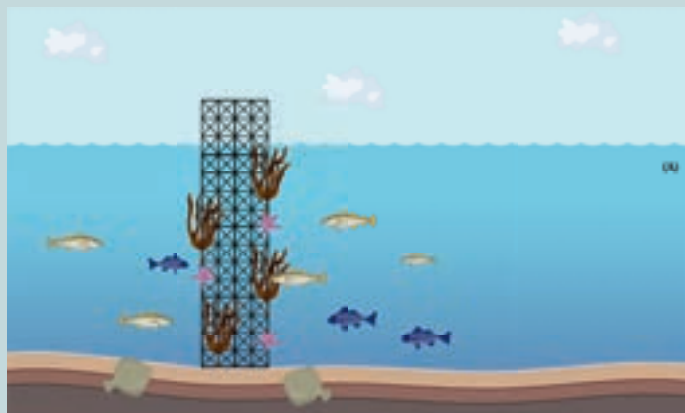
biodiversity at distances varying from 5 m to 10,000 m from the platform foundations. The results were clear. Fish abundance was highest just 5-20 m from the platforms and declined upon moving away from the platform foundations. The study also found that species richness often increased closer to the foundations, with several species like Atlantic cod, observed within 5 m from the foundations. However, cod abundance declined steeply further away from the platforms. Cod size also varied with proximity to the platforms. Average fish lengths were around 37 cm at a distance of 10 m but dropped to 28 cm at 110 m from the foundations.

The summer 2021 study was the first scientific examination of fish near platforms in the Danish part of the North Sea. Indeed, the study

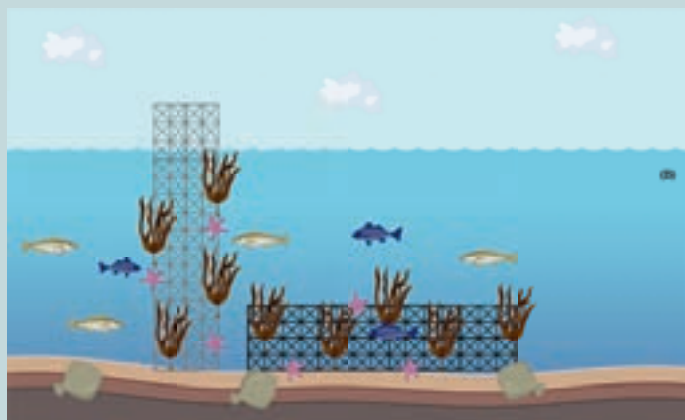
indicated that platform foundations play a role for fish abundance and biodiversity. The study covered several platform foundations and revealed some general trends. Often, fish abundance and species richness declined quickly with distance from the platforms, indicating that the greatest platform effects are observed within the first 100 m of the platform. The 2021 sampling was, however, opportunistic and lacked systematic sampling and balanced sample sizes. Another study was therefore planned and conducted during summer 2023.

Increased fish abundance, biodiversity, and fish body size near a platform in the North Sea

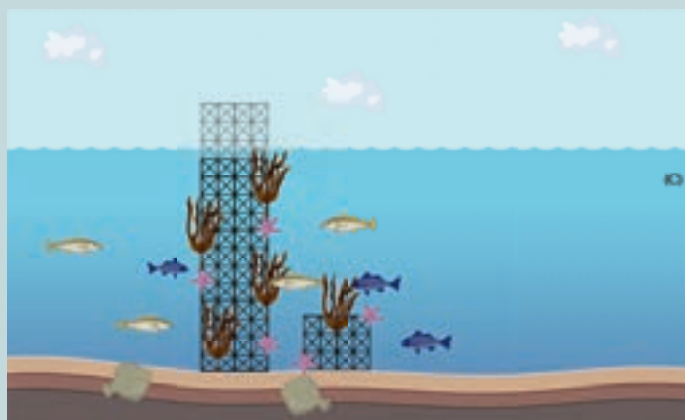
Following the broader assessment of fish abundance near different



Decommissioning methods for offshore O&G platforms: leaving foundation in place



Laying foundation on its side on the seabed



Removing the top of the foundation and placing it next to the base

platforms, researchers targeted a single platform to better quantify fish abundance patterns in detail. In 2023, adequate sampling was conducted systematically and planned carefully in advance. The assessment aimed to examine the impact of an offshore O&G

platform on fish abundance, fish size and species richness. The platform selected is called Skjold and is more than 40 years old and surrounded by a 500 metre no-fishing zone. Researchers sampled fish abundance and biodiversity at distances ranging between



Removing the top of the foundation and taking it to shore for recycling



Transporting the complete foundation to a designated reefing area



Complete removal of the foundation and recycling on land

1 m and 600 m away from the platform foundation. The data clearly revealed that fish abundance, body size, and species richness were highest near the platform. In fact, 100% of the observed species occurred within 20 m of the platform, with the highest fish diversity recorded just 1 metre away from the foundation. Species like Atlantic cod were much more abundant near the platform, and their numbers declined sharply at further distances. Cod sampled near the platform averaged 43 cm in body length, greatly exceeding the body length of the cod sampled 50-100 m from the platform. Thus, consistent with the 2021 study, cod were simply larger near the platform.

In addition to cod, other species also exhibited distinct abundance patterns around the studied platform. For example, dab (*Limanda limanda*) abundance was more than 15 times higher next to the foundation than at 600 m from the foundation. Similarly, saithe (*Pol-lachius virens*) was only observed within 50 m from the platform. However, unlike cod, no clear body size patterns were observed for dab and saithe. Thus, the role of the platform foundations seems to differ between species. The site-specific approach allowed researchers to confirm general trends initially observed in the 2021 study. Using systematic sampling in 2023, this study provided a more



Atlantic Cod sampled by the researchers near a North Sea oil and gas platform in 2023.

quantitative understanding of the correlations between foundation proximity and fish abundance, fish body size, and species richness. These findings indicate the significant positive effects that platform foundations often have on local fish communities. To preserve and improve marine biodiversity more generally, it remains important to understand the cumulative effects of numerous offshore foundations on marine life in the North Sea.

Future perspectives of Atlantic cod in the North Sea and removal of offshore structures

Atlantic cod abundance in the North Sea has fluctuated greatly over the past decades and remains at historically low levels. Many cod populations have experienced significant fluctuations due to overfishing and climate change, despite recovery plans. Improving conditions for cod and other fishes is crucial for their recovery. Enforcing stricter fishing regulations are likely to help, as regulations directly control overfishing in crucial habitats and elsewhere. Optimised regulations could help, for example, by reducing fishing pressure allowing populations to recover. Atlantic cod fisheries in

the North Sea follow technical recommendations, but fishing quotas ultimately rely on international agreements, for instance, between the EU, Norway, and the UK. Our studies in 2021 and 2023 confirmed that cod abundance and body size are significantly higher near platform foundations and face sharp declines further away. This suggests that offshore platform foundations exhibit reef effects, providing shelter, feeding, and nursing opportunities for cod and other species. Therefore, repurposing obsolete platforms as artificial reefs may represent an opportunity for expanding productive areas where cod is protected. However, this approach would need specific guidelines and updated policies.

The legislation in the North Sea currently states that most platforms should be fully removed after ceasing operations, a process called decommissioning. The platforms are taken to land for recycling, seeking to avoid environmental impacts. Policymakers are aware of the direct ecological impacts of full platform removal activities. However, perhaps better strategies should be evaluated for decommissioning. In the US and elsewhere, decommissioning often includes Rigs-to-Reefs

approaches. Rigs-to-Reefs is a programme that aims to maintain the artificial reef effects created by foundations after their operational life. Rigs-to-Reefs can be done in multiple ways, based on the local characteristics and requirements. One method involves tipping the structure over and laying it on its side on the seabed. Another method involves separating the top of the platform, and either placing it next to the base on the seabed or taking it to shore for recycling. There is also the option of removing the whole platform and taking it to a designated reeving area or to shore for recycling.

A study done in the North Sea examined the extent to which decommissioned platforms support marine life. In the study, cod aggregated near the inactive platform, and fish were larger in body size than those recorded away from the inactive platform. The study suggested that inactive platforms likely offer favourable conditions for marine life when left completely in their original location (figure 4A). Platform removal is often expensive and also disruptive to marine life. Therefore, we suggest that policymakers consider revisiting existing regulations based on recent ecological evidence. We encourage policymakers to consider repurposing platform

foundations as artificial reefs, as our North Sea studies from 2021 and 2023 showed positive impacts of platform foundations on fish abundance, body size and species richness. For such a Rigs-to-Reefs program, each platform should be assessed individually and must not release harmful components, even if the platform is inactive and left in the marine environment. With the right approach, leaving submerged structures at sea may offer greater ecological benefits than complete removal. However, further studies are needed to reveal which decommissioning options might deliver the best biodiversity outcomes for the North Sea.

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Abundant flatfish in an underwater picture taken about 50m from an oil and gas platform in the North Sea in 2023.

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Acknowledgements

The authors kindly acknowledge the Danish Underground Consortium (TotalEnergies, Noreco, and Nordsøfonden) for granting permission to publish the data from the studies. We would also like to express our gratitude to DTU Offshore for its support. This research has received funding from the Danish Offshore Technology Centre (DTU Offshore) under the ABN program. The funding sources had no role in study design, data collection and analysis, the decision to publish, or preparation of the manuscript. The authors thank everyone that has contributed to cruise planning, data collection, data analyses, interpretation etc.

Green transition in Danish marine systems

Focus on sustainability and compensation strategies

In recent years, the urgency of addressing environmental challenges has prompted a renewed focus on marine ecosystems. A conference held at Roskilde University, Denmark, “Green transition in Danish marine systems—focus on sustainability and compensation strategies” brought together experts to discuss strategies for enhancing biodiversity while ensuring sustainable resource management.

The conference featured two insightful keynotes followed by parallel sessions with the following themes, “Aquaculture and compensation strategies” led by Associate Prof. Per Meyer Jepsen (Roskilde University) and, “Biodiversity measures and compensation strategies” led by Associate Prof. Kasper Elgetti Brodersen (Roskilde University). The conference was sponsored by Food and Bio Cluster, Denmark and co-funded by the European Union.

Collaboration is instrumental in building lasting solutions

Efforts to shape the future of Denmark’s marine ecosystems have highlighted an integrated approach to fostering sustainable change. The recent conference at Roskilde University was structured into keynote addresses and expert-led sessions and offered innovative strategies for addressing the challenges and opportunities within marine



The conference at Roskilde University on the green transition in Danish marine systems highlighted the importance of all stakeholders working together to create solutions.

restoration, aquaculture, and biodiversity preservation. The keynote presentations set the stage by emphasising the necessity of an ecosystem-based approach to marine management. This holistic framework integrates ecological, social, and economic considerations to create sustainable solutions. Central to this approach is the engagement of all stakeholders—scientists, policymakers, industries, and local communities—working in unison to ensure a balanced and effective green transition. As noted, the complexity of marine ecosystems demands a comprehensive strategy that bridges ecological science with the socio-economic realities of those dependent on marine resources.

Complementing this call for integration, explained in another keynote that posed a foundational question: *Why are we doing this?* This reflective stance underscored the importance of articulating the purpose of marine initiatives to foster broad inclusion and collaboration. By connecting communities with the intrinsic value of these efforts, the discussion highlighted the potential for turning collective visions into actionable outcomes, uniting scientific innovation with localised implementation to achieve shared goals. These high-level insights were supported by actionable strategies targeting aquaculture and compensation measures. A focus on balancing ecological restoration with sustainable food production revealed a range of innovative solutions. These included cultivating micro- and macroalgae, mussels, and oysters, alongside advancements in land-based

recirculating aquaculture systems. A key highlight was a case study from Denmark's largest trout producer, which showcased the use of science-based targets for nature (SBTN) to assess, document, and mitigate environmental impacts. The example underscored the necessity of viewing aquaculture as an integrated value chain, ensuring sustainable practices across all stages of production while enhancing transparency and accountability.

New tools and measures to monitor and mitigate environmental changes presented

Parallel discussions centred on biodiversity restoration, exploring strategies to mitigate habitat degradation and promote ecosystem resilience. The introduction of new tools, such as the Biodiversity State Indicator (BSI by DHI, Denmark), demonstrated advances in monitoring and managing biodiversity through ecological data and species-specific analysis. Another critical focus was habitat connectivity, with evidence showing that disruptions in marine ecosystems can lead to cascading biodiversity losses. Innovative methods like eDNA were presented to enhance monitoring precision and inform targeted restoration efforts.

Seagrass restoration emerged as a pivotal topic, highlighting its multifaceted benefits. In addition to providing essential nursery habitats for juvenile fish species, seagrass meadows contribute to ecosystem stability by reducing sediment erosion and offering new services, such as in-situ preservation of

archaeological sites through anoxic sediment stabilisation. The use of protective measures, including BESE (Biodegradable EcoSystem restoration Elements) elements and cages, was shown to reduce disturbances from invasive species like green shore crabs, significantly enhancing restoration success rates. These efforts demonstrate the critical role of nature-based solutions in achieving both ecological and cultural preservation objectives.

The discussions culminated in a shared vision for the future of marine ecosystems, a vision where biodiversity thrives, ecosystems are resilient, and sustainable food production supports both local communities and global markets. Achieving this requires the integration of cutting-edge tools, data-driven insights, and a commitment to collaboration across sectors. As highlighted, the pathway to a sustainable marine future lies in embracing innovative solutions that are both inclusive and adaptable, ensuring that progress is built on a foundation of shared purpose and collective action. This comprehensive dialogue marks a significant step forward in addressing the complexities of marine ecosystem management, offering an inspiring blueprint for global efforts to secure a sustainable blue future.

Preserving marine biodiversity can help ward off other threats to the environment

The “Green transition in Danish marine systems—focus on sustainability and compensation strategies” conference at Roskilde University provided

a platform for researchers and practitioners to exchange knowledge and strategies for enhancing marine biodiversity while addressing the challenges posed by human activities and climate change. The insights shared during the sessions underscored the importance of collaborative approaches, innovative monitoring techniques, and effective management strategies in safeguarding Denmark's marine ecosystems for future generations.

As we move forward, it is imperative that policymakers, researchers, and stakeholders continue to work together to implement the findings from such conferences, ensuring that marine biodiversity remains a priority in the face of ongoing environmental challenges. The main conclusion from the common session that concluded the day was that working with a mission-driven approach could pave the way for future efforts to collectively collaborate on ensuring a healthy Danish marine area. But it is imperative that the mission is not only at a Danish level but also on a European scale since a lot of EU countries face similar challenges and pressures to shared marine areas.

Roskilde University and the conference conveners plan to host a similar event in 2026

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Ingredients from algae and plants reinvent the wine gum as a nutraceutical

Research-driven product development

The uses of algae are becoming ever more varied. Already the base of products for food, feed, fuel, and fertiliser, algae are also used by the food ingredients industry, as well as cosmetics, pharmaceutical, and nutraceutical companies.

New uses for algae are constantly being invented as innovators and entrepreneurs seek to exploit the benefits of algae. And there are several benefits both for consumers and the environment. Algae are rich in amino acids and contain other beneficial compounds including antioxidants which protect cells from oxidative stress and support cardiovascular function. They are a source of omega-3 fatty acids which are associated with enhanced cardiovascular health and reduced risk of cardiac disorders. Moreover, algae fix carbon dioxide, nutrients like nitrogen and phosphorus, and produce oxygen, characteristics that contribute to mitigating water pollution and ocean acidification and reducing coastal eutrophication. They contribute to coastal ecosystem regeneration thanks to their ability to dissipate wave action and thereby prevent coastal erosion. In addition, algae are deployed to produce biofuels, as plant bio-stimulants, and play a role in bio-packaging.

Europe seeks to bolster its algae industry

Despite this range of uses, European production of algae is miniscule (less than 1% of the global total in 2022, according to the FAO), while countries in East Asia, led by China and Indonesia, produce 97%. The European Union introduced an algae initiative in 2022 to encourage the production of algae and boost consumption in the EU, goals which align with the EU's bioeconomy strategy of strengthening food security and limiting (and adapting



Minimelis

The Minimelis laboratory is where all the research and development is carried out before the wine gums are manufactured.

to) climate change. Some products for human consumption based on algae are found in EU markets. Macroalgae or seaweeds are used mainly for food such as thickeners or preservatives, while microalgae are typically used in food supplements and nutraceuticals. Spirulina, a cyanobacteria, goes into food, food supplements, and nutraceuticals.

Interest in the health benefits of algae has spurred companies to innovate. In Spain, a newly founded company, Minimelis, adds algae to wine gums and markets them as vitamin wine gums. These are healthy because of the vitamins from the algae and because they are sugar free, says Jorge Nuñez, the founder and owner of the company. Mr Nuñez, a Spanish national, established the company in 2012 while working in Chile. In Santiago,

where he was based together with his wife, he noted the absence of candy stores and decided to open the first one. However, he was keen that the store was stocked with healthful sweets low on calories and sugar and so started studying formulation and worked on developing his own brand. The candy stores were stocked with products imported from Spain and proved to be quite successful. By the time Mr Nuñez returned to Spain the candy store had expanded to 25 units across the country. Although the venture did well commercially, Mr Nuñez knew that ultimately the family would move back to Spain. We wanted our three daughters to be educated in Europe and our ties to relations and friends in Spain were a further reason, he explains. However, the Chilean experience fostered in Mr Nuñez a desire to continue as an entrepreneur in the

healthy sweets business, although by training he is an architect who was originally sent to Santiago to put up a hospital.

A steep learning curve

Back in Spain Mr Nuñez studied the potential of vitamin wine gums and also explored building a brand for these products, activities that called for a lot of research. For the first few years, his company owned a laboratory where all the research and development was carried out, while the actual manufacturing of the products was outsourced. This worked for a while but ultimately called for too much coordination between his company, raw material suppliers, the manufacturer, and the client. Mr Nuñez decided instead to put up his own manufacturing facility, the construction of which started

in 2022 and was completed in May 2024. The investment amounted to some EUR1.5m and in September the factory crossed a milestone when it manufactured one tonne of the vitamin wine gums in a single shift. Production is slower than with conventional wine gums because the temperature maintained during the process is lower, says Mr Nuñez. Working at the same temperature as ordinary wine gums would allow the company to produce three times as much in one work shift. However, the higher temperature would destroy all the vitamins and minerals with which the wine gums are enriched.

The covid-19 pandemic expanded sales of nutraceuticals and dietary supplements in 2020 as consumers sought protection from viral infections, but across the globe the market for these products has grown steadily over the last decade. While estimates vary, the market is expected to reach USD250bn by 2030 up from USD150bn in 2022 propelled by increasing demand for immune-boosting supplements following the pandemic. Several factors drive this growth including greater health awareness, ageing populations particularly in rich countries, a rise in lifestyle diseases such as diabetes, and obesity, as well as more research and development in the field of nutrition that has led to a greater variety of more specialised products targeting specific conditions; probiotics, for example, for gut health. Mr Nuñez hopes to benefit from these trends. Researchers at Minimelis are always on the lookout for new ingredients, healthful extracts from plants, for example, which can be added to the wine gums. Identifying a new component is only the first stage; thereafter the researchers must find out how it can be safely added to the wine gums without losing

any of its health benefits in the process. In general, the company tries to use only natural ingredients in its products, but this is not always possible for technical or economic reasons. However, omega-3 fatty acids derived from algae, and pigments from spirulina are among the natural ingredients that are included in some varieties. Including vitamins, minerals, and botanical extracts in the wine gums has an immediate and dramatic effect on their price. Sugar-free wine gums are already more expensive than conventional wine gums, but with these other ingredients the price difference is roughly 1,000%, says Mr Nuñez. Healthful ingredients have a lot of benefits, but they do come at a price.

Wine gums as dietary supplements, not sweets

But, he adds, a distinction needs to be made between the market for wine gums and that for dietary supplements. We cannot be on the candy market as our products are too expensive. Our job is to market our products as supplements, not wine gums. We sell them in this form because we think it is an easier and nicer way to take them. Among the Minimelis supplements is one that helps the person relax, while another offers high levels of protein. Yet another product is intended to boost the immune system. While plant- or algae-based ingredients are preferred, it is not always feasible to use them due to the risk that the active molecules are denatured in the manufacturing process. As dietary supplements, the wine gums are promoted in the market for nutraceuticals, pharmaceuticals, and cosmetics, and at fairs and events dedicated to this sector. Currently, the products are sold in Spain and Portugal, where the company has agreements with distributors in different areas



Production was initially outsourced, but the coordination between company, raw material suppliers, the manufacturer, and the client became too complex, so Mr Nuñez decided Minimelis should have its own production facility.

in each country who are responsible placing the products in pharmacies and health stores. In addition, a small fraction of the production is sold online directly to retail customers in Spain. This maintains a link with the end consumer and generates some useful feedback about the product and could potentially be developed into a new sales channel if it proves popular. The company also plans to start selling in central European countries in 2025 and moving into the Nordic countries the following year. In terms of other sales points, supermarkets are the next target, Mr Nuñez says. In the US they are a common outlet for this kind of product, but this is not yet the case in Spain or Portugal.

Greater vertical integration is desirable

In the future Mr Nuñez would like to make the company more vertically integrated, producing both the ingredients and the final product. This would call for a bigger laboratory and more staff to do the necessary research but would allow Minimelis to take on and develop all the projects that come its way. It would also make the company less reliant on ingredient suppliers and better able to ensure consistent quality and stable prices for its raw materials. This would in turn benefit consumers who, Minimelis has already established, seem to prefer guzzling gummies to popping pills.

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Director of operations: Jorge
Nuñez López

Activity: Production of dietary
supplements in the form of wine
gums

Products: Protein supplements,
immune system boosters,
relaxants

Brand: Minimelis

Volume: One tonne/shift

Markets: Spain, Portugal

Number of employees: 10

NorMar Trading AS offers refurbished equipment and service*

Modern fish processing equipment in the seafood industry

The global seafood industry has emerged as a pivotal sector within the food production landscape, driven by rising consumer demand for high-quality, sustainable protein sources. Fish processing, a critical link in the supply chain, ensures that seafood products meet market standards for safety, taste, and convenience.

In 2024, the worldwide fish processing equipment market was valued at approximately EUR 2.03 billion and is projected to grow at a Compound Annual Growth Rate (CAGR) of 4.1%, reaching EUR 3 billion by 2033. This growth reflects increasing urbanisation, dietary shifts toward protein-rich foods, and heightened awareness about sustainable food production practices.

Modern fish processing facilities are characterised by their reliance on state-of-the-art equipment, enabling efficient, hygienic, and environmentally friendly operations. These advances are particularly relevant as global fish production has surpassed 180 million tonnes annually, with aquaculture accounting for over half of this output. To process such high production volumes while adhering to strict regulatory standards, companies are investing heavily in innovative technologies that optimise every stage of processing, from sorting and filleting to packaging and waste management.

Focus on sustainability

The transition from manual to automated and semi-automated processes has not only increased production capacity but also improved product consistency and



Modern fish processing factories depend on state-of-the-art machines that are efficient, hygienic, and environmentally benign.

reduced labour costs. For example, automated filleting machines can handle over 25 fish per minute, significantly outperforming traditional methods. Concurrently, the industry faces the dual challenge of maximising yield and minimising waste. It is estimated that advanced equipment can recover up to 90% of edible fish meat, compared to less than 70% with older technologies.

Additionally, sustainability is becoming a cornerstone of the industry. Modern processing plants are adopting energy-efficient machinery and incorporating circular economy principles, such as repurposing fish by-products for use in animal feed,

fertilisers, or biofuels. This not only reduces environmental impact but also unlocks additional revenue streams. With such innovations leading the way, the seafood industry is poised for a technological revolution, ensuring it meets the growing global demand while maintaining its commitment to sustainability and quality.

Automation and robotics

Automation and robotics have become integral to modern fish processing, enabling increased efficiency and precision while reducing the reliance on manual labour. Among the standout technologies is Marel's FleXicut system,

which automates trimming of fish fillets, significantly reducing labour costs and improving product yield. Another example is the Baader 144 automated gutting machine, which uses advanced engineering to perform hygienic and precise gutting operations at high speeds, catering to diverse fish species. Additionally, it is likely the first fish processing machine to use a camera system for controlling the gutting and cleaning quality of each processed fish.

Sorting technology has also seen remarkable improvements. For instance, Marel automated sorting systems leverage advanced sensors to classify fish by size

*Promoted content

and quality, streamlining operations and ensuring consistency. Similarly, Uni-Food offers modern skinning machines designed to handle delicate fish species without damaging the product, demonstrating how robotics enhance both speed and care in processing.

These innovations underline the transformative impact of automation in addressing industry challenges, such as labour shortages and demand for consistent, high-quality products. By integrating robotics and automation into processing lines, seafood companies can achieve unparalleled precision and efficiency.



Refurbished equipment is a way for processors to equip their factories with machinery that is reliable and efficient and costs significantly less than comparable new equipment.

Advanced filleting machines

Modern filleting machines exemplify the advancements in fish processing technology, combining precision engineering and cutting-edge design to optimise yield and minimise waste. A notable example is Marel's MS 2730, a filleting machine designed specifically for salmon processing. This machine not only ensures consistent and high-quality fillets but also incorporates technology to reduce downtime through easy maintenance and quick adjustments for different fish sizes. Additionally, the machine can be equipped with a back/belly trimming kit, which helps to minimise the manual trimming of fillets.

Another standout is the Baader 582 filleting machine, which offers flexible and efficient filleting for whitefish. It features automated cutting programs that adapt to varying fish shapes, sizes, and conditions, maximising yield while maintaining product integrity. Its hygienic design facilitates thorough cleaning, ensuring compliance with stringent food safety standards.

The Uni-Food FR-9000 is another innovation in the field, specialising

in small and medium-sized fish. Its unique design allows for minimal operator intervention while delivering precision cuts. The machine's modular setup enables easy integration into existing processing lines, providing scalability for growing operations.

These advanced filleting machines demonstrate how technology addresses the critical needs of the seafood industry: efficiency, precision, and adaptability. By investing in such equipment, fish processing companies can enhance productivity while meeting the high standards demanded by global markets.

Breakthroughs in processing technology

While the fish processing industry faces significant challenges, the future holds immense potential for technological breakthroughs that could reshape its operations. Emerging trends in processing equipment and techniques promise to address key concerns while propelling the sector toward greater efficiency and sustainability.

Innovations such as machine vision systems are beginning to revolutionise quality control processes.

Systems like Marel's SensorX detect bones and other impurities with unparalleled accuracy, ensuring product consistency and safety. Additionally, AI-driven software is being tested to optimise processing lines in real time, reducing waste and improving throughput.

In the realm of filleting and cutting, advancements in waterjet technologies are offering unprecedented precision and minimal product loss.

Focus on refurbished equipment

Restored equipment is gaining traction as a cost-effective and environmentally friendly solution for fish processing businesses. Companies like Normar Trading AS specialise in refurbishing previously used machinery, offering it to clients at significantly lower prices compared to new equipment. These restored machines undergo rigorous testing and customisation to meet specific operational needs, ensuring reliability and efficiency.

This approach not only reduces the financial burden on smaller and medium-sized enterprises but also addresses the environmental issue

of equipment disposal. By extending the lifecycle of machinery, the industry minimises waste and decreases its ecological footprint. Additionally, these providers offer post-sale support and maintenance services, further enhancing the value of restored equipment for buyers. As more businesses recognise the benefits of refurbished machinery, this practice is poised to play a pivotal role in advancing sustainability and accessibility within the fish processing sector.

Adaptability is the future

Future machines are expected to become increasingly modular and adaptable. This will allow processors to customise equipment configurations based on seasonal demands, species variations, or market trends, ensuring maximum flexibility and efficiency.

By embracing these emerging technologies and sustainable practices, the fish processing industry can overcome current limitations and position itself as a leader in innovation, meeting global demand with efficiency and responsibility.

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Extending shelf life and preserving nutrients and vitamins

Gentle techniques for rapid deep-freezing

Deep freezing is a time-honoured technique that has roots in ancient practices, notably among the Inuit of Greenland who used it to preserve fish. However, it was not until the early 20th century, with the innovative patents of Ottesen and the pioneering work of Clarence Birdseye, that the method gained traction in industrial settings. Today, market analysts project that the global trade in deep-frozen fish and seafood will approach a staggering USD 400 billion by 2028.

Freshly caught fish has a notoriously short shelf life and is not always available everywhere. This limitation makes frozen fish a viable alternative, as it can be stored for months without compromising flavour or nutritional quality. In addition, frozen fish is often pre-portioned and practically boneless, allowing for quick and easy meal preparation. Its consumer-friendly attributes have solidified its status as one of the most popular seafood options; virtually every supermarket boasts an expansive frozen fish section. Additionally, freezing serves a crucial role in food safety—extreme cold effectively eliminates parasites that may lurk within. Not only large nematodes, but also tiny ones that are only visible under a microscope. To protect against parasites, deep-freezing is even mandatory for fish products intended for raw consumption.

Rapid freezing offers advantages over regular freezing

While freezing is a powerful preservation method, it is important to clarify that it does not sterilize food as high-heat processes do. Instead, freezing slows chemical processes, particularly oxidative and enzymatic activities, and inhibits bacterial growth. However, bacterial decomposition

can still occur at lower temperatures where the bacteria themselves can survive. That is why it is so important to maintain the cold chain without any breaks to prevent bacterial activity from resuming and spoiling the food. Clarence Birdseye's research revealed a critical insight: the speed of freezing significantly impacts the quality of the frozen product. Slowly frozen water forms large ice crystals that can damage cell walls and result in moisture loss or dehydration. In contrast, rapid freezing—often referred to as flash freezing—produces smaller ice crystals that cause less damage. The amount and extent of cell wall damage and thus the moisture loss ('drip loss') are inversely proportional to the speed of freezing. This finding has led to the development of fast and efficient industrial flash freezing processes. A clear distinction exists between conventional home freezing and industrial deep freezing.

While a home freezer can take up to 24 hours to freeze fish, industrial methods achieve a temperature of -18°C in less than three hours. This advanced freezing technology preserves the fish's freshness, texture, and essential nutrients. The selection of industrial flash freezers is expansive, and choosing the right freezing



The principle of the horizontal plate freezer goes back to Clarence Birdseye, who received more than 160 patents for his groundbreaking inventions.

technology is influenced by a combination of financial, functional, and technical considerations. From small laboratory to large-scale applications, everything is possible. Which process and equipment is best suited for a specific application depends on the size, shape, and

composition of the raw material, as well as the desired end product. Fish fingers are cut from compact, deep-frozen fillet blocks with defined dimensions and have different requirements than interleaved fillets. These are placed in layers on plastic sheets and deep-frozen, so that they can

be removed individually from the packaging later. The same applies to separately deep-frozen IQF (Individual Quick Frozen) fillets, which can be taken out and prepared as needed, without having to thaw the entire package.

What factors influence the choice of deep-freezing technology?

When selecting a device for deep-freezing fish, financial, functional, and technical aspects must be considered. Financial, as the acquisition and operating costs of the technology must be aligned with the company's profile and turnover. Functional, because the device must be suitable for deep-freezing the raw material. Horizontal plate freezers are not suitable for freezing whole tuna, for example. Additionally, the freezing technology chosen must fit in with other operational processes. It does make a difference whether a continuous flow or batch operation is used. Then, if a deep-freezing device appears to be suitable, further technical prerequisites must be considered. For example, if you decide on a high-performance and versatile cryogenic freezer, you must take into account that you will need a regular supply of liquid nitrogen or liquid carbon dioxide for its operation. Where this is not secured, the acquisition of this type of device makes little sense.

As with other foods, the main goal of deep-freezing fish and seafood is to quickly remove the heat by exposing it to as low an external temperature as possible. There are several technical options for implementing this principle. For example, deep-freezing can occur through direct contact between the fish product and a severely cooled surface (contact or plate freezer). In so-called



To reduce the risk of breakage of blocks made from very fatty fish products, they are often filled with water to stabilize them before deep-freezing.

'blast freezers', on the other hand, a cold air stream is continuously blown over the fish to enable heat transfer. In cryogenic processes, the fish products are sprayed or briefly immersed in extremely cold liquid nitrogen (-196°C) or liquid carbon dioxide (-78°C), leading to immediate freezing on the surface and subsequent rapid freezing through the whole product.

Plate freezer

The plate freezer from Birdseye was the first piece of equipment to be developed, in which the packaged fish is clamped between two plate-shaped hollow bodies through which a refrigerant with a temperature as low as -40°C flows. These devices are equipped with hydraulic systems that can move the plates together and apart, pressurizing the product. In order to utilize this freezing principle efficiently, the fish products should have a uniform, flat shape (e.g. fillet blocks), which enables full-surface

contact and is a prerequisite for rapid heat extraction. The cooling plates can be arranged horizontally (HPF) or vertically (VPF). Horizontal plate freezers are mainly used for freezing packed cartons with rectangular blocks of fish fillets. The plates must be cleaned regularly between freezing cycles and any ice residue removed to ensure close contact between plates and cartons. If this contact is not guaranteed over the entire surface, the freezing time can be three to four times longer.

In vertical plate freezers, fish can also be frozen unpacked. The upright plates form a kind of container into which the fish is gradually loaded from above. This is particularly practical at sea if the fish is to be filleted or otherwise processed later on land. The only limiting factor here is the maximum weight of the blocks, which must be able to be transported without damaging the fish and with reasonable physical effort. Fish such as cod and

haddock produce compact blocks with a density of around 800 kg/m^3 . However, blocks of fatty fish are not as strong and stable as blocks of lean fish. This is why a little water is often added to herring to fill cavities in the block and give it more stability. The slurry also protects the fish from oxidation and prevents it from drying out prematurely. Contact freezing methods also include immersion in ice-cold solutions, which flow around even irregularly shaped products and ensure even heat transfer through close contact. In the traditional Ottesen process, highly concentrated sodium chloride brine solutions were used for this purpose. However, sugar, alcohol, glycol, or glycerine solutions are also generally suitable, as long as they do not impair or distort the product's typical taste, colour, aroma, or health value.

Cold air freezing

The most commonly used method for deep freezing is heat

extraction using air. However, this relatively thin medium does not have good heat transfer rates and therefore has to be constantly kept in motion with fans (forced convection). The higher the air flow rate, the faster and more evenly the fish product freezes. For example, a fish fillet takes about four times as long to freeze in the stagnant air of a cold store as it does in a constant airflow of 5 m/s. Air blast freezers come in various designs suitable for both batch and continuous operation. Depending on the operating principle, a distinction is also made between fluid bed and belt freezing, as well as spiral and tunnel freezing processes. The fish products are usually laid out freely or in flat trays on a conveyor belt that transports them through a freezing tunnel through which ice-cold air continuously flows. For small and light products such as shrimps, the air flow can also be introduced from below through the mesh belt, so that the individual pieces swirl up and literally float on the air bed, where they are deep-frozen separately (IQF, individual quick freezing). This process is called 'flow freezing' or fluidized deep-freezing.

Air blast freezers are usually used in a continuous process. The fresh fish is normally fed into the device at one end and comes out frozen at the other end. The use of this type of device is limited, among other things, by the required freezing time, which should not exceed 30 minutes if possible. Otherwise, there are structural and technical limitations because the linear freezing tunnel then becomes very long, which makes the supply and continuity of the cold air flow more difficult and expensive. Spiral freezers are a solution to this problem, as their



Vertical plate freezers can be conveniently filled from above. Here, for example, with shaft waste, which is deep-frozen in blocks until it is delivered to the fish meal factory.

design allows the device to take up a particularly small footprint. Here, the frozen products lie on an endless freezing belt that winds around a rotating drum and slowly spirals upwards in the ice-cold air.

The conveyor belt on which the fish products lie has a significant influence on the quality of the frozen end products. It must be flexible, easy to clean, corrosion-resistant, and suitable for direct contact with food. In addition, it must not extend the freezing time too much. In practice, stainless steel mesh belts are often used, but these are quite expensive and can affect the appearance of the finished product if the structures of the belt show on the contact surface of the fillet. Open mesh belts can also make it difficult to remove the frozen products. If fillet tissue sticks to the belt, this can lead to weight loss. Such defects are practically impossible with plastic belts. Although they are often cheaper

to buy, they extend the freezing time by around 10%. The freezing time of continuous cold air belt freezers depends not only on the type of conveyor belt, but also on the principle of air circulation. Industrial units work with either cross or row airflow, which affects both the freezing time and the product-specific energy requirements. To ensure high efficiency in the row arrangement, the air flow is aligned so that the coldest air always hits the coldest fish first (counter-current principle).

Technically, it is extremely difficult to direct the cold air stream over the belt onto the fish in such a way that it freezes effectively and saves energy. Air takes the path of least resistance. It avoids the relatively narrow spaces between the products and swirls around in the empty space above. The quality and efficiency of a cold air freezer is therefore also measured by how well the manufacturer succeeds in directing the

air stream as precisely as possible onto the fish using baffles and other design details.

Cryogenic process

The cryogenic process is currently the fastest, gentlest, and most quality-preserving, but also the most expensive method of freezing. Here, too, the products are transported on a conveyor belt through a tunnel, at the entrance of which they are greeted not by cold air, but by liquid carbon dioxide (-78°C) or liquid nitrogen (-196°C). These non-toxic gases are sprayed directly onto the unpackaged fish or seafood, absorbing their heat and cooling them to freezing temperatures in an extremely short time. At the moment of spraying, the carbon dioxide turns into dry ice and steam, which heats up by absorbing the heat from the food and is therefore continuously extracted to ensure consistently low temperatures. The use of liquid nitrogen follows the same principle, but due to the extremely low temperature,

requires a high degree of control in order to achieve consistent product quality and protect the operating personnel from health hazards. Cold-resistant protective clothing is essential for cryogenic freezing processes to prevent accidents. This is especially true when liquid CO₂ is used in confined spaces. Here, measuring devices are essential that immediately sound the alarm if the oxygen content in the room air drops too low and endangers the breathing of the staff.

In modern liquid nitrogen freezers, deep freezing usually takes place in two stages. In the first step, the fish on the stainless steel conveyor belt comes into contact with a counter-current of nitrogen gas (temperature around -50°C). During this pre-cooling phase, the fish freezes

on the surface, and up to 50 percent of the product's heat is removed. Only then does the product pass under the liquid spray, where the fish freezes completely. It usually remains in the device for a few minutes afterwards to stabilize the process and achieve uniform temperature conditions in the tissue.

The advantages of cryogenic freezing with liquid nitrogen include the speed of the process and the small size of the freezer. Since it does not require compressors, condensers, or coolers, maintenance, and operating costs are comparatively low. However, the liquid nitrogen must be stored in a vacuum-insulated pressure vessel with continuous venting to keep the contents cool and the internal pressure low. Nevertheless, around 0.5 percent of the

contents are lost every day during storage, and an estimated 10 percent of the liquid is lost when the storage vessel is filled. It must also be taken into account that liquid nitrogen is relatively expensive and not always available in sufficient quantities everywhere. In general, it can be assumed that cryogenic deep freezing is up to four times more expensive than conventional air blast freezing.

Like liquid nitrogen, liquefied carbon dioxide is sprayed directly onto the product. Unlike nitrogen, however, this coolant has the advantage that up to 80 percent of it can be recovered and liquefied again. This makes the process much more economical, especially for large freezer units. In addition, carbon dioxide can be stored in insulated

containers at moderate pressure, which significantly reduces storage losses. Optionally, very large frozen goods, such as whole tuna, can also be completely immersed in the coolant, which greatly accelerates heat dissipation and enables very rapid deep-freezing. Liquid carbon dioxide is particularly suitable for this type of freezing because, unlike other coolants such as NaCl brine, whose viscosity increases significantly as the temperature drops, it flows completely around the product and ensures surface contact. In addition, CO₂ is completely harmless to the product and changes the taste and texture only slightly, if at all. With brine, on the other hand, it cannot be ruled out that salt will penetrate the fillet meat due to osmotic effects. *Manfred Klinkhardt*

GUEST PAGES

EMODnet—freely accessible, high-quality European marine data and products

Adding waves of value to marine data

Marine waters in the EU host a wide range of commercial, scientific, and recreational activities. Knowledge about these waters is critical to understand ocean ecosystems, inform EU policy, and support the Blue Economy with marine knowledge that enables smart planning of marine space to maintain and expand the scope of these activities, whilst also conserving and restoring marine ecosystems.

EMODnet, or the European Marine Observation and Data Network, seeks to provide this information as high quality data and data products to multiple user groups, such as scientists, policymakers, and industry stakeholders, as well as the general public. An EU-funded initiative, namely the *in situ* marine data service of the EC Directorate-General Maritime Affairs and Fisheries (EC DG

MARE), funded by the European Maritime Fisheries and Aquaculture Fund, EMODnet was established in 2009 to streamline and harmonise marine data collection, processing, and distribution. It addresses the challenges associated with accessing information on Europe's vast and diverse marine environments by creating a centralised platform where data is free, accessible, and interoperable. The network of more than



Dr Kate Larkin, Head of the EMODnet Secretariat

120 partners integrates data from numerous sources, including research institutions, government agencies, and commercial entities, thereby significantly enhancing the ability to monitor, assess, and manage the marine environment and its resources.

Diverse data and information, organised into seven themes

The EMODnet service offers data and data products across seven broad themes covering diverse aspects of the marine environment, including bathymetry, geology, biology, chemistry, physics, seabed habitats, and human activities (at sea). A user can navigate across all thematic and the hundreds of parameters on offer via a common map viewer and central metadata catalogue, allowing users to explore data layers and products, e.g., composite maps, and download data in standard formats. The bathymetry theme, for example, provides high-resolution maps of seabed topography, supporting maritime spatial planning, the siting of offshore platforms and more, while the biology theme offers data on species occurrence and distribution from microbes and phytoplankton to marine mammals, vital marine biodiversity information for research and innovation, environmental policy and conservation efforts.

Whilst the core mandate of EMODnet is European regional seas, some thematic offer a global coverage of parameters. For ocean physics, this includes surface water temperature – including near real-time delivery – and at European-scale a wide range of physical parameters, including underwater noise and river

runoff data as part of EMODnet's expanding offer for the coastal zone and land-sea interface. And the EMODnet Human activities¹ thematic covers subjects ranging from aggregate extraction to wind farms and vessel density. Another recent development is the availability of national marine spatial plans in geospatial formats allowing users to see different layers of activity in the plan. Conversely, countries in the process of developing their marine spatial plans can draw on EMODnet data, for example, on areas that are more vulnerable to storm surges or coastal erosion, to make their plans more climate smart.

In an interview with Eurofish Magazine, Dr Kate Larkin, head of the EMODnet secretariat, says that EMODnet had evolved significantly over the last 15 years from a bottom-up scientific network to a fully operational service accessed by >120,000 users a year. "EMODnet is a unique marine knowledge asset in Europe, offering the most diverse offer of data and data products from the marine environment and human activities at sea. This interdisciplinary approach combining marine environment and human activities data is crucial for users, to support holistic assessments of the status of Europe's regional seas, and to enable evidence-based decision-making, including for the management of marine space". Explaining the data pipeline to EMODnet, she says, EMODnet is fully reliant on marine data collected by Europe's Ocean observation and marine monitoring community. Here we are talking about *in situ* data, collected via samplers, sensors and platforms in/close to the water. Many of these data are taken by Member States for national,

regional and European obligations and requirements, yet the data can also be commercial data and even data from citizen science initiatives. She notes that EMODnet adds value by firstly assembling these disparate ocean observations and primary data and then working with Research Infrastructures and Data infrastructures e.g., SeaDataNet, to standardise, harmonise and integrate these data into Findable, Accessible, Interoperable, and Reusable (FAIR) pan-European data layers, with data and accompanying metadata harmonised to EU and international standards.

Bringing the EU closer together through data sharing

Among EMODnet's significant achievements is fostering cross-border collaboration and data sharing, which is essential given that marine ecosystems transcend national boundaries. By offering a standardised framework for data collection and sharing, EMODnet helps to reduce duplication of efforts and increase efficiency across member states. Data from hundreds of different providers across the EU is meaningless unless it can then be made interoperable. EMODnet plays a critical role here by harmonising the data and metadata to European (and international) standards, including those stemming from the INSPIRE directive. For a user this means that they can look at a data set, for example, marine mammal populations in Europe, containing data from different sources, and can download the data as a single pan-European layer or can go in deeper to download individual data sets. Applying these standards to the metadata means

that all EMODnet data is offered with a minimum set of comparable information, a development that also enables human-to-machine and machine-to-machine searches. This in turn means that EMODnet data is now being automatically harvested by global data and meta-data services, e.g., the Ocean Data Information System (ODIS), a key initiative of IOC-UNESCO and the UN Ocean Decade. Making the data interoperable enables flagship data products to be produced, for example, the EUSeaMap broad-scale seabed habitat map for Europe. This is made possible by integrating interoperable multidisciplinary data from the seafloor, namely the substrate, seafloor bathymetry (depth and elevation), seafloor biodiversity, bottom water currents, etc. This assembly and standardisation process also enables the map to have predictive capability, whereby the seabed habitat from one area can be used to predict the seafloor biodiversity in another area that has not been fully mapped, if the bathymetric and substrate characteristics are similar. This product is particularly relevant for ocean sustainability, conservation and restoration efforts, and is employed, for example, by Regional Sea Conventions in regional sea assessments.

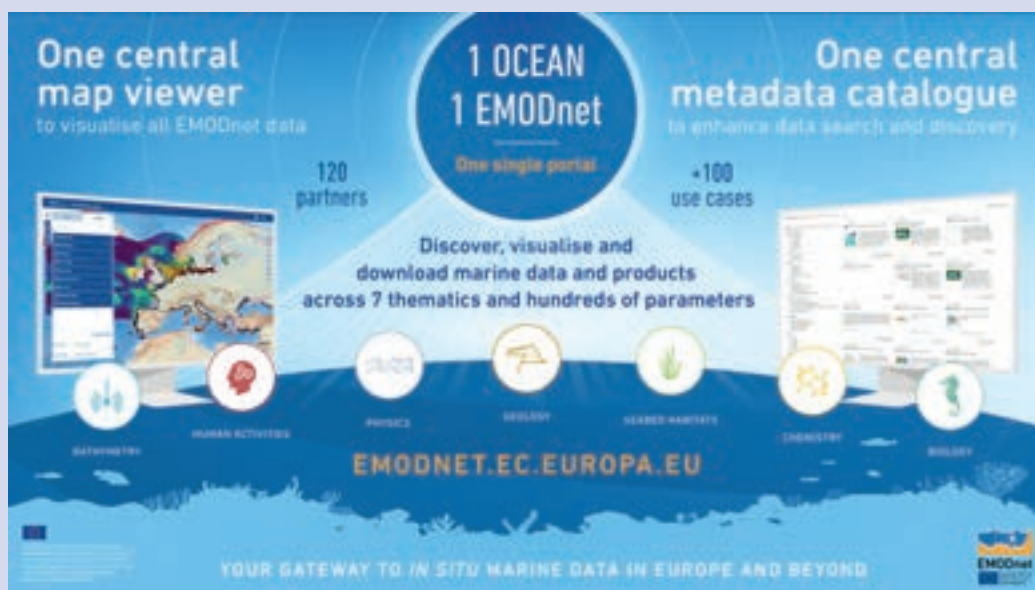
A user-driven service

EMODnet is used by a large and expanding user community, serving multiple user groups, such as scientists, policymakers, and industry stakeholders, by providing the information necessary for research, policy development, and sustainable business practices. It also supports EU policies and strategies, such as the Marine

¹ Eurofish International Organisation, the publisher of the Eurofish Magazine, is a partner in EMODnet Human Activities

Strategy Framework Directive (MSFD) and the Maritime Spatial Planning Directive (MSPD), and the broader European Green Deal and EU Climate Action targets. Whilst Member States collect data as part of their regulatory monitoring obligations, EMODnet can help unlock these data so they can be then used for multiple purposes. Regarding maritime spatial planning (MSP), EMODnet is involved in the European technical group for MSP, facilitating close dialogue with Member States but also with regional sea conventions and European policymakers. In this way, EMODnet experts have directly contributed to defining MSP models and methodologies that can be used by countries to produce their maritime spatial plans in more harmonised formats.

Increasing the number of users of the service calls for outreach work to create awareness as well as to understand the reasons why stakeholders may not yet use the portal. This could be due to a lack of familiarity, but equally could be that the data are not offered in the right format or resolution for a specific use. As an EC service, EMODnet is restricted in how it can track users. The secretariat and wider partnership therefore invest in targeted dialogues with intermediate and end-users from small-medium enterprise companies building marine and maritime applications to national authorities, Regional Sea Conventions and European projects. EMODnet offers an extensive database of use cases that demonstrate the concrete use of EMODnet data and data products to drive understanding, research and innovation, and underpin marine management and smart, sustainable operations at sea. To achieve this, the secretariat also collaborates closely with EMODnet



EMODnet offers a central portal where users can freely access marine data covering seven broad themes.

experts to organise events, which are often sector specific. These help identify key marine data requirements by specific data groups, and to explore data sharing opportunities. To date, this has included dedicated workshops on EMODnet marine data for Aquaculture which were organised in 2020-2021 together with the European Aquaculture Technology Platform (EATiP), among others, and events between 2022-2024 with the offshore renewable energy, coastal tourism, ports, marinas, and recreational boating sectors. Dr Larkin notes that the increased presence of public and private data on EMODnet will also in time further incentivise the private sector to contribute as well, especially if private players can see that their data is harmonised and made interoperable for free by EMODnet, so they receive FAIR data back and contribute to advancing European marine knowledge. Other user focused events include hackathons where users test the services for specific purposes to produce societal applications. Feedback obtained from events and from the online portal helpdesk is used to inform

priorities for future improvements of the service.

New technological developments power the European Digital Twin Ocean

In recent years, EMODnet has embraced advances in technology to transform its data services as a key contribution to the digital transition. As a result, since January 2023, EMODnet has offered a centralised portal, backed up by a fully searchable central metadata catalogue. This has been a game-changer for the user, with a central map viewer for discovery and visualisation and access to FAIR data and metadata via the extensive catalogue. In addition, this technical leap has been critical to enable EMODnet's key role in the European Digital Twin Ocean (EU DTO). Together with Copernicus Marine Service, EMODnet powers a lake of marine environmental and human activities data as part of the EDITO-Infra initiative that underpins an ever-expanding cloud-based toolbox that is set to further transform big data analysis, scenario building

and decision-making in the marine domain. And, into the future, machine learning (ML) and other artificial intelligence (AI) tools could be applied, not only to the data analysis, but to also the data and metadata management and service provision "With developments in ML and AI it is possible to envisage applications that not only transform data analyses, but also the foundational data services themselves. For instance, ML could be used to update the metadata catalogue or tag the catalogue with specific information that make the data even more searchable e.g., for Blue Economy sectors, MSFD Descriptors, etc." All in all, with its comprehensive, freely accessible marine data resources, EMODnet is setting a standard for data-driven, collaborative marine data services management in Europe and beyond. And, with a new EMODnet Vision to 2035 in production, EMODnet's community will set out priorities for EMODnet's service evolution over the next decade, coming soon in spring 2025. For more information visit emodnet.eu.

DIARY DATES

12-13 February 2025

AquaFarm*

Pordenone, Italy

Tel.: +39 0434 232261

pdeodorico@fierapordenone.it

www.fierapordenone.it

4-6 March 2025

NASF

Bergen, Norway

Andre@nor-seafood.no

https://nor-seafood.com/



16-18 March 2025

Seafood Expo North America/

Seafood Processing North America

Boston, USA

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customerservice@divcom.com

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Seafood Expo Global/Seafood Processing Global *

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Seagriculture *

Rotterdam, Netherlands

info@dlg-benelux.com

https://seagriculture.eu

19-21 August 2025

Aqua Nor

Trondheim, Norway

post@nor-fishing.no

https://aquanor.no/



10-12 September 2025

Seafood Expo Asia

Singapore

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22-25 September 2025

Aquaculture Europe *

Valencia, Spain

eas@aquaeas.eu

https://www.aquaeas.org/



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DanFish International *

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https://danfish.com



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https://www.conxemar.com/en/exhibition/

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World Aquaculture 2025

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Imprint

Publisher Eurofish International Organisation
H.C. Andersens Boulevard 44-46
DK-1553 Copenhagen V
Denmark

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eurofish.dk

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Frequency 6 issues per year

Circulation 2500 copies

Subscription details

Price: EUR 100,-
To subscribe send an email to info@eurofish.dk

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ISSN 1868-5943

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