Project title: Mediterranean Innovation Alliance for sustainable blue economy
Acronym: BLUE BIO MED

Priority Axis 4: Enhancing Mediterranean Governance
4.1: To support the process of strengthening and developing multilateral coordination frameworks in the Mediterranean for joint responses to common challenges

https://blue-bio-med.interreg-med.eu/

Deliverable 3.2.3	**Technology and market forecast**
Description	The report highlights the technology and market future trends for the different sectors pertaining the blue bioeconomy and their linkages with the Sustainable Development Goals. The deliverable is structured into different sections: 1. *Introduction* 2. *How to read this document* **3. *Technology forecast and importance of SDGs in Blue Bioeconomy*** 4. *Complete report on patent and NPL analysis* - *Part I: Fishery and Aquaculture* - *Part II: Blue Biotechnology* - *Part III: Blue Sustainable Development* 5. *Key points on Patent and NPL* 6. *Final remarks*
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Index

3. Technology forecast and importance of SDGs in Blue Bioeconomy

The impact of COVID-19 pandemic

The covid-19 crisis has negative effect on the European economy and on the EU Blue Economy as well. The winter 2021 Economic Forecast of European Commission projected that overall, the EU economy would contract by 6.3% in 2020 before a future recovery of 3.9% in 2022.

Sector	Size	Impact 2020	Recovery path
Established sectors			
Marine living resources	Medium	Strong	Prompt
Marine non-living resources	Small	Strong	Prompt
Marine renewable energy	Nascent	Medium	Prompt
Port activities	Medium	Strong	Prompt
Shipbuilding and repair	Small	Strong	Lagged
Maritime transport	Medium	Strong	Prompt
Coastal tourism	Very large	Strong	Very lagged
Emerging sectors			
Blue bioeconomy	Small	Strong	Prompt
Ocean energy	Nascent	Small	Prompt
Desalination	Nascent	Small	Prompt
Maritime defence	Small	Small	Prompt
Cables	Nascent	Small	Prompt
Research and Education	Nascent	Small	Prompt
Marine observation	Nascent	Small	Prompt

Figure 1. Preliminary assessment of the impact of the COVID-19 economic crisis on Blue Economy. European Commission (2021). The EU Blue Economy Report. 2021. Publications Office of the European Union. Luxembourg.

According to the Blue Economy report 2021, the main marine activities affected by the outbreak of COVID-19 were all the established sectors, whereas the emerging sectors were the least impacted (Figure 1). Fishery is among the sectors most immediately impacted by the crisis. Due to the widespread restriction in the starting of the pandemic many vessels stayed at ports and the EU fishery activities generally decreased also affected by the closure of both HORECA channels and local open markets. The limitation affected mostly the Small-Scale Fishery activities which largely suffered for the

pandemic[1]. Looking at the emerging sectors, most of them suffered small overall impacts in 2020 and are expected to recover swiftly[2].

Fishery and Aquaculture

Fishery: Pelagic and Demersal Large-Scale Fisheries (LSF) and Distant Water Fleet (DWF) and Small-scale Fisheries (SSF)

Market overview

Global fish production has reached about 179 million tonnes in 2018. Among them, 156 million tonnes were used for human consumption while the remaining 22 million tonnes were destinated to non-food uses such as fishmeal and fish oil. Overall, **capture fishery** and **aquaculture** accounted, respectively, for 54% and 46% of the total marine organisms consumed in 2018. Specifically, during 2018, the global capture fishery was estimated around 96.4 million tonnes with an increase of 5.4 percent of the average of the previous three years [1]. In the **Mediterranean area**, the production is still dominated by fishing activities covering 80% of the total production [2] with an average landing estimated at 787 900 tonnes for the 2016-2018 period. In this area, Italy is the main producer, holding the 22.7% of the total landings, followed by Algeria (13.1%), Tunisia (12.2%), Spain (10%), Greece (9.3%) and Croatia (8.9%) [3].

The **global market of wild fisheries** is expected to reach about 91 Mtons in 2030 but during the last two decades is facing a stagnation affecting the overall production [4]. This lack of growth in wild fisheries products is related to the depletion of the natural fish stock due to decades of overfishing, mismanagements of the marine resources, climate change and other anthropogenic impacts on marine resources [1].

Regarding the global production, the Asian Pacific region (represented mostly by China), scores the highest production, followed by Europe and North America. **Europe** is the continent with the greatest fishing region, and the European countries which mainly contributes to fishery industries are France, Spain, and Italy [5].

In 2019, fisheries in the Mediterranean Sea registered a fishing fleet of approximately 82 000 vessels, with ships ranging from under 6 to over 75 metres, and overall reported landings which oscillate around 800 000 tonnes, mostly concentred in the western Mediterranean and the Adriatic Sea. Greece scores the highest number of vessels with a total of 14934 boats, followed by Italy (12060 vessels), Spain (8886 vessels), Portugal (7791 vessels), Croatia (7605 vessels) and France (6262 vessels) [6]. Among them, almost 82% of the total European fleet are small-scale vessels [3].

Small-Scale Coastal Fleet (SSF) are vessels of less than 12 meters in length over all (LOA), which work in a short distance from the home port, use quite diversified range of passive gears, sell their products within local market directly to the consumers and are owned by family-based companies with none or few employees. This type of fishery is widespread in the **Mediterranean Sea** especially in Greece, Italy, Portugal, and Croatia, and generally operates in lagoons and the coastal area of the continental shelf [7]. SSF have generally lower impact on nature and are seasonally diverse in terms of species, fishing ground and gears allowing to respect the biological and migratory cycles of different species. In the Mediterranean

[1] Coronavirus response EUMOFA's weekly data and trends analysis Weeks 12 and 13. https://www.eumofa.eu/documents/20178/376827/EUMOFA_COVID_WEEK+16.pdf

[2] European Commission (2021). The EU Blue Economy Report. 2021. Publications Office of the European Union. Luxembourg

Sea, the SSF sector encompasses over 84% of the fishing vessels and provide a significant opportunity for employment [8]. The remaining 20% of the European Mediterranean fishing vessels are represented by **Pelagic and Demersal Large-Scale Fisheries (LSF)** and **Distant Water Fleet (DWF)** which include larger vessels (usually much larger than 12 meters LOA). The Mediterranean large-scale fisheries are mainly made up of vessels using active gears, i.e., gears that are towed (in the case of demersal ad pelagic trawlers) or used to circle the flock (purse seiners). Usually, the large-scale fisheries are highly dependent on a small number of species [2].

Figure 2. Small-scale in comparison to non small-scale in Europe (Source: Small-Scale Coastal Fleet in EU. European Commission)

Overall, Mediterranean catches cover fish, crustaceans, molluscs, other aquatic animals, and aquatic plants that are taken for all purposes, covering a wide range of marine areas such as high-sea fishing areas, offshore, inshore, or brackish water areas. The main species caught by Mediterranean EU fleets are finfish such as European anchovy (*Engraulis encrasicolus*), European pilchard (*Sardina pilchardus*), European hake (M*erluccius merluccius*), red mullet (*Mullus barbatus*), but also invertebrates such as venus clam (*Chamelea gallina*), deep water rose shrimp (*Parapenaeus longirostris*), common cuttlefish (*Sepia officinalis*).

Legal protection of technical solutions

During the first two decades of the century, filing events of patent applications regarding technical innovations in the **fishery** field are mainly involving the Asian Pacific region, followed by the United States of America and Europe (Figure 3). In Europe, the Spanish patent authority registered the highest number of patent applications related to fishery (with a total number of 11 filing events). However, looking at the number of patent applications filed to the European Patent Office (EPO) it appears that the European territory may be as attractive as several countries simultaneously addressed by patent applications filed through an alternative harmonized procedure (the so called PCT applications) (Table 1).

Figure 3. The number of filing events partitioned from 2000 to 2020 (EP and PCT not included).

Table 1. Number of filing events registered at the European Patent Office (EPO) and at the World Intellectual Property Organization (WIPO) from 2000 to 2020.

Supranational authorities	
EPO	30
WIPO	49

It is worth recalling that the patent applications filed to a specific patent authority, for example USPTO do not necessarily refer to applicants who are also resident in the USA, since within such number might be included also the patent applications filed by foreigner players, moreover there is no graphical means for representing on a map the filing events following the harmonized application procedures (EP or PCT). Therefore, the above map does not necessarily identify the premises of the patent applicants. It rather permits the identification of those countries in which there is awareness about the implications that the legal protection of the inventions might have on the trades and in addition provides an approximate quantitative analysis. Among the players of the fishery industries showing relevant commitment toward the IPR based exloitation there are Iceberg Luxembourg (LU), State Grid Corporation of China (SGCC) (CN) and Shanghai Ocean University (CN).

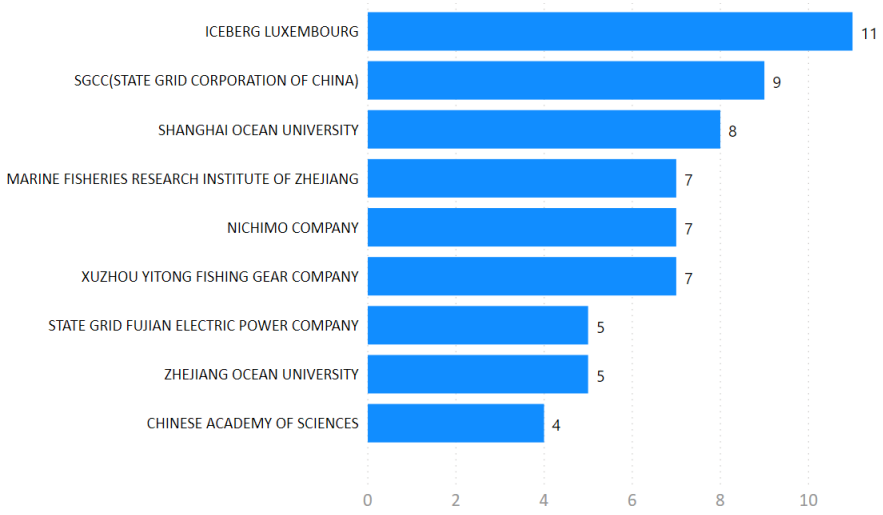

Figure 4. Patent families' number per assignee

Looking at the grant rate of the patents, Parsons Controls Corporation (US) followed by Byks AS (NO) and Iceberg Luxembourg (LU) score the highest rates. A detailed version of the report allows to further investigate to assess whether several patents refer to the same inventions or rather deal with different innovative technical concepts claimed by a specific applicant.

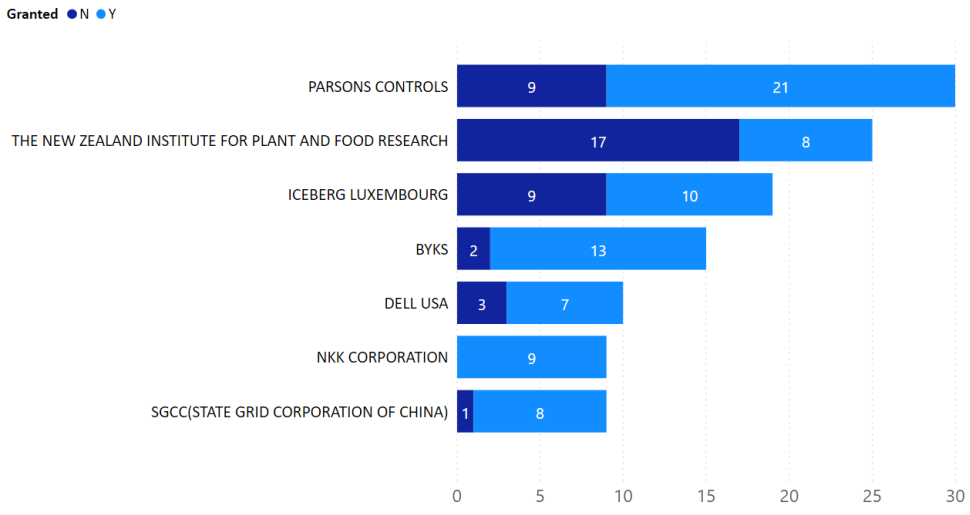

Figure 5. The legal status of the patent applications

Case Histories: Fishery

The patent applications chosen as example from each patent dataset generated upon consulting the Orbit Intelligence patent database and subsequently analyzed by means of Patstat Online (Autumn 2020 edition) are usually selected from a pool of patent documents in which the granted patents are ranked considering the residual validity expressed in terms of the years preceding the expiry date ranked in decreasing order. Therefore, unless exceptional situations, relatively recently filed patent application are preferred. The concepts highlighted usually refer to recent technical implementations, though likely susceptible of further refinement. The inventions of the following examples might not necessarily be conceived by the players scoring the highest number of patent applications or granted patents in

the analyzed technical context. A more detailed version of the present report permits to complement such information, since the consultation of the complete report allows to identify each player corresponding to the documents of the patent dataset. In the present shorter version, the attention is rather focused - whenever applicable - on small companies, start-ups or even private inventors.

1) *EP2967018A1 (APPARATUS AND METHOD FOR HARVESTING AQUATIC ANIMALS) THE NEW ZEALAND INSTITUTE FOR PLANT AND FOOD RESEARCH LIMITED* (Research · Plant & Food Research (plantandfood.com))

This invention relates to an apparatus and method for harvesting aquatic animals. In one embodiment, the apparatus and method are suitable for trawl harvesting of aquatic animals. The apparatus may be suitable for storing and treating aquatic animals. There is a need for an apparatus and method that enable aquatic animals to be harvested, while minimising both physical damage to the aquatic animals and the stress induced in the harvesting process to improve the quality of the aquatic animals that are harvested. An apparatus for harvesting aquatic animals has a cod end portion and an elongate lengthener portion. The cod end portion has an open leading end and a closed trailing end and side wall(s), the side wall(s) and the trailing end being substantially impervious to water. The elongate lengthener portion has a leading end, a trailing end, and side wall(s), at least a major part of the side wall(s) comprising a material substantially impervious to water. The trailing end of the lengthener portion is operatively connected to the leading end of the cod end portion. The elongate lengthener portion comprises a plurality of escapements through which water can pass from an interior to an exterior of the apparatus to cause a general reduction in the water flow rate inside the apparatus when the apparatus is submerged in a body of water and there is water flow relative to the apparatus.

2) *EP2781650A1 (Light emitting fishing ropes and use thereof) LANKHORST EURONETE PORTUGAL* (Home (lankhorsteuronete.com))

The present invention is directed to a light-emitting rope, such as a fishing rope, which is provided on at least part of its outer surface with a luminescent material. The luminescent material may for instance be applied by intertwining common yarns with luminescent yarns. **The rope of the invention can be used in fishing methods, such as fly shoot fishing, resulting in improved yields and improved quality of the fish caught**. One of the drawbacks of the existing fly shoot techniques is that it is limited to daylight operation because it relies on the visibility of the rope and/or the dust clouds, in particular the visibility from the perspective of the fish. This means that fly shoot fishing can only be carried out for a limited period of time. In particular in winter time the hours of sufficient visibility are very limited. This detracts considerably from the economic feasibility of fly shoot fishing. The present invention aims to provide a solution to this problem. In addition, the present inventors found that other types of fish may be caught using the ropes of the present invention compared to fly shoot fishing using ordinary ropes. The use of the fishing ropes in accordance with the present invention results in the catch of demersal fish species that live and feed on or near the bottom of the sea or lakes. These species are not limited to just strictly benthic species (such as flounder, sole, turbot, plaice and halibut) but also benthopelagic fish, i.e. fish that can float in the water column just above the sea bottom.

3) *EP2734039A1 (A TRAWL DOOR OR PARAVANE WITH REMOTE CONTROL ADJUSTMENT) JOSAFATSSON ATLI MAR*

The present invention relates to a trawl door, deflector, vane or paravane f**or remote controlled maneuvering during towing through the water**. Trawl doors in general, are used for demersal, semi-pelagic and pelagic fishing and paravanes are used for seismic surveys; they have the same basic purpose and can be of the same

construction**. The main purpose of trawl doors is to control opening of the fishing trawl to optimize catching performance of the complete fishing gear**. The main purpose of paravanes is to spread the seismic system with a number of streamers behind a vessel. The present invention relates to a trawl door, deflector, vane or paravane for remote controlled maneuvering during towing through the water.

Patent dataset's features

Fishery: analysis of **357 non-duplicated patent families** corresponding to **688 patent applications**. No limitation is assumed concerning the applications' filing timeframe.

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Aquaculture[4]: Marine Finfish aquaculture (MFA) and Shellfish aquaculture (SA)

The "Marine Finfish aquaculture (MFA) and Shellfish aquaculture (SA)" was divided into sectors which are: aquaculture and fish feed.

Market overview

Aquaculture is the process of rearing aquatic plants and animals in water environments for commercial and domestic uses. The Food and Agriculture Organization (FAO), defines aquaculture as "the farming of aquatic organisms, including

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[4] The topic will be further developed in the section "Marine Environmental Technologies"

fish, molluscs, crustaceans and aquatic plants". The FAO reported that aquaculture is probably the fastest growing food-producing sector which accounts for 50 percent of the world's consumed fish [1].
Aquaculture is one of the major drivers of the food industry worldwide. The rise of this sector is primarily driven by the following factors:

- The growing demand for seafood products both for human consumption and non-food commodities;
- The increasing seafood trade between countries;
- The decline of natural fish stocks and decreasing catches of wild capture fisheries due to overfishing environmental pollutions and habitat disturbance;
- The growing number of Blue economy initiatives focused on the improvement of aquaculture infrastructures.

However, major farmed species appreciated in western markets (e.g., salmon, seabream, seabass) are carnivores and need fish derived material (I.e., from wild catches) in the feed. This limits the potential growth of aquaculture and restrict sustainable aquaculture to only a part of the farmed species, I.e., the herbivores such as mussel and clams [6]. Globally, the **aquaculture market** is dominated by the Asian Pacific region, followed by South America and Europe. In **Europe**, the aquaculture market value is projected to reach USD 1,847.0 billion by 2023 with a Compound Annual Growth Rate (CAGR) of 6.5% from 2018 to 2013 [2]. The major countries engaged in the production of aquaculture in the Mediterranean region are Turkey, France, Spain, Italy, while among the rest of Europe segment there are Croatia and Greece [3].

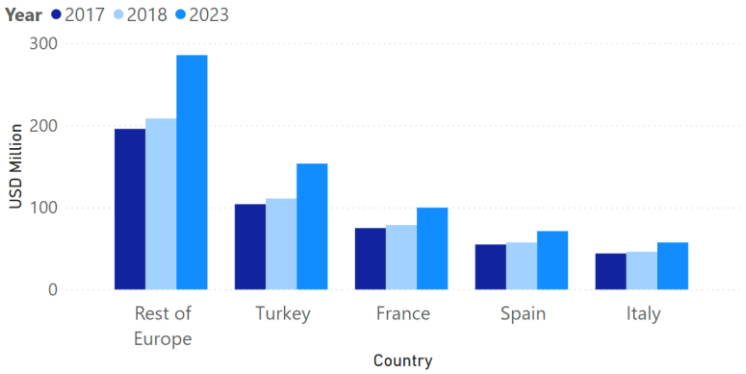
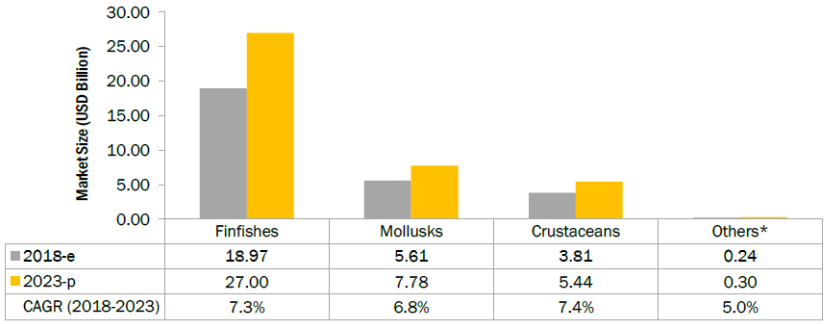


Figure 6. Aquaculture Market in EU, by main competitors, in the period 2017-2023 valued in United States Dollar (USD).

In **Italy**, aquaculture has developed into an industry of national importance, especially for the farming of molluscs (mussels, *Mytilus galloprovincialis*, and Manila clams, *Ruditapes philippinarum*). However, this sector is not fully developed yet and most of the farmers still used traditional extensive aquaculture [2].
Considering the trade of aquaculture products, the **EU**, including both imports and exports with third countries, totalled EUR 33,37 billion in 2019, making the EU the second largest trader of these products in the world following China. Imports, which accounted for around 80% of the total, amounted to EUR 27,21 billion to cover domestic consumption [3].
Regarding the aquaculture market, the preferred rearing system is the **marine culture** which employs either fish cages or substrates for molluscs and seaweed such as stakes, ropes, and rafts. This type of farming is projected to rise significantly at a growth rate of 7.5% during the forecast period ranging from 2018 to 2023.
The main **farmed animal** species are finfish (seabream and seabass) and molluscs (oyster, mussels, Manila clams), and crustaceans. Globally, finfish farming is the dominant market sector, and the same trend is observed in Europe whereas finfish production is projected to reach USD 1,103.6 million by 2023 at a CAGR of 6.9% from 2018.
Finally, in Europe, the molluscs segment is forecasted to reach USD 411.5 million in 2023 with a projected CAGR of 6.0% from 2018.



	Finfishes	Mollusks	Crustaceans	Others*
2018-e	18.97	5.61	3.81	0.24
2023-p	27.00	7.78	5.44	0.30
CAGR (2018-2023)	7.3%	6.8%	7.4%	5.0%

Figure 7. Aquaculture Market, by Aquatic Animal Species, in the Period 2018- 2023 Valued in United States Dollar (USD). e – Estimated; p – Projected. Finfish includes tilapia, carp, trout, milkfish, bait minnow, yellowtail, mullet, and catfish; Others includes sea bream, sea brass, and frogs.*

In the last decades, one of the main challenges in aquaculture is the production of **fish meal**. Marine fish farming requires feed to grow the animals and some of the species farmed are carnivores, thus they need fish-derived proteins in the feed; 25% of total fish production worldwide is transformed into feed for fish farms. This represents a major issue for aquaculture sustainability because wild fish stocks are overexploited and because farming carnivorous fish is ecologically inefficient. Since the transformation of proteins in the feed into body protein always imply a loss, in fact, the feeding farmed species with feeds containing wild caught fish derivates is ecologically unsustainable. Therefore, an important sector regards the **fish feed** industry and their innovations including the increase of feed conversion ratio, the reduction of fish protein in the feed and the substitution with alternative protein sources. This implies looking for new formulations, including alternative mixtures of fish feed or other products aiming to reduce the content of fish meat and to increase the content of proteins and oils from alternative sources (e.g., insects, vegetables, discards from the meat industry) [6].

Usually, aquafeed encompasses one or more artificial and/or natural feedstuffs in the form of pellets or extruded bits for aquatic animals. Overall, the **global aquafeed market** is expected worth USD 71 million by 2025, growing at CAGR of 7.2% from 2020 to 2025. The most common ingredients used in the aquafeed industries are soybean, corn, fishmeal, fish oil and additives [4]. However, in recent years alternative sources of fish meal are explored due to the increasing demand of sustainable solutions for the growing industry of aquaculture products. The sustainability of aquaculture depends significantly on the nature and quality of the feed used, for such reason new sources such as insect proteins are increasingly gaining attention in the aquafeed industry.

Insect meals could be a great replacement of traditional fishmeal, firstly insects are part of the natural diet of fishes, particularly in the juvenile stage. Moreover, insects are a great source of protein, amino acids, minerals, and vitamins. Overall, the global market for insect meals in aquaculture in estimated at USD 44 million in 2019 and is projected to reach USD 380 million in 2025 with a CAGR of 43% in the forecasted period [5].

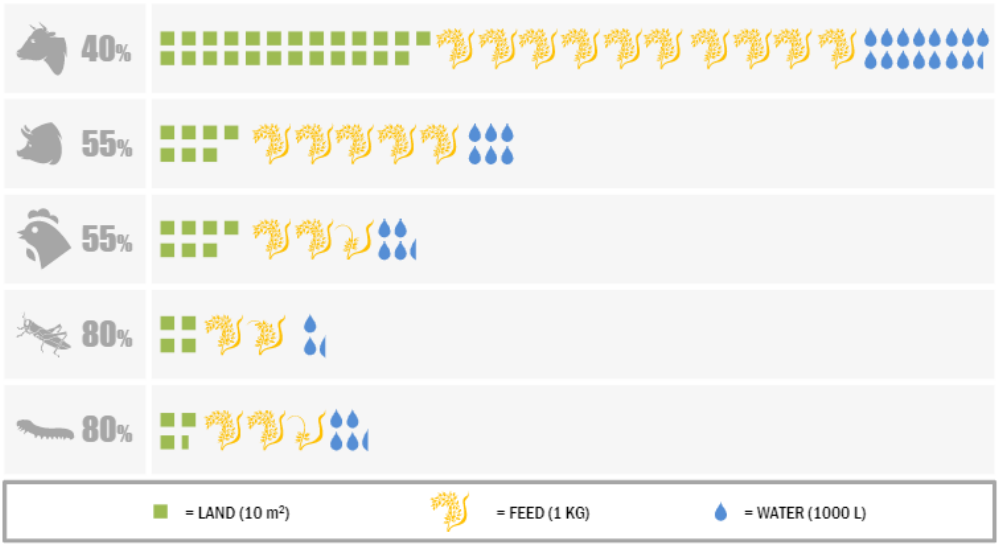


Figure 8. Environmental benefits of using insects for food and feed [5]

Legal protection of technical solutions

Technical innovations impacting on the **aquaculture** industry seem highly considered in the Asian Pacific region, followed by the United States of America and Europe, as demonstrated by the high number of patent applications filed to the patent authorities located in those regions. In the EU, the Spanish national authority scores the highest number of patent applications (7 filing events), without considering the possibility that nationalization procedures might also originate from the filing of EP/PCT applications. Overall, the number of filing events registered by EPO and WIPO, from 2005 to 2019, are almost equivalent, thus suggesting that the players might consider the exploitation of technical implementations either covering the European territories or additional territories where the IPR based legal protection could be achieved following the PCT harmonized procedure.

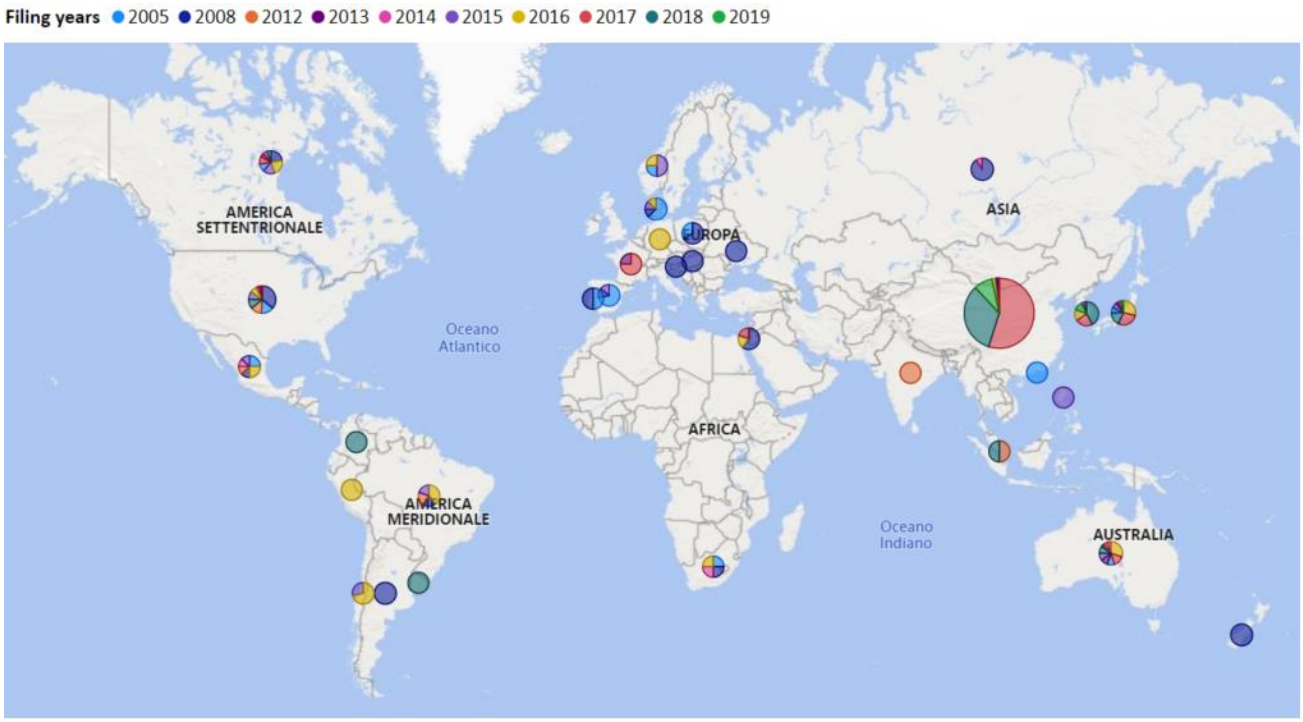


Figure 9. The number of filing events partitioned according to the earliest filing year (EP and PCT not included).

Table 2. Number of filing events registered at the European Patent Office (EPO) and at the World Intellectual Property Organization (WIPO) from 2005 to 2019.

Supranational authorities	
EPO	24
WIPO	36

According to the score based on patent families' number related to the aquaculture sector, industries worth of consideration may be the South China Sea Fisheries Research Institute (Chinese Academy of Fishery Sciences) and the Yellow Sea Fisheries Research Institute (Chinese Academy of Fishery Sciences) both located in China. On the European side the French company Genocean may be detected as a relevant player.

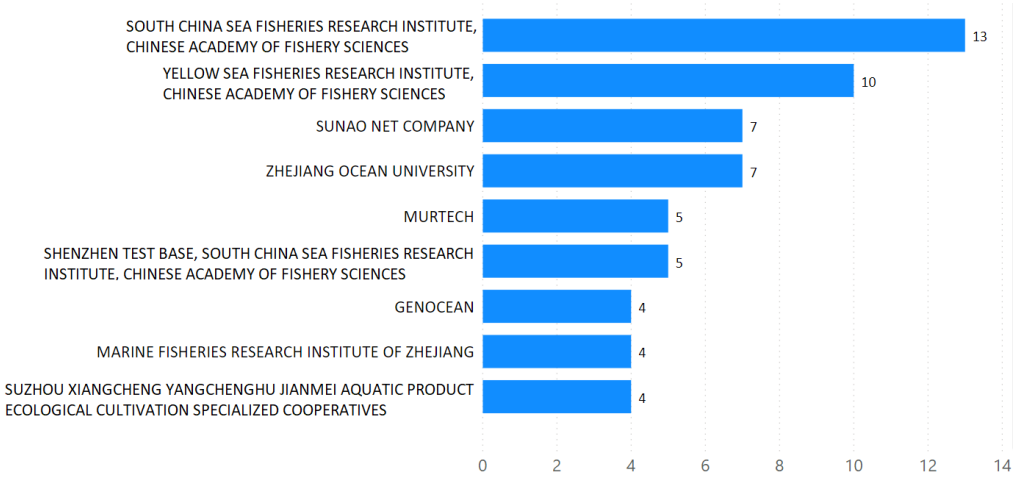


Figure 10. Patent families' number per assignee

As far as the patents' grant rate is concerned, Xyleco (US) is leading the sector, followed by DSM Nutritional Products and Kiverdi, Inc. (US).

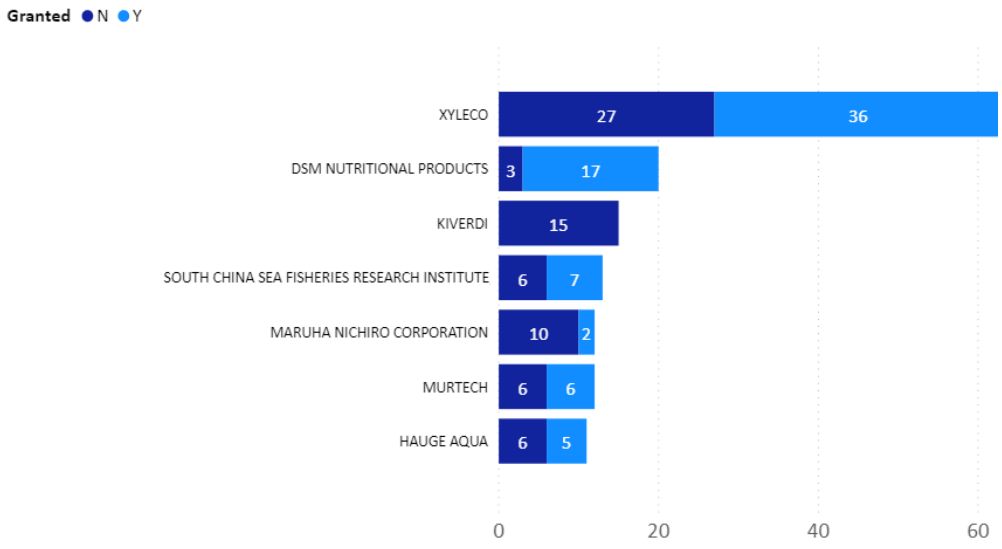


Figure 11. The legal status of the patent applications

Case Histories: Aquaculture

1) *FR3054952 (= WO2019081184A1) (DEVICE FOR REARING AQUACULTURE ANIMALS AT SEA) GENOCEAN*

The invention relates in general to devices for breeding aquaculture animals at sea, in particular shellfish and more particularly oysters. In recent years, a number of oyster farmers have had the idea of creating so-called suspended breeding enclosures, of the swing type, in which the oysters would be more easily set in motion than in oyster pockets traditionally fixed on the tables […]. In this context, the invention aims to provide a sea rearing device which does not have the above drawbacks and which makes it possible to improve the results in terms of shell shape, meat content and economy of workforce.

2) *EP3285570A1 (FLOATING AND SUBMERSIBLE CLOSED-CONTAINED FISH REARING TANK, AND METHOD OF REARING FISH) HAUGE AQUA* (Hauge Aqua AS)

The invention relates to a closed-contained floating, and submersible system for farming and storage of finfish and other aqueous species.

3) *EP2276795A2 (PROCESSING BIOMASS) XYLECO INC.* (Xyleco, Inc. | Leading the Sustainable Industrial Revolution ™)

This invention relates to processing biomass, to compositions including saccharide units arranged in a molecular chain, to methods of producing amino acids or antibiotics, to methods of producing edible or immunostimulatory material, and to products of such methods. In one aspect, the present invention **includes methods of preparing feed materials for animals** (e.g., humans and animals, including but not limited to food animals, pets, zoo animals, etc.), and for plants (e.g., agricultural plants or crops or aquatic plants, in particular in a hydroponic solution or in aquaculture), **and aquatic organisms** (e.g., **fish, crustaceans, mollusks and the like**).

***

The technical innovation regarding **fish feed** appears evenly acknowledged across the globe, however the Chinese patent authority (CNIPA/SIPO) scores the highest number of patent filings, 542 events counted from the beginning of the century. In EU, almost every national patent office is addressee of at least one patent application. The highest number of applications has been filed to the Spanish patent authority which scored 34 filing events, followed by the Portuguese patent office with 19 events. Only three patent applications have been filed to the Italian patent and trademark office. However, as already pointed out, these numbers do not account for the possibility of nationalization procedures following the filing of EP/PCT applications.

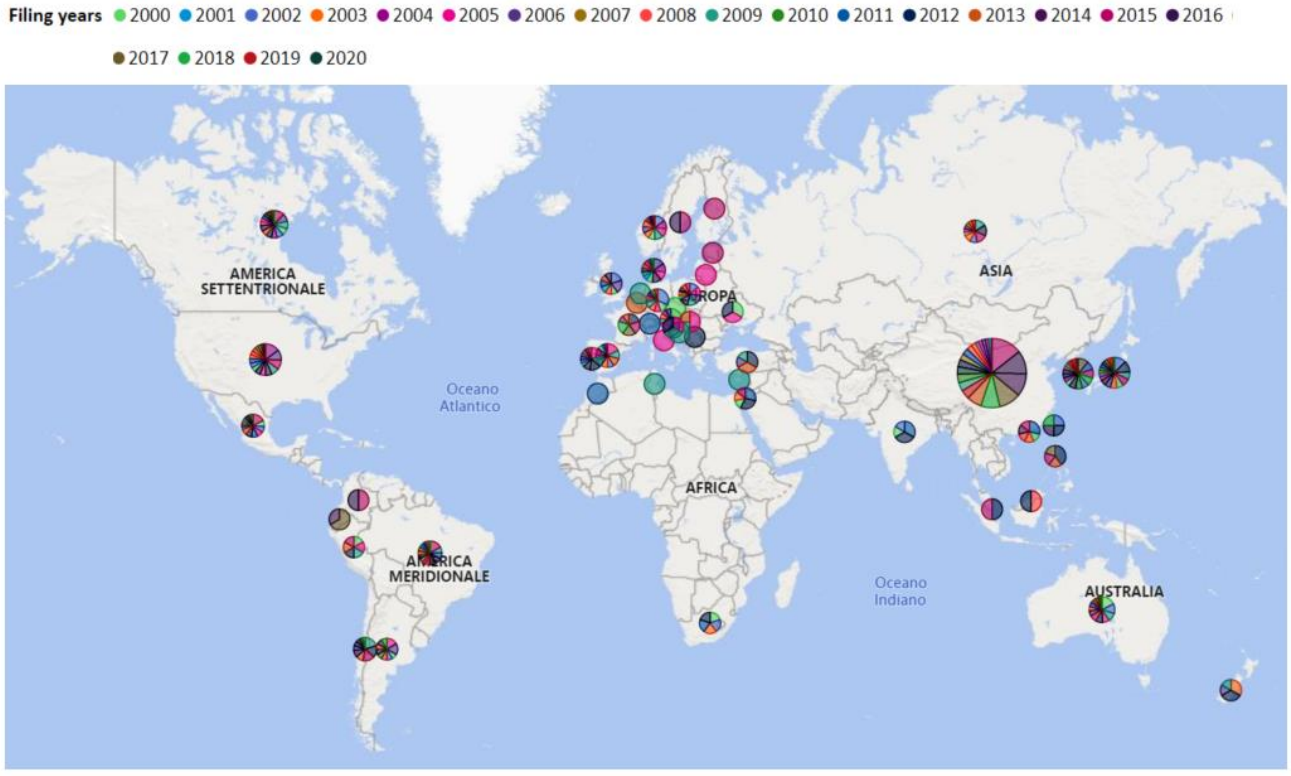


Figure 12. The number of filing events partitioned from 2000 to 2020 (EP and PCT not included).

In fact, when considering the patent filing events registered by EPO versus the WIPO the number is relevant in either case, thus confirming the worldwide relevance of this sector based on the commercial opportunity.

Table 3. Number of filing events registered at the European Patent Office (EPO) and at the World Intellectual Property Organization (WIPO) from 2000 to 2020.

Supranational authorities	
EPO	111
WIPO	135

Considering the number of applications filed, relevant competitors may be the Chinese Weihai Hongrun Marine Technology Company and the American company Dupont. The former owns 11 while the latter owns 10 patent families.

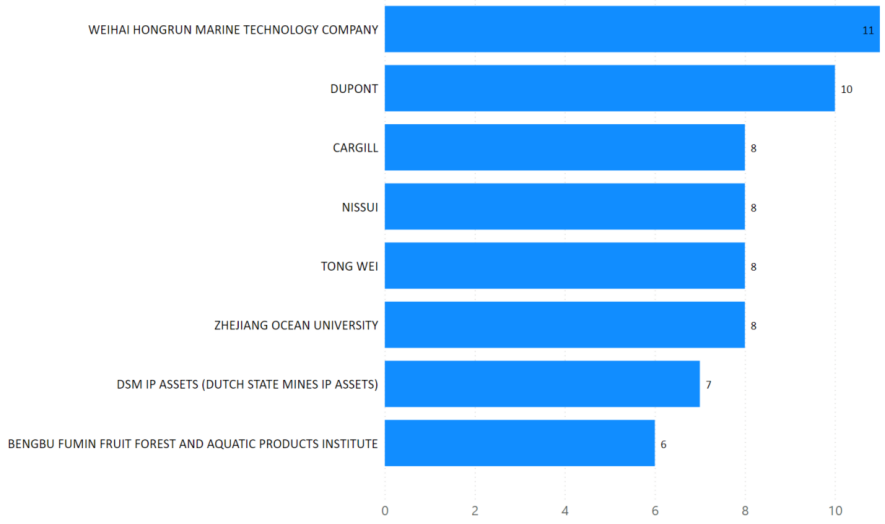


Figure 13. Patent families' number per assignee

Considering the patents' grant rate, the US company Advanced Protein Technologies owns 35 granted patents, being followed by the Global Food Corporation Cargill (US), the Dupont Company (US) and by Trouw International (NL), each one being owner of 34 granted patent.

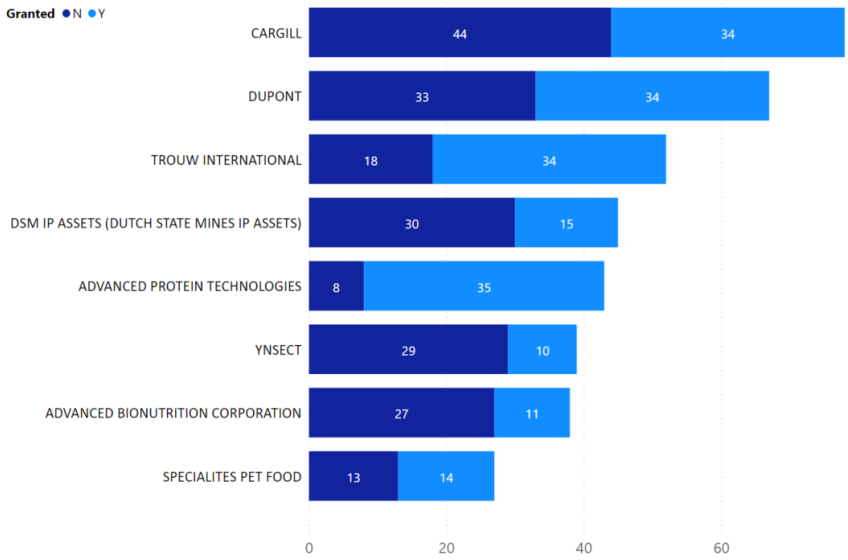


Figure 14. The legal status of the patent applications

Case Histories: Fish meal

1) *FR3087092A1 (POUDRE D'INSECTES POUR EVITER UNE DEFORMATION SQUELETTIQUE D'UN POISSON ET/OU RENFORCER LA SOLIDITE D'UNE ARETE DE POISSON PENDANT L'ELEVAGE) YNSECT*

The invention relates to the field of aquaculture (or fish farming) and more particularly **an insect powder for its use in aquaculture**. Fish farming involves the regular handling of fish.

For example, in the case of rearing in a closed space (tanks, traps or cages), manipulations such as for example the recovery of fish from their confined space, the transfer of fish from one confined space to another, or manipulations aimed at vaccinating fish. The term "fish" refers to a fish at any stage of its development, such as, for example, at the fry, juvenile or adult stage. **These various manipulations, even if they are carried out with care and according to good practices, can cause skeletal deformation if the fish is not strong enough.**

Surprisingly**, the Applicant has noticed that the administration of insect powder to a fish made it possible to avoid a skeletal deformation of said fish, in particular by reinforcing the solidity of a bone**.

2) *FR3038913A1 (BIOMASSE DE THRAUSTOCHYTRIDES, PROCEDE DE CULTURE ET UTILISATIONS) ADISSEO FRANCE, FERMENTALG*

The invention relates to the field of cultures of microalgae, particularly Thraustochytrids. **Its objects are a Thraustochytrid biomass rich in proteins, its process for obtaining it and its uses in food**.

STATE OF THE ART Several sources of plant proteins are known for their use in human or animal food, directly or as food supplements, **to provide animals and humans with amino acids necessary for their metabolism**.

These protein sources are understood to be sources of amino acids available to animals or humans once the food has been ingested. The best known source of vegetable protein used in animal feed is soybean, generally used in the form of cake, solid residue remaining after extraction of the oil. However, the use of soybean meal has several drawbacks associated with its origin.

3) *EP1738655A1 (Gelified feed for animals, and method of production) ADISSEO FRANCE, VITEN Srl*

This invention has as its **object feed for animals** according to the preamble of the main claim.

A non-limitative list of beneficiaries such as small pets form part of the following groups:

- large and medium-sized parrots (Lori, Ara, Amazonian, Cockatoo and similar);
- small rodents and lagomorphs (hamsters, guinea-pigs, rabbits and similar);
- other birds whose diet is mainly based on sugary substances;
- **aquarium fish**;
- reptiles (Testudinates, in particular tortoises and fresh-water turtles; Squamata, in particular lizards and iguanids).Other animals that can benefit from such feed can be the most varied like for example:
- dogs;
- cats;
- horses;
- working animals, including for example elephants;
- **fish also of large sizes such as dolphins and orcas in aquariums**,
- etc.

Patent dataset features

Aquaculture: analysis of **467 non-duplicated patent families** corresponding to **717 patent applications**. Applications' filing timeframe: priority year 2017 → oct. 2020.

Fish feed: analysis of **809 non-duplicated patent families** corresponding to **2037 patent applications**. Applications' filing timeframe: priority year 2017 → oct. 2020.

Bibliography

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[3] THE EU FISH MARKET 2020 EDITION. EUMOFA European Market Observatory for Fisheries and Aquaculture Products;

[4] MarketsandMarkets Knowledge Store (https://www.mnmks.com/) report "Aquafeed Market - Global Forecast to 2025", June 2020;

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Seafood processing and trade

Market overview

The **processing of seafood** adds value to the production of fisherman and small fish farmers, diversifying the sources of income of coastal communities and reduces the seasonality mainly linked to the biological cycles of exploited resources (mainly wild but also farmed). The seafood processing sector includes:

- The preparation and preservation of fish, crustacean and molluscs: freezing, deep-freezing, drying, smoking, salting, immersing in brine, canning, etc.;

- The production of fish, crustacean and mollusc products: cooked fish, fish fillets, roes, caviar, caviar substitutes, etc.;
- The production of processed fish dishes;
- The production of fish meal for animal feed;
- The activities of vessels only engaged in the processing and preserving of fish.

Several factors are currently driving the growth of this sector, such as the need to process, packaging and storage perishable commodities, the growing of the aquaculture industry, the rising demand for seafood products, the globalization process and the increase of trading, mechanization, and robot-driven operations [3]. Therefore, the seafood processing sector is being rapidly transformed into a high-volume industry.

As anticipated, **Seafood products** are perishable commodities, and their transportation and storage must be regulated. For this reason, the processing of seafood products industries relies on advanced technologies and materials that can face the challenges of the delicate handling of those products. The introduction of robotics and state-of-art automated equipment have increased product efficiency and consistency ensuring the production of high volume and better quality of the products. Moreover, manufacturers are providing more efficient food packaging solutions using new materials such as environmentally friendly paper boxes, polyethylene-terephthalate-laminated containers, super lightweight plastic film and sterilized cans to ensure a longer product shelf-life. Life of seafood products is also increased by using modified atmosphere in packaging and transformation using very low temperature [4;5].

The **global processed seafood market** is expected to reach the total value of USD 267,231 million by 2023, at a CAGR of 5.2% in the period 2018 – 2023 [1].

Globally, Asia Pacific and Europe encompass a large part of the market where **Europe** is expected to reach the market value of USD 36,075 million by 2023. In the EU the seafood processing sector contributes positively to the blue economy adding around 45% of the Gross Value Added (GVA) and generating employment, particularly in the form of jobs for women.

Analysing the market by product type, **fish** are the main processed food produced, followed by **crustacean** and **molluscs** [3]. Those products are processed using different manufacturing methods. Specifically, the frozen seafood segment is dominating the market, followed by the dried seafood, smoked and canned segments [3]. As the EU demand for fish products greatly exceeds the supply that fish catching and aquaculture sectors can deliver, the international trade for processed fish products is increasing. Therefore, the processing industry is highly dependent on international developments including prices, exchange rates, trade agreements, tariffs, and geopolitical aspects.

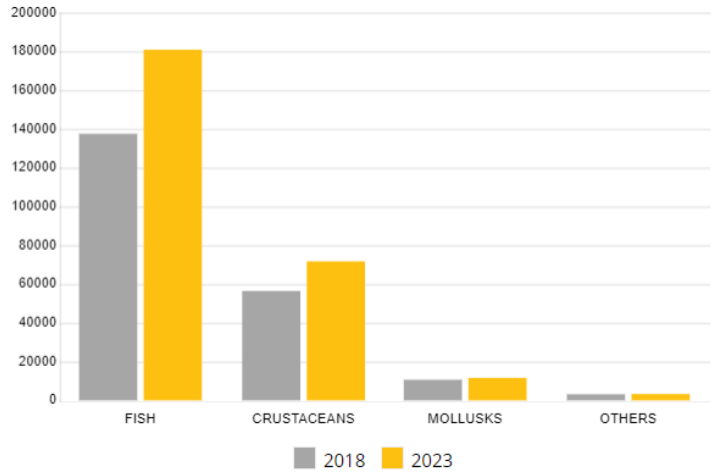

*Figure 15. Processes Seafood Market Size, by type, in the period 2016- 2023 valued in United States Dollar (USD). *Others include turtles and sea urchins.*

Legal protection of technical solutions

Legal protection of technical innovation regarding **seafood derivate** and processing is well established in the Asian Pacific region, especially in China, and in the United States. In the Mediterranean region, Spanish patent authority registered the highest number of filing events in the last two decades, followed by the Portugal and Slovenia. Looking at the number of patent applications registered by EPO and WIPO, the data suggests that inventors might prefer harmonised procedure for filing their patent applications, being the PCT procedure slightly preferred if compared to the EP harmonised procedure.

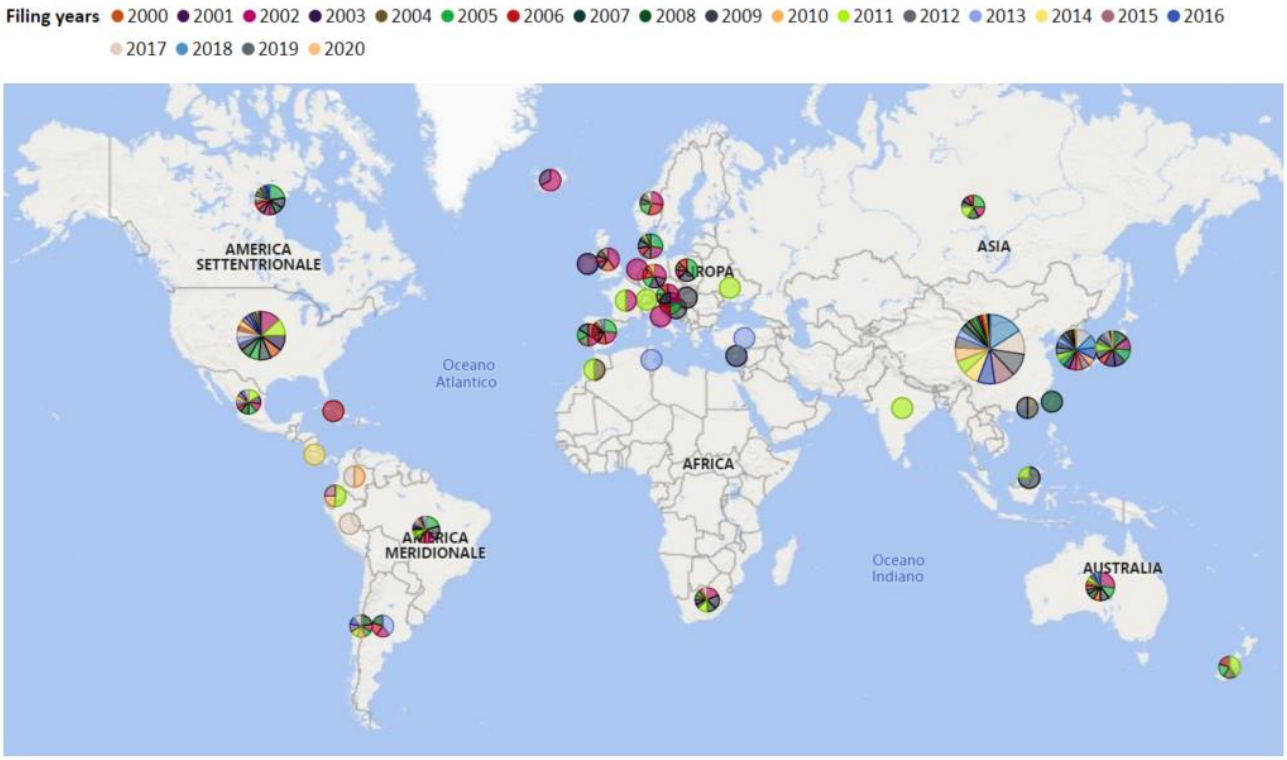

Figure 16. The number of filing events partitioned from 2000 to 2020 (EP and PCT not included).

Table 4. Number of filing events registered at the European Patent Office (EPO) and at the World Intellectual Property Organization (WIPO) from 2000 to 2020.

Supranational authorities	
EPO	60
WIPO	84

Looking at the main competitors, the Intercontinental Great Brands (Kraft Foods) and Zhejiang Ocean University an industry based in the United States and a Chinese university, respectively. At the European level, W. Neudorff GMBH (DE) is leading the sector with the highest number of patent families.

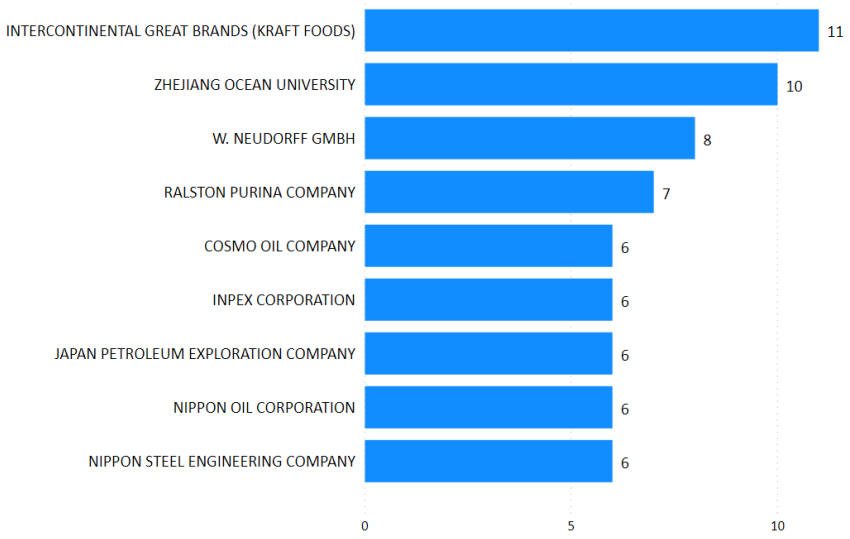

Figure 17. Patent families' number per assignee

Regarding the granting of the patents, W. Neudorff GMBH (DE), Cosmo Oil Co., Ltd (JP) and Inpex Corporation (JP) are leading the industry.

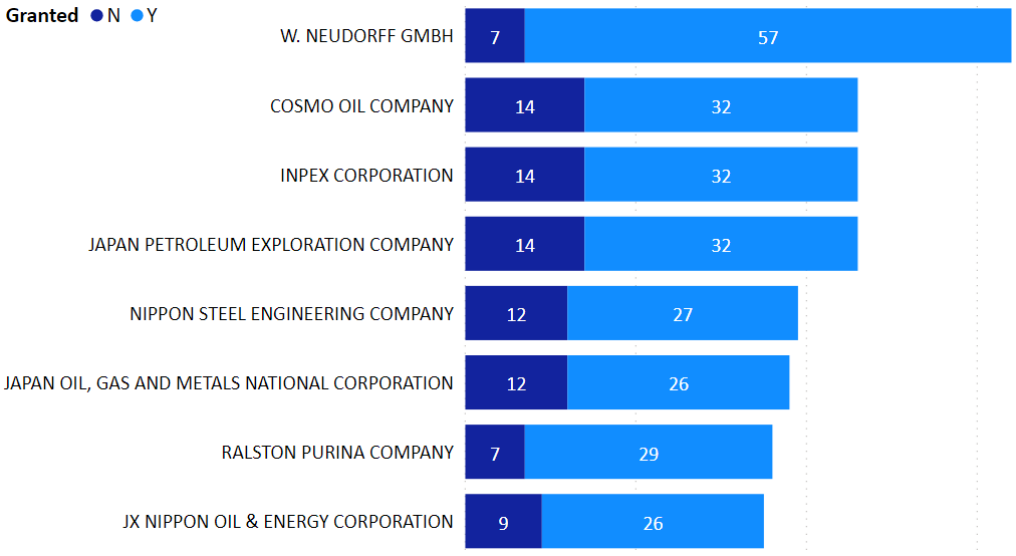

Figure 18. The legal status of the patent applications

Case Histories: Seafood derivate and Processing

1) *AU2003235718B2 (= EP1469748B1) (PREPARATION OF PRODUCTS HAVING ROASTED APPEARANCE) NESTLE'* (Nestlé: Good food, Good life | Nestlé Global (nestle.com))

The invention relates to a food composition comprising a particular coating for obtaining, after rapid cooking, **products having a roasted appearance**. The present invention **may be applied to animal food and may be in the form of pieces which have a roasted appearance**, mixed with a sauce or a base.

These pieces can be prepared from a mixture of 55 to 85% of meats and meat by-products and/or of fish and fish by-products, of 10 to 25% of cereals, and of 6 to of water, said pieces preferably being prepared from a mixture of 58 to 68% of meats and meat byproducts and/or of fish and fish by-products, 10 to of cereals, 0 to 5% (preferably 2 to of plant proteins and 5 to 14% of water.

2) *EP3013367A1 (EDIBLE PLASTICIZERS FOR FOOD AND FOOD PACKAGING FILMS) EMPIRE TECHNOLOGY DEV LLC* (Automated Laboratory Technologies (empiretechdev.com))

Disclosed are plasticizers, salts thereof, chelates thereof and cleavage derivatives thereof, that exhibit a superior combination of properties. **The plasticizers can be used for a variety of purposes, including food preparation, cosmetics, beverages and polymeric matrices**. The plasticizers can be prepared by esterifying gallic acid, fulvic acid, or tannic acid. **Consumer interest in and awareness of the health properties of food plasticizers has also been increasing in recent years**. This has simultaneously increased global sales of food plasticizers and foods that are recognized as being naturally rich in antioxidants. As the sector develops, food plasticizers are now being used in the manufacture of a greater variety of foods. In one embodiment, the food product includes a dairy product, fat, oil, fat emulsion, edible ice, fruit, vegetable, fungi, seaweed, nuts, seeds, confectionery, cereal, cereal product derived from cereal grains, bakery ware, meat, meat byproduct, **fish, fish product**, egg product, sugar, artificial sweetener, spices, condiment, soup, sauce, salad, protein mix, non-dairy beverage, savory snack, or combinations thereof.

3) *EP2931061A1 (METHOD OF PREPARING A FOOD COMPOSITION) HILL'S PET NUTRITION* (Hill's Pet Nutrition - Cibo per cani e gatti che trasforma la vita)

The invention provides a method of **preparing a moist animal food composition comprising a food component**, wherein the method comprises: treating the food component with transglutaminase and at least one further agent selected from gluten and alginate. The invention further provides a method of increasing the firmness of a food component comprising treating the food component with transglutaminase and at least one further agent selected from gluten and alginate.

Typically, the food component comprises a protein source. Optionally, the protein source is an animal protein source. The protein source may comprise both an animal protein source and a vegetable protein source. **Optionally, the protein source comprises meat, a meat by-product or fish**.

4) *WO2013033618A1 (=US8846604B2) (LIPID COMPOSITIONS WITH HIGH DHA CONTENT) ARCTIC NUTRITION* (Arctic Bioscience| Norwegian Herring Roe | Premium Caviar Extracts (arctic-bioscience.com))

The invention provides **lipid compositions comprising phospholipids having a high docosahexaenoic acid (DHA) content, which compositions are preferably extracted from natural sources**. The lipid compositions are excellent sources of highly bioavailable DHA and they can be used in oral delivery vehicles, dietary supplements, functional foods, and the like. **Omega-3 fatty acids are often referred to as "essential" fatty acids because they are needed for human health but are not sufficiently produced by the body alone**. The two major health promoting omega-3 polyunsaturated fatty acids are eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). EPA and DHA **are naturally found in certain cold-water fatty fish such as salmon, tuna, and mackerel**.

The modern diet is typically deficient in omega-3 essential fatty acids and has become overloaded with pro-inflammatory omega-6 fatty acids, especially arachidonic acid. **This heavy imbalance of omega-6 to omega-3 fatty acids in the modem diet is thought to lead to an overall inflammatory state that contributes to several diseases**.

Patent datasets' features

Seafood processing: analysis of **563 non-duplicated patent families** corresponding to **1370 patent applications**. No limitation is assumed concerning the applications' filing timeframe.

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Sustainable Development Goals (SDGs)

Fisheries and Aquaculture and linkages with the SDGs

Figure 19. Sustainable Development Goals and linkages with the Fishery and Aquaculture sector of BLUE BIO MED project. For more info concerning the SDGs please visit THE 17 GOALS | Sustainable Development (un.org).

The **Fishery and Aquaculture** sector has consistent linkages with **6 SDGs**. Starting with the environmental protection, the BBM projects aligns its core mission with the **Goal 14 "*Life Below Water*"** (Table 5). This Goal aims at enhancing the sustainable use of oceans, seas and marine resources through the investment into new environmentally and friendly economy. Starting with fishery, the Goal 14 devotes several targets to the reduction of overfishing and the preservation of the wild stocks demanding the regulation of large-scale fishery and improvement efforts to fight illegal unreported and unregulated fisheries. In detail, the **Target 14.1** supports the enhancement of fishery management to reduce the sea-based pollution from fishing vessels such as discarded fishing gear which are turned into harmful marine debris (included in ghost fishing). Furthermore, **Target 14.1** supports the application of integrated approaches that consider inputs of nutrients from land as a factor influencing the productivity and the potential exploitation of the sea. The **Target 14.2** focuses on the sustainable management of the marine and coastal ecosystems highlighting the importance of a joint action both on land and at sea. The **Targets 14.4** and **14.7** specifically address the issues related to the increasing and uncontrolled exploitation of marine resources pointing out that more sustainable fishery industries are needed to restore the wild fish stocks and assure the future availability of fish products [1]. The **Target 14.b** points out the importance of the Small-Scale Fishery (SSF), highlighting the need to preserve this delicate economy which can represent a sustainable way to exploit wild fish [2]. Finally, **Target 14.c** expresses that a common policy across the basin is needed to achieve the sustainable management of the Mediterranean basin.

Table 5. SDG 14 "Life Below Water". Relevant Targets and Indicators to the Fishery industry.

Targets	Indicators
14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution	**14.1.1** Index of coastal eutrophication and floating plastic debris density
14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans	**14.2.1**Proportion of national exclusive economic zones managed using ecosystem-based approaches
14.4 By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics	**14.4.1** Proportion of fish stocks within biologically sustainable levels
14.7 By 2030, increase the economic benefits to small island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism	**14.7.1** Sustainable fisheries as a percentage of GDP in small island developing States, least developed countries and all countries
14.b Provide access for small-scale artisanal fishers to marine resources and markets	**14.b.1** Progress by countries in the degree of application of a legal/regulatory/policy/institutional framework which recognizes and

	protects access rights for small-scale fisheries
14.c Enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in the United Nations Convention on the Law of the Sea, which provides the legal framework for the conservation and sustainable use of oceans and their resources, as recalled in paragraph 158 of "The future we want"	**14.c.1** Number of countries making progress in ratifying, accepting and implementing through legal, policy and institutional frameworks, ocean-related instruments that implement international law, as reflected in the United Nation Convention on the Law of the Sea, for the conservation and sustainable use of the oceans and their resources

The Aquaculture activities are tackled in the SDGs within the target reported in the Table 6. The **Target 14.1** highlights how sustainable aquaculture need to cause minimal pollution compared to extensive aquaculture (such as those carried out traditionally in transition environments, such as lagoons). Moreover, more sustainable and climate-smart aquaculture could also positively impact the **Target 14.2** since farming areas at sea could be biological protected areas, attractive spots for wild species and/or sites to apply integrated approaches (farming + protecting) supporting the construction of a much more resilient economy. In general, the **Goal 14** focuses on the sustainable management of the coastal and marine ecosystems which could be negatively impacted by an unregulated aquaculture industry. Hence, the development of sustainable aquaculture based on new techniques, rearing systems and species is fundamental for the realisation of those targets [1].

Table 6. SDG 14 "Life Below Water". Relevant Targets and Indicators to the Aquaculture industry.

Targets	Indicators
14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution	**14.1.1** Index of coastal eutrophication and floating plastic debris density
14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans	**14.2.1** Proportion of national exclusive economic zones managed using ecosystem-based approaches
14.7 By 2030, increase the economic benefits to small island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism	**14.7.1** Sustainable fisheries as a percentage of GDP in small island developing States, least developed countries and all countries

When looking at the environmental protection, the Fishery and Aquaculture sector is also aligned with the **Goal 13 "Climate Action"** and in particular with the target **13.1** "*Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries*". Thus, small scale fishery activities could positively help to reduce the consequences of climate changes such as the introduction of alien species though new targeted captures.

Moving to the economic dimension, the **Goal 12 "Responsible Consumption and Production"** addresses the need to decouple the economic development from environmental degradation and unsustainable use of natural resources. This phenomenon is particularly significant in the fishery industries which threat the availability of fish through the overfishing of wild stocks. For this reason, this Goal perfectly aligns with the need for enhancing SSF sector, rather than Large Scale Fishery, which could ensure a lower environmental impact through a lower number of catches, the selection of seasonally diverse fish species and the use of environmentally friendly techniques and thereby moving towards a more sustainable market. For the aquaculture sector, moreover, this Goal is important since choices of farming systems and species could lead to more responsible and sustainable productions and for this reason the selection of herbivory species to farm or developing feeds using proteins not derived from fish increase the potential for aquaculture to contribute to this goal. This Goal in fact also focuses on the reduction of food loss and waste through the improvement of the efficiency of food systems. This theme is tackled under the "Seafood processing and Trade" section of the report, which focuses on the development of a new type of food market characteries by the reduction of waste and the loss of seafood products. In the table below are reported the specific targets that are aligned with the Fishery and Aquaculture sector.

Table 7. SDG 12 "Responsible Consumption and Production". Relevant Targets to Fishery and Aquaculture sector.

Targets
12.2 By 2030, achieve the sustainable management and efficient use of natural resources
12.3 By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses
12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment
12.7 Promote public procurement practices that are sustainable, in accordance with national policies and priorities
12.8 By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature
12.a Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production

The economic dimension is also tackled by the **Goal 9 *"Industry, Innovation and Infrastructure"***, which aims at promoting the conversion of traditional industries into inclusive and sustainable ones and promoting the investment in infrastructures, innovation, and research for long-term sustainable development. This topic is relevant especially for the aquaculture sector which is defined as "the fastest growing food-producing sector" by FAO in 2021 (Aquaculture. (2021). Food and Agriculture Organization of the United Nations. http://www.fao.org/aquaculture/en/) and it is in desperate need of new technologies to allow for manageable growth without damaging the marine ecosystem.
The targets of the SDG 9 related to the Fishery and Aquaculture sector are reported in the table below.

Table 8. SDG 9 "Industry, Innovation and Infrastructure". Relevant Targets to Fishery and Aquaculture sector.

Targets
9.3 Increase the access of small-scale industrial and other enterprises, in particular in developing countries, to financial services, including affordable credit, and their integration into value chains and markets
9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities
9.5 Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending
9.b Support domestic technology development, research and innovation in developing countries, including by ensuring a conducive policy environment for, inter alia, industrial diversification and value addition to commodities

Finally, fishery and aquaculture industries positively contribute also to the **Goal 8 *"Decent Work and Economic Growth"*** aiming at achieving a more sustainable development of the sector related industries through the improvement of resource efficiency and the decoupling of economic growth from environmental degradation. The specific targets related to the Fishery and Aquaculture sector are reported in the Table 9.

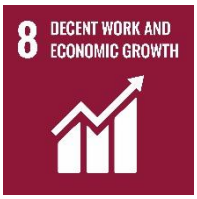

Table 9. SDG 8 "Decent Work and Economic Growth". Relevant Targets to Fishery and Aquaculture sector.

Targets
8.2 Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labour-intensive sectors
8.3 Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services
8.4 Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-Year Framework of Programmes on Sustainable Consumption and Production, with developed countries taking the lead

Considering the social dimension, Fishery and Aquaculture also positively help the achieving of the **Goals 2 *"Zero Hunger"*** thanks to the key role of these industries in the global production of food both at small and large scale. The Goal highlights the need to promote more sustainable production of sea-based food and to preserve the small-scale producers living in the coastal regions and assure the supply of healthy food in all the communities. This Goal also aligns with the Seafood processing sector of BBM, evidencing as the development new methods of conservation and distribution of Seafood products could improve the availability of fish and shellfish to the population. The specific targets related to the Fishery and Aquaculture sector are reported in the Table 10 .

Table 10. SDG 2 "Zero Hunger". Relevant Targets to Fishery and Aquaculture sector.

Targets
2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient
2.3 By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment
2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality

Challenges for the sustainability

The presence of targets directly connected to **Fishery and Aquaculture** within the Sustainable Development Goals such as the SDG 14, suggests the importance of these sectors in the blue economy. The interest for these sectors is rapidly increasing together with a new environmental sensibility and political attention. Concerning the **Fishery sector**, even the SDG 14 is giving attention to the SSF, which represent a better option to the large-scale fishery for exploitation of the marine resources because of its great contribution to jobs, traditions and usually price. Thus SSF is gaining more and more importance. Nowadays artisanal fisher communities are included in participatory processes providing insights to the development of international and national law (REF), often participate in governing and managing fishing grounds for example in co-management of coastal protected areas (REF), coasts, and seas [4]. SSF are also characterized by high flexibility in terms of fishing target and tools that if opportunely used can provide the fisher with means to support fluctuations and changes. However, even though there is specific attention to SSF in the SDGs, to achieve the sustainable development of this sector several aspects need to be considered. The target 14b cannot be conceived as a stand-alone target to achieve sustainability but must be coupled with economic and political systems, the institutional landscape, and the market systems [2]. In particular, SSF undergoes several challenges such as high competition both for the resource and for space within SSF and with other fishing gears, difficulties in attracting new generation of fishers, poor capacities of investment, great reliance on local markets.

Moving to the **Aquaculture sector**, the production of farmed aquatic herbivore organisms could reduce the demand of unsustainable fishery products and overall contributes to natural resource conservation goals. However, the early development of this sector was linked to the several negative effects that intensive aquaculture has on the

environment such as, for example, eutrophication, introduction of alien species and loss of habitat. Those challenges have been addressed in the latest developments of the aquaculture sector through the implementation of new techniques for integrated aquaculture reducing releases from the farms; the multidisciplinary approaches to identify most opportune faming placement; the rearing of species with great efficiency in the use of feed; the use of feeds with substitutes of the fish proteins to achieve a more environmentally friendly industry. Hence, to react to the ongoing fast development some implementations of the SDGs are necessary to guarantee manageable development and assuring a trade-off between environmental value and development values. For this reason, strong regulation and the creation of new goals to improve the sustainability is necessary to both facilitates opportunity and constrains excess [3].

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Blue biotechnology

Healthcare and Pharmaceuticals

The “Healthcare and Pharmaceuticals” was divided into sections which are: cosmetics, pharmaceutics and nutraceutics.

Market overview

The **blue biotechnology sector** usually refers to the non-traditionally exploited groups of marine organisms and their commercial implications. The main species considered are: macroalgae (seaweed), microorganisms (microalgae, bacteria, and fungi) and invertebrates. These different organisms are currently used for the extraction of high-value bioactive compounds with high market potential [1].

Specifically, the blue biotechnology sector can include **three industries** that generate different products and services, namely:

- The **pharmaceutical industry** which uses marine organisms to produce medicines (drugs, novel antibiotics, wound healing, anti-inflammatory, immunomodulatory agents) and biomaterials (bio-adhesives, dental-medical biomaterials, disinfectants);
- The **nutraceutical industry** generating new food supplements (prebiotics, ω3 supplements), food products (stabilizer- suspending-bending-foaming agents) and nutraceuticals (antioxidants, anti-inflammatory, anti-HIV);
- The **cosmetics industry** developing functional ingredients (UV filter, viscosity control agents, preservatives) and raw materials (colourants, pigments, fragrances) [2].

Overall, **algae** are the most exploited marine organisms in these industries thanks to their several applications. The term “algae” include both macro and microalgae, ranging from seaweeds to single-celled organisms. Key ingredients that can be extracted from algae are carrageenan, carotenoids, lipids, alginate, algal protein, algal flour, agar, and biologically active molecules for use in human and animal health. Other alternative marine biomasses are undergoing several studies aimed at understanding their future possible applications, but so far, the **algae sector** is the most relevant in Europe, and, up to date, the most developed among the emerging sectors of the Blue Bioeconomy. Algae biomass production has increased globally since 1950, reaching almost 32.67 Mt in 2016, with China, Indonesia and South Korea leading the market. In Europe, which accounted for 0.57% of the total production, algae biomass is mainly supplied by Norway followed by Ireland and France. Globally in 2016, up to 96.5% of the total algae biomass was obtained from farmed algae, whereas only a small percentage was harvested from the wild stock. Instead, in Europe, algae biomass was primarily obtained from wild stock [1]. In the **Mediterranean area** Spain and France are the countries in Europe with the largest number of **macroalgae** companies and **microalgae** producers. France dominates the Spirulina production landscape with 65% of the mapped production units in Europe.

While algae are naturally occurring materials, which can be simply harvested from the wild, global trends seem to indicate that soon algae biomass will be mainly cultivated in aquaculture farms. **Seaweed or macroalgae culture** is very convenient because algae generally do not require any freshwater, fertiliser or other external inputs. There is also no need to repurpose or clear land. Moreover, the regenerative nature of seaweed and their contribution to biodiversity and ecosystem services, makes their farming a particularly promising industry [6]. **Microalgae** can also be **cultivated** in open or closed systems. Open systems are more convenient due to the lower installation and operation costs. In those systems microalgae grow directly in contact with the atmosphere either in pons that are stirred mechanically or in “raceway ponds” which are stirred by a paddle wheel. Closed systems can be photobioreactors or fermenters and are far more expensive. However, they assure a higher volumetric productivity and more controlled conditions, including prevention

of contamination, better control of the cultivation conditions (pH, temperature, nutrient supply, etc.), reduction of water use and CO2 losses [7].

In the **pharmaceutical industry**, algae are used as antimicrobials, antivirals and antifungals, neuroprotective products, and therapeutic proteins and drugs. Moreover, alginates extracted from marine kelp find applications in the medical field for wound healing, tissue engineering and regenerative medicine, and dental health applications. The **global market for algae products for pharmaceutical applications** is expected to reach the value of USD 442.6 million by 2023, growing at a CAGR of 5.7% in the period 2018 – 2023. Asia Pacific and North America are the main contributors to the market. For the **European** region, the algae products market for pharmaceuticals is forecasted to grow to the value of USD 83.1 million by 2023, at a CAGR of 5.3% in the period 2018 – 2023. France, Italy and Spain are the main countries active in this market in the Mediterranean area.

In the **European region**, the main exploited **macroalgae species** for **food industries and cosmetics** are *Laminaria hyperborea, Laminaria digitata* and *Ascophyllum nodosum* which are primarily harvested mechanically by boat.

Concerning the **microalgae**, the main species used for healthy food, nutritional supplements, and antioxidant pigments are *Dunaliella*, *Spirulina*, *Haematococcus* which are mostly produced in aquaculture farms [3]. Specifically, JRC reported that there are around 250 Spirulina farms operating in EU, and among them, 150 are hosted in France [1]. As far as the **food market** is concerned, the microalgae are mainly sold as dried-algae and their demand is increasing constantly thanks to their high-value nutrients content including carotenoids, phycobilins, fatty acids, and antioxidants. The sector is mainly driven by the growing trend of natural cosmetic and **nutraceutical products** and the rising popularity of new generation foods [2]. According to JRC the micro and macroalgae farmed or harvested in Europe are predominantly sold for food related uses (i.e., food supplements and nutraceuticals) and cosmetics.

Globally the **nutraceutical** is one of the fastest growing industry thanks to the rising demand of foods products that provide health and medical benefits, including functional foods and dietary supplements. This industry is forecast to grow considerably and is expected to reach the global market value of USD 336.1 billion by 2023, at a 7.8% CAGR from 2018 to 2023. Within the nutraceutical market, **plant-based functional food** is expected to reach the global value of USD 119.9 billion in 2025, growing at a CAGR of 8.6% from 2020 to 2025. Looking at the **European region**, there is a mix of more mature markets in the western countries, whereas eastern markets hold greater future growth potential. In the Mediterranean area, France is leading the sector followed closely by Italy and Spain thanks to the growing health and wellness consciousness among consumers and the boosting demand for organic products [4].

Figure 20. Algae biomass commercial uses of European Economic Area (EEA) companies. HP: Hydrocolloid production; B: Bioremediation (European Commission (2020). The EU Blue Economy Report. 2020. Publications Office of the European Union. Luxembourg).

Finally, the **cosmetics** industry based on marine biomass is also identified as one of the fast-growing market segments among the blue biotechnology sectors. This growth is related to the large panel of new applications. For example, the **marine collagens** derived from the different parts of marine organisms are compounds largely used in cosmetics products for the regeneration of the skin or as antiaging. Hence, marine collagen has witnessed a relevant growth in the

last five years thanks to its wide application, the benefits for the health and the higher bioavailability if compared to other collagen types. Globally the **global marine collagen market** is projected to reach the value of USD 1,137.3 million in 2026, with a CAGR of 7.9% in the forecast period 2020 - 2026. In **Europe**, the market is estimated to reach the value of USD 367.3 million in the forecast period 2020 – 2026. Among the **Mediterranean area**, France, Italy and Spain are currently the main producers [5].

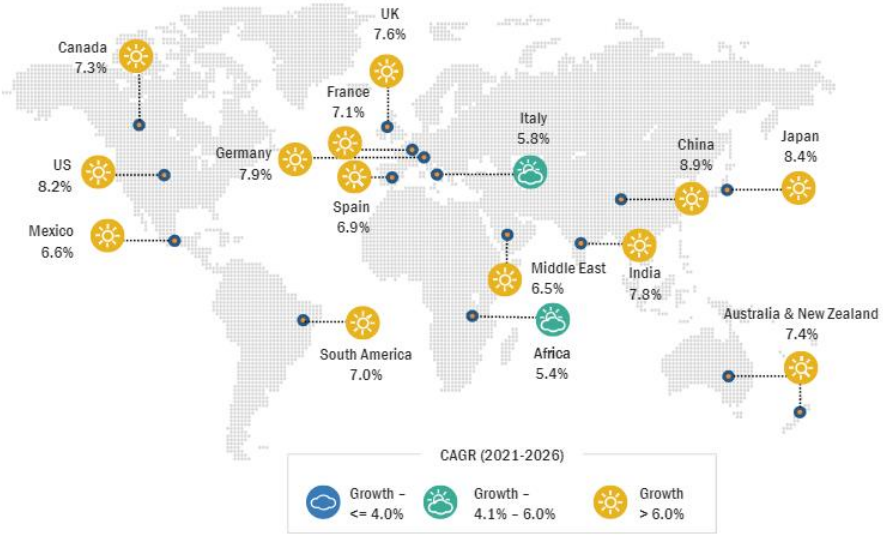

Figure 21. Marine Collagen Market size by Region, CAGRs in the Period 2021-2026.

Legal protection of technical solutions

The applications of marine organisms, mainly algae, in the **cosmetic industries** are steeply increasing between 2000 and 2020, being the total number of patent application filed globally 2475. Moreover, technical innovations are evenly widespread across the countries; USA and Japan national patent offices are scoring, respectively, 426 and 333 patent filing events, the timeframe defined by the earliest filing year encompassing the last two decades. The cosmetic industries in EU are likely flourishing, since the patent authorities of Spain, France and Germany score 68, 61 and 44 patent applications, respectively.

Figure 22. The number of filing events partitioned between 2000 and 2020 (EP and PCT not included)

Additionally, when considering the patent applications filed to the European Patent Office (EPO) versus those filed to the World Intellectual Property Organization (WIPO) the numbers are equivalent and consistent, thus proving the relevance of this sector worldwide.

Table 11. Number of filing events registered at the European Patent Office (EPO) and at the World Intellectual Property Organization (WIPO) from 2000 to 2020.

Supranational authorities	
EPO	214
WIPO	236

The owners of the highest numbers of patent families are Noevir Holdings Co., Ltd and Lion Corporation, both headquartered in the Asia Pacific region. As far as the European scenario is concerned, the German Beiersdorf AG company (including brands such Eucerin, Labello and Nivea) owns the highest number of patent families.

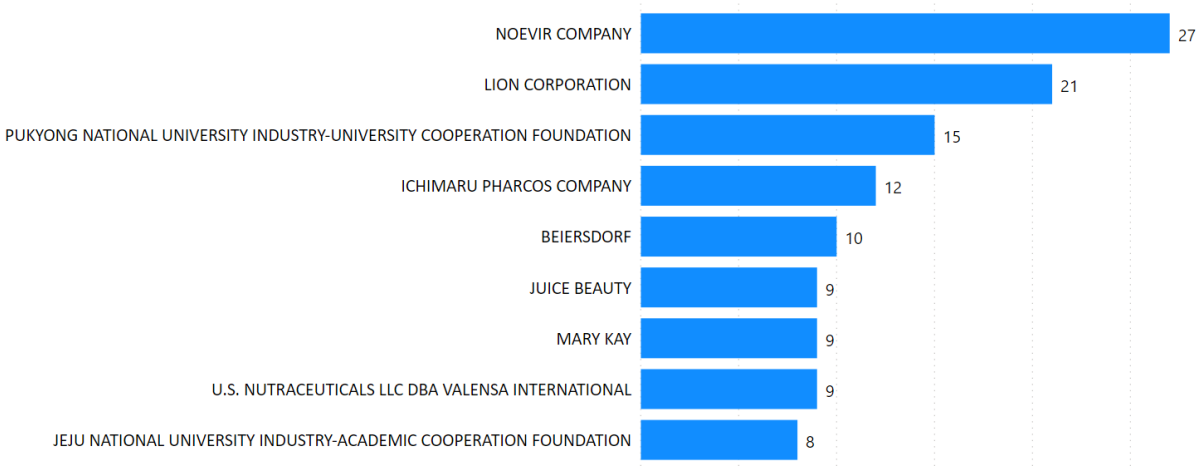

Figure 23. Patent families' number per assignee

Considering the patents' grant rate, the Dutch company Nutricia owns 44 granted patents, being followed by Mary Kay (US) with 31 granted patents.

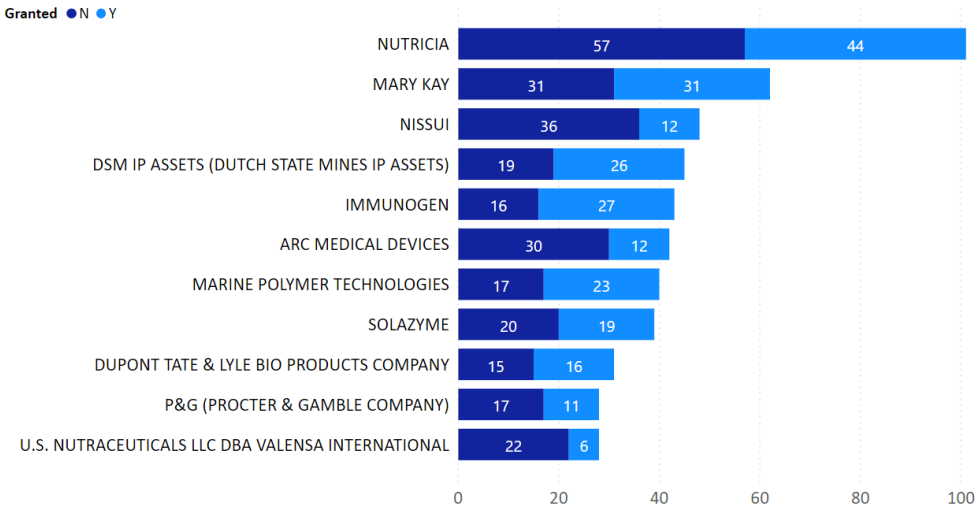

Figure 24. The legal status of the patent applications

Case Histories: Cosmetics

1) *EP3325606A1 (PROTEIN-RICH BIOMASS OF THRAUSTOCHYTRIDS, CULTURING METHOD, AND USES), FERMENTALG* (Home - Fermentalg - Algae you can trust)

One of the goals of the invention is to provide a novel source of proteins for animal or human consumption which meets the objective of wide, economically-viable industrial production, the qualities of which will enable it to replace the common sources such as soybean. The invention shows that, under certain culture conditions, thraustochytrids, known for their use in the production of oils with high polyunsaturated fatty acid contents (notably DHA, EPA) are microorganisms capable of producing a large amount of proteins, which can make them a source of dietary proteins similar to soybean, in particular for animal feed.

CLAIM 18. Use of a biomass as described in any one of Claims 1 to 8 or 17 in the fields of cosmetics and human or animal food.

CLAIM 20. Cosmetic or pharmaceutical composition for humans or animals comprising a biomass as described in any one of claims 1 to 8 or 17.

[The abundance of thraustochytrids has been reported in several different marine habitats5, including the Seto Inland Sea, Japan (Naganuma, Takasugi and Kimura 1998; Kimura, Fukuba and Naganuma 1999; Kimura et al. 2001), the Mediterranean Sea (Santangelo, Bongiorni and Pignataro 2000; Bongiorni and Dini 2002), Greenland and Norwegian seas (Naganuma et al. 2006), the equatorial Indian Ocean (Damare and Raghukumar 2008) and Hawaiian waters (Li et al. 2013).

2) *FR3056907 (EP3519056A1) (PROCESS FOR PREVENTING OR SLOWING THE APPEARANCE OF UNATTRACTIVE SIGNS, GENERATED BY POLLUTANTS PRESENT IN THE ATMOSPHERE, ON THE SKIN, THE SCALP, THE HAIR OR THE MUCOUS MEMBRANES)*

BIOTECHMARINE [FR] (BiotechMarine | SEPPIC)

Process with the aim of preventing or slowing the appearance of unattractive signs, generated by the pollutants present in the atmosphere, on the skin, the scalp, the hair or the mucous membranes, or indeed of eliminating them, comprising a step of application of a cosmetic formulation for topical use, comprising at least one cosmetically acceptable excipient and an effective amount of at least one glycolic extract (GE) of a unialgal biomass of small multicellular macroalgae originating from the Florideophyceae class. Said extract, for the use thereof in a therapeutic method for treating signs of irritation of the skin, the scalp or the mucous membranes, manifesting as redness, sensations of stinging and/or itching, signs of deterioration of the hair, manifesting as an increase in the porosity thereof, the dulling thereof, and/or the weakening thereof with regard to mechanical stresses.

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The technical innovations regarding the **pharmaceutical industries** based on the use of the marine biomass, and of algae especially, appear highly considered in the Asian Pacific region, the CNIPA/SIPO scoring the highest number of patent applications filed (93) between 2000 and 2020, while 58 patent applications have been filed to the USPTO. In EU, 26 patent applications filings event are ascribed to the Spanish patent authority during the same timeframe.

[5] Abundance and molecular diversity of thraustochytrids in coastal waters of southern China | FEMS Microbiology Ecology | Oxford Academic (oup.com)

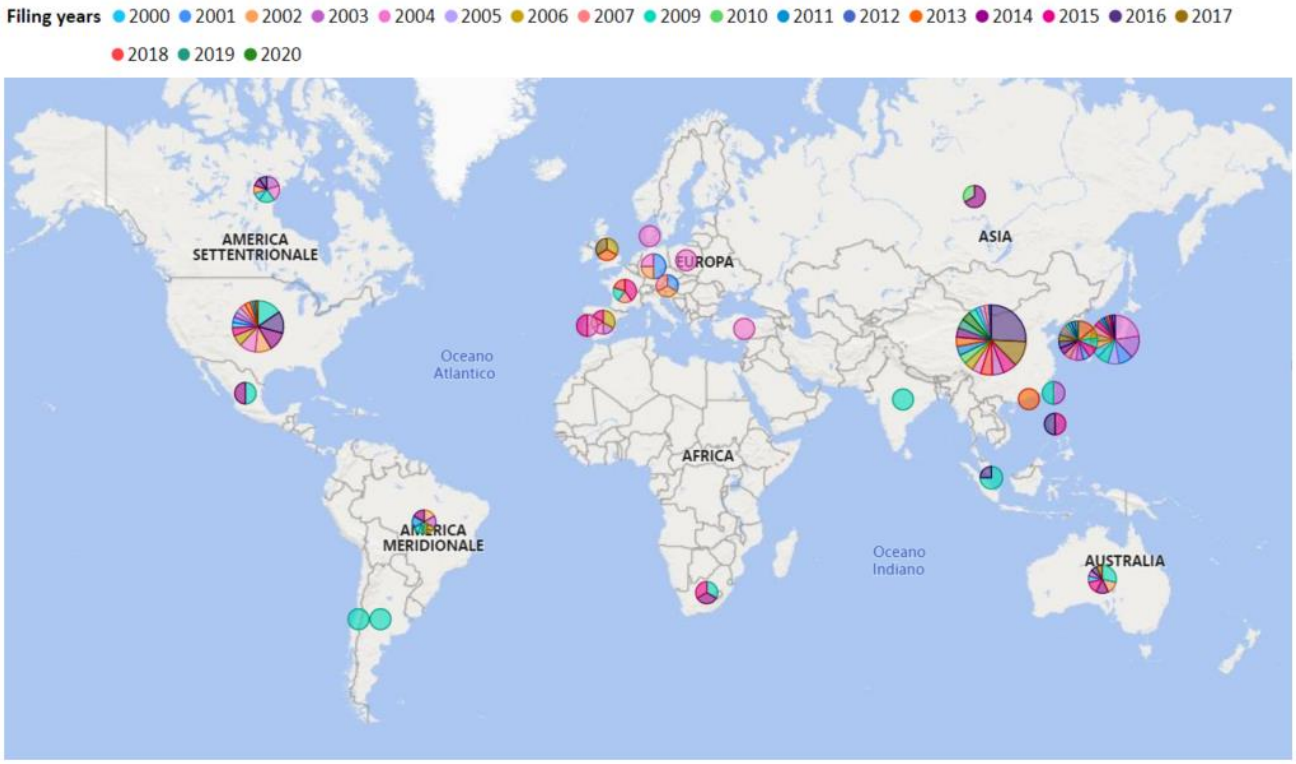

Figure 25.The number of filing events partitioned between 2000 and 2020 (EP and PCT not included)

Looking at the number of patent applications filed to the EPO and WIPO authorities, there is a comparable, yet quite modest rate of applications, thus suggesting that the exploitation of the algae biomass may still be at a preliminary stage.

Table 12. Number of filing events registered at the European Patent Office (EPO) and at the World Intellectual Property Organization (WIPO) from 2000 to 2020.

Supranational authorities	
EPO	32
WIPO	43

The players showing the highest commitment evaluated by counting the patent families' numbers are Taiyo Kagaku Company and Shandong Zhonghai Pharmaceutical Company headquartered in Japan and China, respectively. In Europe, the French company Biotechmarine scores the highest number of patent families owned.

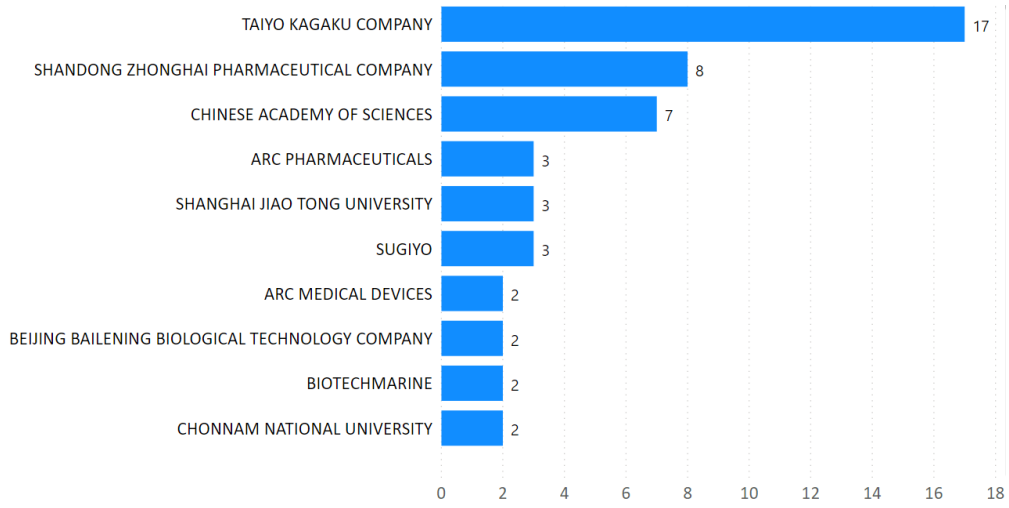

Figure 26. Patent families' number per assignee

Looking at the number of granted patents owned, ARC Medical Devices is leading the sector followed by the French chemicals company Biotechmarine which owns 6 patents granted.

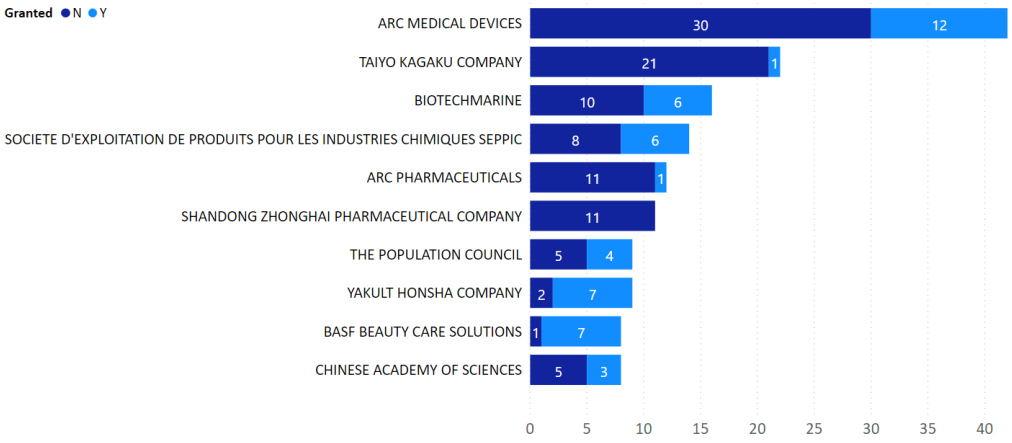

Figure 27. The legal status of the patent applications

Case Histories: Pharmaceutical

1) *WO2014077575A1 (AGAR-DERIVED NEOAGAROOLIGOSACCHARIDE COMPOSITE COMPOSITION PREPARED BY DAGA ENZYME REACTION AND HAVING ANTI-OBESITY AND ANTI-DIABETES EFFECTS)*

DYNEBIO (다인바이오 (dynebio.co.kr))

The present invention relates to an agar-derived **neoagarooligosaccharide composite** composition having an **anti-obesity and antidiabetic effect** prepared by a DagA enzyme reaction. More specifically, the present invention relates to a neoagarooligosaccharide composition comprising Streptomyces coelicolor DagA and an agarose or agarose enzyme. The present invention relates to a composition for preventing, treating and improving obesity or diabetes by containing a reaction product obtained as a reaction as an active ingredient.

Agar is a representative algae-derived polysaccharide widely used for food additives, pharmaceuticals, cosmetics, livestock feed, and industrial materials for a long time and is one of the relatively abundant fisheries resources of which domestic production is about 3,600 tons per year. **However, in actual use, only a**

part of the total production is processed by simple processing and used as cheap raw materials, and the rest of the production is neglected. Therefore, there is a great demand for research on the development of new uses and the added value of abundant domestic agar.

2) *US2011021457A1 (=EP2459200A1) (PHARMACEUTICAL COMPOSITIONS COMPRISING MODIFIED FUCANS FOR USE IN THE TREATMENT OF FIBROUS ADHESIONS AND OTHER DISORDERS) ARC MEDICAL DEVICES* (ARC Medical Devices Inc. |)

Compositions comprising fucan agents and the use of said compositions in the **treatment, prevention, inhibition etc, of fibrous adhesions**, peritonitis, ischemia, reperfusion injunry, endotoxemia, keloids and keloid trait scarring, dermatitis and rosacea. The preferred fucan agents are characterized by their molecular weight distribution. **A variety of fibrous adhesions are discussed in this document. Terms such as surgical adhesions, post-surgical adhesions, postoperative adhesions**, adhesions due to pelvic inflammatory disease, adhesions due to mechanical injury, adhesions due to radiation, adhesions due to radiation treatment, adhesions due to trauma, and adhesions due to presence of foreign material all refer to adherence of tissues to each other due to a similar mechanism and are all included in the term fibrous adhesions.

Fucans (including fucoidan and modified fucans) **are high molecular weight sulphated polysaccharides extracted from brown seaweeds**, Percival, E., and McDowell, R. H., Chemistry and Enzymology of Marine Algal Polysaccharides, pp. 157-175 (Academic Press, New York, 1967), and as is well known can be found **from other sources** such as in the taxonomic families of **Fucales** and **Laminariaceae**, or from **other marine algae and seaweeds and echinoderms, sea cucumbers, sea urchins** or other sources as desired including synthetic sources.

Other patents with relatively long residual validity are owned by Fermentalg and Biotechmarine.

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Another fully developed sector related to the blue biotechnologies is the **nutraceutical industry** based on the exploitation of marine organisms. 2489 patent applications have been filed from 2000 to 2020, with USA, South Korea and Japan national patent office being addressees of the highest number of patent applications. In the European countries, the nutraceutical industry is well developed across the region, most patent applications being filed to the German, French and Spanish patent authorities between 2000 and 2020.

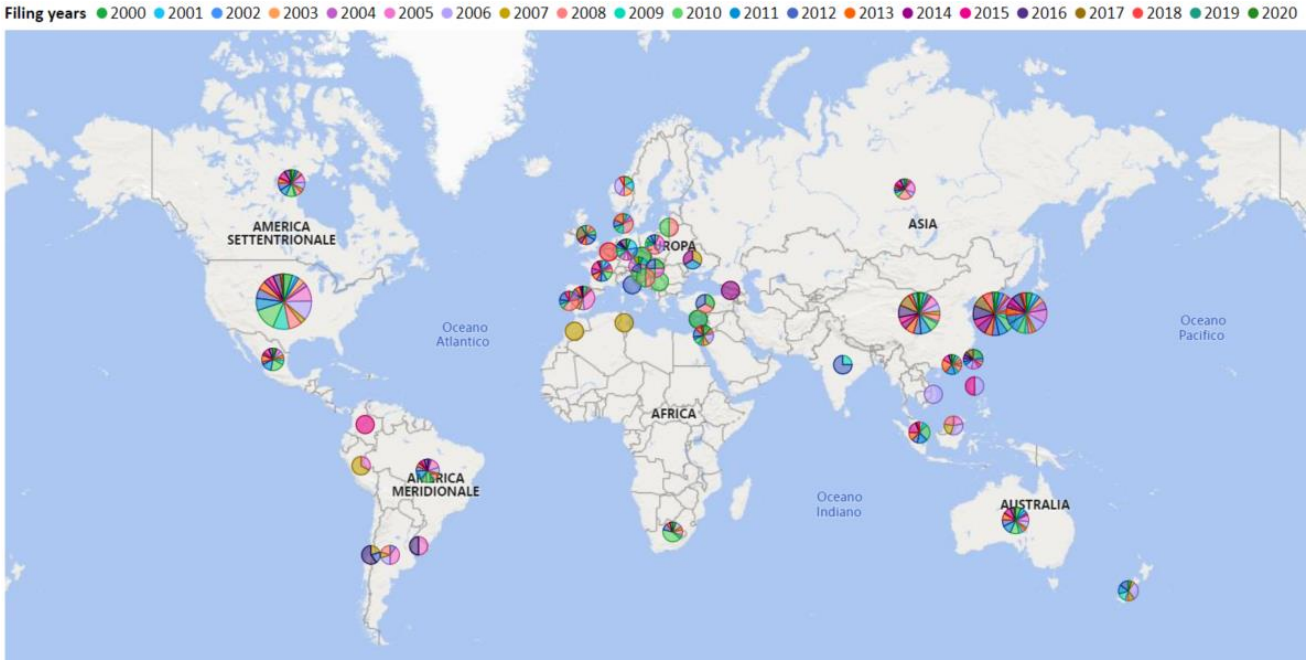

Figure 28.The number of filing events partitioned between 2000 and 2020 (EP and PCT not included)

The number of patent applications filed to the EPO is almost equivalent to the number of applications filed to the WIPO. The data taken altogether indicate that the technical innovations involving the use of marine biomass in the nutraceutical sector are considered of utmost importance not only in Europe but also in a relevant number of extra-european countries.

Table 13. Number of filing events registered at the European Patent Office (EPO) and at the World Intellectual Property Organization (WIPO) from 2000 to 2020.

Supranational authorities	
EPO	224
WIPO	252

The players who own the highest number of patent families are U.S. Nutraceuticals LLC DBA Valensa International (US) and Jeju National University (KR), while players headquartered in Europe are not significantly represented.

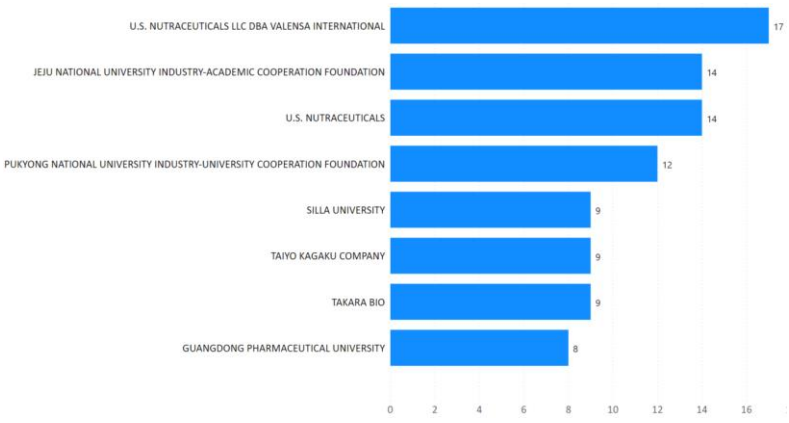

Figure 29. Patent families' number per assignee

Upon considering the legal status of patent applications, it turns out that Heliae Development LLC (US) and Nutricia Group (NL) are owing the highest number of granted patents.

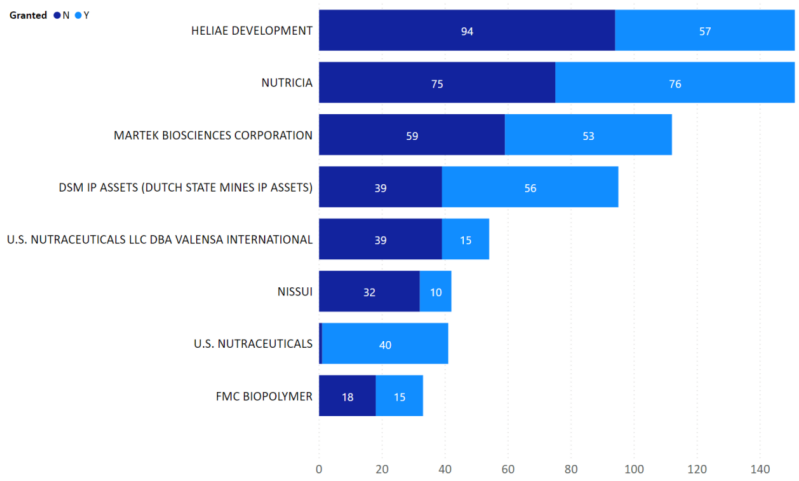

Figure 30. The legal status of the patent applications

Case Histories: Nutraceutics

1) *EP3082459B1 (GRANULES OF PROTEIN-RICH MICROALGAL BIOMASS FLOUR AND METHOD FOR PREPARING SAME) CORBION BIOTECH* (Corbion)

The present invention thus relates **to the microalgal biomass suitable (or appropriate) for human consumption which is rich in nutrients, in particular in proteins**. The invention relates to a protein-rich microalgal biomass flour which can be incorporated into food products **in which the protein content of the microalgal flour can totally or partially replace the proteins present in conventional food products**. The microalgal biomass flour also provides other benefits, for instance micronutrients, dietary fibers (soluble and insoluble carbohydrates), triglycerides, phospholipids, glycoproteins, phytosterols, tocopherols, tocotrienols, and selenium. **For the purposes of the invention, the microalgae under consideration are the species which produce proteins at highly rich levels**. The **applicant company recommends selecting protein-rich microalgae of the Chlorella genus**.

2) *FR3045069A1 (= WO2017103421A1) (METHOD FOR ENRICHING PROTISTS WITH LIPIDS RICH IN POLYUNSATURATED FATTY ACIDS, MORE PARTICULARLY OF THE OMEGA 3 CLASS, AND IMPLEMENTATION OF SAME FOR THE PRODUCTION OF SAID LIPIDS) METABOLIUM* (Metabolium : Compléments alimentaires innovants, 100% naturels)

The invention relates to **a method for enriching protists, preferably microalgae, with lipids rich in polyunsaturated fatty acids, in particular of the omega 3 (ω3) class**, said method comprising the culture of protists in a culture medium comprising at least one selenium-containing compound, and to the enriched protists thus obtained, as well as to a method for producing lipids rich in polyunsaturated fatty acids, in particular of the ω3 class, implementing the enrichment method according to the invention.

In humans, PUFAs play an essential role in the development and optimal functioning of the brain, the heart and many other organs and tissues […]. Thus, **the market for PUFAs of the ω3 class exceeded 2 billion dollars in 2014**. According to the market study «Omega -3 PUFA Market by Type (DHA, EPA, ALA), Source [Marine (Fish, Algal, Krill, Others), Plant (Flaxseed, Chia Seed, Others)], Application (Dietary supplement, Functional F&B, Pharma, Infant

Formula, Others) & Geography—Global Trend & Forecast to 2019», **this market would exceed 4 billion dollars in 2019**. Certain foods are naturally rich in them, such as oily fish (herrings, sardines, mackerels etc.) and certain vegetable oils (rape seed, nut, soyabean etc.). However, **although fish oils currently represent the main industrial source of PUFAs, they can no longer continue to cope with the increase in demand**, in particular for DHA. In fact, the sustained demand for high-quality fish oils should be seen in the context of over-fishing, leading to the introduction of increasingly strict regulations on fishing, and a reduction in the overall production of fish oil. **The production of fish oils also poses problems of refining, in particular due to the unpleasant taste and smell of these fish oils, their poor oxidative stability and their content of cholesterol and toxic products**. Therefore, their use has been limited, in particular in the food supplement market.

3) *EP3292197A1 (METHOD FOR OBTAINING A BIOMASS OF A MICROALGA OF THE SPECIES TETRASELMIS CHUII ENRICHED IN SUPEROXIDE DISMUTASE (SOD)) FITOPLANCTON MARINO SL* (Fitoplancton Marino - Home)

The invention relates to a method for enriching a biomass of a microalga of the species Tetraselmis chuii in superoxide dismutase (SOD) by placing said microalga under abiotic stress conditions. The invention also relates to a biomass enriched in SOD as well as to an extract of the microalga and to the uses thereof as a pharmaceutical composition, as a cosmetic or in foodstuff.

Microbial and animal enzymes were once the primary choice of industry, offering economic, functional products of acceptable quality. However, due to negative media attention associated with microbial and animal derived products, consumers are demanding an alternative, Today's food and cosmetic chemists are faced with the challenge to replace traditional animal derived enzymes with others that offer the same functionality but are derived from natural "green" sources (e.g., algae). Microalgae diversity promises to provide new and diverse enzymes and biocatalysts and has the potential to make industrial biotechnology an economic, sustainable success. So far, only a few enzymes have been isolated and characterized from marine phytoplankton. Research has demonstrated the presence of unique haloperoxidases (e.g., vanadium bromoperoxidase with a high degree of stability to thermal and organic solvent denaturation) in algae.

Due to the positive consumer opinion on enzymes, efforts are made to find new areas of application in food and cosmetic products (such as functional foods, nutricosmetics, enzymes in skin protection).

Patent datasets' features

Cosmetics: analysis of **833 non-duplicated patent families** corresponding to **2778 patent applications**. No limitation is assumed concerning the applications' filing timeframe.

Pharmaceutics: analysis of **191 non-duplicated patent families** corresponding to **433 patent applications**. No limitation is assumed concerning the applications' filing timeframe.

Nutraceuticals: analysis of **654 non-duplicated patent families** corresponding to **2623 patent applications**. No limitation is assumed concerning the applications' filing timeframe.

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Agriculture, Livestock and Food processing

The "Agriculture, Livestock and Food processing" focuses on soil fertilisation.

Market overview

In addition to the applications previously analysed, the **blue biotechnology sector** might have a relevant impact also on the improvement of **animal feed** (nourishment, food supplements), **veterinary products** (antibiotics, antiseptics, and vaccines) and **agricultural products** (biofertilizers). Several factors are positively affecting the growth of these sectors such as:

- the increasing demand of natural products aimed at reducing the use of synthetic pesticides and antibiotics,
- the search for natural animal food with high nutritional value,
- the need to increase plant and animal health reducing the environmental impacts,
- the rising need of reducing the presence of allergens in the food.

The high diversity of **marine microorganisms** and their ability to withstand extreme conditions are evidencing several opportunities for the discovery and further development of peculiar compounds applicable both to the Agriculture and the Livestock sectors [1].

Agriculture is one of the major sources of environmental pollution especially due to the runoff of synthetic fertilizers. For this reason, the use of new and less environmentally harmful fertilizers obtained from marine organisms such as algae, seaweeds, and fish derivates is needed to reduce the long-term alteration in the acid-base balance (pH), osmotic pressure, conductivity and improve the water holding capacity and fertility of the soil.

The blue biotechnology emerging sectors are currently focusing on **agrochemicals,** such as **biofertilizers** and **biostimulants**, created with the purpose of protecting crops from diseases without harming the surrounding environment. The global market of **Biofertilizers** is estimated to reach a value of USD 173 million in 2024, with a projected CAGR of 9.1% from 2019 to 2024. The European region is currently the second-largest revenue-generating market for agrochemicals, with a substantial increase in the market's growth in Italy in the last years.

The intensive research in the **biostimulants' sector** and **plant nutritional products** has increased the awareness about the benefits that can be ascribed to the application of the seaweed extracts in agriculture. Currently, extracts from marine algae are used in the agriculture industry and commercially exploited as **seaweed extracts**. The most widely used seaweeds for agricultural purposes are related to the group of red algae. Seaweed extracts act as biostimulants mainly due to the presence of **plant hormones**. Hormones usually present in seaweed extracts are auxins, cytokinins, gibberellins, abscisic acid, and ethylene. Moreover, **seaweed extracts** enhance soil fertility and increase crop productivity under various environmental stress conditions. The application of seaweed extracts improves soil structure and aeration, increases biotic and abiotic stress tolerance, enhances seed germination, and stimulates root growth, flower set, and fruit production.

The global **biostimulants** market is currently dominated by **Europe**, in terms of value, due to the adoption of modern agricultural technologies such as precision farming, plant biotechnology and organic – based active ingredients.

Another new application for marine biomass is **animal therapeutics**, involving the production of vaccines, anti-infectives and antifungals, and food supplements [2]. The global market for **veterinary products** is expected to reach the value of USD 66.5 billion by 2024, with pharmaceutical products leading the sector followed by feed additives, vaccines and diagnostics' products. Animal food supplement, defined as an ingredient or a combination of ingredients added to the basic feed mix, is characterized by a stable market trend with a global projected value of USD 23,295 million in 2024, and an estimated CAGR of 5.0 % from 2019 to 2024. The **European region** represents at the moment the second-largest market, with France the country leader of this sector in the region [3].

Legal protection of technical solutions

Technical innovations concerning **soil fertilisers** based on fish derivatives appear susceptible of commercial exploitation in the Asian Pacific region, especially in China because the highest number of patent applications (512) are filed to the CNIPA/SIPO. When considering specific European countries only few patent applications have been filed during the timeframe 2011 - 2020, respectively to the UK, Germany, and France national patent authorities. However, as already pointed out, these small numbers do not account for the possibility of nationalization procedures following the filing of EP/PCT applications.

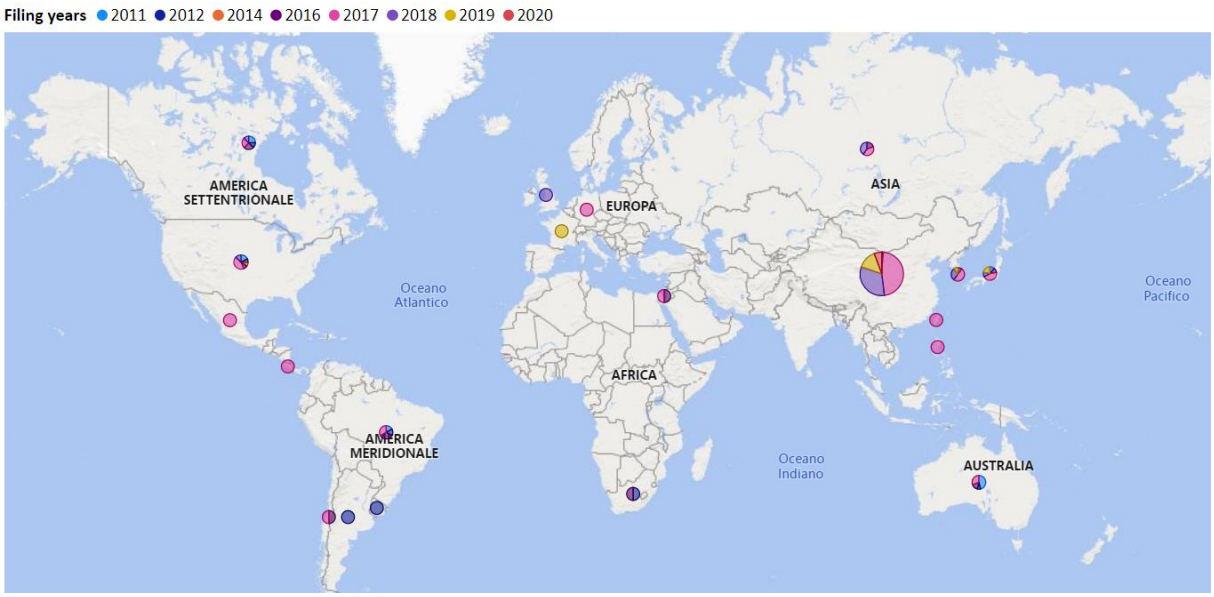

Figure 31. The number of filing events partitioned according to the earliest filing year (EP and PCT not included)

Nevertheless, the small number of patent applications filed to the EPO suggests that scarce importance is dedicated to soil fertilizers based on marine biomass as far as the commercialization opportunities in Europe are concerned.

Table 14. Number of filing events registered at the European Patent Office (EPO) and at the World Intellectual Property Organization (WIPO) from 2011 to 2020

Supranational authorities	
EPO	8
WIPO	17

When the players are ranked upon evaluation of the patent families owned, the Chinese Academy of Science (CN) and Xuancheng Yunxiang Network Technology (CN) appear as leaders.

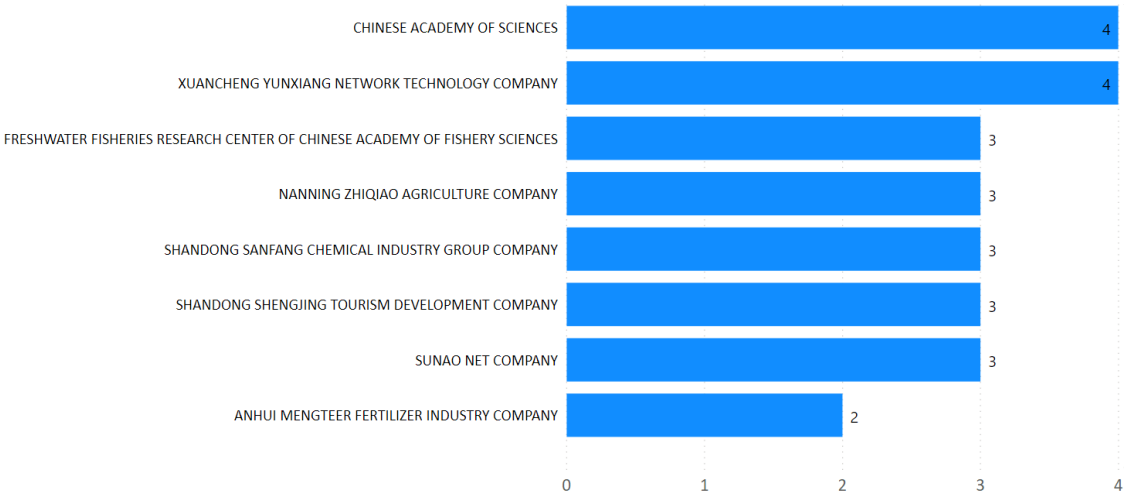

Figure 32. Patent families' number per assignee

The Nippon Steel Corporation (JP) is the company that owns the highest number of granted patents.

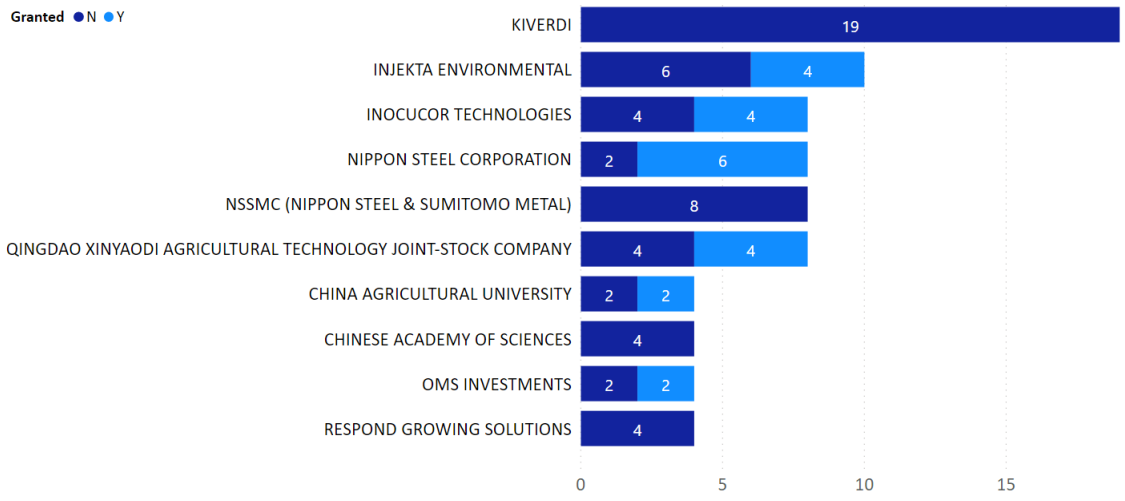

Figure 33. The legal status of the patent applications

Case Histories: Soil fertilisers

1) *EP2663635A2 (MICROBIAL COMPOSITIONS AND METHODS) INOCUCOR (*Inocucor - Cycle Capital Management)

The present invention comprises compositions and methods for enhancing biological processes, such as plant growth or bioremediation. For example, the present invention comprises compositions and methods for effectively remediating chemical and organic wastes and reducing the environmental risk from manure, septic, sewage, oil pollution, and other contaminants. The present invention comprises compositions and methods comprising microbial organisms, which may be used in methods including but not limited to, bioremediation and development and maintenance of healthy ecosystems. Compositions may comprise a mixture of microorganisms, comprising bacteria, fungi, algae, and/or other indigenous or exogenous microorganisms, all of which form a micro ecosystem with roles for its members.

2) *WO2019135641A1 (FERTILIZER USING FISHES AND WILD ANIMAL AND MANUFACTURING METHOD THEREOF) HAN Shin Chul*

The present invention relates to a fertilizer using fishes and wild animals and a manufacturing method thereof. The present invention may contribute to environmental protection by mixing fishes and/or wild animals with cornstalks and rice bran to effectively transform the same into fertilizer, and the manufactured fertilizer, as substitute fertilizer, may be of great help for farmers to cultivate environmental-friendly crops without the side effect of acidifying soil from the use of chemical fertilizers. In addition, since the entire production process of the fertilizer is performed only with water-soluble substances, the present invention has an advantage in that the fertilizer is absorbed immediately and used when applied to crops.

In many patent applications the use of fish meal or fish bone meal is quoted.

Patent datasets' features

Soil fertilization: analysis of **530 non-duplicated patent families** corresponding to **631 patent applications**. No limitation is assumed concerning the applications' filing timeframe.

Bibliography

[1] Francocci F., Paifelman E., Ciappi E., Cedre A., Le Corff C., Ruel C., Efstratiou C., Falini G., Giannakourou A., Solano-Lopez J.M., Strogyloudi E., Raddadi N., Pistocchi R., Valentini S. and Barbanti A., 2019. MISTRAL Blue Growth Book. State of the art assessment and overview on the most relevant drivers and opportunities in the Mediterranean Blue Economy. MISTRAL project, Deliverable D3.1.2; DOI 10.5281/zenodo.3242281

[2] MarketsandMarkets Knowledge Store (https://www.mnmks.com/) reports "Agrochemicals Market - Global Forecast to 2025", March 2021 and "Biostimulants Market – Global Forecast to 2025", April 2019.

[3] BCC Research (https://www.bccresearch.com/) report "Global Markets for Animal Therapeutics and Diagnostics", March 2020.

Industrial Processes and Manufacturing

The "Industrial Processes and Manufacturing" focuses on the sea organisms genetics.

Market overview

The **blue biotechnology field** comprises several **industrial processes and manufacturing procedures.** These processes may significantly rely on the optimized use of **enzymes**, for example aimed at the generation of end-products such as detergents, pulp and paper and textiles. Other processes can include the fermentation of the **biomass** rather than being obtained following the traditional chemical synthesis. Moreover, the improvement of genetic features of certain organisms might positively impact on the valorisation of materials recovered with the aim of producing innovative **biopolymers** and **biomaterials**. Examples may concern the recycling mollusc's shell wastes for civil construction materials improving the integrate waste management scheme. Likewise, the re-use of the organic fraction obtained from fish or by-catch products for the biopolymer production highlights other advantageous features for the biotechnological processes [1].

The use of **enzymes** in the industrial and manufacturing processes has several positive implications, such as the higher product quality, the lower manufacturing cost, the less waste production, and a reduced energy consumption. Hence, the use of enzymes to replace the traditional chemical processes and to obtain more sustainable solutions, is currently increasing globally.

The **global industrial enzymes market** is expected to reach the value of USD 7.0 billion by 2023, growing at a CAGR of 4.9% in the forecast period 2018 – 2023 [2]. The most common sources of industrial enzymes are **microbes** which can provide a broad chemical diversity combined with the feasibility of large-scale production and a low price point.

Microbic organisms are also involved in the **manufacturing sector**, especially for the production of baked and fermented foods, industrial enzymes, commodity and specialty chemicals, and biopolymers. Manufacturing is one of the major segments among the market of microbial products, following the healthcare and the energy sectors, with a global projection to reach the value of USD 60.3 billion in 2023, at a CAGR of 16.3% between 2018 and 2023 [3].

In recent years several implementations of technologies based on the **genomes' information** applied to the exploitation of the marine resources have been developed. The market segment for these applications is expected to reach the value of USD 703.3 million in **Europe** in 2025, starting from the value of USD 523.6 million in 2020, with an estimated CAGR of 6.1% in the period 2020 – 2025. Among the **Mediterranean area** France, Greece, Italy and Spain are the regions in which the genomics market opportunities are highly considered.

Researchers are currently using sequencing (especially *Next – Generation Sequencing* (NGS)) and gene expression analysis in applications such as nucleotide polymorphism and copy number variant detection in marine organisms used as feedstock crop for biofuel production (e.g., Switchgrass (*Panicum virgatum*)). NGS technology is also used for **DNA barcoding** to identify **fish larvae and eggs** and provide the complete description of a defined fish population in the marine environment. Genomics technologies are also used in **aquaculture** and **fisheries**. Genomics in aquaculture helps in enhancing productivity, improving the fish health, preserving the fish populations, and maintaining ecosystem integrity. However, the use of genomics in this application segment is still in the nascent stage [4].

Legal protection of technical solutions

Technical innovations focused on the use of **genomic technology** in the marine research are in their early stage of development with a total of 296 filing events from the beginning of the century. 143 patent applications have been filed to the Chinese patent office. In Europe and especially in countries bordering the Mediterranean Sea, the legal protection based on IPRs is poorly considered since only 3 patent applications have been filed to the Spanish patent office. Even if such small numbers do not contemplate the possibility of nationalization procedures following the filing of EP/PCT applications, the number of patent applications filed following these two harmonised procedures is small too, only in part indicating that the applicants seem more interested in protecting their invention globally rather than at the European level.

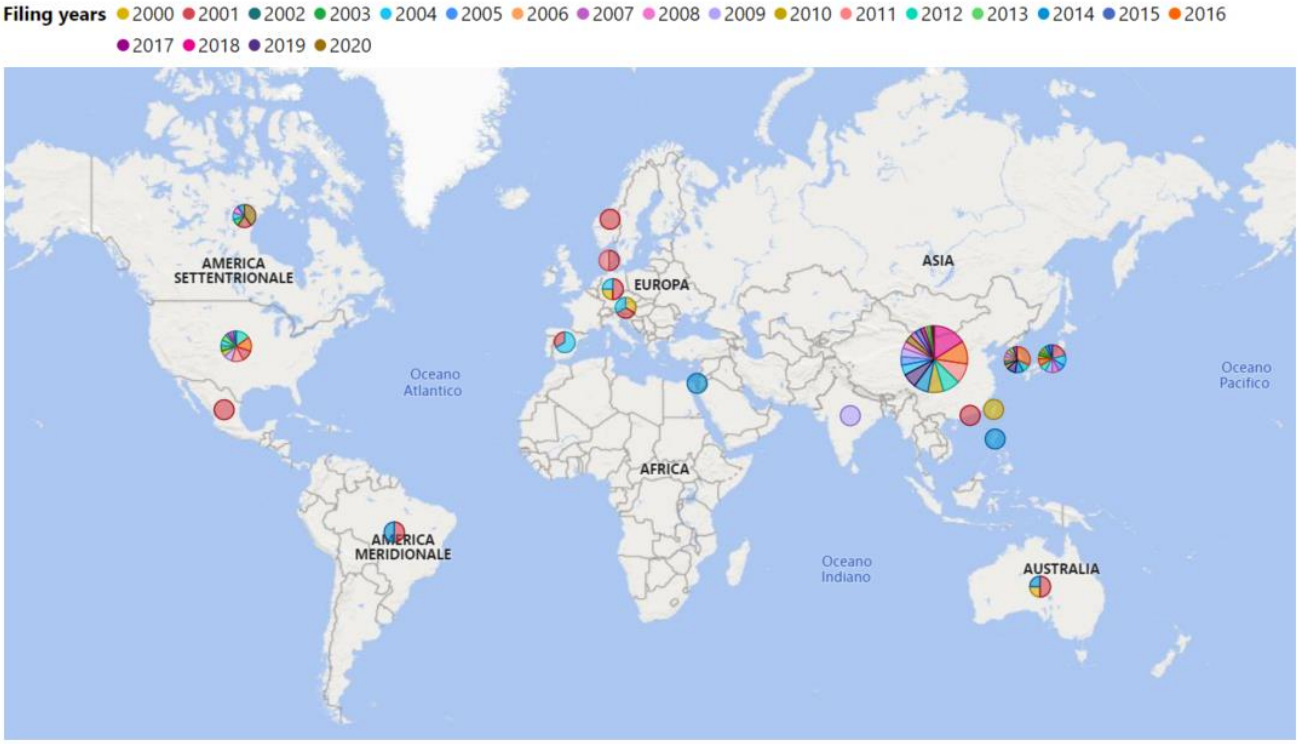

Figure 34. The number of filing events partitioned from 2000 to 2019 (EP and PCT not included)

Table 15. Number of filing events registered at the European Patent Office (EPO) and at the World Intellectual Property Organization (WIPO) from 2000 to 2020

Supranational authorities	
EPO	14
WIPO	28

The main players in the sector are Chinese Academy of Science and Ocean University of China both headquartered in China. The former owns 18 patent families, while the latter 12.

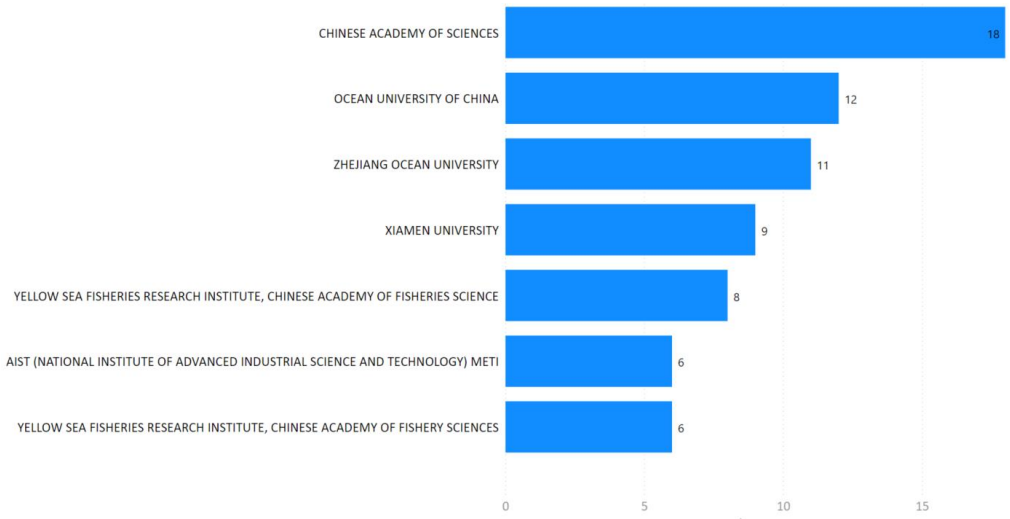

Figure 35. Patent families' number per assignee

Upon considering the number of granted patents, it turns out that Dupont Nutrition Biosciences (DK) owns the highest number of granted patents (14). The Chinese Academy of Science (CN) follows with 11 granted patents.

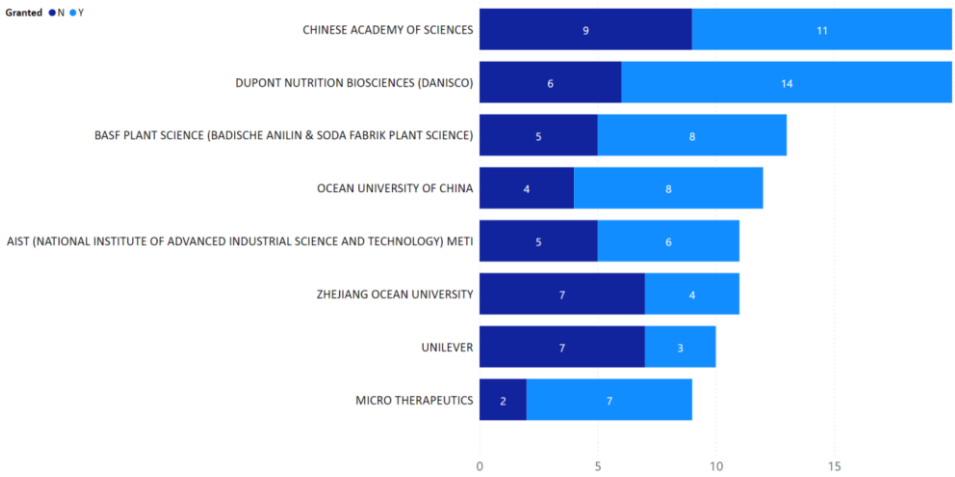

Figure 36. The legal status of the patent applications

Case Histories: Genomic Technology

1) *EP2913499A1 (SYSTEMS AND METHODS FOR IMPROVED COMBINED CYCLE CONTROL) GENERAL ELECTRIC COMPANY (*GE.com | Building a world that works | General Electric)

The present invention relates to establishment of a series of artificial luciferases based on artificial amino acid sequences extracted by **amino acid alignment of copepod-derived luciferase sequences in a database based on amino acid similarity**. The group of **ALucs has superior luminescence characteristics**, such as an increase in **luminescence intensity**, an increase in **luminescence stability**, or an increase in **wavelength of the luminescence** spectrum, **which were not obtained before**. Further, by using the artificial luciferases (ALuc) of the present invention, **it is possible to provide a novel, superior bioassay system, such as a bioluminescent probe, two-hybrid assay, a luminescent capsule, or the like having improved measurement** function.

2) *EP2889307A1 (ALPHA-CONOTOXIN PEPTIDE, AND MEDICAL COMPOSITION AND PURPOSE THEREOF) HAINAN UNIVERSITY* (Hainan University)

The present invention provides a novel ±-conotoxin peptide, pharmaceutical composition and use thereof. The present invention further provides a propeptide of the conotoxin peptide, **a nucleic acid construct, expression vector and transformed cell of the conotoxin peptide as well as a fused protein of the conotoxin peptide**.

The present invention discloses a method for blocking acetylcholine receptors as well as a use of the conotoxin peptide in the manufacture of a medicament. **The ±-conotoxin peptide of the present invention can specifically block acetylcholine receptor has activity for treatment of neuralgia, addiction, Parkinson's disease, dementia, schizophrenia, cancers, and can be used in the manufacture of a medicament for analgesia and smoking cessation and drug-withdrawal, a medicament for treatment of mental diseases and cancers, as well as a tool drug for neurosciences**.

3) *US2016244787A1 (PRODUCTION OF FATTY ALCOHOLS FROM ENGINEERED MICROORGANISMS)* CODEXIS Inc. (Enabling the promise of synthetic biology | Codexis)

The invention provides a fatty alcohol composition comprising the fatty alcohols produced according to any one of the aspects above wherein the fatty alcohol composition is used in a detergent composition, a personal care composition or a cleaning composition.

The terms "cleaning compositions" and "cleaning formulations" refer to compositions that find use in the removal of undesired compounds from items to be cleaning, such as fabric, dishes, contact lenses, other solid substrates, hair (shampoos), skin (soaps and creams), teeth (mouthwashes, toothpastes, etc.), etc. The terms further refer to any composition that is suited for cleaning, bleaching, disinfecting and/or sterilizing any object and/or surface. **The fatty alcohol forming acyl-CoA reductases (FARs) useful in the present invention catalyze the direct reduction of acyl-CoA and/or acyl-ACP substrates to fatty alcohols** wherein free fatty aldehydes are essentially not released as an intermediate.

In some embodiments, the **FAR is a prokaryotic enzyme**. In some embodiments the FAR is **derived from a species of Marinobacter including, but not limited to,** M. algicola, M. alkaliphilus, M. aquaeolei, M. arcticus, M. bryozoorum, M. daepoensis, M. excellens, M. flavimaris, M. guadonensis, M. hydrocarbonoclasticus, M. koreenis, M. lipolyticus, M. litoralis, M. lutaoensis, M. maritimus, M. sediminum, M. squalenivirans, and M. vinifirmus**, and equivalent and synonymous species thereof**.

Patent datasets' features

Sea organisms' genetics: analysis of **203 non-duplicated patent families** corresponding to **364 patent applications**. No limitation is assumed concerning the applications' filing timeframe.

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[1] Francocci F., Paifelman E., Ciappi E., Cedre A., Le Corff C., Ruel C., Efstratiou C., Falini G., Giannakourou A., Solano-Lopez J.M., Strogyloudi E., Raddadi N., Pistocchi R., Valentini S. and Barbanti A., 2019. MISTRAL Blue Growth Book. State of the art assessment and overview on the most relevant drivers and opportunities in the Mediterranean Blue Economy. MISTRAL project, Deliverable D3.1.2; DOI 10.5281/zenodo.3242281

[2] BCC Research (https://www.bccresearch.com/) report "Global Markets for Enzymes in Industrial Applications", September 2018;

[3] BCC Research (https://www.bccresearch.com/) report "Microbial Products: Technologies, Applications and Global Markets", August 2018;

[4] MarketsandMarkets Knowledge Store (https://www.mnmks.com/) report "Genomics Market - Global Forecast to 2025", January 2021.

Biofuels

Market overview

Biofuels include solid, liquid, or gaseous matters derived from recently dead biological materials. This type of fuel is different from fossil fuels since in the latter case the source is long dead biological materials. In the last century, the adverse impacts caused by the extensive consumption of traditional fossil fuels, such as Greenhouse Gases (GHGs) emission, has led to an increment in the production of biofuels. This increase is driven by several factors such as the growing number of projects and initiatives focusing on the improvement of these products and by the rising interest of the exploitation of renewable energy sources. The European Commission promotes the use of biofuels and bioenergy to accomplish various climate and energy targets, such as the 20% reduction of the GHGs emission, increasing the energy consumption from renewable sources, and promoting the research and innovation focused of new environmentally friendly biofuels [1].

Considering the **Blue biotechnology sector**, the main source of biofuels among marine organisms are **algae**. Biofuels obtained from algae are usually defined as third-generation biofuels [2]. Algae are considered attractive feedstocks with many advantages over terrestrial crops. Algae biomass lacks the recalcitrant lignocellulosic components, therefore it can be converted to fuels more easily than lignocellulosic feedstocks. Moreover, algae have a higher oil content compared to farmland crops which can yield 90.000 litres per hectare compared to soybean which can produce about 450 litres of oil per hectare. Also, algae are photosynthetic eukaryotes characterized by high growth rate and high population densities, thus implying rapid accumulation of feedstock. Finally, they can be used to develop a wide range of biofuels such as diesel, petrol, and jet fuel. **Macroalgae** can be transformed into biomethane, bioethanol and biobutanol through fermentative processes due to their lower concentration of lipids/oils. Microalgae can be rather processed to obtain biodiesel, biomethane, bioethanol, bio-oil (or bio-crude) and bio-hydrogen obtained through fermentation or thermochemical processes thanks to the higher lipids' accumulation capacity of the microalgae [1]. The algae currently under study for their suitability as a mass-oil producing crop include mainly the **aquatic unicellular green algae** (Chlorophyceae; including *Nannochloris sp*., a member of the class Chlorophyceae), Diatom algae (Bacilliarophyta), algae member of the class Haptophyta and others (e.g., *Botryococcus braunii*, *Dunaliella tertiolecta*, *Euglena gracilis*, *Isochrysis galbana*, *Phaeodactylum tricornutum*, *Prymnesium parvum*, *Spirulina* sp *and Tetraselmis chui*).

The **global market for liquid biofuels** is constantly increasing and is forecast to grow at a CAGR of 2.5% to USD 153.8 billion in 2024, with most of the growth coming from biodiesel and advanced biofuels such as cellulosic ethanol. In fact, biodiesel market has a projected value of USD 78,646 million in 2024 at a 3.2% CAGR evaluated in the timeframe 2019 - 2024. Globally, the greatest market growth will be registered in the EU member states whereas the Asian-Pacific, South America, Africa, and Middle East regions will not see significant growth due to the lack of investment.

At the **European level**, the **total production of biofuels** is expected to reach USD 32,987 million litres in 2024. Limiting the forecast to the **biodiesel**, the market is expected to increase to USD 26.7 billion in 2024, being the CAGR 7.6% in the timeframe 2019 - 2024. In the **Mediterranean Area** the main consumers are Spain, France and Italy [2].

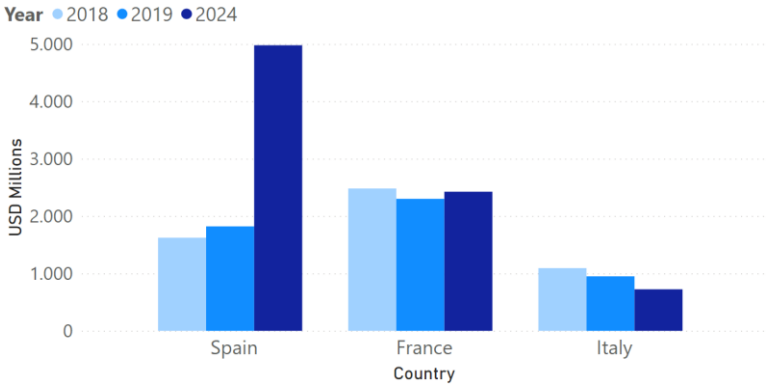

Figure 37. Biodiesel Consumption Market Value in the Mediterranean Area, by Country, Through 2024 (USD Millions)

Legal protection of technical solutions

The highest numbers of patent applications concerning technical innovations linked to the **biofuels' sector** concern the applications filed to the United States Patent and Trademark Office and to the Chinese patent authority, respectively. In the European region, the national patent authority scoring the highest number of patent applications in the biofuels industry is the Spanish patent office, followed by the authorities of Denmark and France. The numbers of applications filed to each of the three authorities are 14, 4 and 3, respectively. Such small numbers do not contemplate the possibility of nationalization procedures following the filing of EP/PCT applications.

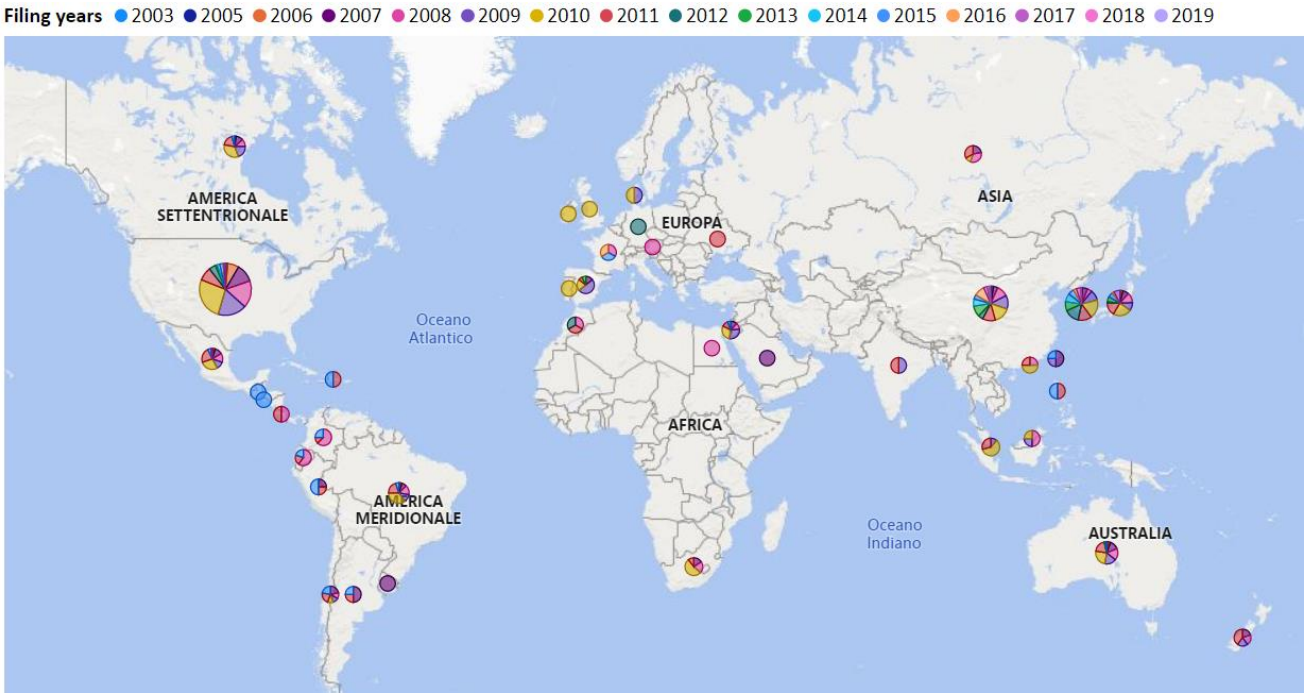

Figure 38.The number of filing events partitioned according to the earliest filing year (EP and PCT not included)

As a matter of fact, the number of patent applications filed to the EPO is quite consistent, thus suggesting that the players might consider the whole European region valuable for exploiting the technologies implying the transformation of the marine biomass into biofuel.

Table 16. Number of filing events registered at the European Patent Office (EPO) and at the World Intellectual Property Organization (WIPO) from 2003 to 2019

Supranational authorities	
EPO	79
WIPO	140

Among the players ranked according to the highest number of patent families owned, Heliae Development (US) and KRIBB- Korea Research Institute of Bioscience and Biotechnology (KR) score the highest number of patent families.

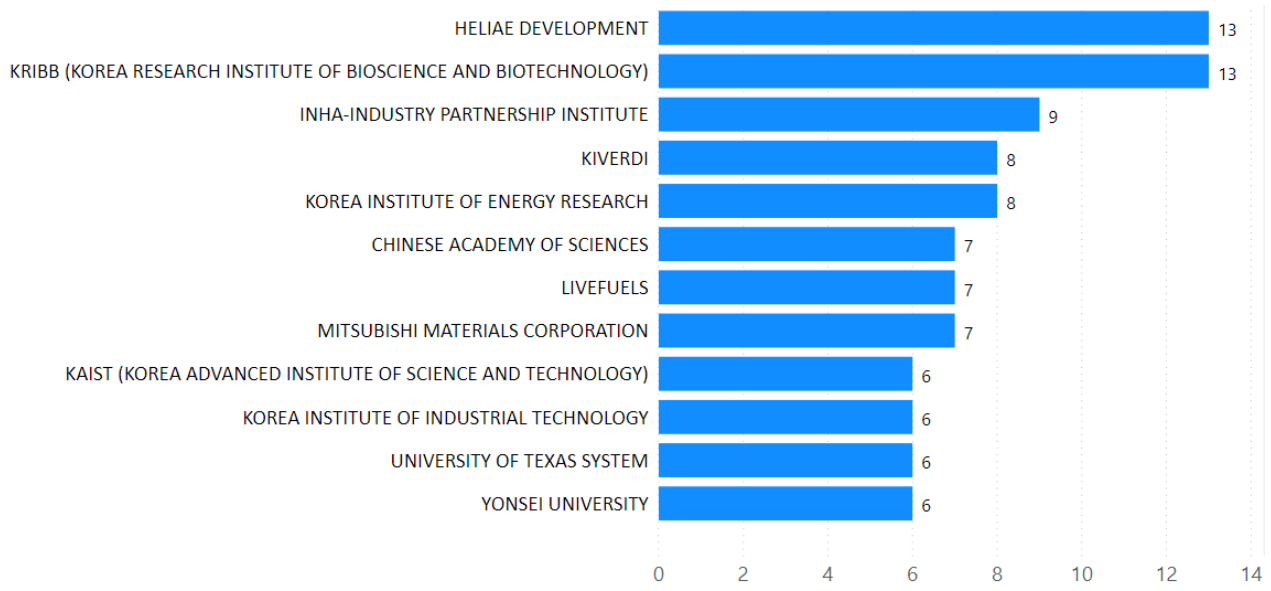

Figure 39. Patent families' number per assignee

Heliae Development (US) owns the highest number of granted patents (66), being followed by Biogenic Innovation (22 granted patents).

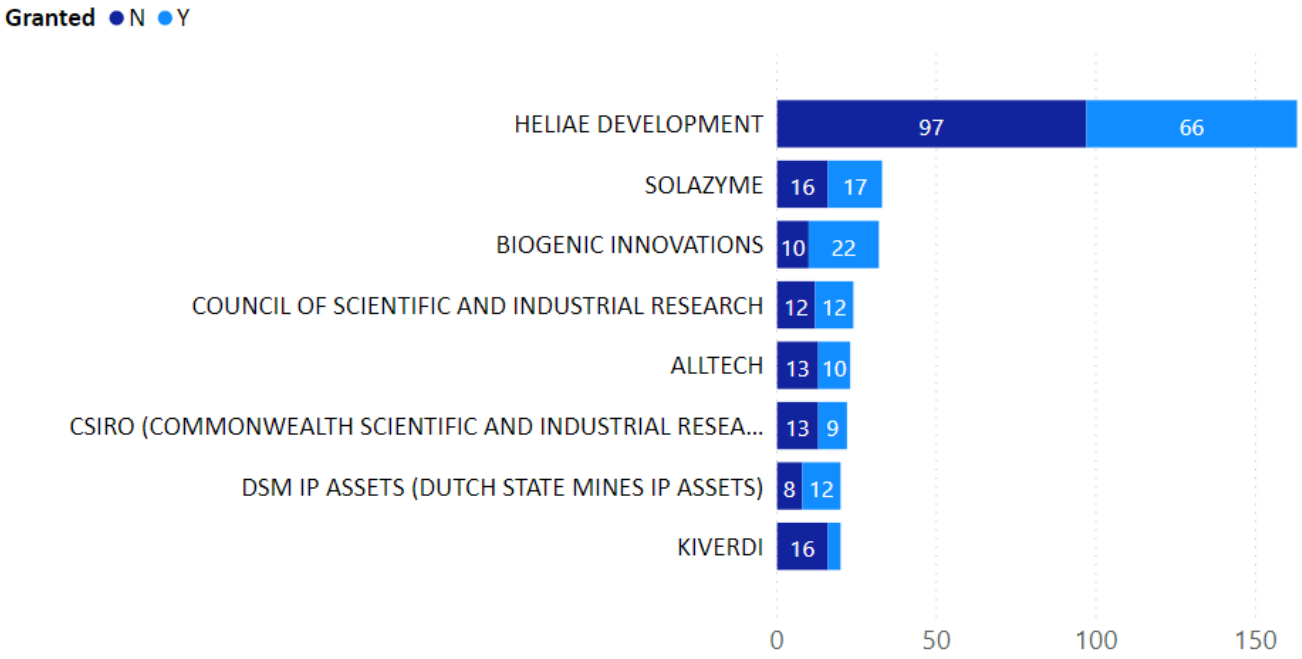

Figure 40.The legal status of the patent applications

Case Histories: Biofuels

1) *WO2018091836A1 (ALPHA-1,3-(3,6-ANHYDRO)-D-GALACTOSIDASES AND THE USE OF SAME FOR HYDROLYSING POLYSACCHARIDES) CENTRE NAT RECH SCIENT* (Centre national de la recherche scientifique (cnrs.fr)), *UNIV PARIS CURIE*

The present invention relates to the isolation, purification and characterization of a novel polypeptide having α-1, 3- (3,6-anhydro) - D-galactosidase activity, and its uses. The present invention finds applications, for example, in the cosmetics, agrifood, pharmaceutical or **biofuels fields** […]. There is therefore a need for enzymes capable of catalyzing the hydrolysis of the α-1, 3 bond in carrageenans.

These enzymes would be essential for several applications: (i) for carrying out the complete hydrolysis of carrageenans and therefore opening the way towards their saccharification and the possible production of bioethanol from red carrageenophytic algae; (ii) to produce pure 3,6-anhydro-D-galactose. Like any monosaccharide, it could have multiple applications, in particular to serve as new building blocks in chemistry; (iii) to obtain new oligosaccharide agents which can be used in the agro-food, cosmetic and / or pharmaceutical industry. It is important to note that the gene could also be directly used through a synthetic biology approach, as has been done for the production of **bioethanol from brown algae**.

2) *EP3199620A1 (USE OF NITRIC OXIDE OR NITRIC OXIDE DONOR FOR INDUCING THE PRODUCTION OF TRIACYLGLYCEROLS IN MICROALGAE) COMMISSARIAT À L'ÉNERGIE ATOMIQUE ET AUX ÉNERGIES ALTERNATIVES* (CEA - Accueil - De la recherche à l'industrie), *CENTRE NAT RECH SCIENT* (Centre national de la recherche scientifique (cnrs.fr))

The invention relates to a method for accumulating triacylglycerols (TAG) in microalgae by adding a nitric oxide donor to the growth medium. The invention also relates to a method for producing fatty acids, biofuels, pharmaceutical or cosmetic compositions, and also food supplements, comprising a triacylglycerols

accumulation step in microalgae according to the invention. Finally, the invention relates to the use of a nitric oxide donor to accumulate triglycerides in microalgae.

Patent dataset features

Biofuels: analysis of **364 non-duplicated patent families** corresponding to **1219 patent applications**. No limitation is assumed concerning the applications' filing timeframe.

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Bio-monitoring and Bio-remediation

Market overview

The blue biotechnology for **bio-monitoring** and **bio-remediation** involve the application of marine organisms to track, determine, quantify and remove contaminants and pollutants released in the marine ecosystems. The use of marine organisms for monitoring and remediation purposes presents several advantages, such as the use of native organisms to gain information concerning the marine environment status and the possibility of providing information helpful to protect coastal activities or the resources upon which marine-related economic and social activities depend. Moreover, the use of marine microorganisms and their derived products is beneficial to the environment since such compounds are biodegradable, non-toxic and highly stable [1].

Biomonitoring

In the biomonitoring sector of the blue bioeconomy, marine organisms, mainly algae, are used to provide information about the environmental conditions through qualitative or quantitative responses. Commonly monitored environmentally **harmful pollutants** are metals, organic compounds, biological contaminants, and radioisotopes which can be revealed by a multiplicity of biomarkers. A biological sensor or **biosensor** is an analytical device used to detect a substance. These types of sensors combine a biological component with a physicochemical detector. Biosensors are pollution monitoring sensors used for the assessment of specific environmental parameters, for example biological oxygen levels in water.

The **global market for environmental sensing and monitoring technologies** is projected to reach a record growth during the forecast period, 2019 to 2025, with a 6.3% CAGR. Moreover, during those five years, the market value is expected to rise and reach a total of USD 25.9 billion in 2025, starting from USD 19.1 billion in 2020. This significant growth is driven by several factors such as stringent and improved government regulations concerning discarded contaminants and the increased public sensibility towards the negative effects of the environmental pollution and climate change issues.

As far as the technologies are concerned, the **air sensing sector is predominant**, being followed by the **water monitoring** sector. Interesting, the water monitoring industry is expected to be among the strongest growing segment and is estimated to reach a market share of 33.2% by 2025. Globally, the water pollution monitoring application segment is projected to reach USD 8.6 billion in 2025, growing at a CAGR of 7.1% during the forecast period 2020-2025. This significant increment is determined by several factors, such as the increasing scarcity of drinking water, the increase of pollutants and the rising impact of the anthropic pressure.

Globally, the **monitoring market** is led by North America, Asia Pacific, and Europe. The **European region** accounted for USD 4.1 billion in 2020 and is expected to reach a value of USD 6.0 billion by 2025, growing at a CAGR of 6.4% between 2020-2025. Moreover, in Europe, the water monitoring industry is the second largest sector with a projected value of USD 2.0 billion in 2025, with a 7.4% CAGR. This increase is driven by many technologically advanced industrialized countries which cause a high rate of pollution thus needing adequate systems for monitoring the contaminants. The largest market is led by France, while Italy does not appear significantly involved in the development of the monitoring technologies being scarce as well the investments made in this specific sector [2].

Bioremediation

Bioremediation implies the use of biological resources such as plants, algae, or microorganisms to eliminate or reduce the contaminants in polluted environments. The effectiveness and the remediation rate of the method depend on several factors, such as the contaminant types and concentrations and site-specific characteristics (e.g., temperature, moisture content, availability of nutrients, pH of the medium and microbial community). However, this sector is consistently evolving due to several factors. Firstly, the rising concentration of polluted areas contributes to increase the demand of more cost-effective initiatives aimed at the recovery of contaminated water. Secondly, the problem of water scarcity is rising the demand for new methods aimed at restoring the aquatic environments. Finally, the increasing number of the industrial activities offering bioremediation services are pushing the market toward significant investments in R&D activities helpful to counteract the diffuse environmental degradation.

Globally, the **bioremediation market** is projected to reach USD 186,300 million in 2023, with a CAGR of 15.4% in the forecasted period (2017-2023). Bioremediation technology has numerous applications for treating industrial wastewater and sewage, lakes, ponds, rivers and streams, and aquacultures. The use of natural beneficial microbes in water bioremediation accelerates the digestion of chemicals and hydrocarbons, resulting in a rapid and safe removal of toxins present in water bodies. Notably, the application of bioremediation technology in **water bodies** is expected to be considered a market priority in the following years.

New bioremediation techniques focused on the treatment of freshwater and marine ecosystems are favouring the growth of several market opportunities. **Phytoremediation**, which involves the use of plants or algae to reduce or eliminate the toxic elements from the environment, have held the largest market share in the past years. Hence, this market is expected to grow up to USD 41.9 billion by 2023 with a projected CAGR of 13.7%. The water bodies segment is dominant in the global phytoremediation market, followed by natural calamity affected areas. The water bodies segment application for phytoremediation is expected to reach globally USD 41.9 billion by 2023.

Overall, site remediation activity is increasing in **Europe**. Several full-scale projects have been carried out, leading to better understanding the advantages of bioremediation, especially for contaminated soils. Phytoremediation technology is expected to reach USD 23.4 billion by 2023. The **Water bodies** segment application for bioremediation in Europe is expected to reach USD 28.3 billion by 2023 [3].

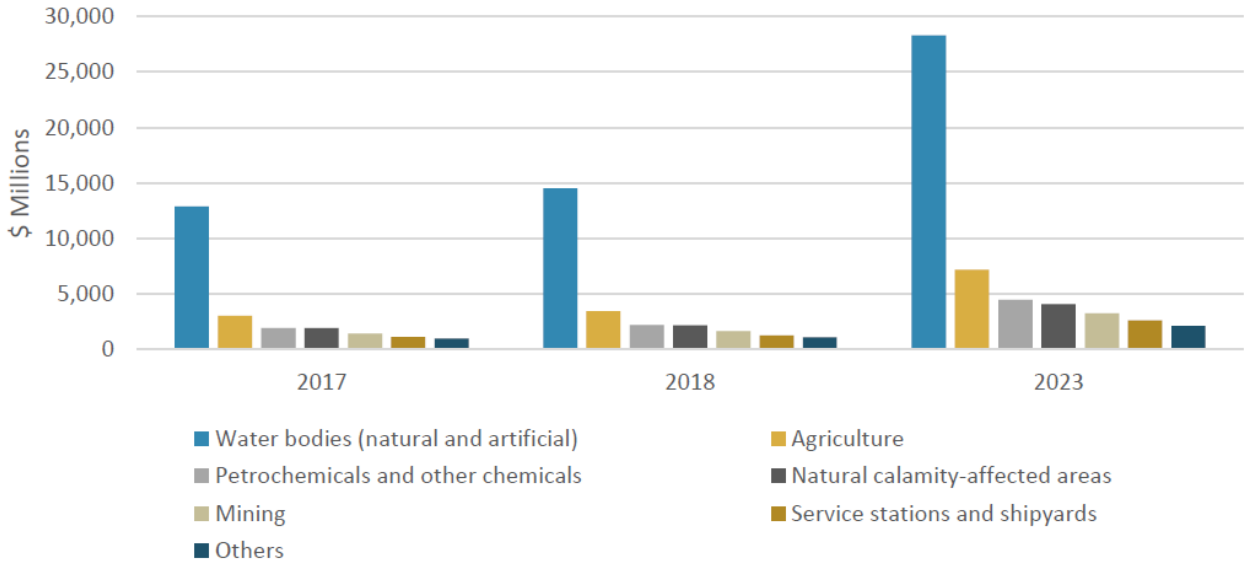

Figure 41. European Bioremediation Market, by Application, 2017 - 2023 (USD Millions)

Legal protection of technical solutions

Seawater purification, mainly identified as desalination and collection of harmful pollutants from seawater, is an emerging sector, open to technical innovations, as reflected from the still low number of patent applications filed worldwide, excluding the Asian Pacific regions. The national Chinese patent authority scores 298 patent filing events, followed by the national patent offices of South Korea and Japan. As far as the European area is concerned, the number of filing events in this sector is low, with the national offices of Denmark and France holding 4 and 3 filing events, respectively. Nevertheless, the filing events registered by EPO between the period 2008-2020 are almost 50, thus suggesting that companies become interested in investing in the European territory.

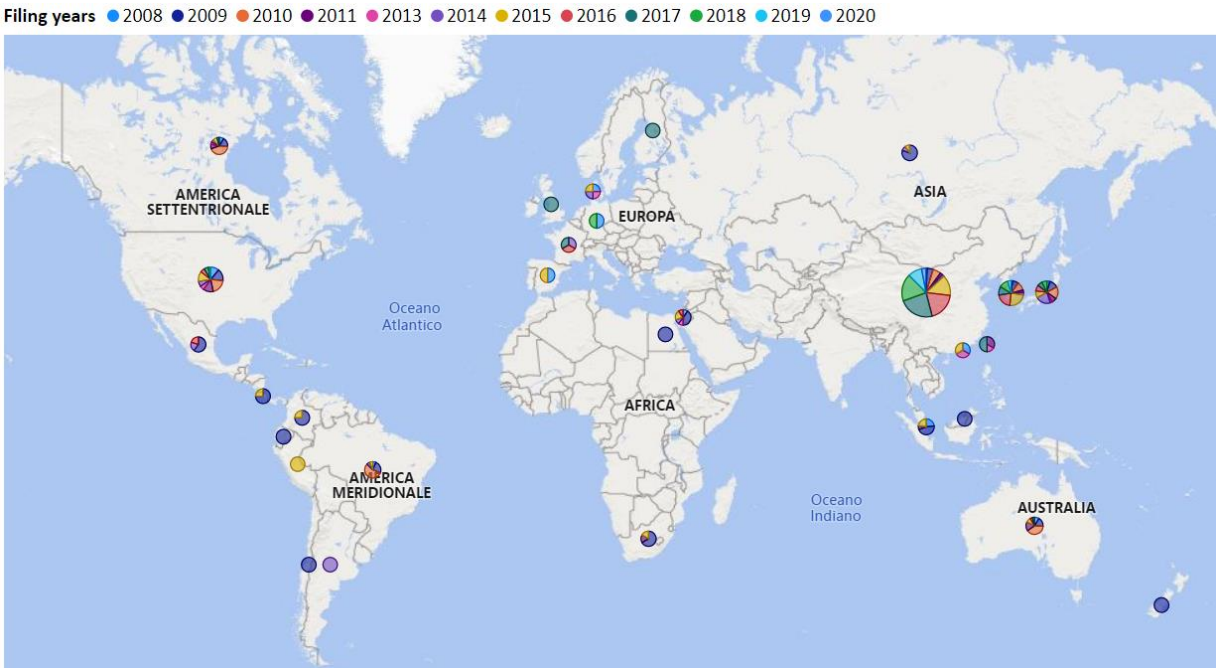

Figure 42. The number of filing events partitioned according to the earliest filing year (EP and PCT not included)

Table 17. Number of filing events registered at the European Patent Office (EPO) and at the World Intellectual Property Organization (WIPO) from 2008 to 2020

Supranational authorities	
EPO	48
WIPO	73

Upon a deeper examination of the players, McAlister Technologies (US) owns the highest number of patent families followed by the Chinese Academy of Sciences (CN) with 9 patent families. The other relevant assignees are headquartered in China where the economic opportunities offered by the technical implementations seem to attract the investments.

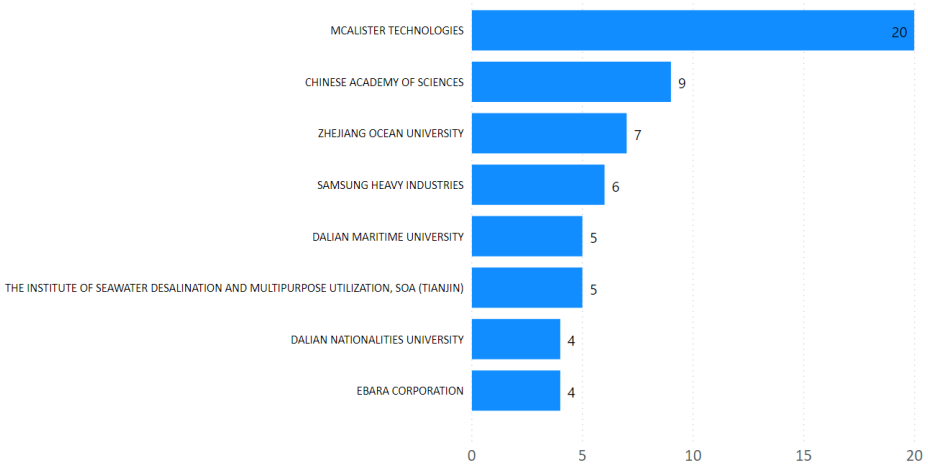

Figure 43. Patent families' number per assignee

When analysing the grant rate, McAlister technologies is again the main player which owns 89 granted patents. Harvard University (US) follows, with 15 granted patents. In EU, the Danish company Aquaporin is leading the sector focusing its research on water purification for human and industrial use, but owns just six granted patents.

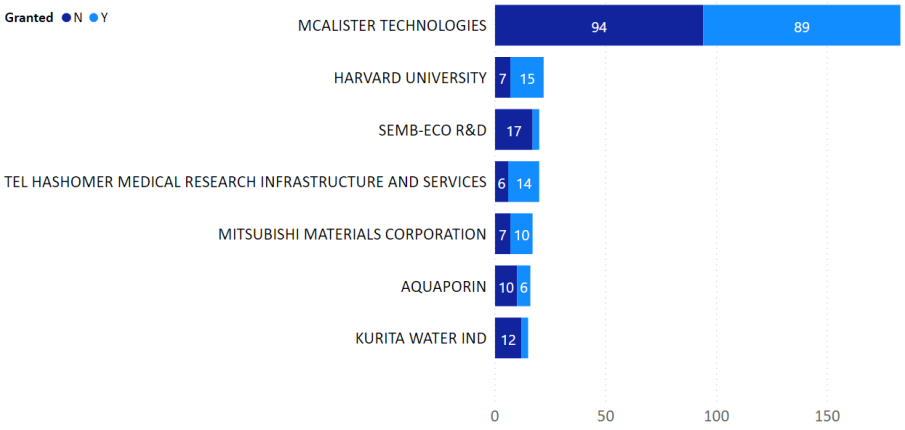

Figure 44. The legal status of the patent applications

Case Histories: Seawater purification

1) *FR3077069A1 (PROCEDE D'EXTRACTION DE COMPOSES ORGANIQUES FLUORES A PARTIR D'UN MILIEU AQUEUX LES CONTENANT) CEA* (CEA - Accueil - De la recherche à l'industrie), *UNIV DES SCIENCES ET DE LA TECHNOLOGIE HOUARI BOUMEDIENE* (Accueil (usthb.dz))

   The invention relates to a process for extracting fluorinated organic compounds, in particular perfluorinated, from an aqueous medium, such as water or an aqueous solution, containing them. More specifically, **the invention relates to a process for extracting fluorinated pollutants, in particular perfluorinated pollutants from an aqueous medium containing them** by bringing this aqueous medium into contact with a solid extractant compound. The process according to the invention thus allows the selective separation of fluorinated compounds from seawater and brackish water.

2) *WO2018122306A1 (= FR3061170) (METHOD FOR TREATING SEAWATER BY BIOFLOCCULATION AND FLOTATION AND CORRESPONDING INSTALLATION) VEOLIA WATER SOLUTIONS & TECH* (Home | Veolia (veoliawatertechnologies.com))

   The method and corresponding installation allow seawater to be biologically treated in order to purify it. The use of bioflocculation makes it possible to avoid using exogenous coagulation and/or flocculation agents, allows a significant reduction in the clogging power of the water treated, allows an improvement of the yield and a reduction of the quantities of sludge produced to be treated then discharged. The design of wastewater treatment processes, using this technology, is closely dependent on the quality of the water to be treated, which conditions in particular the choice of treatment steps and their operating mode. **For example, biomass treatment processes - fixed and / or free - are specific to the water to be treated**.

   Indeed, **biomass is not an inert ecosystem**. Conversely, it is a dynamic ecosystem whose development depends on the quality of the water to be treated. Thus, the biomass used for wastewater treatment and that used for seawater treatment will have different profiles and properties. Biomass can consist of homogeneous or heterogeneous biomass. **It can include any microorganism capable of contributing to the treatment of water, in particular bacteria and microalgae**. Biomass generally contributes to the treatment of water by biological degradation of the organic pollution contained in this water.

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The **Environmental remediation** sector of the Blue-Bioeconomy relies on well-established RTD activities reflected by a high rate of patent applications filed worldwide (2390). In the EU, the technical innovations contributing to the environmental remediation appear evenly distributed with each member state characterised at least by one patent application filed between year 1999 and year 2020. The national patent offices located in Denmark and France are addressee of the highest number of patent applications with 19 and 14 events, respectively. Interesting, the number of patent applications filed to the EPO are almost equivalent to the number of applications filed to WIPO, thus suggesting that the commercial opportunities foreseen are relevant as far as the European region is concerned.

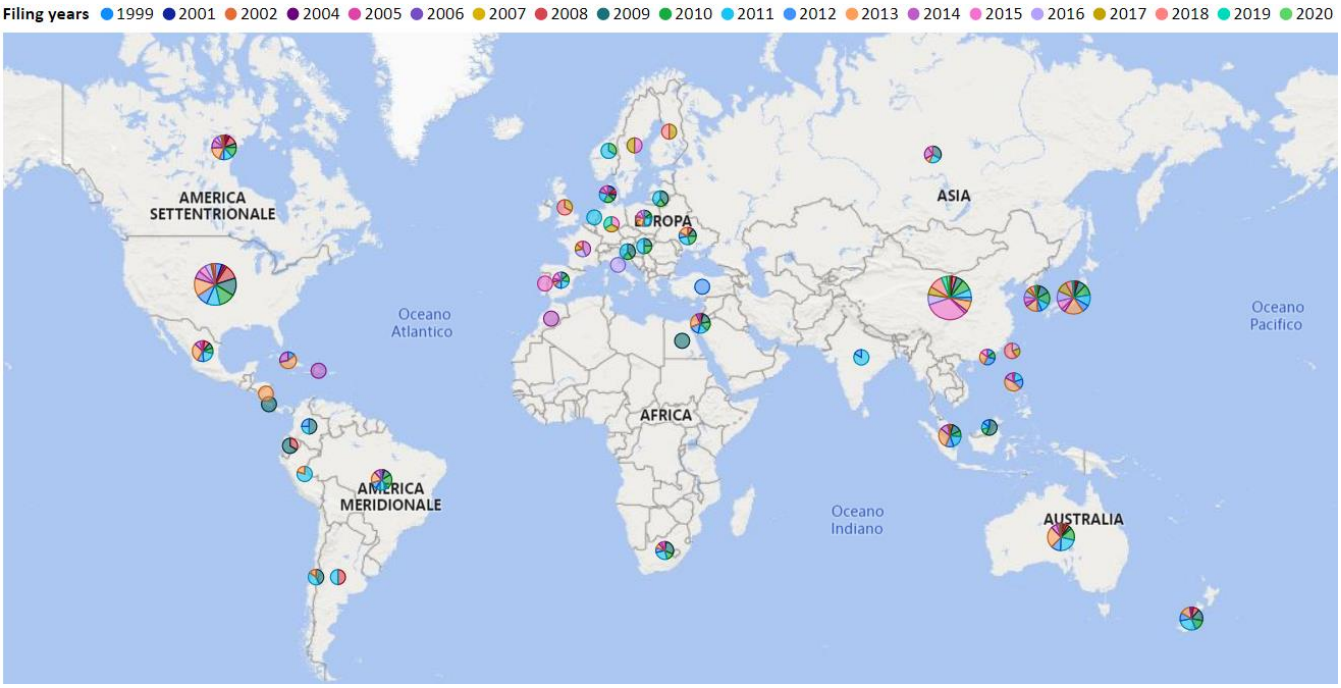

Figure 45. The number of filing events partitioned according to the earliest filing year (EP and PCT not included)

Table 18. Number of filing events registered at the European Patent Office (EPO) and at the World Intellectual Property Organization (WIPO) from 2008 to 2020

Supranational authorities	
EPO	157
WIPO	167

The highest number of patent families is owned by McAlister Technologies (US) which is as well a relevant player in the sector concerning the seawater purification. As expected from the above data several Chinese score meaningful numbers of patent families owned.

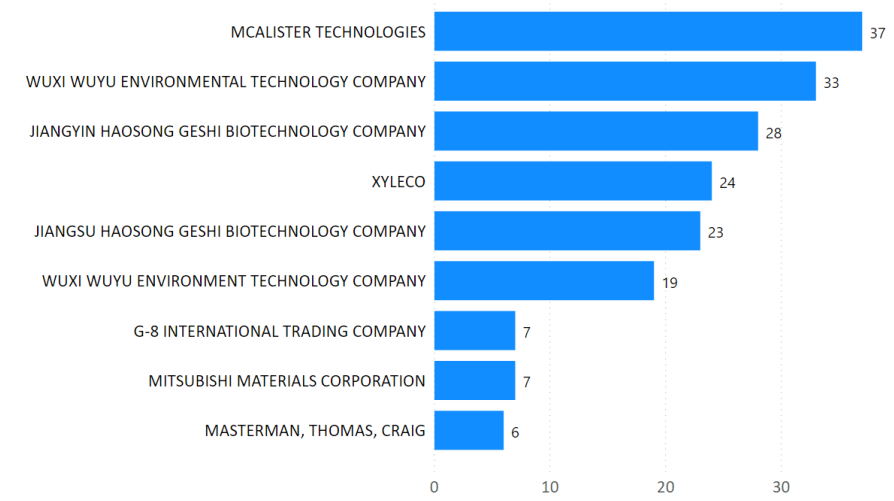

Figure 46. Patent families' number per assignee

A deeper analysis concerning the legal status of the patent applications shows that Xyleco Inc. (US) may be a leader, being followed by McAlister Technologies (US). In EU, a relevant competitor is the French company Finance Developpement Environnement Charreyre—FIDEC scoring 92 granted patents.

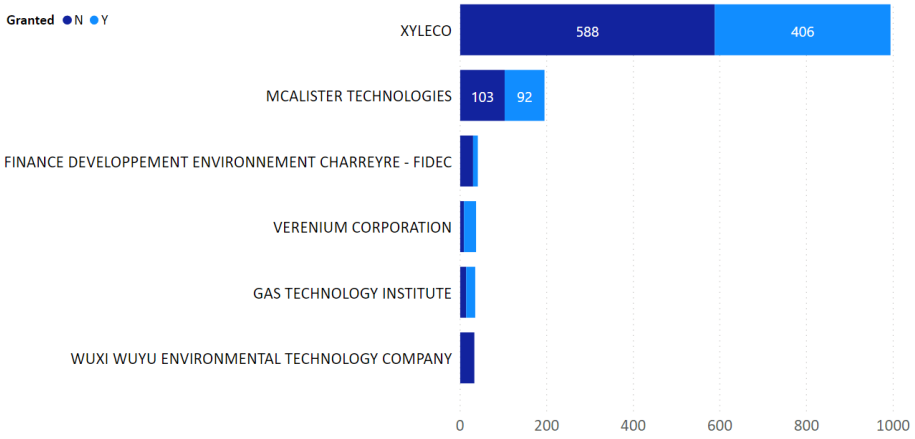

Figure 47. The legal status of the patent applications

Case Histories: Environmental remediation

1) *CN106731712A (COMPOSITE MICROBIAL DEODORANT WITH MODIFIED DENITRIFYING BACTERIA, RADIX CODONOPSIS, MINT AND SPIRULINA) WUXI WUYU ENVIRONMENTAL TECHNOLOGY CO., LTD.*

The invention relates to a composite microbial deodorant with modified denitrifying bacteria, *Radix Codonopsis*, mint and **Spirulina**. The composite **microbial deodorant** is composed of a microbial agent, plantextract, **alga extract** and water, wherein the microbial agent comprises, by mass, 20 to 40% of *Lactobacillus plantarum*, 20 to 40% of beer yeast, 1 to 5% of modified denitrifying bacteria, 1 to 5% of modified nitrifying bacteria and 1 to 5% of *Azotobacter chroococcum*; the plant extract comprises, by mass, 5 to 10% of pine needle extract, 5 to 10% of *Radix Codonopsis* extract and 2 to 5% of mint essential oil; and the alga extract is composed of 0.5 to 2% by mass of wall-broken extract of Spirulina. The composite microbial deodorant with modified denitrifying bacteria, *Radix Codonopsis*, mint and Spirulina is low in cost, high in efficiency, wide in application scope and practical in concrete production.

2) *EP2890798A1 (METHOD FOR OBTAINING SACCHARIFIED BIOMASS WITH RADIATION AND ELECTRODIALYSIS) XYLECO INC* (Xyleco, Inc. | Leading the Sustainable Industrial Revolution ™)

Many potential lignocellulosic feedstocks are available today, **including** agricultural residues, woody biomass, municipal waste, oilseeds/cakes and **seaweed**, to name a few. At present, **these materials are often under-utilized**, being used, for example, as animal feed, biocompost materials, **burned in a co-generation facility or even landfilled**.

Generally, **the methods and equipment used for producing useful products from a biomass material are described herein**. Generally, many methods include treating a recalcitrant biomass, e. g. treating with electron beams, and then biochemically and/or chemically processing the reduced recalcitrance material to a mixture of sugars, for example, glucose, xylose, arabinose, fructose, sugar alcohols, e. g. xylitol and other products. Salts (e.g., ions) generated during processing of the feedstock can be removed via the process of electrodialysis, e. g. common or standard electrodialysis (ED), electrodialysis reversal (EDR) and/or bipolar membrane electrodialysis (EDBM).

Patent datasets' features

Seawater purification: analysis of **503 non-duplicated patent families** corresponding to **875 patent applications**. Applications' filing timeframe: priority year 2017 → dec. 2020.

Remediation: analysis of **476 non-duplicated patent families** corresponding to **2390 patent applications**. Applications' filing timeframe: priority year 2015 → mar. 2021.

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[2] BCC Research (https://www.bccresearch.com/) report "Environmental Sensing and Monitoring Technologies: Global Markets", August 2020;

[3] BCC Research (https://www.bccresearch.com/) report "Bioremediation: Global Markets and Technologies to 2023", May 2019.

Sustainable Development Goals (SDGs)

Blue Biotechnologies and linkages with the SDGs

Figure 48. Sustainable Development Goals and linkages with the Blue Biotechnology sector of BLUE BIO MED project. For more info concerning the SDGs please visit THE 17 GOALS | Sustainable Development (un.org).

The **Blue Biotechnology** sector of BBM project could positively contribute to **4 SDGs**. Each group of marine organisms, from bacteria to macroalgae, have the potential for biotechnological valorisation which could improve the sustainability of several industries. Starting with the biosphere related goals, the Blue biotechnology aligns with the **Goal 14** ***"Life Below Water"*** assuring marine protection and preservation through the sustainable used of marine resources. Moreover, it can contribute to the marine conservation using genomic tools to select more resilient phenotypes more suitable in challenged ecosystems Blue biotechnology could also help the fight against harmful contamination and pollutions thanks to the implementation of the biomonitoring and bioremediation techniques [1;2]. The main targets aligned with the SDGs 14 are listed in the table below.

Table 19. SDG 14 "Life Below Water". Relevant Targets to the Blue biotechnology sector.

Targets
14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution
14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans

The new solutions developed in the bioremediation field could also contribute to the **Goal 6**, for example, innovations derived from marine microorganisms could represent better solution for the wastewater treatment [1]. Cutting edge biotechnology application could also improve the seawater purification and desalination capacity which will assure drinkable water in the coastal areas assuring environmentally friendly process. The main targets withing this Goal that are related to the Blue biotechnology sector are listed in Table 20.

Table 20. SDG 6 "Clean Water and Sanitation". Relevant Targets to the Blue biotechnology sector.

Targets
6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all
6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally

Moving to the society related goals, the development of new products in nutraceutical, cosmeceutical and medical industries are boosting the realisation of the **Goal 3** ***"Good Health and Well-Being"***. More sustainable alternatives of marine-derived bioproducts are floating the markets especially as food supplement. Marine organisms, mainly algae, are now gaining more and more attentions thanks to their proven beneficial effects. Medicine, also obtain new marine-based chemical compounds that are newly discovered from anticancer to analgesic drugs. The relevant targets related to the Blue biotechnology sector are listed in the Table 21

Table 21. SDG 3 "Good Health and Well-Being". Relevant Targets to the Blue biotechnology sector.

Targets
3.8 Achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all
3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination

Finally, the new and vibrant development of Blue biotechnology industries could also improve the resource efficiency and technical development to achieve the **Goals 9** ***"Industry, Innovation and Infrastructure"*** through the improvement of several emerging and established industries focused on a more sustainable and environmentally friendly production [1;2]. The targets related to the sector are listed below.

Table 22. SDG 9 "Industry, Innovation and Infrastructure". Relevant Targets to the Blue biotechnology sector.

Targets
9.3 Increase the access of small-scale industrial and other enterprises, in particular in developing countries, to financial services, including affordable credit, and their integration into value chains and markets
9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities
9.5 Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending
9.b Support domestic technology development, research and innovation in developing countries, including by ensuring a conducive policy environment for, inter alia, industrial diversification and value addition to commodities

Challenges for the sustainability

Innovative use of marine organisms fosters innovation and promotes new business models representing a strong bridge between science and industry. Blue biotechnology could positively support the realisation of several SDGs at

social, economic and environmental level solving challenges in several sector both in the seas and on land. There are many bioactive compounds that have not been exploited to their full commercial possibility and other are still to be discovered with potential future benefits in human health sector, in the production of marine products, in the monitoring of marine environment. The new discoveries have, however, potentially a very broad application possibly affecting several sectors. However, marine biotechnology in Europe is at its early stages, evidenced by a high number of publications which are around a third of marine biotechnology publication globally. Whereas the interest of the subject is constantly rising in the academic world, the industries are left behind. The number of patents is low and globally only 13% patents filed in connection with new marine molecules are European, suggesting limited success in developing products from promising resources. Hence, a stronger effort and an increased financial support is needed for the European development of this fields to foster long-term innovation to help the achieving of several SDG to assure a more environmentally friendly future of this promising sector [3].

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Blue Sustainable Development

Monitoring and Observing Systems for Marine Environment

The “Monitoring and Observing Systems for Marine Environment” was divided into sectors which are: Maritime surveillance, maritime mapping, sea water sensors and underwater Unmanned vehicles.

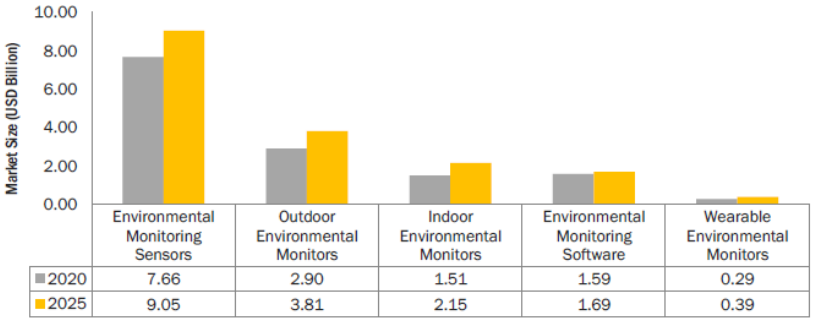
Market overview

The **Monitoring and Observing systems of the marine environment** sub-sector aims at the prevention and identification of activities and sources that can cause different impacts on the marine environment such as pollution, oil spill and illegal fisheries. Moreover, it involves the active monitoring of human activities to assure a better management of marine based industries, for example fishery and aquaculture. Those services can be achieved through the integrated contribution provided by several maritime surveillance systems implemented thanks to a widespread database management and innovative applications of the information technologies.

The consistent growth of the **environmental monitoring** market is driven by several factors such as the constantly rising levels of pollution, a favourable regulatory scenario, the ongoing installation of environmental monitoring stations and the increasing public awareness about marine pollution.

Globally, the **environmental monitoring market** is projected to reach USD 17.10 billion by 2025 from USD 13.96 billion in 2020 at a CAGR of 4.1%% for the forecasted period 2020 - 2025. The market shares may be ascribed to different product types such as the monitoring sensors, software, and outdoor or indoor monitors. Overall, the environmental sensors

segment, defined as remote sensing products used for indirect pollution assessment of inaccessible areas, holds the main market share, followed by the outdoor environmental monitoring systems.



	Environmental Monitoring Sensors	Outdoor Environmental Monitors	Indoor Environmental Monitors	Environmental Monitoring Software	Wearable Environmental Monitors
2020	7.66	2.90	1.51	1.59	0.29
2025	9.05	3.81	2.15	1.69	0.39

Figure 49. Environmental Monitoring Market, by Product Type, in the Period 2020 - 2025 valued in United States Dollar (USD) Billion.

Among the Monitoring and Observing systems of the marine environment sector, **Unmanned surface vehicles** (USV) are used to measure water quality, temperature, salinity, pH values, and currents, in addition to understanding the dynamics of the ocean through the use of **sensors**. USVs can autonomously navigate and collect information with respect to water quality, which is relayed back to operators on the shore in real-time. They also enable both inland and offshore hydrographic surveys by collecting high-quality and high-resolution ocean data. Currently there is increasing use of USVs for water quality monitoring and ocean data mapping, which, in turn, is expected to drive the growth of the unmanned surface vehicle market, globally. The **sensors market segment for USV** is expected to reach the value of USD 70.3 million in 2023 globally, growing at a CAGR of 14.8 % in the period 2018 – 2023. Other payloads include conductivity, Temperature and Depth (CTD) sensors, pollution monitoring sensors, warning systems, automatic target detection systems and wind sensors. The global market segment for these **other types of sensors** is projected to reach USD 19.7 million by 2023, at a CAGR of 12.24% between 2018 and 2023. In **Europe** the market for **USV** is expected to reach the value of USD 253 million in 2023, growing at a CAGR of 15.2% in the period 2018 – 2023. In the **Mediterranean area** the most relevant market players are France and Italy [3].

Focusing on the environmental applications, the **water pollution monitoring** sector is the second-largest market followed by the air pollution monitoring. In Europe, Germany is leading the sector, followed by France due to the relevant commitment of both countries in fields such as industry, military surveillance, smart city projects and healthcare [1].
Another emerging sector related to monitoring and observation of the marine environment is based on the development of the **autonomous underwater vehicles (AUV)**, a category of **Unmanned Underwater Vehicles (UUVs),** based on devices that can travel underwater without requiring input from an operator. AUVs are fast becoming accepted as highly useful data gathering platforms within the worldwide marine science community, and are used for monitoring, geophysical surveys and oil and gas exploration. AUVs made more convenient the ocean exploration and sampling having importantly contributed to the increase of the availability, quality, and quantity of scientific marine data. These UVs contribute gather a wide series of information from the 3 dimensionality of the water masses and are efficiently used for oceanographic monitoring and mapping. In particular, AUVs can also be equipped with visual cameras and multibeam for high resolution images and seabed mapping that are used to inform oceanographic models, might help defining areas of great ecological relevance (essential fish habitats), support monitoring of reefs and managing deep sea issues (wrecks, accidents). Maritime industries are also utilizing UUVs for applications such as offshore oil production and exploration. Overall, the **market of AUVs** is valued at USD 3,260 million in 2020 with a projected value of USD 4,380 million in 2025 and a CAGR of 6.6% between 2020 and 2025 [2]. However, in **Europe** this market is still at its early-stage, while in contrast the USA and the Asian Pacific region are leading the sector.

In the field of hydrographic survey, **Multi-Beam Eco Sounders** (MBES) are a type of sonar used to map the seabed. MBES have become an important tool for depth measurement purpose and hydrographic studies. (Hydrographic survey equipment market)

Anti-submarine Warfare (ASW) generally focuses on mitigating and eliminating enemy diesel-electric submarines from transit routes and protecting High Value Units (HVUs), such as amphibious warfare ships and logistic ships. For the naval forces of any country, establishing and maintaining highly effective anti-submarine warfare capabilities are crucial, which, in turn, leads to increased demand for unmanned surface vehicles. The anti-submarine warfare segment is projected to grow at a CAGR of 14.48% between 2018 and 2023 [3].

Legal protection of technical solutions

The technical innovations regarding the monitoring and observing Systems for marine environment are rising in the last decades. **Maritime surveillance** technologies are evenly distributing across the globe with the Chinese patent authority scoring 255 patent filing events, followed by the USPTO with 135 patent filings. In EU, the maritime surveillance industry might be considered relevant in almost all the countries, the national patent authorities of France and Spain scoring for the time being the highest number of patent filings events, 64 and 16, respectively.

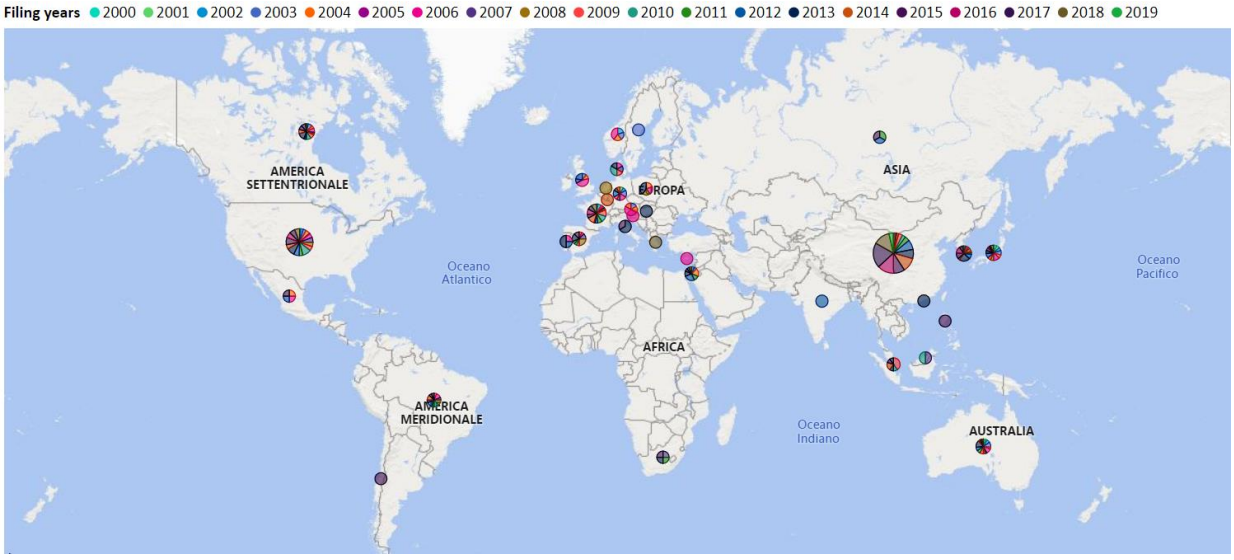


Figure 50. The number of filing events partitioned from 2000 to 2019 (EP and PCT not included)

The number of patent applications filed to either the European Patent Office (EPO) or the World Intellectual Property Organization (WIPO) is almost the same thus suggesting that the industries are investing in protecting their new technical innovations in a relevant number of countries, being the European region considered of utmost importance.

Table 23. Number of filing events registered at the European Patent Office (EPO) and at the World Intellectual Property Organization (WIPO) from 2000 to 2019

Supranational authorities	
EPO	90
WIPO	101

As far as the count of patent families' numbers related to maritime surveillance is concerned, the Thales group headquartered in France and specialized in harbour safety appears as the leader. Two additional relevant players are two Chinese universities: The Shanghai Maritime University (CN) and Wuhan University of Technology (CN).

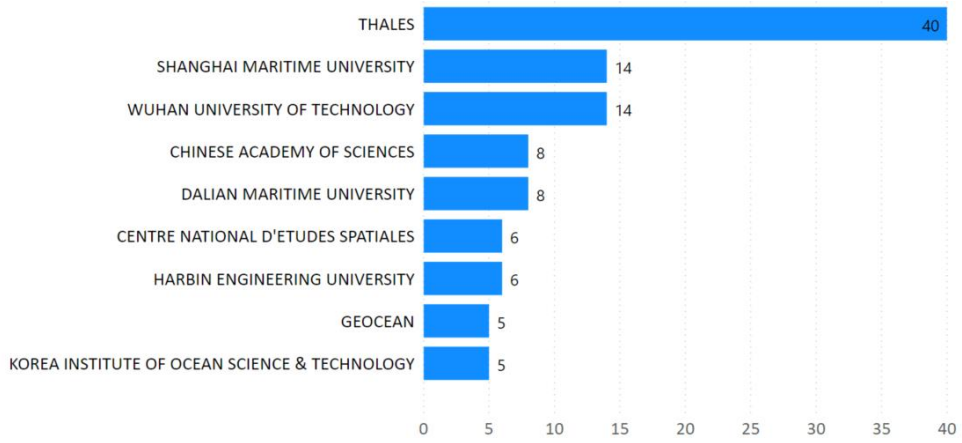


Figure 51. Patent families' number per assignee

Thales Group (FR) owns the highest number of granted patents (67) being followed at a considerable distance by other competitors such as In Situ Srl which owns 11 granted patents and is headquartered in Italy, namely in Friuli Venezia Giulia region.

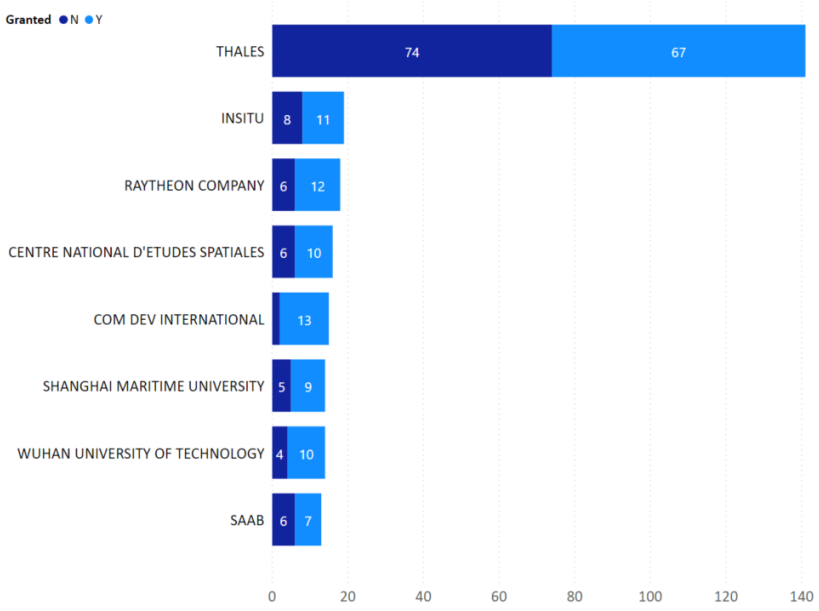


Figure 52. The legal status of patent applications

Case Histories: Maritime Surveillance

1) *FR3083633A1 (= WO2020007981A1) (METHOD AND DEVICE FOR DISPLAYING HIGH-DYNAMIC SONAR OR RADAR DATA) THALES* (Thales - Building a future we can all trust (thalesgroup.com))

The invention relates to the field of **sonar or radar**. More specifically, the invention relates to a method and a device **allowing the visualization of data whose amplitude dynamics are too great to be directly rendered on a visualization means such as a screen or on paper** after printing. In the specific field of sonar, it applies both to imaging sonar (bottom imaging, for hydrographic or military purposes, for example in mine warfare), and to sounder data, possibly multi-beams such as (MBES) for "MultiBeam Echo Sounder", or to

anti-submarine warfare sonars (ASuW) for "Anti-Submarine Warfe" or even to any high dynamic display such as displays known as Active Geography Plot (AGP) described in patent application EP120488B1 or Energy Geography Plot (EGP) described in patent application EP1360522B1.
In the field of radar, it is particularly indicated in the visualization of high contrast data, such as encountered in maritime surveillance.

2) *FR3049145A1 (= WO2017158112A1) (BEACON FOR OBSERVING AN OBJECT, ASSOCIATED OBSERVATION SYSTEM AND METHOD FOR TRANSMITTING OBSERVATION DATA) SIGFOX* (Sigfox - The Global Communications Service Provider for the Internet of Things (IoT))
The present invention relates to **a beacon for observing an object and more generally to an observation system comprising such a beacon**. **An example of such an object** 14A to 14N **is** a predetermined agricultural zone on the ground, the humidity of which is observed for agricultural purposes, or even **a boat whose position is observed for the purposes of maritime surveillance**.

*****

Another relevant industry involved in the monitoring and observation of the Sea is **marine mapping**, which has registered a considerable growth in the last decades, especially in North America and in the Asian Pacific region where the national patent authorities score the highest number of filing events. The European countries altogether scored 21 filing events, in particular the German and the Spanish national patent authorities score 8 and 4 filing events, respectively. However, the number of EPO patent applications (69) is considerable, thus suggesting that several European territories may be considered relevant as far as the commercial opportunities are concerned.

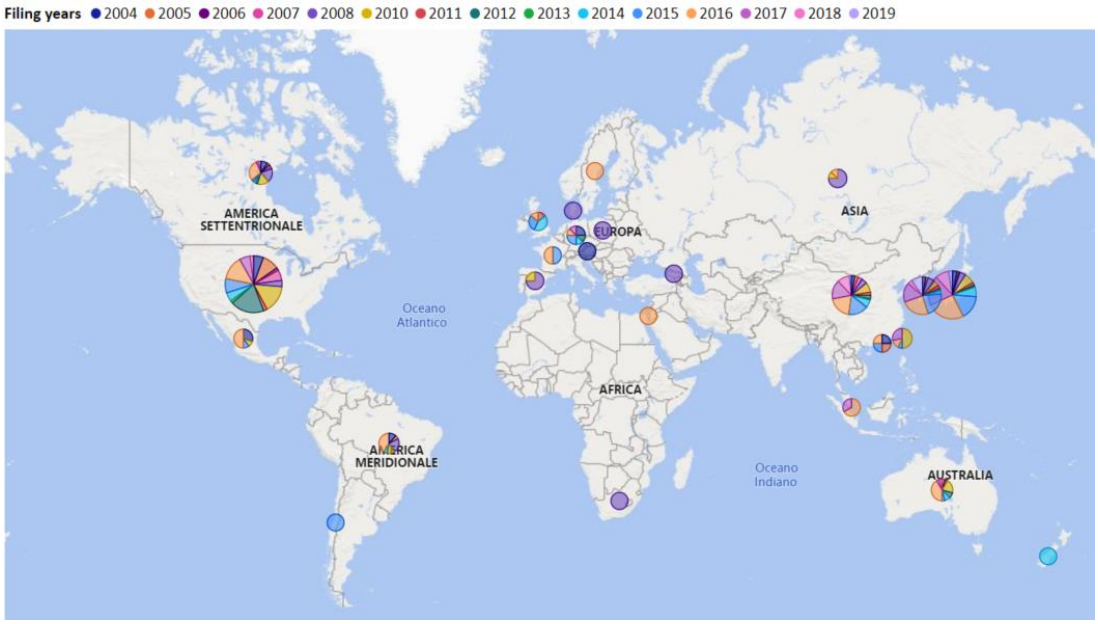


Figure 53. The number of filing events partitioned from 2004 to 2019 (EP and PCT not included)

Table 24. Number of filing events registered at the European Patent Office (EPO) and at the World Intellectual Property Organization (WIPO) from 2004 to 2019

Supranational authorities	
EPO	69
WIPO	93

Relevant players in this sector are Sunrise R&D Holdings company (US) and Pioneer Corporation (JP) who own respectively 14 and 11 patent families related to marine mapping. In EU, the main competitor in the number of patent families may be the Here Global Technologies headquartered in Holland.

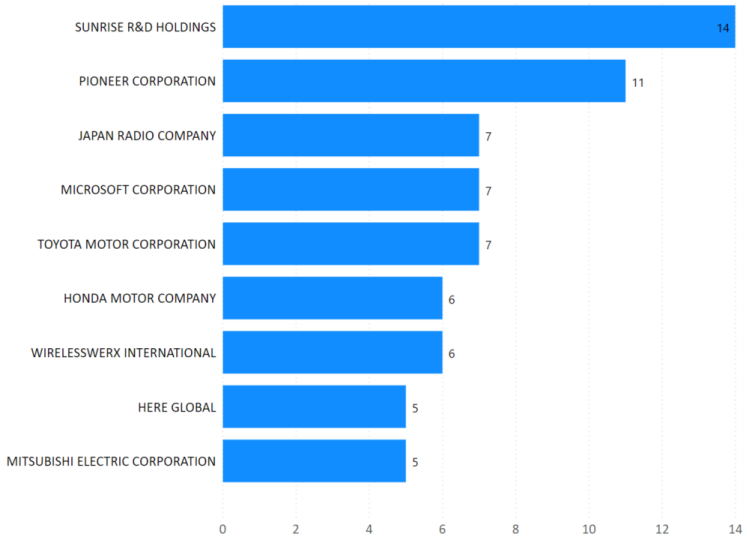


Figure 54. Patent families' number per assignee

Following the analysis of the granted patents it turns out that the Sunrise R&D Holdings company owns the highest number of granted patents (42). Two US companies, Wireless Werx Inc and Microsoft follow, the former owns 21 patents while the latter owns 15 patents.

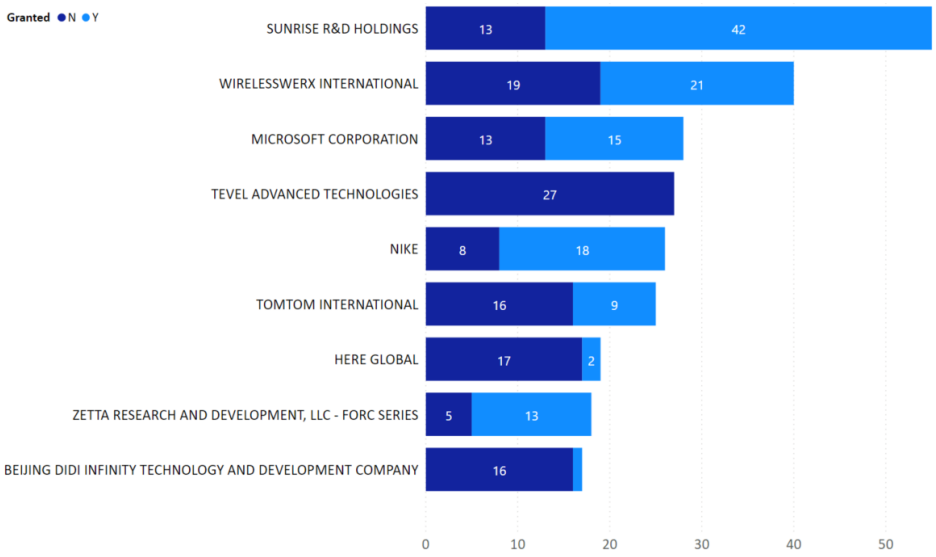


Figure 55. The legal status of the patent applications

Case Histories: Marine Mapping

1) *FR3055158A1 (= WO2018033686A1) (SYSTEM FOR AIDING NAVIGATION USING VISUAL AND LATERALIZED INTERFACES) ONTRACKS* (onTracks - YouTube)

The invention relates to a system for aiding navigation comprising an electronic device and first and second man-machine interfaces cooperating with said electronic device. The latter produces an orientation setpoint, in the form of a message (mc) emitted to one of said first and second man-machine interfaces according to the orientation of a change of direction. Each man-machine interface (advantageously comprises display means for delivering a luminous indication in response to the reception of said message (mc). Positioned advantageously respectively on the left and on the right within the field of vision of a user (U) of the system, the display means of said first and second man-machine interfaces afford said user (U) a particularly intuitive and non-invasive visual and lateralized aid to navigation.

2) *EP3137850A1 (METHOD AND SYSTEM FOR DETERMINING A POSITION RELATIVE TO A DIGITAL MAP) TOMTOM GLOBAL ASSETS B V* (TomTom | Home)

This invention relates to methods and systems **for improved positioning accuracy relative to a digital map**, and which is needed for highly and fully automated driving applications. More specifically, embodiments of the invention, **relate to the generation of reference data** (e.g. through crowd sourcing techniques), the format of the reference data, and the use of the reference data **through a comparison to sensed data from a vehicle to accurately position the vehicle on the digital map**.

3) US2014200806A1 (APPARATUS AND METHODS FOR ROUTING) CARNEVALI GIUSEPPE

An electronic navigational system may automatically develop nautical routes, may retrieve previously-developed nautical routes, or may combine previously developed route(s) or route segment(s) with an automatically developed route or route segment(s). Exemplary embodiments in accordance with principles of inventive concepts include **a marine electronic system** (which may include an electronic navigational router, a plotter, fish finder, or other electronic marine navigational aid) **that includes a graphical user interface including an input device and a display, a processor to control the display** […]. Exemplary embodiments in

accordance with principles of inventive concepts include a marine electronic system wherein a processor is configured to **accept user input to define shallow areas, to correlate the user-defined shallow area with cartographic data, and to display the user-defined shallow areas**.

*****

Technological innovation regarding the **sea water sensors** has grown during the last twenty years, yet the examination of the applications filed to the national authorities hosted in the countries bordering the Mediterranean Sea, such as the Spanish or the French patent office reveals small numbers, 6 and 3 events, respectively. However, as already pointed out, these numbers do not account for the possibility of nationalization procedures following the filing of EP/PCT applications.

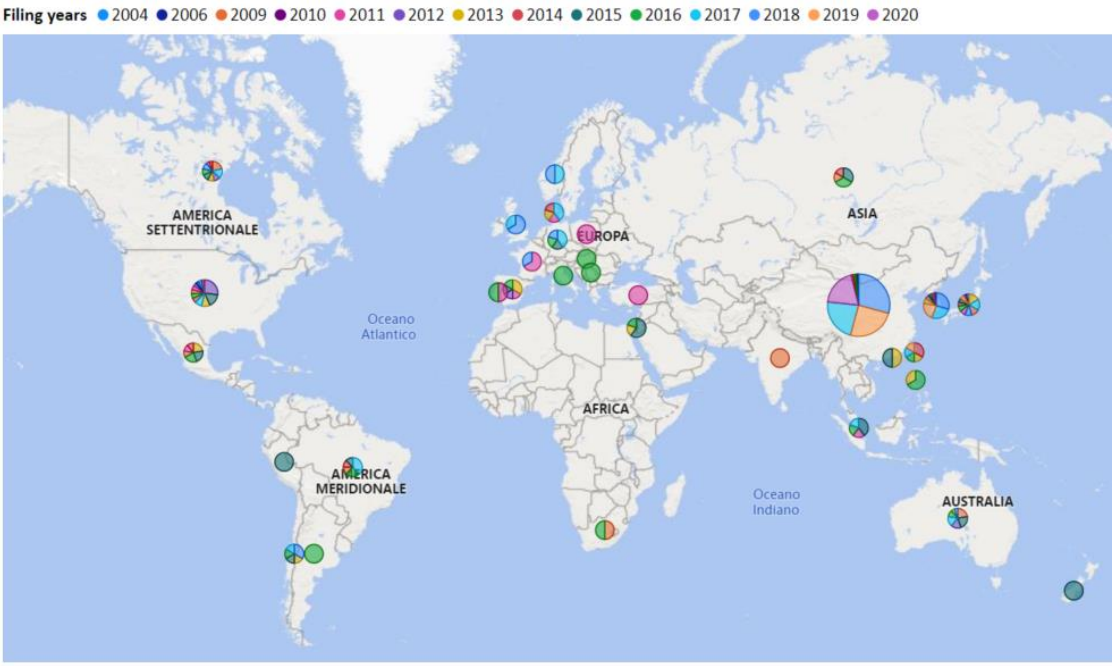


Figure 56. The number of filing events partitioned according to the earlies filing years (EP and PCT not included)

The number of applications filed to the EPO is 58, thus suggesting that the European territory might as a whole offer interesting commercialization opportunities as far as the sea water sensors are concerned.

Table 25. Number of filing events registered at the European Patent Office (EPO) and at the World Intellectual Property Organization (WIPO) from 2004 to 2020

Supranational authorities	
EPO	58
WIPO	77

A relevant player may be the Zhejiang Ocean University (CN) since it owns 23 patent families, being followed by the Chinese Academy of Science (CN) which owns 20 patent families.

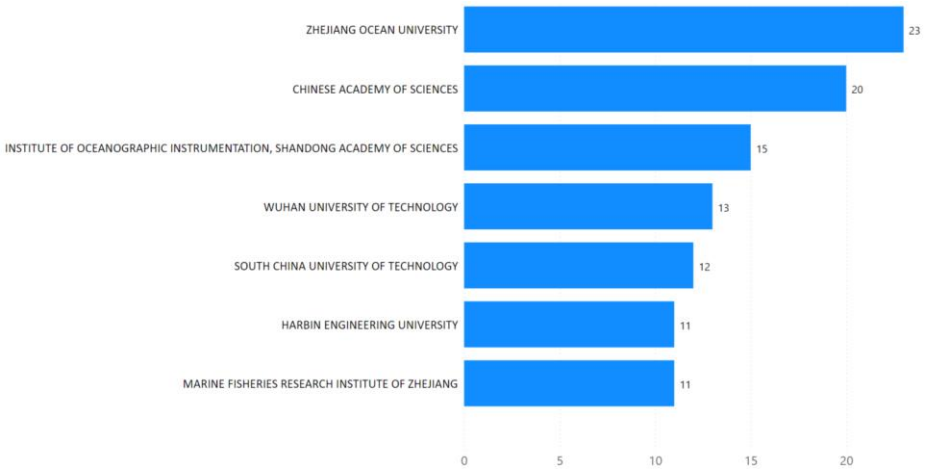


Figure 57. Patent families' number per assignee

Considering the number of granted patents, 7AC Technologies (US) is the company with the highest number of granted patents (29) while the US company Omni Medsci Inc. Follows, with a total of 26 patents granted.

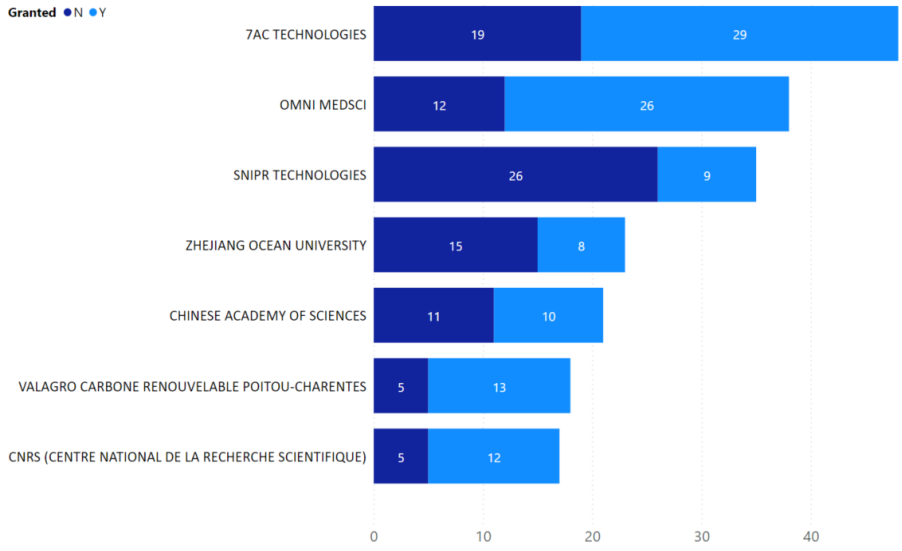


Figure 58. The legal status of the patent applications

Case Histories: Sea water sensors

1) *WO2011072065A2 (MICROBIALLY-BASED SENSORS FOR ENVIRONMENTAL MONITORING) INTACT LABS LLC*

The present invention provides **novel, low-cost, real-time bio-electrochemical sensors for environmental monitoring**, **particularly surface water monitoring**. The sensors of the invention are **based on the metabolism of one or more types of electricigenic/electrogenic microorganisms** and provide an inexpensive, durable, and accurate tool useful to monitoring agencies, research institutions, watershed management organizations, and farmers concerned with monitoring and controlling nutrient run-off over large coverage areas.

2) *AU2019100001A4 (AN IN-SITU TEST DEVICE AND METHOD TO MEASURE THE AMOUNT OF POLLUTANTS RELEASED FROM INTERIOR OF MARINE SEDIMENTS UNDER WAVE ACTION) OCEAN UNIVERSITY OF CHINA (中国海洋大学英文 (ouc.edu.cn))*

The invention relates to the field of **marine sampling technology and marine pollutant sediment dynamics**, in particular to **an in-situ test device and method to measure the amount of internal pollutants released from marine sediments under stimulated wave action**.

The pollutants in **marine sediments mainly come from urban sewage, industrial wastewater, ship emissions and accidental leakage**. **Nearshore activities lead to an increase in the amount of pollutants in marine sediments**. Sediments in bays, ports and coastal waters contain pollutants of high concentration, such as **heavy metals, tributyl phosphate, petroleum hydrocarbons, polychlorinated biphenyls, insecticides, etc**. Pollutants hidden in marine sediments move into seawater and spread with the flow of seawater, thereby posing a great danger to the nearshore ecological environment.

The monitoring of pollutants in marine sediments plays an important role in marine environmental protection.

3) *CN107048622A (PORTABLE OCEAN SWIMMING SMART BAND) XIAMEN ZHONGYANRONGYUAN TECHNOLOGY CO., LTD.*

With the development of science and technology, sports bracelets are more and more welcomed and used by people. However, the traditional sports bracelets are used in non-underwater environments, and **the bracelets suitable for underwater environment, especially in seawater environment are rare in the current art**.

In order to solve the above mentioned problems in the background art, the present invention provides **a portable marine swimming smart bracelet, comprising**:

A water quality monitoring module for collecting water quality data of seawater and transmitting the collected data to a data processing control module;

GPS positioning module, the GPS positioning module transmits the real-time position information to the data processing control module;

A data processing control module that correlates the real-time position information and the water quality status data and sends the correlated data to the data storage module;

The data processing control module sets a standard value for the water quality status data and determines whether the water quality status data exceeds the standard value so as to control whether the alarm module is activated and sends an alarm message.

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Additional technological innovations regarding the monitoring of the marine ecosystem rely on the **UUV**. The number of UUV filing patent events is steeply increasing in the last five years. In EU, the Spanish patent authority, with 6 events, scores the highest number of patent applications filed to a national authority. However, as already pointed out, these small numbers do not account for the possibility of nationalization procedures following the filing of EP/PCT applications. Indeed, 63 patent applications have been filed to the WIPO.

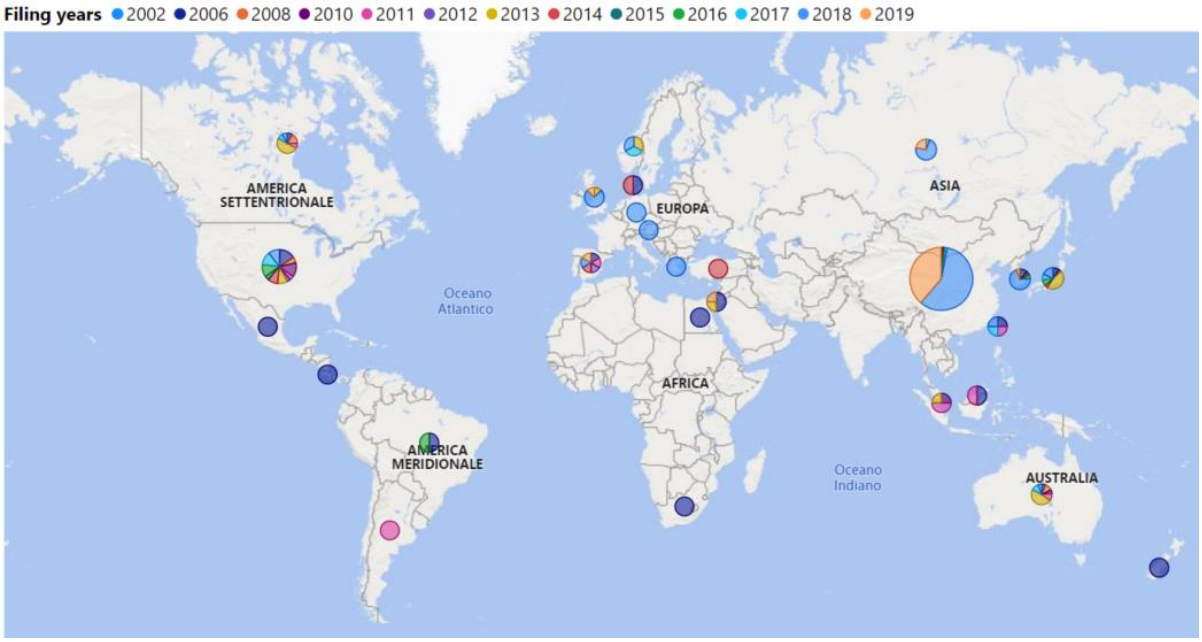


Figure 59. The number of filing events partitioned according to the earlies filing years (EP and PCT not included)

Table 26. Number of filing events registered at the European Patent Office (EPO) and at the World Intellectual Property Organization (WIPO) from 2002 to 2018

Supranational authorities	
EPO	36
WIPO	63

The most relevant players are likely resident in China, being Harbin Engineering University and Northwestern Polytechnical University and Zhejiang University two institution who own consistent numbers of patent families.

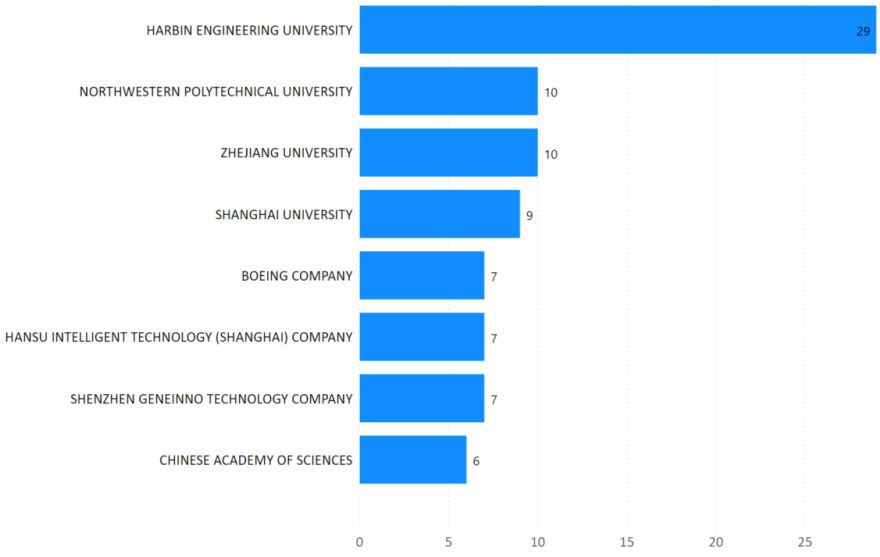


Figure 60. Patent families' number per assignee

As far as the patents' grant rate is concerned, two companies, namely Liquid Robotics (US) and Hadal Company (UK) are leading.

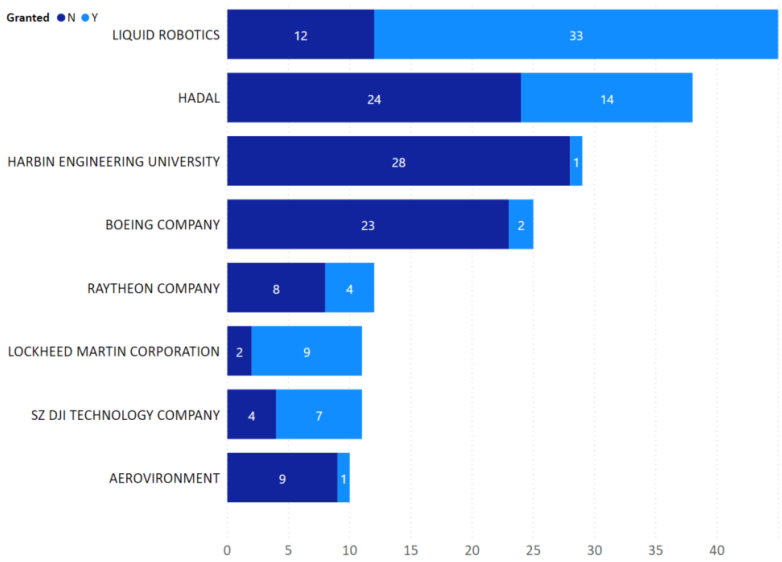


Figure 61. The legal status of the patent applications

Case Histories: UUV

1) *EP3137375A1 (SUBMERSIBLE ELECTRIC THRUSTER) BLUEROBOTICS (Blue Robotics - Underwater ROVs, Thrusters, Sonars, and Cameras*)

The present invention relates to a thruster and in particular to **a submersible electric thruster**. Unmanned and robotic marine vehicles, such as remotely operated underwater vehicles (ROVs), **autonomous underwater vehicles (AUVs)**, and autonomous surface vessels (ASVs), **have become invaluable tools for marine exploration**. They are **commonly used for scientific, industrial, commercial, and recreational purposes. These vehicles generally use thrusters for propulsion**.

2) *EP2969736A2 (SYSTEMS AND METHODS FOR A ROBUST UNDERWATER VEHICLE) HADAL Inc.*

Underwater vehicles are typically controlled using actuated fins that protrude from the vehicle into the flow field around the hull. If the fins on the vehicle come into contact with a foreign object moving with a different velocity than the vehicle, the inertia of the vehicle can cause extremely high forces to develop on the fin, coupling, and actuation system. **In order to prevent transmission of these forces into the structure of the vehicle and limit damage to the actuators driving the fins, there exists a need for a force limiting coupler between the actuation system and the fin**.

3) *EP1973775A2 (WAVE POWER) LIQUID ROBOTICS* (Liquid Robotics (liquid-robotics.com))

In accordance with the present invention, **we have discovered novel wave-powered devices**, and novel methods **using wave-powered devices**. Toe invention will be chiefly described **with reference to water vehicles which travel over the surface of the water** when they are placed in water having waves moving across the surface of the water (hereinafter referred to as "wave-bearing water"). **In such vehicles, at least part of the wave power moves the float over the surface of the water** (the remainder of the wave power, if any, being converted into other useful forms, or wasted). However, the invention is also useful when the float is held in a fixed location, e.g. by

an anchor or other attachment. In preferred embodiments, **the invention makes it possible for unmanned water vehicles to carry out tasks which would be tedious, expensive or dangerous to carry out using vehicles operated by human beings**.

Patent datasets' features

Maritime surveillance: analysis of **470 non-duplicated patent families** corresponding to **1050 patent applications**. No limitation is assumed concerning the applications' filing timeframe.

Marine mapping: analysis of **309 non-duplicated patent families** corresponding to **886 patent applications**. Applications' filing timeframe: priority year 2015 → oct. 2020.

Seawater sensors: analysis of **897 non-duplicated patent families** corresponding to **1329 patent applications**. Applications' filing timeframe: priority year 2017 → jun. 2021.

UUV: analysis of **504 non-duplicated patent families** corresponding to **724 patent applications**. Applications' filing timeframe: priority year 2018 → sept. 2020.

Bibliography

[1] Markets&Markets Knowledge Store (https://www.mnmks.com/) report "Environmental Monitoring Market – Global Forecast to 2025", June 2020;

[2] Markets&Markets Knowledge Store (https://www.mnmks.com/) report "Autonomous Underwater Vehicle (AUV) Market – Global Forecast to 2025", April 2020;

[3] Markets&Markets Knowledge Store (https://www.mnmks.com/) report "Unmanned Surface Vehicle Market – Global Forecast to 2023", November 2018.

Marine Environmental Technologies

The "Marine Environmental Technologies" section focuses mainly on the precision aquaculture sector.

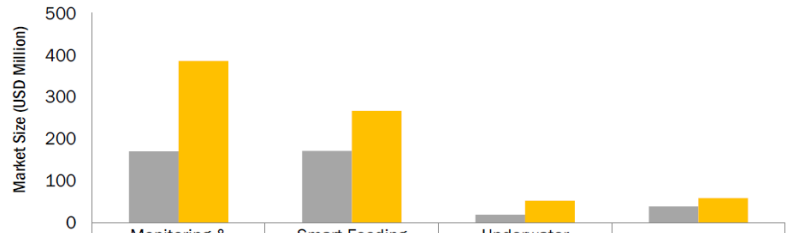
Market overview

The **marine environmental technologies** included in the Blue Sustainable Development sector are referring to the technologies used for the safe exploitation of the marine environment. Among the new technologies targeting the marine resources, the **Precision Aquaculture** (PA) is significantly appealing. Specifically, PA is based on the application of control-engineering principles to fish production, thereby improving the farmer's ability to monitor, control and document biological procedures in fish farms using smart electronic devices and computing capabilities. These technological innovations are improving the overall production and efficiency of the aquaculture industry which, as anticipated, shows a steeply rising market trend. The most important factors driving the growth of PA market include:

- Surging adoption of advanced technologies such as Internet of Things (IoT), remotely operated vehicles (RoVs), and artificial intelligence (A.I.) in aquaculture farms;
- Growing investments in aquaculture technology and R&D projects aimed at the adoption of innovative devices;
- Rising income levels and demand for protein-rich fish feed;
- Increasing worldwide the governments' support developing infrastructure tailored to the aquaculture needs.

The **global PA market** is projected to reach a value of USD 763.7 million in 2024, being 14% the predicted CAGR in the period 2019 – 2024. Overall, the main systems provided by the PA market include the smart feeding systems, the monitoring systems, the control systems and the underwater ROVs.

Smart feeding systems segment comprises the devices designed to help aquaculture farmers to save a significant number of hours of labour each day and to substantially lower the feeding and the operation coast. This market segment is forecasted at USD 267 million in 2024, at a CAGR of 9%. **Monitoring and Control systems** segment mainly implicates the use of water sensors and of machine learning technologies for the assessment of the well-functioning of the aquaculture farms. This segment is projected to reach a value of USD 386 million in 2024, showing a remarkable CAGR of 18%. The market for **underwater remotely operated vehicles** (ROVs) is expected to grow at the highest rate in the years, being the value of USD 52 million expected by 2024, and a CAGR of 23% between the period 2019 - 2024.



	Monitoring & Control Systems	Smart Feeding Systems	Underwater ROVs	Others
2019	170	171	18	38
2024	386	267	52	58
CAGR (2019–2024)	18%	9%	23%	9%

Figure 62. Global Precision Aquaculture Market by System Type, in the Period 2019-2024 valued in United States Dollar (USD) Million. "Others" includes underwater lighting systems, net inspection and cleaning systems, lice counting systems, and aeration systems

Globally, the American region is expected to be the fastest-growing market in the coming years, whereas the Asia Pacific region is likely to continue to account for the largest size of the precision aquaculture market. The **European market** for PA is expected to reach the value of USD 141.6 million in 2024, with a CAGR of 11%. This growth is related to the presence of various commercial aquaculture farms and favourable government policies. In the **Mediterranean area** the leading countries in the sector include France, Italy and Spain. **Italy** is identified as the fastest-growing country of the EU in the period 2020 - 2024.

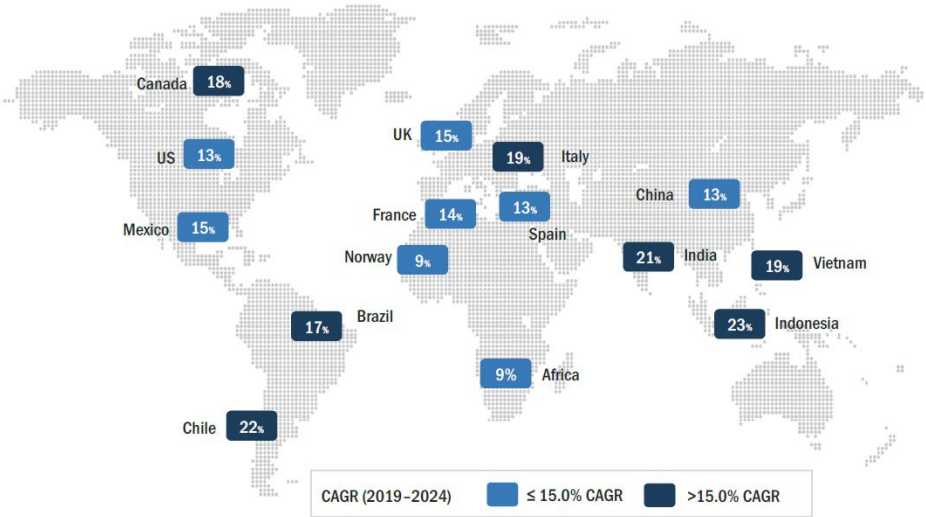


Figure 63. Global Precision Aquaculture Market by Region in the Period 2019-2024. The numbers inside the boxes denote the CAGR of individual countries (2019–2024)

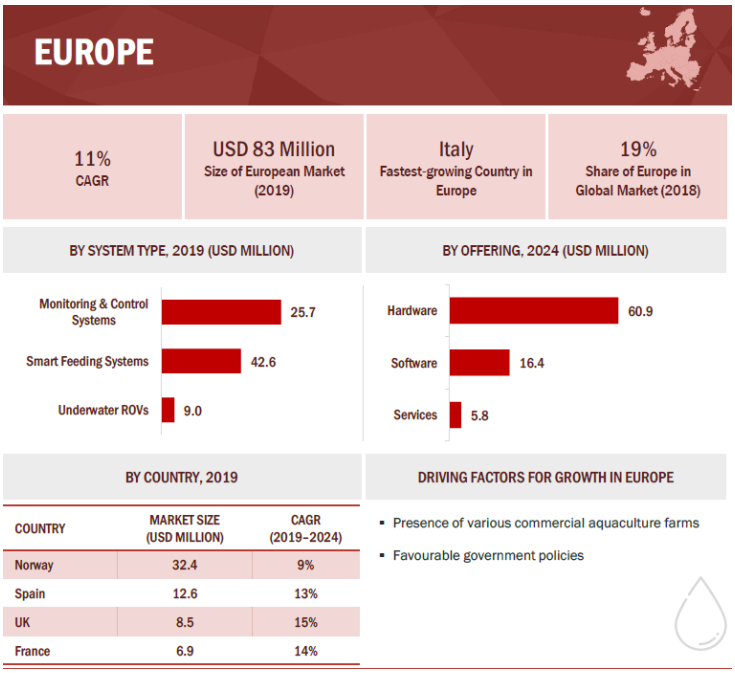


Figure 64. Precision Aquaculture Market Snapshot in Europe

Legal protection of technical solutions

Strategies reflected by filing events of technical innovations regarding the **precision aquaculture** appear well established in the Asian Pacific region, especially China, and in the American region, mainly in USA, Canada, and Brazil. In the Mediterranean region, the Spanish national patent authority scores the highest number of patent applications filed (5 events). However, the number of patent applications filed to the EPO is relatively higher (43) suggesting that the small numbers of applications filed to the national authorities could not account for the possibility of nationalization procedures following the filing of EP/PCT applications. The possibility that the whole European region may be attractive as far as the commercial exploitation of technical innovations is concerned seems not negligible.

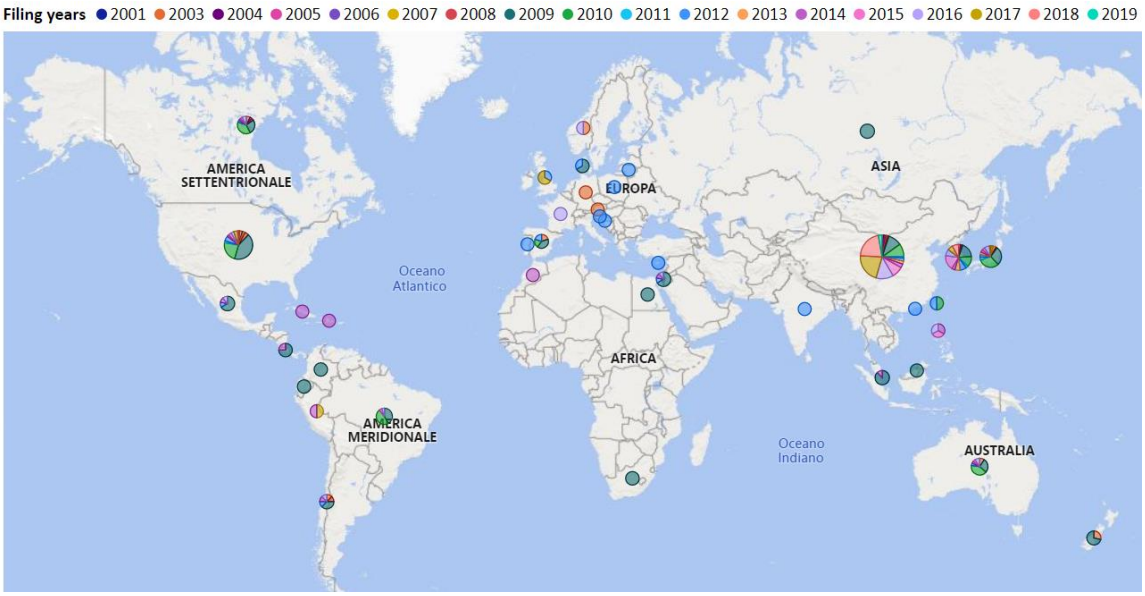


Figure 65. The number of filing events partitioned from 2001 to 2019 (EP and PCT not included)

Table 27. Number of filing events registered at the European Patent Office (EPO) and at the World Intellectual Property Organization (WIPO) from 2000 to 2019

Sovranational authorities	
EPO	43
WIPO	62

It seems that one of the most relevant players who owns the highest number of patent families McAlister Technologies headquartered in USA, scoring 34 patent families. Fujian Qiangmin Information Technology CO., ltd. (CN) and Globit CO., Ltd (KR) follow, with 5 patent families each.

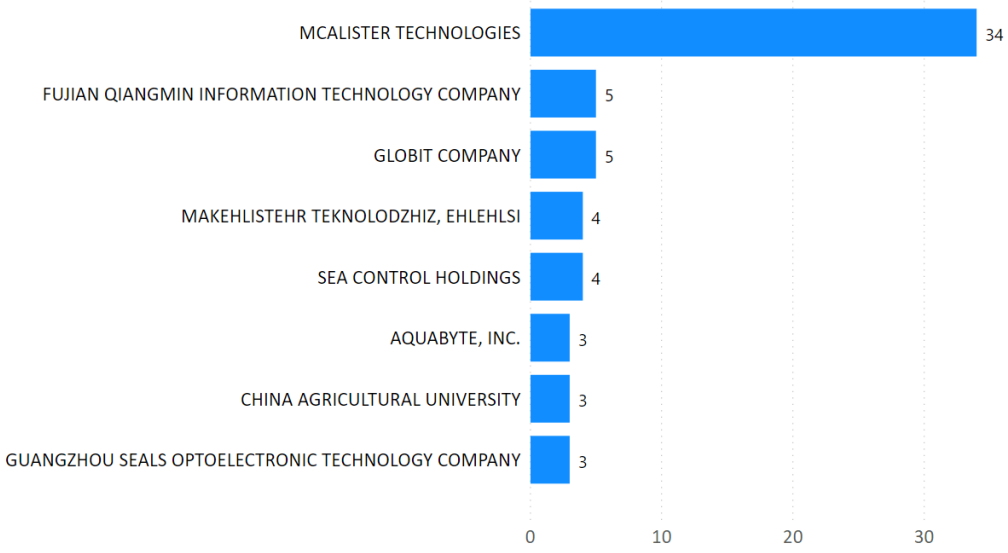


Figure 66. Patent families' number per assignee

When considering the number of granted patents, McAlister Technologies maintains the leadership with 104 granted patents. Whereas Canadian Biogenic Innovations follows, yet such players scores only 21 granted patents.

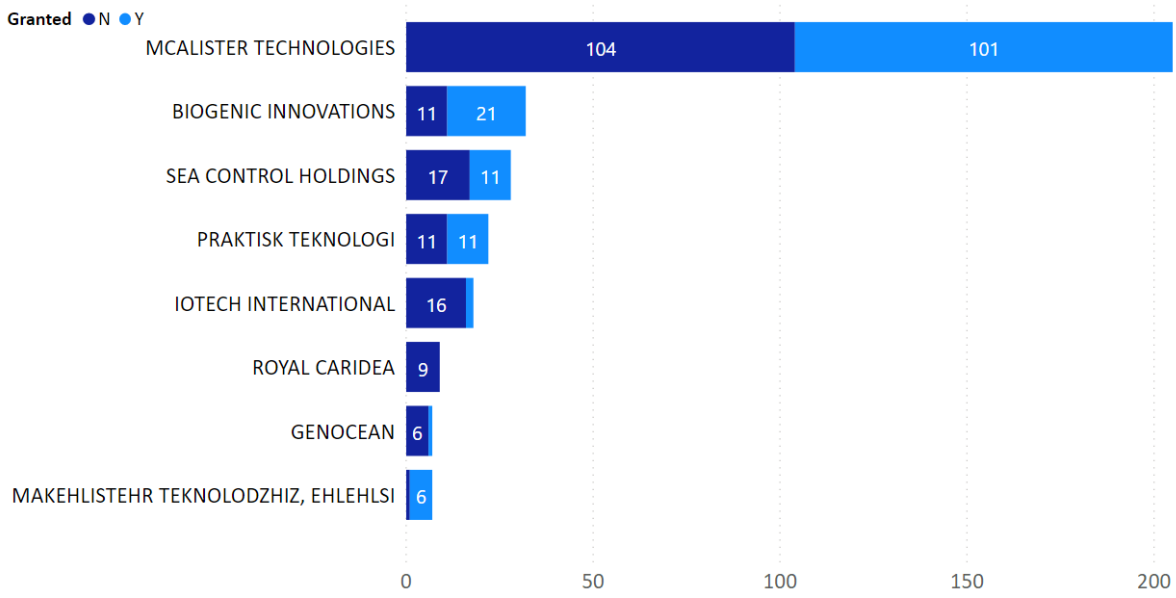


Figure 67.The legal status of patent applications

Case Histories: Precision Aquaculture

1) FR3054409B1 (DISPOSITIF D'ELEVAGE EN MER D'ANIMAUX D'AQUACULTURE) GENOECEAN

Device **for rearing aquaculture animals at sea**. The invention generally relates to devices for rearing aquaculture animals at sea, in particular shellfish and more particularly oysters.

2) CN102902240A (INTELLIGENT AQUATIC PRODUCT MONITORING SYSTEM BASED ON INTERNET OF THINGS) WUXI BEYOND INFORMATION TECHNOLOGY CO LTD

The technical problem mainly solved by the invention is **to provide an aquatic product intelligent monitoring system based on the Internet of Things**, which **enables automatic monitoring of the aquaculture/transportation process of aquatic products in real time**, rapid detection of abnormalities and real-time regulation, and maximum safety of aquaculture/transportation.

In order to solve the above technical problem, the present invention provides an aquatic product intelligent monitoring system based on the Internet of Things, comprising at least one monitoring center, and various types of wireless sensors distributed in various regions of aquaculture and/or transportation, each wireless sensor and monitoring center.

3) EP2398937A1 (ELECTROLYTIC CELL) MCALISTER TECHNOLOGIES

Renewable resources for producing electricity are often intermittent. Solar energy is a daytime event and the daytime solar-energy-concentration potential varies seasonally. Wind energy is highly variable. Falling water varies seasonally and is subject to extended drought. Biomass is seasonally variant and subject to droughts […]. In another aspect, improved electrode performance is provided by facilitating the growth and maintenance of microorganisms that convert aqueous derivatives of organic substances such as carbonic, acetic, butyric and lactic acids along with compounds such as urea into hydrogen […]. In another aspect, an electrolyzer

such as disclosed herein may be applied **to provide rapid conversion of acids that are typically produced by anaerobic digestion including** applications with municipal wastewater and landfills along with wastes form slaughterhouses, dairies, egg farms, and other **animal feeding centers** or similar.

Patent dataset's features

Precision aquaculture: analysis of **269 non-duplicated patent families** corresponding to **669 patent applications**. No limitation is assumed concerning the applications' filing timeframe.

Bibliography

Markets&Markets Knowledge Store (https://www.mnmks.com/) report "Precision Aquaculture Market - Global Forecast to 2024", December 2019.

Methods and Tools for the Preservation and Management of Marine Ecosystem and the Reduction of Anthropogenic Pressure

The "Methods and Tools for the Preservation and Management of Marine Ecosystem and the Reduction of Anthropogenic Pressure" was divided into section which are microplastics and bioplastics.

Market overview

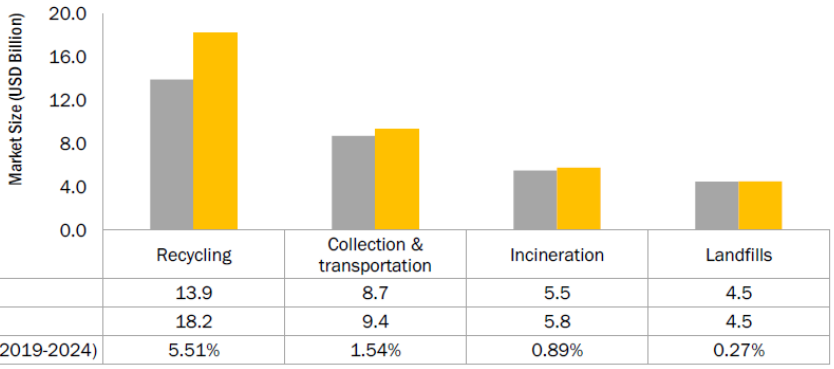
The **Blue Sustainable Development** sector includes a topic focused on the methods and tools for the preservation and management of marine ecosystems and for the reduction of the anthropogenic pressure to achieve an adequate level of environmental protection. One of the main side effects of sea-based human and industrial activities is **pollution**, which is threatening the commercial and the recreation activities depending on the marine resources. Moreover, the sea pollution is also one of the main causes of the loss of biodiversity and of the degradation of the marine environment.

Marine pollutants, concern a wide range of different contaminants such as chemical and toxic substances, nutrients, litter and underwater noise [1] most of whom coming from land sources which are washed or blown into the ocean. Among them, **plastic litter** is identified as the fastest-growing pollutant in aquatic systems especially when considering the smaller debris ranging from below 5 mm to 100 nm and identified as "microplastics" and "nanoplastics", respectively [2;9].

Over the past 50 years, the role of plastics in the economy has consistently grown, determining an increasing consumption of such material which has reached 359 million tonnes globally in 2018 [3]. However, while the production is very high, the recovery rate of such material very often does not ensure immediate profits or recycling opportunities. The global rate of recycling of plastic materials is low. In **Europe** this activity accounts for less than 30% of the total production of plastic currently undergoing to recycling procedures. Moreover, it has been estimated that 95% of the plastic packaging material is discarded after a very short first-use cycle. Hence, very large quantities of mismanaged plastic wastes leak into the environment contaminating either the land or the sea. Globally, 5 to 13 million tonnes of plastics (4% of the overall plastics production) end up in the oceans every year and it is estimated that plastics account for over 80% of the marine litter [4].

Nevertheless, the **global market for plastic waste management** is increasing in recent years thanks to governmental legislation and regulation that advocate the proper handling and disposal of plastic waste and are aimed at increasing the awareness of the consumers by means of specific programs addressing the sustainable management, as well as the need to remove and recycle the plastics' waste from the sea. The global market for **plastic recycling** is projected to reach USD 18.2 billion in 2024, with a CAGR of 5.51% predicted during the timeframe 2019 - 2024. Although in the recent years more

controls in the wastes reduced the inputs at sea, the long lasting life of the plastic material and their inevitable disaggregation into microparticles, result in an increasing trend of plastic concentration worldwide.



	Recycling	Collection & transportation	Incineration	Landfills
2019-e	13.9	8.7	5.5	4.5
2024-p	18.2	9.4	5.8	4.5
CAGR (2019-2024)	5.51%	1.54%	0.89%	0.27%

Figure 68. Plastic Waste Management Market by service in the period 2019 – 2024 valued in United States Dollar (USD) Billion. e-Estimated; p-Projected; Compound Annual Growth Rate (CAGR).

Upon a deeper analysis based on the identification of the **plastic polymer types**, the polypropylene (PP) dominated the plastic waste management market, followed by low-density polyethylene (LDPE) and high-density polyethylene (HDPE).
Recycled plastics offers various benefits including the reduction of water pollution (through lesser landfill waste or disposal of waste in oceans) and reduction air pollution (caused by the landfills). Moreover, it creates opportunities for a lesser dependence on fresh raw materials (fossil fuels) for manufacturing new plastics, thus facilitating the onset of a sustainable development, consistent with the circular economy concept.
In **Europe**, the plastic waste management market is forecasted to reach USD 7.52 billion in 2024 at a CAGR of 2.5% between 2019 and 2024. In the **Mediterranean area** France, Spain and Italy account for the largest share in the European plastic waste management market, thanks to the strong influence of environmental and governmental regulations and the concomitant increase of the prices of feedstocks. As consequence, the use of recycled plastic polymers is encouraged with the aim of producing new packaging or building materials, and to innovate especially for the clothing and the automotive sectors [5].

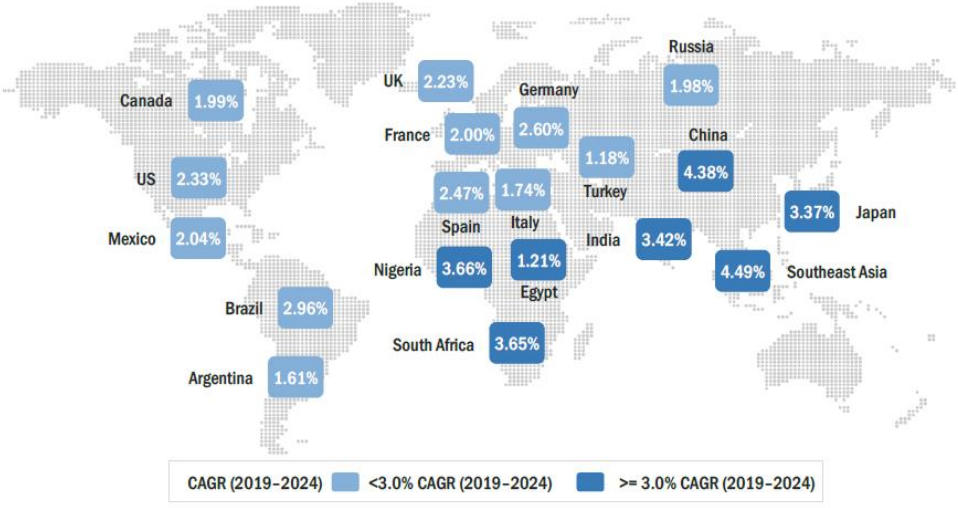


Figure 69. Plastic Waste Management by Region in the period between 2019-2024. The numbers inside the boxes denote the CAGR of individual countries

Bioplastics derived from marine organisms are new materials with an emerging applicability in the blue bioeconomy sector. In recent years, the increasing evidence of the environmental impacts of petroleum-based plastic products has increased the demand of new safer plastic materials such as the **bio-based plastics** [6]. The term bioplastics refers to either the bio-based origin of the plastics or to the biodegradable features of the plastics.

Overall, **biodegradable bioplastics** are made from renewable resources and can be naturally recycled by biological processes by-passing the exploitation of limited resources and reducing the greenhouse gas emissions [7]. Several sources can be used to produce bioplastics such as plant-based materials, natural polymers (i.e., carbohydrates, proteins, etc.) and other small molecules (sugar, disaccharides, and fatty acids). Nowadays, bioplastics are mainly obtained from terrestrial crops such as corn and potatoes which are, on the other hand, valuable food supplies yet require large quantity of land and water to be cultured at large scale. **Microalgae** represent potentially a more suitable biomass source for the bioplastic production since their use is not in competition with the food production, they can be easily farmed, and permit high lipid accumulation, a key characteristic to produce bio-based plastics [6].

The **global market for biodegradable bioplastics** is projected to reach a value of USD 11,468.9 million in 2025 at a CAGR of 19.0% in the timeframe 2020 - 2025. This significant growth is due to several drivers such as:

- The shift in consumer preference toward eco-friendly products;
- The increasing use of bioplastics in the packaging industry;
- The improvement of waste management regulations in Europe;
- The push towards green procurement policies and regulations induced by the governmental institutions.

Europe is gradually conforming to the strict government norms regarding the use of plastics in the region. The market for bioplastics in Europe is expected to reach the value of USD 8,800 million in 2025, at a CAGR of 18.1% in the forecasted period 2018 – 2025. Italy, France, and Spain are the main producers of bioplastics in Europe due to heavily investments in innovative packaging technologies improved to suit the customers' demand in these countries [8].

Legal protection of technical solutions

Technical innovations regarding the collection, the monitoring, the quantification, and the evaluation of the effect of **plastic debris** in the environment are rising. In particular, the research and industries are focusing on the smaller debris such as microplastics because their impact on marine ecosystems and organisms are still poorly understood. As far as the patent applications are concerned, the Asian Pacific region is leading, scoring the highest number of patent applications dealing with the **microplastics** analysis, especially considering that 212 patent applications have been filed to the CNIPA/SIPO. The European region scores the second highest number of patent applications (26) filed during the timeframe 2004 to 2020 however, as already pointed out, these small numbers do not account for the possibility of nationalization procedures following the filing of EP/PCT applications. As far as the national patent authorities are concerned, Germany scores 16 applications, whereas in Italy no filing events were detected about applications aimed at remediation to environmental damages caused by the microplastics.

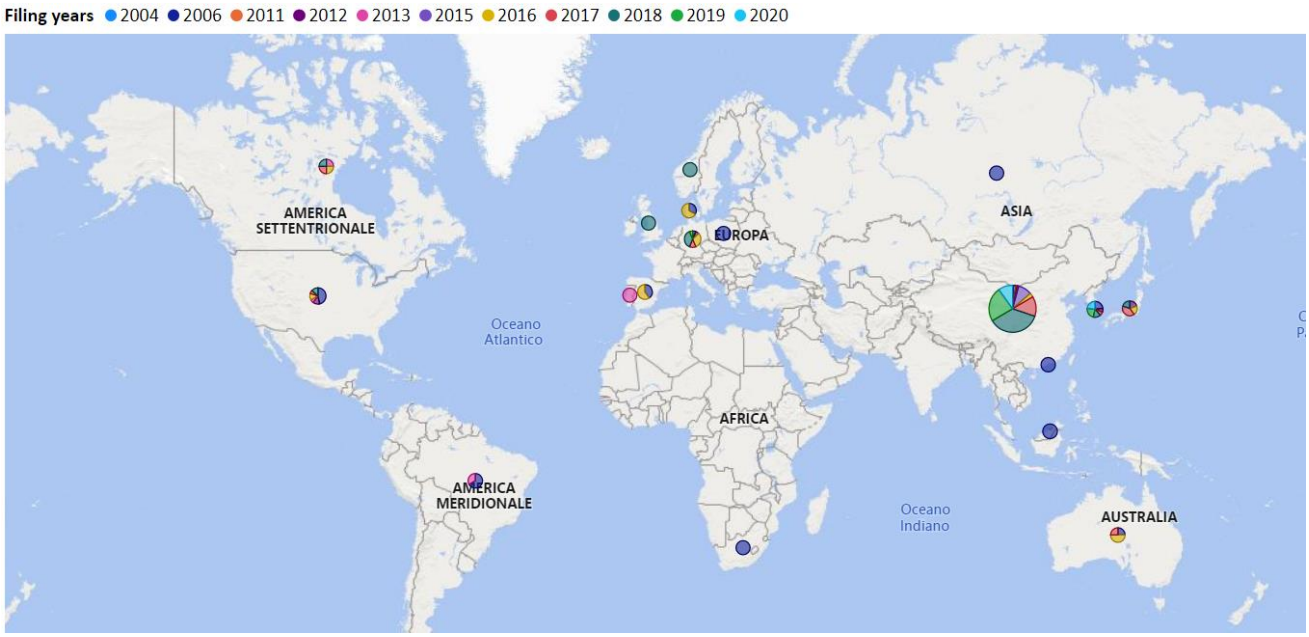


Figure 70.The number of filing events partitioned according to the earliest filing year (EP and PCT not included)

Interestingly, comparable numbers of applications are filed to the EPO and to the WIPO suggesting that technical innovations concerning the detection, quantification, and monitoring of microplastics are evenly rising the interest toward the commercial opportunities, thus indicating a widespread and growing awareness of their negative effects on the environment and therefore the need of a more accurate detection of these harmful substances.

Table 28. Number of filing events registered at the European Patent Office (EPO) and at the World Intellectual Property Organization (WIPO) from 2000 to 2019

Sovranational authorities	
EPO	15
WIPO	17

Depending on the number of patent families owned, it seems that the main competitors are headquartered in China, in particular the Chinese Research Academy of Environmental Sciences (CRAES) with a total of 27 patent families owned.

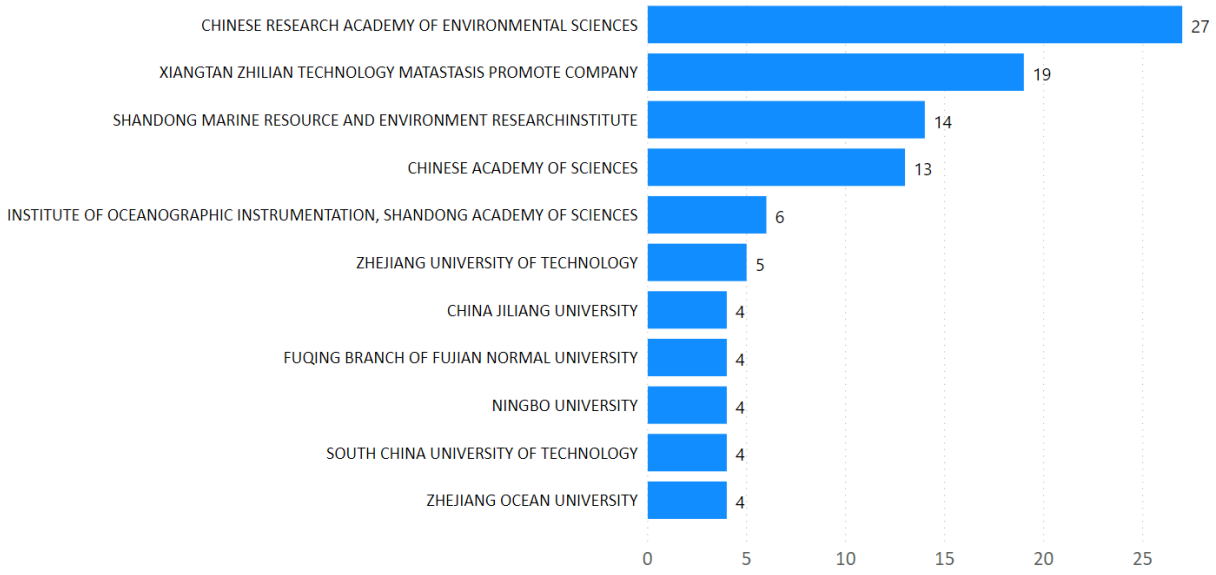


Figure 71. Patent families' number per assignee

As far as the granted patents are concerned, B. Braun Melsungen headquartered in Germany owns 27 granted patent patents, being followed by the Chinese Research Academy of Environmental Science (CN) which owns 21 granted patents.

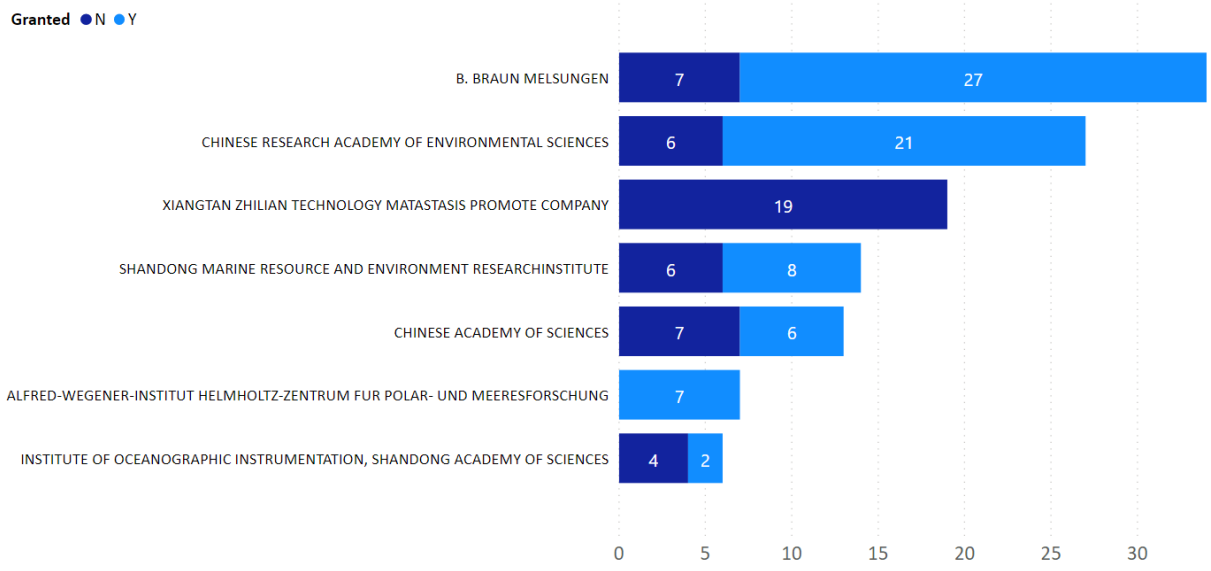


Figure 72. The legal status of patent applications

Case Histories: Microplastics

1) *EP3272421A1 (SEPARATOR FOR THE FLUID-BASED SEPARATION OF MICROPLASTIC PARTICLES FROM SEDIMENTS AND USE OF THE SEPARATOR) ALFRED-WEGENER-INSTITUT HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG)* (Home - AWI)

The invention relates to **a separator for the liquid-based separation of microplastic particles from sediments** with a base block with a liquid inlet, a sieve arrangement, a separation tube and with a head block with a microplastic particle outlet and with a liquid outlet, a sediment inlet and a sediment outlet and to a

use of the separator in a process for the liquid-based separation of microplastic particles from sediments. Microplastics include both primary particles, for example basic pellets and granulates in cosmetics, hygiene and cleaning products, as well as secondary particles that have been fragmented by physical, chemical and biological action from macroplastics, containers of all types, but also fiber tissue.

Plastic waste floating in the sea takes an extremely long time to break down.

Due to the weather and water, however, it slowly decomposes and becomes microplastic, which sinks to the bottom of the water and is absorbed by marine animals. **The spread of microplastics in the marine environment is increasingly being documented**. Microplastic particles with a diameter between 38 µm and 1 mm can now be found in almost every kilogram of sand sediment. The microplastic particles occurring in these size fractions correspond to the natural sediment or phytoplankton, so **that it can be assumed that a whole range of marine organisms - starting with microorganisms such as zooplankton, mussels, lugworms, seabirds and fish - absorb plastics and are potentially affected by harmful effects. Humans are also affected**, as the pollutants given off by the plastics accumulate, for example, in mussels or sea fish and are absorbed by them. There are therefore different demands on research.

2) *CN108421299A (MULTI-CHAMBER RECIPROCATION TYPE OCEAN MICRO PLASTIC SYNCHRONOUS COLLECTION AND SEPARATION DEVICE WITH SAND-REMOVING SCREW ROD), CHINESE RES ACAD ENV SCIENCES* (Chinese Research Academy of Environmental Sciences (craes.cn))

The invention relates to an environmental pollution monitoring and separating device, in particular to **a multi-chamber reciprocating marine micro-plastic synchronous collecting and separating device with a sand removing screw**.

Microplastics refers to plastic particles with a diameter of no more than 5mm, which has become one of the hot issues of international concern. In 2014, **the first UN Environment Conference** (UNEP1) **listed micro-plastic pollution as one of the top ten environmental issues to be solved in the world**. In 2015, **UNEP2 included marine microplastics as the second largest scientific issue in environmental and ecological science research**, and together with global climate change, ozone depletion and ocean acidification, became a major global environmental issue of global scientists' attention. **The micro-plastics in water are mainly derived from human use of micro-plastic particles**, […]. Among them, the plastic beads (Microbeads) added in personal care products is one of the direct sources of water micro-plastics. In some personal care products such as shower gel, facial cleanser, toothpaste and some cosmetics such as eye shadow, mascara, moisturizer and other personal care products, plastic beads made of polyethylene and polypropylene are artificially added during the production process. After personal washing, the plastic microbeads in the wastewater enter the sewage plant through the sewer. Due to the small size, light density and large quantity of plastic microbeads, it is difficult to effectively remove these plastic microbeads by the conventional treatment process of the current sewage plant, and most of the plastic microbeads will enter the natural water body and eventually enter the ocean for a long time. Potential harm to freshwater and marine ecosystems and even human health through the food chain.

***

Technical innovations involving **bioplastics** have been acknowledged worldwide in the last decades as anticipated in the market analysis. The highest number of patent applications have been filed to the Chinese patent office (305 filing events). In the European countries the highest number of patent applications has been filed to the French authority (9 filing events), although patent applications have been filed to almost every national patent office.

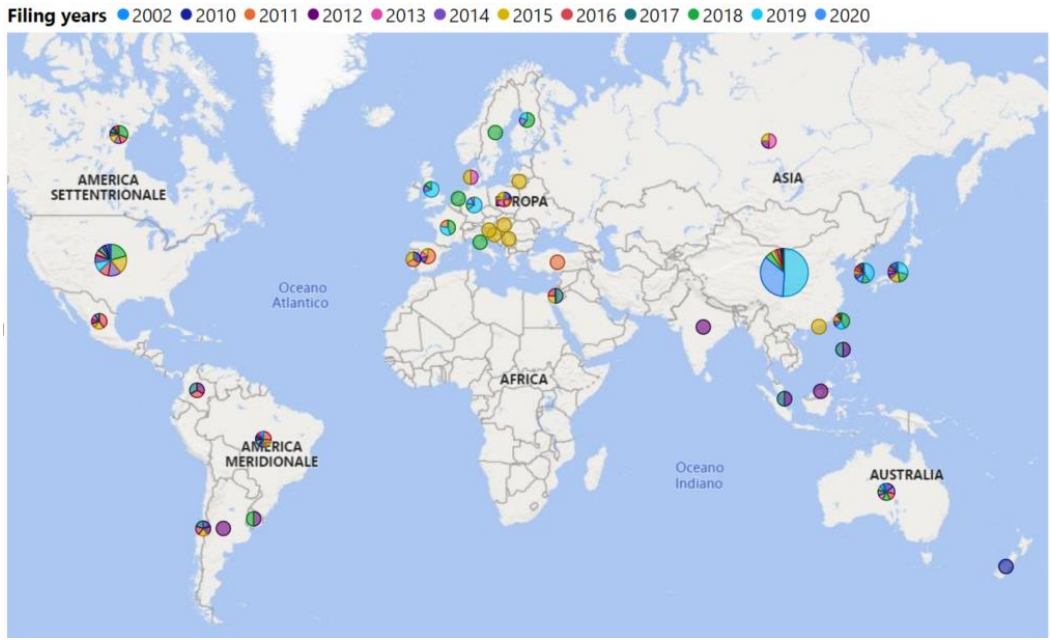


Figure 73. The number of filing events partitioned from 2002 to 2020 (EP and PCT not included)

As already pointed out, such filing events do not account for the possibility of nationalization procedures following the filing of EP/PCT applications. The number of patent applications filed to the WIPO is substantially higher than the number of applications filed to the EPO indicating that the legal protection of inventions may be considered strategically relevant not only in Europe but in many extra-European countries.

Table 29. Number of filing events registered at the European Patent Office (EPO) and at the World Intellectual Property Organization (WIPO) from 2002 to 2020

Sovranational authorities	
EPO	60
WIPO	153

Upon counting the number of patent families, the US company BioLogiQ and Beijing Yiside Logistics Technology Company (CN) own the highest number of families, 18 and 16, respectively.

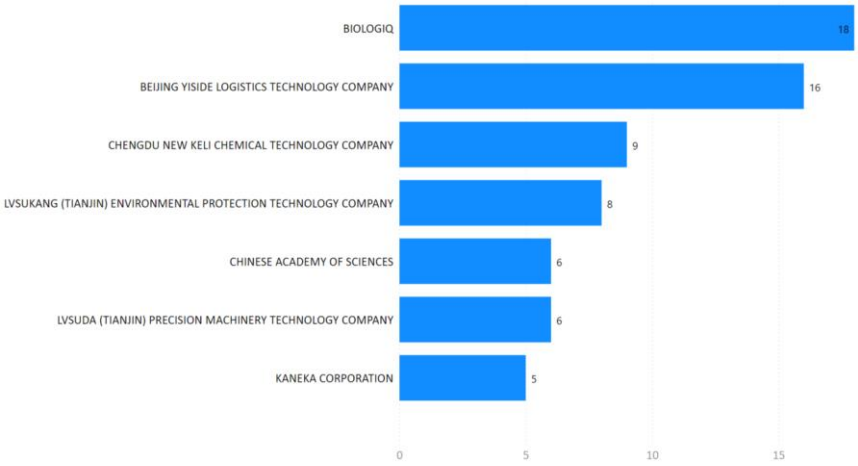


Figure 74. Patent families' number per assignee

As far as the patents' grant rate is concerned, the company Texchem Polymers headquartered in Malaysia and the CNRS (Centre National De La Recherche Scientifique) located in France score the highest numbers of patents owned.

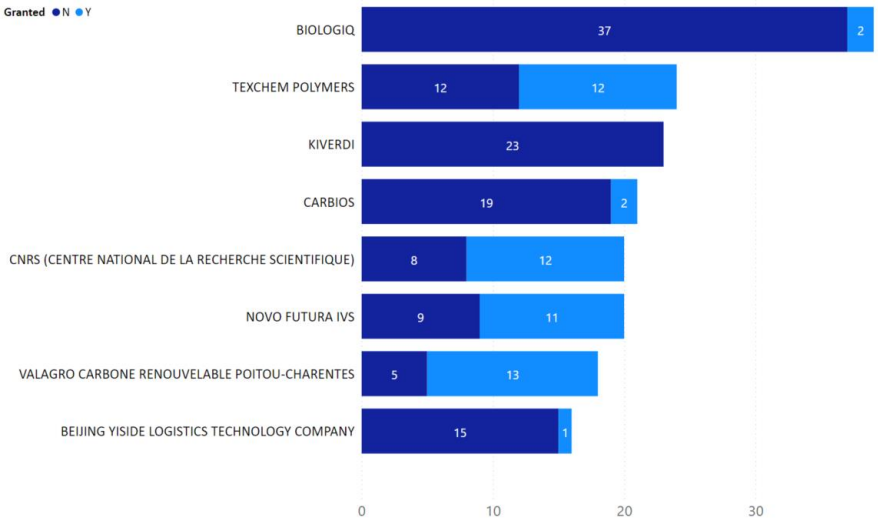


Figure 75. The legal status of the patent applications

Case Histories: Bioplastic

1) *FR3077561A3 (SACHET POUR FRUITS ET LÉGUMES EN LIBRE-SERVICE) ADERCARTA SPA* (Carte e sacchetti alimentari | Adercarta)

   The invention relates to **a bag for self-service fruits and vegetables**, comprising a folded sheet and gluing means applied to the folded sheet, to form a body comprising a mouth and a closed bottom, wherein the sheet is of **calendered, semi-transparent paper and comprises cellulose fibers and epichlorohydrin**, wherein the **cellulose fibers consist only of virgin fibers, the present sachet being semi-transparent, resistant to moisture, recyclable and compostable**.

2) *FR3083544A1 (MATIERE PLASTIQUE À HAUTE TENEUR EN PLA COMPRENANT DES OLIGOMERES D'ACIDE LACTIQUE) CARBIOLICE* (Carbiolice ≡ Compostable plastic solutions)

The present invention relates **to a plastic composition based on biodegradable and biobased polyesters**, in particular **for the preparation of films of plastic**.

3) *EP3307811A1 (MASTERBATCH COMPOSITION COMPRISING A HIGH CONCENTRATION OF BIOLOGICAL ENTITIES) CARBIOS (*Carbios - Innovating for a true circular economy in plastics*)*
The present invention relates to **a novel masterbatch composition comprising a high concentration of biological entities**.
The invention also relates **to a process for producing such masterbatch composition, and the use thereof for the production of plastic articles**.
The present invention provides improved methods and compositions **for producing plastic articles with increased biodegradability**.

Patent datasets' features

Microplastics: analysis of **241 non-duplicated patent families** corresponding to **327 patent applications**. No limitation is assumed concerning the applications' filing timeframe.

Bioplastics: analysis of **600 non-duplicated patent families** corresponding to **1098 patent applications**.
Applications' filing timeframe: priority year 2019 → Jun 2021.

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Sustainable Development Goals (SDGs)

Blue Sustainable Development and linkages with the SDGs

Figure 76. Sustainable Development Goals and linkages with the Blue Biotechnology sector of BLUE BIO MED project. For more info concerning the SDGs please visit THE 17 GOALS | Sustainable Development (un.org)

The **Blue Sustainable Development** sector of BBM project aligns with **4 SDGs**.

Starting with the biosphere dimension, the progresses of the **Goal 14** ***"Life Below Water"*** for a better use of seas and marine resources are closely linked to the challenges of BBM project, which are aimed to balance the economic, social and environmental dimension for a sustainable development. The widespread over-exploitation of the seas is affecting the ecosystem as a whole and its services. Several challenges, from marine pollution, eutrophication, habitat degradation, to illegal fishery, must be firmly addressed to contribute to the realisation of Goal 14 which will consequently affect also **Goals 13** ***"Climate Action"***. In particular, its target **13.1** "*Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries*".

New technologies for the monitoring and observation of marine environments will strongly help the achievement of SDG 14 and related targets. Starting with the **Target 14.2**, ocean monitoring could provide better data for sustainable management and protection of blue ecosystems. Finally, the development of new technologies such as sea water sensors and UUVs are also improving the technology transfer focused on the preservation of marine biodiversity contributing to the **Target 14.4** [1].

Moving to the marine pollution, the fight against marine plastics is largely addressed both in the **Target 14.1** and in the BBM project. The reduction floating plastic debris, from macro to nano, is a key challenge that the European countries are addressing with several initiatives and studies. New solutions are now developed to improve the retention and the dispersion of plastic form land as well as new investment of bio-based materials such as biodegradable plastics.

Table 30. SDG 14 "Life Below Water". Relevant Targets and Indicators to the Blue Sustainable Development.

Targets	Indicators
14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution	14.1.1 Index of coastal eutrophication and floating plastic debris density
14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans	14.2.1 Proportion of national exclusive economic zones managed using ecosystem-based approaches

The marine natural capital of seas includes both living and non-living resources which are the source of marine ecosystem services. The ecosystem services are the benefits that people obtain from the marine ecosystems, and thus they support human well-being. Ecosystems can provide a higher number of services when their functionalities are preserved, assuring more benefits for the people form health and entertainment to the development of industries. For this reasons, sustainable management of the marine areas could positively affect - through several ways - also **Goals 3** ***"Good Health and Well-Being"*** and **9** ***"Industry, Innovation and Infrastructure"*** [2]. The relevant targets of the two goals are reported in Table 31 and Table 32 , respectively.

Table 31. SDG 3 "Good Health and Well-Being". Relevant Targets to the Blue Sustainable Development

Target
3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination

Table 32. SDG 9 "Industry, Innovation and Infrastructure". Relevant Targets to the Blue Sustainable Development

Targets
9.5 Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending
9.b Support domestic technology development, research and innovation in developing countries, including by ensuring a conducive policy environment for, inter alia, industrial diversification and value addition to commodities

Challenges for the sustainability

The Blue Sustainable Development sector aligns with the SDGs indicated above and has great potential to contribute to sustainability in the blue sector by contributing to more jobs, increase of welfare and improve ecological

resilience and health. This sector highlights the importance of preserving the ecosystem services provided by the marine environments from pollution and uncontrolled exploitation through innovative technologies. Coastal and marine ecosystems supply a variety of ecological functions that turns, directly or indirectly, into economic services and goods for human consumptions: from the supporting fish populations and ecosystem stability to the mitigation of climate change through carbon sequestration [3]. Overall, marine and coastal renewable resources , if properly managed, can continue to provide goods and services also for future generations. However, much of the economic and social development has come also through the unsustainable use of the ecosystems [4]. In the Mediterranean Sea the mismanage [6] and depletion of the resources is preeminent due to several factors. Being a semi-enclosed basin, the Mediterranean area is much more vulnerable to a combination of natural and anthropogenic pressures such as marine pollution, illegal fishery, unregulated industrial activities, habitat modifications, introduction of exotic species, climate change and rising temperature [3]. The pressure resulting from all those elements should be faced jointly and in the same way by the different countries bordering the basin. For this reason, to achieve a more sustainable management of the Mediterranean natural capital, a strong and common regulation is needed across all EU member states and Southern Mediterranean countries. Consequently, the success of the above-mentioned SDGs is strictly linked with a coherent implementation of the exiting international policies which should accommodate the inevitable diverging priorities among actors involved into a joint framework of overhierching goals and constrains. To obtain this joint progress towards a more sustainable management, a common international legislation for the Mediterranean Sea must be achieved, as specifically mentioned in SDG 14.c.

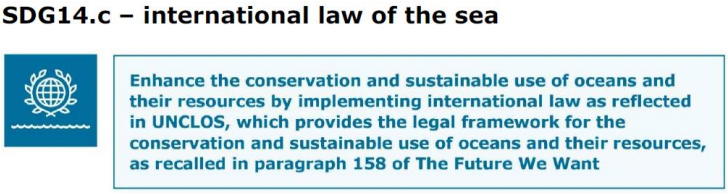

Figure 77. SDG 14.c

This SDG highlights also the importance of the implementation of legal obligations under international law to enhance the conservation and sustainable use of seawater and its resources. However, the implementation of this goal requires more than a formal improvement of the existent international marine governance framework but the improvement of effective coordination and cooperation between international organisations and countries. Moreover, it needs a strong cooperation and exchange of technical assistance and capacity building in order to reduce development differences across the different parts of the basin. [5]. Therefore, enhancing cooperation between Mediterranean countries is crucial for the sustainable use of the marine environment which will consequently influence the realisation of several other goals. In fact, it is thus remarkable that Blue Sustainable Development sector involves the three pillars of sustainability, i.e., the ecological, social and economic dimension. However, in order to pursue applied sustainability, the great challenge linked to this sector is pointing towards new technological development and innovations to ensure first of all the ecological sustainability by accounting primarily the lowest possible ecological impacts and externalities because only in this way the other two pillars of sustainability (social and economic) can be successfully met.

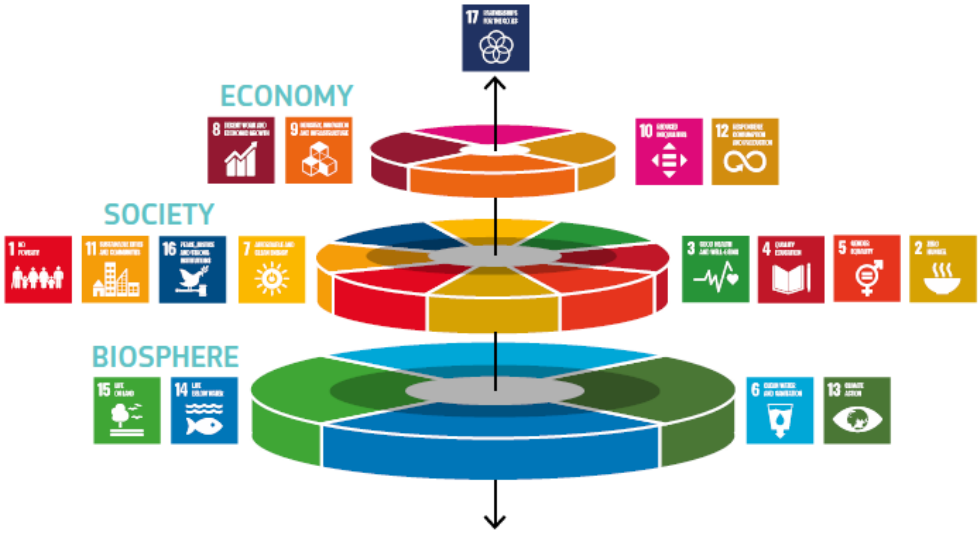

Figure 78. The "wedding cake" model of sustainability. For more information, please visit [THE 17 GOALS | Sustainable Development (un.org)](un.org).

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