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DIVERSIFY

Removing production bottlenecks of emerging species for European aquaculture

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SEVENTH FRAMEWORK PROGRAMME

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DIVERSIFY:

Enhancing the European aquaculture production by removing production bottlenecks of emerging species, producing new products and accessing new markets

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On 29-30 January 2014, the European Commission project DIVERSIFY (FP7-KBBE-2013, GA 603121) had its kickoff meeting at the Hellenic Center for Marine Research (HCMR) in Iraklion, Crete, Greece. The project is coordinated by Dr. Constantinos C Mylonas of the Institute of Marine Biology, Biotechnology and Aquaculture (IMBBC), one of the three institutes of the HCMR. DIVERSIFY has a total budget of 11,8 million € for its 5 year duration and it is one of the largest research project in the area of aquaculture funded by the European Commission. DIVERSIFY's consortium (Table 1) includes twenty research and academic institutions, three Large Enterprises, nine Small and Medium Enterprises (SME), five Professional Associations and one consumer NGO.

The project DIVERSIFY (www.diversifyfish.eu) has identified a number of new/emerging finfish species, with a great potential for the expansion of the EU aquaculture industry. Although the emphasis is on Mediterranean cage-culture, fish species suitable for cold-water, pond/extensive and fresh water aquaculture have been included as well. These new/emerging species are fast growing and/or large finfishes marketed at a large size and can be processed into a range of products to provide the consumer with both a greater diversity of fish species and new value-added products. The fish species to be studied include **meagre** (*Argyrosomus regius*) and **greater amberjack** (*Seriola dumerili*) for warm-water marine cage culture, **wreckfish** (*Polyprion americanus*) for warm- and cool-water marine cage culture, **Atlantic halibut** (*Hippoglossus hippoglossus*) for marine cold-water culture, **grey mullet** (*Mugil cephalus*) a euryhaline herbivore for pond/extensive culture, and **pikeperch** (*Sander lucioperca*) for freshwater intensive culture using recirculating systems.

These species were selected based both on their biological and economical potential, to cover the entire European geographic area and to stimulate different aquaculture types. In collaboration with the participating SMEs and/or Large Enterprises, DIVERSIFY will build on recent/current national initiatives for species diversification in aquaculture, in order to overcome the documented bottlenecks in the production of these species. Research will be carried out in the scientific disciplines of Reproduction and Genetics, Nutrition, Larval and Grow out husbandry, Fish health, Final product quality and Socioeconomics. The combination of biological, technological and socioeconomic research planned in DIVERSIFY are expected to support the diversification of the aquaculture industry and help in expanding production, increasing aquaculture products and development of new markets. To ensure the dissemination and implementation of the new knowledge that will be developed by the project, a wide range of dissemination activities have been planned, targeted both to the aquaculture production and its associated sectors (*i.e.*, food processing and retailing), as well as the European consumers.

Meagre cages.

Seriola in cage.

Stripping eggs from meagre.

Participating organizations in DIVERSIFY

Greece: Institute of Marine Biology, Biotechnology and Aquaculture (HCMR/IMBBC); ARGOSARONIKOS FISHFARMS AE; AQUACULTURE FORKYS AE; IRIDA AE; Hellenic Research House AE; VAS. GEITONAS & Co Ltd; Federation of Greek Maricultures.

Spain: Institut de Recerca i Tecnologia Agroalimentaries (IRTA-San Carles de la Rapita); Parque Científico y Tecnológico de la Universidad de Las Palmas de Gran Canaria; Centro Tecnológico de la Acuicultura de Andalucia (CTAQUA); Universidad de la Laguna; Instituto Español de Oceanografía; Asociación Empresarial de Productores de Cultivos Marinos-APROMAR; Consellería do Medio Rural e do Mar-Xunta de Galicia; Ayuntamento de A Coruña (Museos Científico Coruñeses); CULMAREX SAU; CANEXMAR SL; ANFACO-CECOPESCA.

France: French Research Institute for the Exploitation of the Sea (IFREMER); Université de Lorraine; ASIALOR Sarl

Israel: Israel Oceanographic and Limnological Research-National Center for Mariculture; DOR AQUACULTURE Ltd

Norway: Institute of Marine Research, National Institute of Nutrition and Seafood Research; Skretting Aquaculture Research Center AS; Stirling White Halibut AS

The Netherlands: LEI-Wageningen UR (DLO/LEI); Eindhoven University of Technology

United Kingdom: The University of Aberdeen

Italy: Universitá degli Studi di Bari «Aldo Moro»; AZIENDA AGRICOLA ITTICA CALDOLI Srl

Belgium: Université de Namur; European Food Information Council

Denmark: Technical University of Denmark, Aarhus University (MAPP Center)

Germany: German Association of Fish Processors (Bundes Verband Fisch, BVFi E.V.)

Hungary: Hungarian Aquaculture Association (Mayar Akvakúltra Szövetség, MASZ)

MEAGRE

Meagre is found in the Mediterranean and Black Sea, and along the eastern Atlantic coast (Haffray et al., 2012). It has attractive attributes for the market that include **large size, good processing yield, low fat content, excellent taste and firm texture** (Monfort, 2010). The species also has attractive biological characteristics such as a **fast growth of ~1 Kg per year** (Duncan et al., 2013), a **low feed conversion ratio of 0.9-1.2** (Duncan et al., 2013; Monfort, 2010) –which is similar to the Atlantic salmon-, relatively easy larval rearing (Papadakis et al., 2013; Roo et al., 2010; Vallés & Estévez, 2011, 2013) and established induced spawning protocols for the production of viable eggs (Duncan et al., 2012, 2013; Mylonas et al., 2013a, b). Meagre was first produced in 1997 in a commercial hatchery in France and since then it has exhibited annual production increases as high as 7 fold (FAO, 2012). In 2010, European meagre aquaculture production was 2,387 t, mainly in Spain, with smaller quantities from France, Portugal, Italy, Greece, Cyprus and Croatia (FAO, 2012). Production of meagre is also carried out in Egypt, but there it is based exclusively on the collection of wild fry.

A survey of meagre producers carried out during the proposal stage of DIVERSIFY identified four principal bottlenecks to the expansion of the industry. Firstly, **variable growth rates** are reducing yield greatly (Duncan et al., 2013). A multidisciplinary approach is required in order to examine the role of genetics, nutrition --particularly dietary requirements during weaning, nursery and grow out-- feeding behaviour and grow out husbandry. Secondly, the distribution of this fish only in specific areas in the Mediterranean region has resulted in the acquisition of broodstocks from a limited number of sources (mainly a hatchery in France), resulting perhaps in a **limited genetic variation of the**

Checking PIT tag.

available broodstocks. This will have significant negative implications for the future initiation of breeding selection programs, which are necessary to move the industry to the next level of efficiency and production. Thirdly, the industry must address issues in **fish health**, emerging diseases, parasites (Koyuncu et al., 2012; Merella et al., 2009; Ternengo et al., 2010; Toksen et al., 2007) and the wide occurrence of Systemic Granulomas (Elkesh et al., 2012), which may stem from the fact that no diets have been developed for this fish. Finally, **socioeconomic factors have been identified as bottlenecks**, including the need for a more expanded market and diversification of provided products (Monfort, 2010) beyond the whole fresh fish. National initiatives for meagre domestication are underway in Spain and Greece (kranios.weebly.com), and DIVERSIFY will build on the acquired information by targeting specific issues recognized as bottlenecks for further production.

GREATER AMBERJACK

This is a cosmopolitan species (Andaloro & Pipitone, 1997; Cummings et al., 1999; Thompson et al., 1999) of great interest to the aquaculture sector due to its **excellent flesh quality**, **worldwide market availability** and high **consumer acceptability** (Nakada, 2000). Its rapid growth (*i.e.*, **short time to market size**) and large size makes this species **very suitable for product diversification and development of value added products**. In the Mediterranean (Lovatelli & Holthus, 2008), farming started with capture-based activities using wild juveniles (Crespo et al., 1994). Fish of ~90 g reached ~1 kg in a year, and 6 kg in a period of 2.5 years (Jover et al., 1999; Mazzola et al., 2000). The high growth rate of cultured greater amberjack and its feeding on fish of low commercial value made the activity profitable. Using standard dry feeds, wild caught individuals of 50-100 g exhibited great growth performance of 1.8, 4 and 7.5 kg body weight in 1, 2, and 3 years, respectively (Jover et al., 1999; Mazzola et al., 2000). Still, the Mediterranean production in 2012 was only ~2 t, while market price –mainly for capture fisheries catches-- reached values >14 € kg^{-1}. Today, **a very limited commercial activity with hatchery-produced individuals exists in Malta**, though interest exists and efforts have been made by various aquaculture companies in the Mediterranean.

The **major bottlenecks f**or the incorporation of greater amberjack in the EU aquaculture industry include lack of (a) **reliable reproduction** and (b) **production of adequate numbers of juveniles**. In captivity, reproduction has been problematic (Kozul et al., 2001), but **captive-reared broodstocks have reproduced after hormonal treatments** (Fernandez-Palacios et al. 2013; Mylonas et al., 2004), and in some cases also spontaneously (Jerez et al., 2006). Also, some knowledge has been acquired on the nutritional requirements

of reproduction (Rodríguez-Barreto et al., 2012). **DIVERSIFY will study the reproduction in captivity and in the wild, and develop efficient spawning induction methods, as well as appropriate broodstock diets.**

Larval rearing of greater amberjack was done initially using semi-intensive methods (Papandroulakis et al., 2005). Survival was limited (3%), but recently it has been improved with adaptations in feeding regime and diet quality (Anonymous, 2008). Since both the greater amberjack (Matsunari et al., 2012) and its congeners the yellowtail (*S. quinqueradiata*) (Nakada, 2000), yellowtail kingfish (*S. lalandi*) (Ma et al., 2012) and almaco jack (*S. rivoliana*) (Roo et al., 2012) have been produced in hatcheries, once the bottleneck of egg availability is surpassed, the available information on these congeners can hasten the development of larval rearing protocols for the greater amberjack.

Another area of concern for the commercial production of greater amberjack is **fish health**. Bacterial pathogens cited in the literature as potential threats include *Photobacterium damsella* (Crespo et al., 1994) and epitheliocystis (Rigos and Katharios, 2010), and *Cryptocaryon irritans* has caused severe losses in broodstock (Rigos et al., 2001). During grow out, monogenean parasites cause occasional mass mortalities in farmed fish (Grau et al., 2003; Montero et al., 2004), while *Neobenedenia* spp was identified in a major outbreak causing losses in both juveniles and broodstock. Therefore, DIVERSIFY will study the potential pathologies that will occur in the course of the project in an effort to develop **early diagnosis tools**, **veterinary solutions** and **preventive veterinary protocols** that will be available and will support the sustainable rearing of the species.

PIKEPERCH

This freshwater fish is considered to have the highest potential for inland aquaculture diversification in Europe (Wang et al., 2008). Through the EU projects LUCIOPERCA and LUCIOPERCIMPROVE, reproductive control (Kucharczyk et al., 2007) and bio-economic feasibility of pikeperch intensive rearing (Steenfeldt & Lund, 2008; Steenfeldt et al., 2010a,b) have been demonstrated. **Pikeperch demand has been strengthened** by the strong decline of wild catches from Russia, Estonia and Finland from 50,000 t in 1950 to 20,000 t currently (FAO, 2009). Over the last decade, 10 new farms have been built in Europe to produce pikeperch using RAS (Fontaine et al., 2012), producing an estimated 300-400 t (1st Workshop of the European Percid Fish Culture Group, 1 Sept 2012, Prague). Numerous more commercial operations have been designed and/or are under construction in Belgium, Czech Republic, Denmark, France, Germany, Hungary,

Italy, Poland, Portugal and the Netherlands. Year-round production of pikeperch requires constant high temperatures (24-26°C), which is only feasible in RAS to ensure relatively high growth rates (*i.e.*, **production of 1.2 kg fish in 15 -18 months** from non-selected strains). These RAS also allow high densities of 80-100 kg m^{-3} (Dalsgaard et al., 2013). Pikeperch flesh quality has a neutral taste, thus lending itself to different forms of preparation, and the filets are without bones --unlike carp, which competes on the same market segment. At present, pikeperch is sold either as whole fish at a weight of 600-3,000 g or as filets of 100-800 g to markets in Europe (mainly Western, Eastern and Northern areas)

Pikeperch bleeding.

and North-America, showing strong demand. The market value is high at 8-11 € kg^{-1} at farm gate, whole fish.

Identified by a survey addressed to fish farmers in preparation for DIVERSIFY, the **major bottlenecks for further expansion of pikeperch** culture today include (a) **high sensitivity to stressors, handling and husbandry practices** that result in high and sudden mortalities, (b) **low larval survival** (typically 5-10%) and **high incidence of deformities**, and (c) **lack of knowledge of the genetic variability of the used broodstocks**. Identification of genetic relationships among different broodstocks, inbreeding phenomena and loss of heterozygosity is important in aquaculture, since it may result in subsequent reproductive and productive failure (reduced progeny survival, growth, food conversion efficiency and increased frequency of deformities). It is also important to know how the domesticated stocks differ from their wild counterparts, which could potentially be a future source of fish to include in effective breeding programs. Overcoming the above bottlenecks is very important to reduce production costs and, therefore, expand the aquaculture production of this species in the EU, and will be the objective of DIVERSIFY.

ATLANTIC HALIBUT

The **Atlantic halibut is the world's largest flatfish** and can attain a weight of over 300 Kg. It is **highly prized at markets worldwide**, but availability of wild Atlantic halibut is decreasing and the fish is classified as **endangered on the IUCN red list**. Two years ago a complete ban was imposed on Icelandic fisheries, and stocks along the Norwegian coast are declining and under strict regulation. This has led to a **higher market demand for Atlantic halibut than cannot be met by fisheries alone**. Cultured Atlantic halibut has an excellent reputation, but is rarely available outside specialty restaurants due to low annual production. The Atlantic halibut is a semi-fat fish rich in omega-3 fatty acids, with a characteristic flaky white meat with few bones. In terms of product diversification, Atlantic halibut is traditionally marketed as large fish steaks or cutlets. It can be smoked or marinated in the typical Scandinavian style. These characteristics led to the **inclusion of Atlantic halibut in DIVERSIFY, as a great candidate for fish species and product diversification in European aquaculture**.

Research and cultivation efforts of Atlantic halibut started in the 1980's, but the **total annual production of cultured Atlantic halibut is still only ~1,600 t** (Norwegian Directorate of Fisheries). In Europe, Atlantic halibut farms exist in Norway and Scotland. The desired market size is 5-10 kg and production time is currently 4-5 years. Despite a significant research effort between 1985 and 2000, the complicated life cycle of Atlantic halibut made aquaculture progress slow, and very little research funding has been allocated thereafter. However,

during this time slow but steady progress has been made by the farmers in order to improve production stability, and **interest in cage culture is growing**. The remaining **bottlenecks for increased and stable production are related to a steady supply of fry and a need to decrease the production time**. The latter may be achieved with the recent establishment of "all female" juvenile production (Babiak et al., 2012; Hendry et al., 2003). This is expected to have a major impact on production time as females grow faster and mature later –80% of slaughtered fish <5 kg are mature males (unpublished data). DIVERSIFY will address these important bottlenecks with a coordinated **research effort in reproduction, and larval nutrition and husbandry**.

WRECKFISH

Wreckfish is one of the largest Serranid species, **reaching a size of 100 Kg**. It is a deep-water fish found **almost throughout the world** and is characterized by an extended pelagic juvenile phase (Ball et al., 2000; Deudero et al., 2000; Sedberry et al., 1999). Wreckfish is one of the most interesting new species for aquaculture, due to its **fast growth** (Rodriguez-Villanueva et al., 2011; Suquet & La Pomélie, 2002), **late reproductive maturation** (Sedberry et al., 1999), **high market price and limited fisheries landings** --quotas have been reduced by 90% in 2012 in the U.S.A. (NOOA, www.fishwatch.com)-- and ease of manipulation in captivity (Papandroulakis et al., 2008; Rodriguez-Villanueva et al., 2011). Its large size lends itself to **processing and development of value added products**, and its **cosmopolitan distribution may enable** EU exports.

Wreckfish acclimatizes easily to captivity and, despite its large size, no mortalities have been reported due to handling. It accepts inert food easily, being a very voracious carnivore. In a recent study of wild-caught individuals it was shown that fish **grew from 1 kg to**

Stripping eggs from wreckfish.

5 kg in a period of 10 months (Rodriguez-Villanueva et al., 2011). The slow reproductive maturation of wreckfish, which occurs at an age of 5-10 y in captivity,

continued on page 11

wreckfish *continued*

may be a problem for broodstock development and management. On the contrary, its **long juvenile stage is a great advantage from the aquaculture viewpoint**, allowing for commercialization before sexual maturity, and thus avoiding problems linked to maturation, such as reduction in growth, or loss of flesh quality and organoleptic properties.

Lack of reproduction control and of established larval rearing protocols are considered major bottlenecks preventing wreckfish aquaculture. Limited egg collection has been achieved from captive spawners using hormonal induction (Papandroulakis et al., 2008) or stripping of naturally maturing fish (Peleteiro et al., 2011). Embryonic development and the early life stages have been described (Papandroulakis et al., 2008, Peleteiro et al., 2011), indicating that the **large egg size of this fish (~2 mm in diameter) may offer significant advantages for its larval rearing**. Reproduction and larval rearing of a very close relative, the hapuku (*Polyprion oxygeneios*) has been achieved recently in New Zealand (Anderson et al., 2012). The **scarcity of broodstock is a disadvantage for this fish**, but the **clear biological and economical potential of this species justifies allocation of part of the effort of DIVERSIFY** in bringing together almost all partners involved so far in Europe in wreckfish domestication, to **overcome its documented bottlenecks --*i.e.,* reproduction and larval rearing--** in order to produce appropriate numbers of juveniles to launch commercial production.

Reading PIT tag.

Conducting an ovarian biopsy.

GREY MULLET

Farming of grey mullet has been practiced for centuries, but production of this potentially invaluable source of animal protein in Europe has been small and non-intensive (Nash & Koningsberg, 1981; Pillay, 1993). It is a **euryhaline species, found throughout the world** (Oren, 1981) and is a **rapid-growing, herbivorous species** that can be **reared over the wide geographical and temperature range of the Mediterranean basin**. As it is detritivorous in the wild, it has been stocked in fish ponds to improve sediment quality and avoid oxygen depletion (Milstein et al., 1991). Therefore, it can be an **excellent candidate for the enhancement of aquaculture in earthen ponds, coastal lagoons, "valli" and deserted Salinas** that exist throughout the EU Mediterranean countries. Hatchery produced juvenile females have been **grown to 1.9 kg in 2 years** on a fishmeal-containing pelleted feed. The development of fishmeal-free feed will reduce the cost of fish production, and will be **more sustainable and environmentally friendly**. In this way, grey mullet would be more acceptable to an increasingly aware consumer public that demands sustainability and lower environmental impact. Moreover, grey mullet aquaculture has the advantage of providing not only affordable whole fish and fillets, but also **fish roe ("bottarga" in Italian), a high value product (>100 € kg^{-1}),** whose market is expanding around the Mediterranean. Therefore, grey mullet has a great **biological and economical potential for fish species and product diversification, and development of value added products**.

A market for grey mullet is well established, though a niche one, in the Mediterranean. Even without any marketing effort by the aquaculture industry, the European market demand for grey mullet is likely to increase in the coming years, due to the demand from established and newly immigrant families originating from North Africa, Middle East and Asia. Currently, **the industry is a capture-based aquaculture, relying exclusively on capture of wild fry** (ca 1,000,000,000) that are subsequently grown out to market weight (600-1,200 g) in captivity, in lagoons or earthen ponds. The sustainability of such an activity is, of course, questionable, and the **future growth of the grey mullet aquaculture is limited by a number of bottlenecks**, which will be addressed in DIVERSIFY. Firstly, **controlling the reproductive cycle and improving egg quality** via broodstock management and nutrition is necessary not only for the production of robust larvae, but also for producing high value bottarga. Secondly, **development of a larval rearing protocol** is necessary to reduce early mortalities, size dispersion as well as increasing metamorphic synchrony, which will lead to a supply of high quality juveniles. Finally, development of a sustainable, economical, **fishmeal-free grow out feed** is needed, which would perform well under different environmental conditions of temperature, pond type, and water quality, thus broadening the geographical range of grey mullet aquaculture in Europe.

Socioeconomics

(including new product development)

Besides the technical improvement of the selected species, the socio-economic research in DIVERSIFY includes applied market development approach solutions on perception of aquaculture products, market demand, buyer preferences, new product development, value adding and market development. These outcomes will help the EU aquaculture sector and the supply industry in targeted marketing and improvement of its international competitive position.

Based on the development of the EU market and the demand characteristics, the following socioeconomic bottlenecks were identified during the preparation of DIVERSIFY:

- **Demand for seafood in the EU is increasing.** While the EU fisheries are stable or decreasing, the total EU demand for seafood is increasing. This increasing demand is currently fulfilled with imports from third countries. However, in order not to become overly dependent on seafood that is sourced in an increasingly competitive international market, it is important to introduce locally produced, sustainable and safe seafood to meet the demands of EU consumers.
- **EU consumer's negative attitude towards aquaculture fish and products**. This means that effective communication strategies have to be developed for the existing and newly developed products (new fish species and their value added products). This requires changing consumer perceptions and attitudes towards the entire aquaculture industry and range of products.
- **Demand for new aquaculture products in the EU market and subsequently in the world has to be developed**. New quality products for new markets have to be developed and targeted to potential market segments, in order to increase demand in the EU and world markets. New species have to be introduced in the market to diversify the aquaculture assortment, so that the risk of image loss of a specific species has lower market consequences for the whole sector.
- **Demand for European aquaculture products in the world markets has to be created**. Rising global consumption of aquaculture fish constitutes a great challenge and opportunity for the EU aquaculture industry. DIVERSIFY's species, cultured with sustainable methods and leading to high added-value products, can be a driver for growth of the market share of EU aquaculture in local and global markets.
- The range and **added value of the aquaculture products has to increase**. Consumers ask for more convenient products in the seafood market. In addition, the added value and cost price of the products have to be positioned in relation to other protein sources. This requires that the price elasticity of fish must be related to the price elasticity of other protein sources. In addition, additional value of European aquaculture products has to be implemented in chain revenue models that lead to a better livelihood for aquaculturists.
- The **sustainability of the aquaculture sector has to be improved further**, as sustainable fish products are requested more and more by EU and global consumer segments, industrial buyers and regulators; at the same time, investing on a sustainable image of the EU aquaculture will create a competitive advantage for the EU aquaculture industry. This requires that technological innovations have to be achieved, which are driven by market demand (consumers and retailers) and sustainability demands of NGO's.

All the above aspects underline that the image of the aquaculture sector has to be improved. New, sustainable --and high added value-- products with a longer shelf life have to be developed and SME's have to be more innovative for the introduction and market development of these new species.

Each of the species selected for DIVERSIFY has the potential to grow in the market and to be perceived as an added value product, and their **biological and economical potential is expected to stimulate the growth of the European aquaculture sector**. The economic potential of each species in relation to the socioeconomic bottlenecks, and the actions planned in DIVERSIFY to overcome them are:

Meagre is a **large fish with excellent taste**. As it is rather rare in fishery captures in the Mediterranean, it is not well known by consumers and the European market is still a niche product. Market development and consumer acceptance of relative species is done successfully in Japan, Australia and the USA. **Market development is imperative for the EU** and should focus mainly on consumer and retail awareness, and a better positioning with regard to gilthead sea bream and European sea bass. **New product** development could support market development.

The **greater amberjack** is a **large fish with high flesh quality and market value**. In addition to its economic potential in the EU market, cultured greater amberjack has a significant potential for exports, as it is distributed worldwide, and congener species are produced commercially elsewhere. This cultured fish **has proven its potential in** other markets. In Europe, there has recently been an intense interest from the aquaculture sector for this species, but production levels are miniscule. Therefore, **a consumer oriented market introduction of cultured amberjack is necessary**. Also, **market development is necessary for growth** with preservation of the added value and price, once production increases.

Pikeperch is a medium size freshwater fish, with a **good taste and a high market value**. There is already a market in Europe and North America, showing strong demand. The production capacity of this fish is expected to grow fast in the coming years. To keep up the high market value, **product development and market development is necessary** for coordinated growth. Therefore, potential markets and consumer segments have to be identified to maintain or increase the added value.

Atlantic Halibut is a **large fish with a very good reputation** in the north European market and a high market value. Demand exceeds the current production capacity. Market and product development is not necessary for the short run, but a **market development strategy** for the long run is necessary, because new entrants in the market can be expected given the added value of Atlantic halibut.

Wreckfish is a **large fish with excellent flesh**, but not available as a cultured fish. It is distributed throughout the world and products from the capture fishery are highly regarded. A very close relative is produced experimentally in New Zealand, where it is considered one of the best marine fishes. Because of this potential excellence, wreckfish could be interesting for the European market. For this species, technical bottlenecks have to be solved first. So, only **market positioning in relation to other species is necessary** for the short run, and for the long run the **market potential will be identified**.

Grey mullet is **a medium size herbivorous fish, cultured extensively throughout the world, but often not well regarded by consumers**. It has a niche market in the Mediterranean for its flesh and high priced roe. Due to its good taste and low cost of rearing, grey mullet could have large potential market all over Europe, especially within segments of population of North African, Middle Eastern or Asian origin. **Market and new product development** are necessary for growth in the middle-long run in the native European market and the immigrant market.

To cover these market bottlenecks, DIVERSIFY gives a central role to positioning of species, and market and product development. In the first year a competitive market and environment analysis will be done and a study on consumer preferences with regard to cultured fish will be undertaken. Both studies are the basis for the development of new product prototypes, which will be developed in this project. These prototypes will be tested on food safety, preservation and market acceptance by consumers. Communication research will find out ways to overcome the negative image of aquaculture fish. The outcomes of all these studies will be the basis for the business plans per species, which will be developed together with the partner SMEs.

The combination of biological, technological and socioeconomic research activities planned in DIVERSIFY are expected to **support the diversification of the aquaculture industry and help in expanding production, increasing aquaculture products and development of new markets**.

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