Evaluation Period 2018-2021 Institute report

Institute of Marine Biology, Biotechnology & AquaCulture (imbbc)

Hellenic Centre for Marine Research (hcmr)

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Executive Summary

The Institute of Marine Biology, Biotechnology and Aquaculture (**IMBBC**), is one of the three institutes of the Hellenic Centre for Marine Research (**HCMR**). It was established in 2012 with the merging of two of the initial institutes of HCMR, the Institute of Marine Biology and Genetics (IMBG) and the Institute of Aquaculture (IA). IMBBC has two Research Groups, the Marine Biology & Biotechnology (**MB&B**) and the Aquaculture (**AQUA**). The headquarters of IMBBC and its main facilities are in Crete, while some of its important **AQUA** laboratories are in Anavyssos (Attica), the headquarters of HCMR. The IMBBC facilities in Crete include (a) laboratories and offices in the main building of the "*Thalassokosmos*" complex, (b) the aquaculture rearing and research facilities "*Aqualabs*", (c) an underwater biotechnological park located right off the coast in front of *Thalassokosmos* and (d) a pilot net pen marine aquaculture facility in Souda Bay, Chania. Until the summer of 2019, IMBBC also had aquaculture rearing facilities at Agios Kosmas (Athens), but these premises have been reclaimed and sold by the State.

The **MB&B** Research Group carries out work in the fields of genetics/genomics, bioinformatics, bioanalysis and biotechnology, marine biodiversity, and marine ecology and ecosystem management. Modern approaches are employed to assess biodiversity and ecosystem functioning in the marine realm, integrating field observation, documentation and collection, taxonomy, experimental setups, genetics/genomics and modeling. **AQUA** carries out research in the fields of fish biology, reproduction, ethology, nutrition, and pathology of all developmental stages (larvae to harvestable size), and in final product quality improvement and production technologies. Beyond the widely farmed species in the region, emphasis is also given in species diversification, in order to develop a profitable and sustainable aquaculture industry. **AQUA and MB&B collaborate** in various research areas, the most important being genetics/genomics of cultured fishes, and the use of genetics and epigenetics to develop improved strains and broodstock management methods.

In the last year of the reporting period, IMBBC had **25 permanent researchers**; 19 Post-docs; 20 PhD, 21 MSc and 35 undergraduate students; and 78 technicians, administrative and other personnel (Total of 186). More than **70% of the technicians were on contract**, paid by competitive research grants and private funding. Four new permanentrResearchers joined IMBBC and one took a leave of absence (CEO of the EU Research Infrastructure LifeWatch ERIC). Annual funding during the reporting period ranged between **€ 3.3 and € 4.2 million**, with 52% coming from competitive Greek grants and 28% from EU grants, and **18% from private funds**. This means that for every 1 € provided by the State in Permanent Staff salaries, competitive grants and private funding provided another 2 €.

IMBBC has shown a steady increase in publishing high-quality articles, reaching **90 articles in 2021** with **67% published in Q1 journals**. Although HCMR is not an educational institution, IMBBC researchers were involved greatly in teaching courses or seminars in Greek and European universities, and in training students through research projects or practical-training internships. A total of **31 PhD Dissertations** (1.25 per researcher), **45 MSc Theses** (1.8 per researcher) and **120 undergraduate and graduate internships** were supervised by IMBBC researchers in collaboration with 15 Greek universities and organizations and 45 from Europe and the world. Also, **three spin-off companies** were established recently, being the first ever in HCMR.

In order to maintain and increase further the scientific excellence of IMBBC, some critical issues must be addressed. Firstly, due to the significant increase in its research activities,

equipment and personnel since the initial creation of HCMR, **the institute needs new infrastructures**. In addition, because of the loss of the entire Agios Kosmas complex, some of IMMBC's research activities have been compromised and funding reduced, and our researchers now based in Anavyssos have been struggling to find alternatives to accommodate the experimental trials included in research programs and private service contracts. Also, there is significant need for the creation of new laboratory and office space for Crete as well, not only maintain our existing research directions and activities, but also to expand into new ones. In addition, we **lack maintenance and upgrade of our existing facilities and equipment**. The facilities of HCMR were built in the early 2000s and very little (if any) maintenance or upgrading has been done over the years, as there is no provision in the State budget for maintenance and upgrading. More urgently, there is a need to upgrade the sea water supply of IMBBC, as the quality of the water has been degrading continuously, with detrimental effects in the health and welfare of our experimental stocks.

Some aspects of the above two issues will be addressed by the **funding acquired** for the construction of new 800-m^2 aquaculture rearing facilities (€1.8 million) and a new 3,000-m^2 office and laboratory building (€ 5,67 million) in Anavyssos. Also, a new 2,500 m^2 office and laboratory building (€ 6,35 million) will be constructed in Crete that will include also a dedicated "Culture collections" facility. Finally, € 1,67 million will be used for drilling new wells, and the construction of a filtration system for the treatment of sea water.

The second problem is that currently **the institute cannot recruit new permanent researchers or technicians**, either for existing or new research directions, and depends on the State to allocate new positions. Also, a significant number of the permanent researchers and technicians will retire within the next ten years, but many of their positions will not be replaced, because they do not hold an "organizational" position that allows the institute to recruit a new person once someone has retired. Therefore, the status of all permanent staff must be converted to "organizational" by the State, so that the positions will not be lost upon retirement. New positions must also be created by the State, so that we can hire staff for new research directions and also to overlap with existing personnel, since a period of training of the new staff is needed before the more experienced member has retired.

The third problem is the **need to improve the administration and financial policies of the State** and center for the management of research funds. The new Law for Research obliges all public research institutes to abide by the financial management rules of the central government. Unfortunately, these rules provide no flexibility and are inappropriate for research activities. Trying to abide by every financial and administrative rule and regulation is often an impossible task, and results in the loss of valuable time and effort, and the creation of widespread disappointment and frustration among researchers. Therefore, **we propose a new model for the management of research funding**, that should become more similar to a loose subcontract, where a price for the research is estimated by an indicative cost analysis at the proposal stage, so that the reviewers can decide if the requested budget is justified. Once approved, the rules should be limited to those necessary to avoid fraud and illegal activities. All other aspects should be allowed full flexibility, as long as the research goals are achieved, since for any public organization, such as HCMR, systems are already in place to assure that fraud and illegal activities are extremely difficult to occur.

The **future looks positive for the research activities and the role of IMBBC** in studying marine biodiversity and expanding our knowledge, so that we can exploit effectively and sustainably the biological resources of our Seas, and to further strengthen the aquaculture industry and its role in providing healthy seafood to our increasing population.

1 Introduction and Background

1.1 Brief History of the Institute

The Hellenic Centre for Marine Research (**HCMR**) was established in 2001 (Law 2919/2001) by joining the Institute of Marine Biology of Crete (**IMBC**, a **private institute** established in 1985 in Heraklion, Crete) and the National Centre of Marine Research (**NCMR**, a **public institute** established in 1985 in Athens). Initially, **HCMR consisted of five institutes** and in 2012 (Law 4051/2012) four of the initial institutes merged and formed two new ones. The **Institute of Marine Biology and Genetics (IMBG)** and **the Institute of Aquaculture (IA) merged** to form the **Institute of Marine Biology, Biotechnology and Aquaculture (IMBBC**), which is now one of the three institutes of HCMR. Dr. Antonios Magoulas was elected as its first director in 2013 and his term ended in December 2018. In 2019, a 7-member committee consisting of five external researchers and professors, and two researchers from IMBBC selected Dr. Constantinos (Dinos) C. Mylonas as the new director, who was then ratified on 24 January 2020 (ΦΕΚ 43 ΥΟΔΔ, 24/1/2020).

IMBBC has its headquarters and its main facilities (offices, labs, aquaculture facilities, etc.) in the premises of HCMR in Crete, named "*Thalassokosmos*" (see picture below). The "*Thalassokosmos*" complex is located 15 km east of the city of Heraklion and includes the "Main building", the aquaculture facilities "Aqualabs" and the public aquarium "Cretaquarium". IMBBC operates also a pilot net pen marine aquaculture facility (30 mT of production) in the western part of Crete in Souda Bay, Chania, and the Underwater Biotechnological Park (50,000 m^2) about 1 km off the coast of "*Thalassokosmos*". Until the summer of 2019, IMBBC also had laboratories and aquaculture facilities at Agios Kosmas (Athens), but these premises have been reclaimed by the State. As a result, all the laboratories moved to the existing HCMR headquarters in Anavyssos (Attica), but **all the fish rearing facilities have been lost**! Plans are currently been made and funding has been acquired for the construction of a new 3,000-m^3 building for laboratories and offices for the whole HCMR in Anavyssos, and a new aquaculture facility for IMBBC (to be completed by 2026). IMBBC has grown considerably over the past decade, with more personnel, equipment and competitive funding. Unfortunately, this growth was not associated with new facilities, while the majority of new personnel (>70%) is on contract. In addition, only four new tenure-track researcher positions have been created by the State in the last 15 years, and no new permanent technical or administrative staff have been hired.

IMBBC has two Research Sectors (equivalent to the "**Research Groups**" for this evaluation), the Marine Biology & Biotechnology (**MB&B**) and Aquaculture (**AQUA**).

The Hellenic Centre for Marine Research (HCMR) facilities in Crete, named "*Thalassocosmos*", with the main building (left), the *Aqualabs* (far right) and *Cretaquarium* (right).

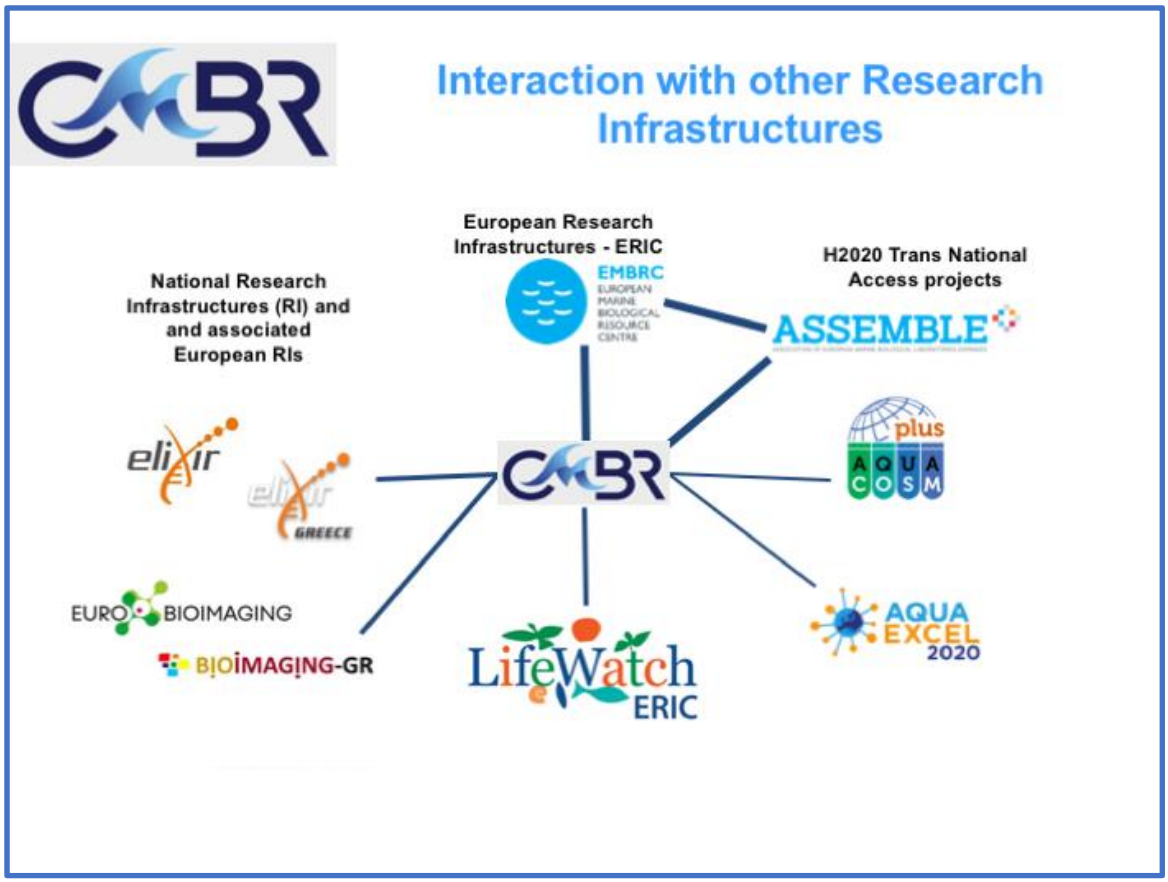
1.2 Mission, Scientific Identity and Distinctive Character of the Institute

The mission of IMBBC can be considered to be what is described for its two predecessor institutes (Presidential decree 164/2003). For the former **IMBG**, which now corresponds to the **MB&B** Research Group, it is "the research and technological developments in the fields of biodiversity, structure, dynamics and management of ecosystems, genetics of marine organisms, the search for new products and organisms, as well as the authentication and origin identification of organisms and their products". For the former **IA**, corresponding to the **AQUA** Research Group, it is "to conduct research, develop technology and know-how, and train scientists in the aquaculture sector and related fields, such as physiology, pathology, ethology, metabolism and genetics, improvement of production and quality, interaction of aquaculture and environment, broodstock enhancement, production technology of aquafeed, selection and cultivation of new species, development of production systems for all developmental stages of cultivated organisms, as well as methodologies for the management of aquaria."

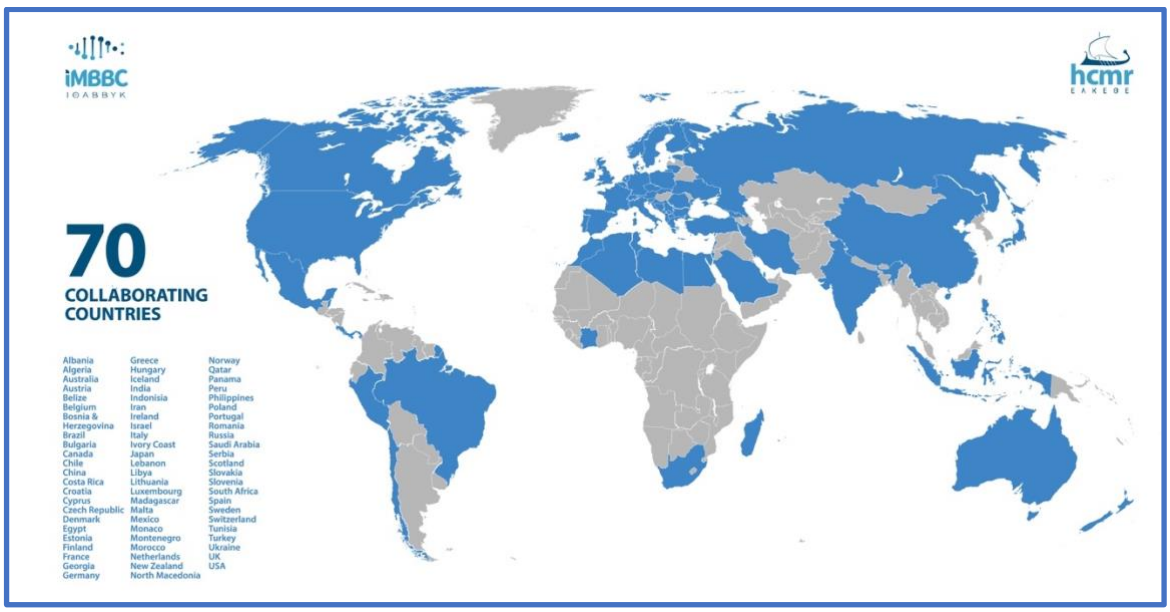
IMBBC has a distinct character among European marine institutes. It is one of the few institutes combining research fields promoting directly economic activities, *i.e.* fish farming and the economic exploitation of the marine biodiversity through biotechnological approaches, together with activities targeting the identification, conservation and management of biodiversity, from microbes to mammals. In **the area of Aquaculture**, we carry out research activities that cover the whole production cycle of marine fish farming, starting from reproduction, through larval rearing and fry production, to grow-out to harvestable size. We work on all aspects of aquaculture, including rearing methodologies and equipment, nutrition and feeding, fish health and welfare, final product quality and breeding selection. It is worthwhile to mention that IMBBC is the only EU marine institute that **operates a pilot scale commercial net pen facility**, which allows research under real industry conditions, with rapid transfer capacity to the industry.

Beginning with a narrow scope of population genetics and coastal ecosystem structure and dynamics, the **MB&B activities evolved rapidly and greatly** to functional, comparative and environmental genomics. Together with the multiplied activities in marine biodiversity and ecology, **MB&B** has entered the area of bioinformatics and data science. Our state-of-the art genetics, genomics, DNA sequencing and bioanalysis facilities allowed an amazing diversification of activities. IMBBC is also unique in Europe in operating an **Underwater Biotechnological Park** near its premises. This is an open-sea underwater research facility supporting multi-disciplinary research and technology demonstration. The fusion of the two original institutes resulted in ever-increasing synergies, allowing the use of advanced analytical methods and approaches in **AQUA** research, while enabling **MB&B** researchers to combine research in marine biology and biotechnology, with aquaculture environments, methods and products, such as the implementation of Integrated Multi Trophic Aquaculture with marine organisms at lower trophic levels (*e.g.* sponges, macrophytes or bivalves).

Finally, IMBBC operates one of the National Research Infrastructures (RI), the "Center for the Study and Sustainable Exploration of Marine Biological Resources" (CMBR), and participates in four European or National RIs. These are the European Marine Biological Resource Center (**EMBRC**), the **LifeWatch** ERIC, **ELIXIR-Gr** and **Bioimaging-Gr**. IMBBC has been a founding member of EMBRC and currently the CEO of LifeWatch ERIC is a permanent researcher of IMBBC. In addition, we have been partners in Trans National Access programs, such as **ASSEMBLE+**, **AQUAEXCEL and AQUAEXCEL2020**.



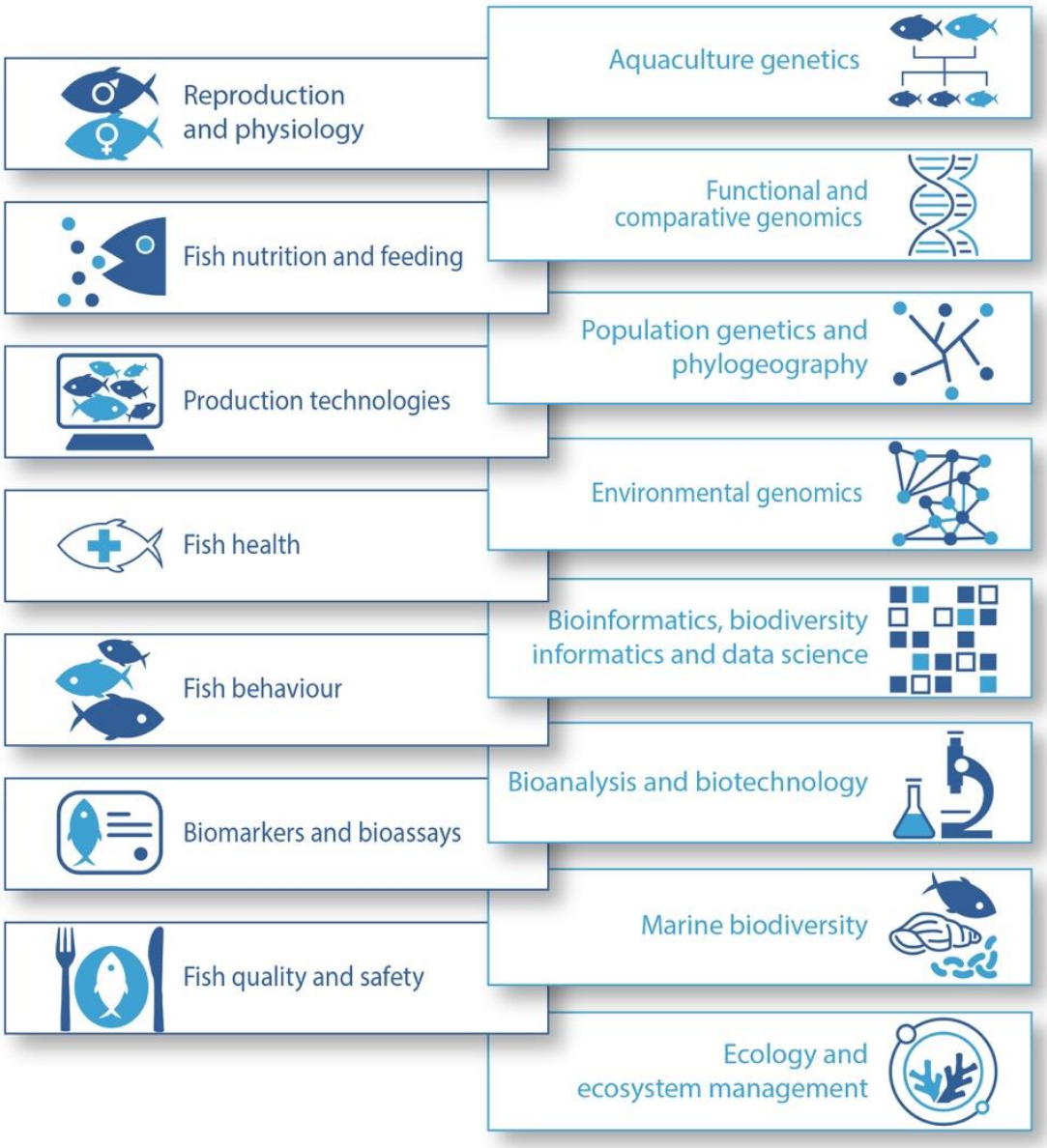
Participation of IMBBC in National and European Research Infrastructures.



Collaboration of IMBBC with various countries, through research projects, training of undergraduate/post-graduate students and consulting services.

1.3 Scientific Orientation of the Institute

a. Current scientific directions and thematic priorities



Snap shot of the current scientific directions of IMBBC as outlined in the website of the institute (https://imbbc.hcmr.gr/research-directions/). The left column presents the directions of the **AQUA** Research Group, and the right column those of the **MB&B** one.

Reproduction and Physiology

Control of reproductive function in captivity is essential for the sustainability of commercial aquaculture production, and in many fish species it can be achieved by manipulating photoperiod and water temperature. However, while gametogenesis may be concluded in captivity in most fishes, oocyte maturation and ovulation in females, and spermiation in males may require exogenous hormonal therapies.

Our research activities are summarized in (a) the study of fish reproductive biology and endocrinology, (b) the identification of the dysfunctions exhibited by female and male broodstocks in captive conditions, and (c) the development of pharmacological methods for the control of reproduction, induction of spawning and improvement of sperm production in fish of interest for the aquaculture industry. In this framework, we carry out applied research aiming at the optimization of broodstock management methods, focusing on marine fishes. Where needed, hormonal manipulations of reproductive function are employed, while we monitor any consequences on gamete quality (eggs and spermatozoa).

Fish nutrition and feeding

Aquafeeds constitute the one most expensive component of aquaculture production, and contributes up to 60% of production costs. Fish feeds should meet the nutritional needs of the fish during the whole growth cycle and under the specific conditions of production, which vary from site to side and over the year. Research on feed formulation and development is, therefore, a combination of satisfying the specific nutritional needs of farmed fish, the aquaculture production technology used, and the cost and sustainability of aquafeed ingredients and feeds.

Fish nutrition and feeding researchers at IMBBC focus in the investigation of the nutritional needs of a number of Mediterranean aquaculture fish through their different life stages, with particular reference in the requirements of minerals, vitamins, essential amino and fatty acids under the evolving scientific, technological and business environment. We also work on the development and testing of novel sustainable aqua feeds, promoting the substitution of the ever more scarce and expensive marine resources with novel and processed conventional ingredients, as well as functional micro-ingredients and dietary supplements. The improvement of the nutritional value of sustainable ingredient sources through biotechnological processes and feed production methods is also one of our interests.

The nutrition team is currently developing new advanced approaches for the evaluation of nutrients, ingredients and feeds using omics technologies. Omics technologies provide a new tool to study the metabolism of living organisms at the level of genes, transcripts, proteins and metabolites. These techniques provide new tools to understand the role and effects of nutrition in the aquaculture species. Finally, we work on the development of feeds for new species in aquaculture, the evaluation of commercial feeds and consultations with the aquaculture and aquafeed industry.

Production technologies

Appropriate husbandry methods are of particular importance for the aquaculture industry. We study the feeding and specific environmental requirements of European seabass (*Dicentrarchus labrax*) and gilthead seabream (*Sparus aurata*) during larval rearing and on-growing. We are also involved in the species diversification of aquaculture production, by developing methods for larval rearing and grow out for greater amberjack (*Seriola dumerili*) and meagre (*Argyrosomus regius*). The species-specific thermal preferences of some species are also studied, in order to understand climate change implications for the Mediterranean aquaculture.

The need for a better farm management in the frame of precision farming, applying principles of circular economy, represent an important research priority. New tools towards human-free operational schemes are developed for cage farming such as (a) an Autonomous Underwater Vehicle (AUV) for frequent monitoring of cages, (b) systems for biomass estimation using stereoscopic imaging and (c) image systems for monitoring fish behavior, aiming to improve feeding and husbandry practices.

Fish health

One of the biggest challenges of aquaculture is to produce healthy and robust fish in a sustainable way. Description of novel diseases and pathogens, development of health management solutions, prevention and treatment methods are the main research priorities of the Institute in this field. We have state-of-the-art research facilities in Anavyssos and Crete with fully equipped laboratories that can provide advanced diagnostic services ranging from basic microbiology to next generation -omics technologies.

Our focus is on disease prevention using innovative and alternative methods aiming to limit the use of antibiotics and chemicals in aquaculture. We develop vaccines, phage therapy products, as well as feed additives of natural origin to enhance the immune system of cultured fish. Our activities are summarized in the following the (a) identification and characterization of fish pathogenic microorganisms, (b) alternative treatments and disease prevention, (c) pharmacokinetics and (d) study and enhancement of fish immune system.

The Aquaculture Microbiology Lab curates a large biobank of fully characterized bacterial pathogens from the Greek aquaculture industry. Moreover, it has established a strong and long-term collaboration with Greek and foreign aquaculture and aquafeed companies. A spin-off company (**Aquatic Biologicals S.A.**) was established in 2020 and after acquiring private and national funding, it is currently constructing its production facility for autovaccines.

AQUATIC BIOLOGICALS
AQUACULTURE HEALTH

Fish behavior

Monitoring fish behavior during the whole rearing process is fundamental for optimizing rearing parameters according to each species' biological and behavioral requirements. We study the effect of environmental, biotic and abiotic factors on the behavioral parameters, such as feeding behavior, learning ability, habitat preferences, swimming and social behavior, to improve fish welfare during culture. We also focus on the development and differentiation of the fish's sensory and functional biological systems, such as the vision and digestive system, which offers the necessary scientific knowledge for developing each reared species' specific larval rearing protocols.

Our activities are summarized in:

- The monitoring and evaluation of fish behavioral indices for optimizing rearing management and increasing production indices.
- The evaluation and optimization of biotic and abiotic rearing parameters (oxygen, light etc.), according to the specific behavioral characteristics of each reared fish.
- The evaluation and optimization of larval rearing protocols based on the development of the biological systems related to feeding behavior (*e.g.* digestive and vision systems).

Biomarkers and bioassays

As aquaculture makes its transition to a major food-producing sector, proper assessment and control of environmental impacts and food safety awareness are becoming increasingly important. Development and understanding of practical and validated tools are needed for assessing nutritional status, metabolic functions and health condition of farmed fish. Biomarkers and bioassays are tools that can provide an early sign of a change in physiology and health condition of an organism. Of particular importance are biomarkers and bioassays that can precede the onset of metabolic disturbance or predict the capacity of an organism to cope with dietary, rearing or disease treatments, or changes in environmental conditions.

In this framework, we identify suitable biomarkers and develop bioassays to evaluate the bioactive properties of feed ingredients and feeds, as well as their effects on nutritional status, metabolic functions and health condition in farmed species.

Our activities are summarized in:

- Evaluating the bioactive properties of feed ingredients and feeds, including antioxidant capacity, toxicity and estrogenic/androgenic activity.
- Identifying suitable biomarkers indicative of antioxidant defense, detoxifying digestive and lipogenic systems in farmed species to optimize dietary manipulations, growth performance, disease treatment and health conditions.
- Developing cost effective bioassays to assess and minimize environmental impacts of farming operations and facilities.
- Providing diagnostic services based on well-established biomarkers and bioassays to the aquaculture sector, regulatory authorities and environmental agencies.

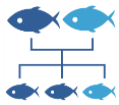
Fish quality and safety

Since the vast majority of aquaculture production is oriented towards human consumption, the quality and safety of products is of capital importance. Quality of seafood can be outlined as the fulfilment of 4 pillars: Safety, Healthiness, Satisfaction and Serviceability. Especially for fish, a 5th term can be introduced, namely Freshness. IMBBC has developed activities which focus on certain capital aspects of fish and seafood quality with emphasis on Mediterranean aquaculture and cover all these pillars.

These include the following:

- Impacts of feeding and aquaculture management in end-product quality (nutritional, sensory quality, safety and traceability).
- Sensory, physicochemical and microbiological freshness and preservation optimization.
- Developing tools/methods for rapid non-destructive seafood freshness detection.
- Solving technical issues in produced quality & processing.
- Optimizing quality of farmed fish and product development.
- Detection, monitoring and hazard analysis of seafood safety (zoonotic parasites, pathogenic bacteria, veterinary drug residues, biological toxins, and heavy metals).

A spin-off company (**FresQo**) is the outcome of a project under the same name, and is based on a rapid non-destructive methodology for assessing seafood freshness. This tool uses a hyper-phasmatic camera that takes photos of a fish or other seafood and based on artificial intelligence and a real-time comparison with a database of photos can read changes in appearance related to freshness alteration and conclude on the current freshness of the seafood.



Aquaculture genetics

Research activities focus on basic and applied research aiming towards the provision of specialized services in the aquaculture industry field. The team has a long-standing experience in the transformation of modern genetic approaches to applicable technologies essential for the private sector through the development of molecular markers and genetic tools for parentage assignment, the production of genetic maps, and Quantitative Trait Loci (QTL) identification for breeding programs in the aquaculture industry.

In past and ongoing projects, we have coordinated efforts towards defining the genetic architecture of body growth, morphological traits, disease resistance, stress response and sex determination using QTL mapping and genome-wide association studies (GWAS) in European seabass, the gilthead seabream and more recently in meagre and the greater amberjack. Our activities are summarized in:

- Enhancement of production efficiency and iimprovement of product quality through the incorporation and use of genetic approaches into aquaculture selective breeding programs (genetic improvement) for robustness, morphology and growth rate.
- Selection for disease and stress resistance, since infectious diseases constitute a major obstacle for the aquaculture industry both in terms of profitability and sustainability, especially in situations where effective therapeutic agents are lacking and are coupled with the moderate to large estimated heritability for many commonly encountered diseases.
- Incorporation of feed efficiency and nutrient retention traits in selective breeding, by studying the genetic potential to select for fish that perform better with alternative feed sources: adaptation of fish to alternative feed and estimation of genotype by diet interactions for these animals adapted to alternative, easily accessible and more environmentally friendly-diets are expected to exert a lower pressure on marine fish meal and oil resources.
- Identification of biomarkers at transcriptional and post-transcriptional level.
- Expression profiling as potential monitoring tool in Aquaculture.

Functional and comparative genomics

Recent and rapid advances in sequencing technologies have radically increased the amount of publicly available sequence information of numerous forms and species of life, with complete genomes and transcriptomes, providing the molecular background of fundamental biology. Nevertheless, genome and transcriptome sequencing are just the first phase towards a better understanding of organisms at the molecular level. The second phase is covered by functional and comparative genomics, which aim to unravel the function and the

regulation of genes and other parts of the genome, as well as offer new insights into evolutionary, biochemical, genetic, metabolic and physiological pathways. In this light, we investigate a broad range of different physiological states (*e.g.* reproduction, development, growth, immune and stress response) in a broad range of marine organisms (from bacteria, microalgae and fungi to teleost) and aim to characterize gene function, evolution and structure.

Our activities are summarized in:

- Mining the genomic information of non-model species.
- Gene evolution through comparative genomics.
- Regulatory networks in reproduction.
- Genome evolution of marine organisms.
- Molecular background in fish development.
- Adaptations of marine taxa to their environment.
- Dynamics in gene activation and regulation following exposure to biotic (*e.g.* bacteria, viruses) and abiotic stressors.
- Roles of RNA regulation and silencing in the maintenance of genome integrity

Population genetics and phylogeography

Population genetics and phylogeography were one of the first disciplines of the Institute, with emphasis on the genetic stock structure analysis of commercially important marine species, such as anchovy, sardine, swordfish, blue-fin tuna and mullets. The aim was to elucidate the evolutionary history of the populations as well as to provide genetic evidence to fisheries' managers for delineating fish stocks. With the advancement of high-throughput DNA sequencing technologies, we shifted to population genomics and phylogenomics, getting beyond the limitations imposed by the small number --until recently-- of molecular markers used. By studying now large amounts of genetic data, we expand our research to address old questions in a novel way shedding light on processes such as biological invasions, adaptation, genomic responses to climate change and speciation.

Our current research activities in the field include:

- Population genomic studies in commercial fish species such as the greater amberjack, swordfish, sardine and anchovy to assess their stock structure.
- Invasive genomics studies in different groups of organisms, from Lessepsian migrant fishes, such as the toxic pufferfish, to seagrasses. The aim is to understand how invasive species respond and adapt to novel environments, which is important for predicting the success of establishment and range expansion, and for developing effective management and conservation strategies.
- Seascape genomic studies of various marine organisms (*e.g.* sardines and anchovies), as well as invertebrates of the coastal ecosystems of Crete, in an attempt to shed more light on adaptation, on how resilient are marine ecosystems and how their current functioning will be modified in the face of human-mediated change.
- Phylogenomics, to explore the evolutionary trajectories of species and try to understand how their shared history explains their unique phenotype. Special focus is given on the positioning of fish species within the tree of life.

- Conservation genetic studies of marine (*e.g.* dolphins, the critically endangered fan mussel and the Mediterranean monk seal) and terrestrial species (*e.g.* roe deer, Eleonora's falcon and the European hare).

Environmental genomics

We study biological diversity at population, species and community level, from microbes to vertebrates, using high-throughput DNA sequencing within their environmental context. Our research brings on a wide range of marine environments including coastal, deep-sea, and extreme habitats, such as volcanically active areas. The aim is to assess marine biodiversity and monitor its changes over space and time, but also to explore its biological potential. We also isolate extremophilic microbes to further explore their prospective use in the field of biotechnology.

We are working on the standardization of DNA metabarcoding methods in the marine ecosystems of the Eastern Mediterranean Sea, for different taxonomic groups, from microbial plankton to fish. We are also using DNA metabarcoding and eDNA to study different ecological questions. We have a very active role in the international Network of Genomics Observatories and the coordination of Ocean Sampling Day (OSD) activities.

Our Research activities are summarized in:

- Microbial genomics and metagenomics in marine extreme environments.
- Marine biodiversity assessment using DNA metabarcoding and eDNA approaches.
- Implementation of Genomics Observatories for biomonitoring, in coordination with international initiatives *i.e.* EMO BON, OSD, ARMS BON (Network of Autonomous Reef Monitoring Structures).

Bioinformatics, biodiversity informatics and data science

Amidst the biodiversity and climate crisis, all types of data such as sequencing, ecological, morphological, literature and environmental are produced in tremendous speeds, leading to what is known as the era of "big data". Data science, bioinformatics and biodiversity informatics provide the means to extract information, find hidden dependencies, identify patterns, infer causal relationships and ultimately understand biological systems in a way that was previously unforeseen. We use bioinformatic methods to study biological molecules, organisms, populations, species and whole systems. We use and develop tools to tackle the challenges that modern biology is facing, working mostly on unexplored ecosystems and organisms, the so-called non-model species. These analyses are mainly performed on our HPC cluster of IMBBC "Zorbas" (**https://hpc.hcmr.gr**).

Our main activities include:

- Data analysis
- Pipeline development, containerization and deployment
- Evolutionary genomics
- Biodiversity information systems
- Literature mining and data integration
- eDNA metabarcoding, omics and systems biology

- Data curation and mobilization
- Data archaeology and rescue

Bioanalysis and biotechnology

Biomolecules are the fundamental building blocks of all living organisms and play indispensable roles in almost every aspect of marine life. At the same time, marine biomass and biomolecules present increasing interest for biotechnological and biomedical applications. In this context, we employ advanced techniques, such as tandem mass spectrometry, ultra- liquid chromatography and microplate-based spectrophotometric methods, to perform qualitative/quantitative analysis of numerous biomolecules in various biological matrices and assess some of their basic bioactivities. By using bioanalysis as a main tool, we conduct research towards the valorization of marine biological resources. Our laboratory is equipped with the knowledge, technical expertise and instrumentation required for the detection of marine biomolecules and the exploration of their potential biotechnological applications.

Our research activities include:

- Investigation of bioactive metabolites of marine organisms/microorganisms.
- Study of the bioremediation and bioproduction potential of marine sponges.
- Biotoxin detection in marine species for seafood safety and valorization of toxic biomass.
- Determination of steroid hormones and biomarkers of health status and physical fitness in farmed fish.
- Targeted proteomic analysis for evaluating specific biological processes and functions in marine organisms.
- Analysis of photosynthetic pigments (chlorophylls/carotenoids) for investigating antioxidant production in microalgae and assessing the trophic status of marine ecosystems.

Marine Biodiversity

We employ current approaches to assess biodiversity and ecosystem functioning in the marine realm, integrating field observation, documentation and collection, taxonomy, experimental setups, genetics/genomics and modelling. All levels of biological diversity are addressed, at local and global scales of observation. Our aim is to advance scientific knowledge and develop novel scientific and technological methods and products.

Our main activities include the following:

- Coastal marine biodiversity and ecosystem functioning: establishment of baseline knowledge of marine biodiversity, addressing the effects of the major drivers, such as climate change, biological invasions and anthropogenic pressures.
- Microbial ecology: assessment of the diversity of microbial communities as important functional components of marine ecosystems, both as free-living and as associates to complex holobionts.

- Biodiversity hot-spots & extreme habitats: research in key marine habitats such as marine caves, coralligenous formations and the deep sea, which are characterized by increased biodiversity and endemism, and high potential for bioprospecting.
- Population connectivity and local adaptation: examination of how environmental gradients and geography affect population structuring and gene dispersal, to expand knowledge concerning the distribution and dispersal pathways of marine species.
- Response to global climate change: effect of sea warming and ocean acidification on the growth, morphology, physiology, reproduction and behavior of marine organisms, through controlled experimental approaches, traditional and 3D micro Computerized Tomography (micro-CT) imaging and genetic analyses.

Ecology and ecosystem management

Our mission is to address current environmental challenges in close collaboration with stakeholders and scientific experts. Research focuses on a holistic approach to the sustainable management of natural resources, including evaluation and monitoring of fundamental biotic and abiotic factors controlling marine ecosystem processes, biodiversity dynamics, climate change, pollution, conservation and sustainable management of coastal resources and habitats. We also develop innovative environmental technologies. Our main research activities include:

- Assessment of the Good Environmental Status (GES) and estimation of the impact of a range of human and large-scale pressures on marine ecosystems.
- Deployment of a seafloor observatory at a depth of 20 m for long-term monitoring of the coastal environment.
- We have designed and applied improved innovative sampling gears to evaluate the role of the understudied hyperbenthic communities (Benthic Boundary Layer, BBL) to nutrient regeneration, carbon cycling and energy transfer to higher trophic levels.
- Assessment of the vulnerability and conservation status of marine taxa and habitats in order to propose guidelines for their protection.
- Assessment of the present status of distribution of non-indigenous species (NIS) and evaluation of future trajectories.

A spin-off company (**Artificial Reef Innovative Applications, *ARIA***) was established in 2021, targeting Recreational Diving with the development of Oases with Artificial Reefs. We have developed a new type of artificial reefs that provide an enhanced availability and heterogeneity of microhabitats and larger structural refugia while fully retaining the form and the aesthetics of the natural rocky reefs. This innovative technology is proposed for the development of recreational diving parks (diving oases). The application of this new concept is proposed as a coastal management tool in order to avert the modern trend of establishing recreational diving parks in environmentally sensitive areas of outstanding ecological and conservation importance.

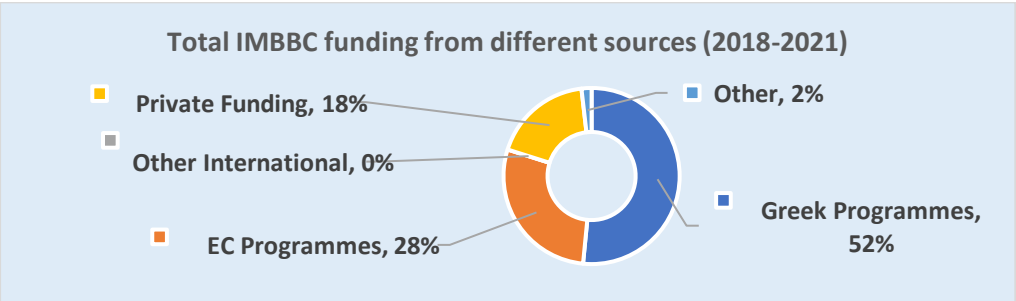
We are also involved in recent years in Ocean literacy networks and consortia. We participate in Working Groups on Ocean Literacy of the European Marine Science Educators Association (EMSEA) and of the European Global Ocean Observing System (EuroGOOS). We are also founding members of the EU4Ocean Platform representing

stakeholders from all over Europe and a diverse spectrum of marine - maritime (science, policy, industry, civil society, outreach) and wider ocean literacy, education, youth, media representatives. Within this framework we assess the content knowledge, the attitudes and behavior of elementary and middle school students as well as the general public in regards to ocean sciences issues. We also develop principles, concepts, policy-oriented documents and citizens' science projects as a good understanding of the role and function of the ocean, which is of paramount importance, constituting the basic tool for the promotion of a healthy and sustainable marine environment, and a target area of the 2030 Agenda for Sustainable Development.

b. Support schemes for the reported directions and priorities

It is important to mention that, unfortunately, **we do not obtain any research funding** from the State -even though we are a public research institute. State funding is limited to the permanent staff of the institute -which is < 30% of the total staff- and this amount accounts for 36% of the total annual expenditure by IMBBC (see Section 4, Table 4-4). This means that **for every 1 € provided by the State, competitive grants and private funding provide another 2 €**.

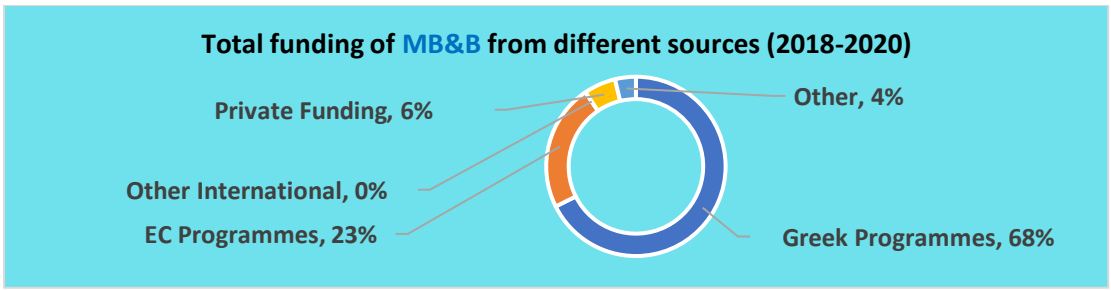
Financial support for the research undertaken at IMBBC comes from three main sources (see doughnut graph below). The **majority of funding comes from competitive grants from National Funding Agencies**, such as the General Secretariat for Research and Innovation, the various "Operational Programs for Fisheries and the Sea" of the Ministry of Rural Development and Food, the Hellenic Foundation for Research and Innovation, the Regional Operational Programs for research from various Regions in Greece, etc. In the reported period, funding from Greek Programs constituted 52% of the total funding obtained by IMBBC. European Union (EU) funds from competitive grants via the Framework Programs, INTERREG, LIFE and other funding schemes constitute the second most important source, accounting for 28%. Finally, a significant amount (18%) comes from the sale of products and services by various researchers, and by private contracts with companies, municipalities and utility companies.

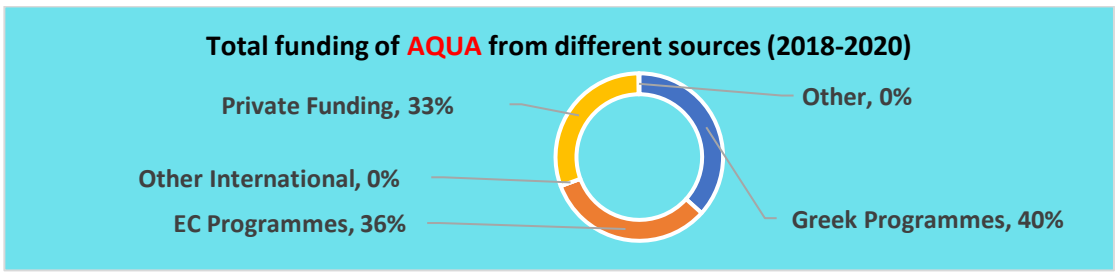


Even though National projects are competitive, they are relatively "easy" to obtain by IMBBC researchers for a number of reasons. Firstly, the grants are smaller and require smaller consortia than the EU projects. Then, due to the excellent quality of our researchers and facilities, and the multitude of research directions covered by IMBBC and the other institutes of the center, our proposals are highly competitive. As a result, we have a very high success rate in these Calls. Unfortunately, National projects allow much less overheads than EU projects, usually < 10% of the total grant for overheads, compared to 25% of EU

projects. Therefore, **the average overhead percentage from all research and service grants for HCMR is only 10%**! This puts significant restrictions on HCMR operations and the ability of the center to create financial reserves. Another problem with the Greek programs is that very often there are significant delays in payments from the funding organizations, causing cash flow problems that are difficult to absorb, when the cash reserves of the center are not adequate. A more appropriate funding of the center's operating costs by the State would have allowed us to create such cash reserves.

The amount of funding that comes from National sources is significantly different between the two Research Directions (see doughnut graphs below). **MB&B** obtains more of its funding from Greek programs (68%), while **AQUA** gets relatively equal amounts of funding from the three main sources (Greek, EU and Private funding).





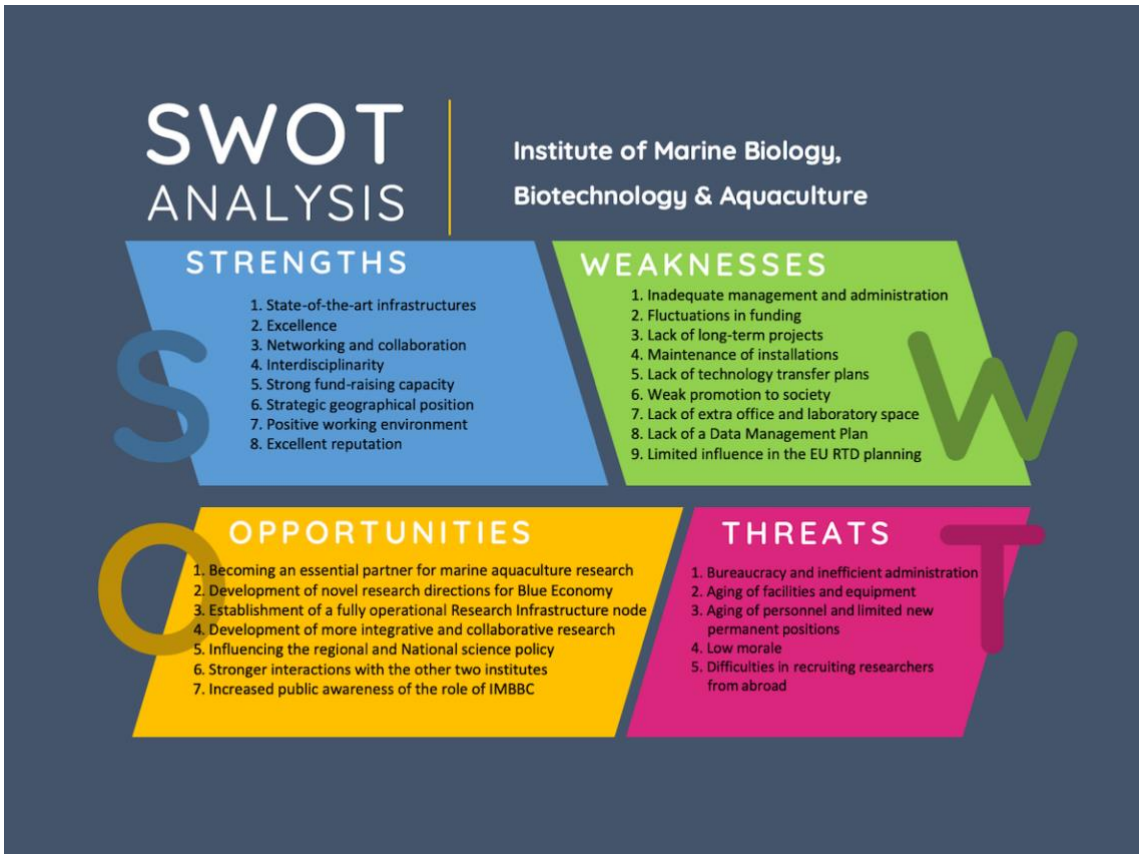
The percentage of private funding differs significantly between **MB&B** and **AQUA**. **AQUA** obtains **5x more funding from private sources**, being a research direction that relates to the dynamic and continuously expanding aquaculture industry, which is especially strong in Greece among European countries. Funding comes from sales of products (eggs, juveniles and autogenous vaccines), analyses (plasma hormone levels, histological evaluations, nutrient analysis of feeds and ingredients, microbiological analysis in relation to fish pathologies of final product quality) and services (broodstock management and reproduction control, evaluation of larval rearing protocols and feeds for larvae/juveniles, health management and evaluation of final product quality).

For **MB&B**, funding comes mainly from analyses and services relating to sequencing, microsatellite genotyping and breeding services of aquaculture companies; micro-CT scans and 3D analysis of a variety of samples for companies and research centers; ecosystem monitoring of marine areas near wastewater treatment plants of different cities in Crete; and assess the suitability of marine areas for the establishment of diving parks.

As mentioned later in the report, private funds from these sources are used by researchers to maintain our facilities and service our equipment, but also to carry out preliminary experiments in existing or new research areas, thus supporting the evolution of our activities and the examination of new priorities.

1.4 Self-assessment and Future Planning

a. Assessment of current strengths and weaknesses (SWOT analysis)



Strengths:

1. State-of-the-art infrastructures: Diverse purpose-built facilities and state-of-the-art equipment, which include extensive aquaculture rearing facilities on land and in sea net pens for the rearing of all life stages of marine fish, aquafeed production capacities, vaccine bio-reactors, modern analytical labs and instruments, a High-Performance Computer (HPC) cluster for big data analyses and an underwater biotechnological park. These facilities address the needs of many scientists and stakeholders interested in the Eastern Mediterranean marine biota and aquaculture, and are available to the Institute of Marine Biological Resources and Internal Waters (**IMBRIW-HCMR**) and Institute of Oceanography (**IO-HCMR**) of HCMR, as well as to outside users as components of national and European Research Infrastructures (RI).

2. Excellence: We have demonstrated excellence in many research fields, most notably in aquaculture, aquaculture genomics and biodiversity. Moreover, IMBBC has been a pioneer, among other research fields, in introducing Next Generation Sequencing technologies in Greece and the use of micro-CT in both aquaculture and biodiversity research. These fields of excellence were recognized in the two latest evaluations by international committees.

3. Networking and collaboration: IMBBC is a reference center for marine research in Greece and has a strong collaborative profile. We participate in many Greek and international consortia within the framework of research projects, academic activities and

Research Infrastructure networks. Through teaching in various undergraduate and graduate programs, we have strong links with several universities in Greece and Europe, and as a public center responsible for providing advice to the government, we are also well connected with the various Ministries involved with research, innovation, education, conservation, agriculture, defense and energy. This allows us to exercise some influence on government strategy in a variety of areas related to the marine environment, research in aquaculture, coastal zone management, water pollution and beyond. Finally, our links to the private sector in the area of aquaculture are historical and impact directly on the industry via the provision of products, services and consultancies.

4. Interdisciplinarity: A high level of interdisciplinarity characterizes the work of IMBBC researchers at different levels: a) among the different research directions of the institute; b) with the other two HCMR institutes; and c) with research centers and universities, in basic and applied research carried out at all levels of the biological organization from molecules to ecosystems, an approach which brings about a multiplier effect on research outcomes.

5. Strong fund-raising capacity: Stemming from its acknowledged excellence in research, its extensive network of collaborators and its interdisciplinary approach, IMBBC has a proven capacity for obtaining competitive research funding, both at the national and European levels. Furthermore, long-term strong links both to the Greek and European aquaculture industry through research collaborations have resulted in significant revenues from contracted research, sales of products and consulting services.

6. Strategic geographical position: IMBBC benefits from its strategic geographical position for marine science and aquaculture, at the center of the Eastern Mediterranean Sea, which is a unique ultra-oligotrophic marine ecosystem and a hotspot for biodiversity, biological invasions and climate change. Moreover, in the area of warm-water marine fish farming, Greece is the largest producer in the EU and the second largest in the Mediterranean, making the IMBBC an essential partner for relevant research consortia and creating opportunities for the provision of products and services to the private sector. Finally, with its excellent climate, landscape and culture, Crete is a very popular destination not only for students, but also as a venue for scientific workshops and conferences.

7. Positive working environment: The modern facilities of IMBBC, its friendly and responsive administration, the good and supportive relations among colleagues, its devotion to excellence and to equality create an attractive work and research environment. This has been recognized, valued and advertised by distinguished researchers, post-docs and students who have had an opportunity to spend time in our institute.

8. Excellent reputation: All the above characteristics have forged an excellent reputation for IMBBC at both the national and international levels, evinced by its high visibility in the European Research Area. IMBBC has an active media profile, including both press and social media profile, and has made several appearances on European and national TV channels. Its publication record is on an ascending trend over the last 5 years, with the institute's publications appearing more and more frequently in high-impact journals.

Weaknesses

1. Inadequate management structure and administrative support: Until recently, IMBBC has lacked a well-defined governance structure, which created certain difficulties in implementing decisions, assigning responsibilities and providing accountability. However, a more solid organizational structure has been implemented since 2020: two new

Departments have been established (MB&B and AQUA) and their Heads elected; the facility units have been clearly defined and their scientific and technical supervisors duly appointed. In terms of administrative support –which operates at the level of HCMR, there are several shortcomings: a lack of adequate personnel; hindrances in setting out and implementing clear procedures; and insufficient support of the researchers in the preparation of proposals, procurements and financial management. This puts a good deal of pressure on the researchers who are, therefore, obliged to deal with issues about which they have little knowledge and less expertise. Unsurprisingly, this results in a considerable waste of scientific time and effort and creates needless friction between researchers and the overarching HCMR administration.

2. Fluctuations in funding: In common with the majority of Greek research institutes, IMBBC receives very limited funding from the State, covering mainly the salaries of the permanent personnel -who comprise <30% of the total personnel of the institute! Moreover, there is a poor tradition in research investment by the Greek private sector, 90% of which consists of small and medium enterprises (SMEs). The high temporal fluctuations existing in national research funding has meant that for some years it has been very difficult to maintain our highly skilled personnel and continue to carry out our research. This leads to a focusing on relatively opportunistic research and a consequent impossibility of establishing a long-term research and technology plan for the institute. Nevertheless, it should be noted that the trend has shown signs of change in recent years, with the State launching more frequent calls for proposals that are relevant to all infrastructures and research directions.

3. Lack of long-term core projects: Though IMBBC has many core activities, it does not have a formal long-term core project within which a number of other grants obtained could be integrated and which would then have a multiplying effect. This would allow us to provide a measure of job security to our on-contract personnel. For example, the other two HCMR institutes enjoy very significant steady annual funding from national grants in order to (a) monitor the ecological and biochemical quality of the marine waters, rivers and lakes (IMBRIW and IO) and (b) to assess the condition of the fisheries and by-catches (IMBRIW). In sharp contrast, future plans for research development and innovation by IMBBC are of high risk, as grant funding depends on the various competitive calls that can vary in their objectives.

4. Maintenance of installations: Unfortunately, State funding does not cover the maintenance and upgrading of our facilities and equipment. It has, therefore, always been a struggle to keep them operational and carry out the necessary services and upgrades for installations such as the land-based and net pet aquaculture facilities, the underwater biotechnological park, the micro-CT scanner, the high-throughput sequencers and the HPC infrastructure. Since the creation of HCMR, the researchers who are the main users of each facility or piece of equipment have met the costs for much-needed maintenance and upgrades, mainly from product sales and service grants (when available) and to a much lesser degree with money from research grants (when eligible). As much as we want to maintain and even to increase product sales and service grants, we are held back by the limitation imposed by the State, which decrees that in order to maintain our "Research Institution" status, we are not allowed to have more than 20% of our income from "commercial activities".

5. Lack of technology transfer plans for research findings: While some regulation of Intellectual Property (IP) does occur, it is largely neglected, thus causing a lack of long-term IP protection and a corresponding lack of Technology Transfer plans. In general, there is

no culture in Greece for patent application, and therefore there is no financial and legal assistance by the State. In addition, there is not much incentive for the commercialization of research findings, and so far, our interactions with the industry have been limited to aquaculture and genetic services.

6. Weak promotion to society: Although IMBBC has an excellent reputation among the scientific community in Greece and abroad, and in spite of its up-beat and positive media presence, until recently it did not have a well-organized communication and dissemination strategy. This has changed over the last 2 years, with strenuous efforts to disseminate the knowledge acquired through the research activities to the wider public, through regular posts in our new website and mainstream media, monthly scheduled interviews of its researchers in a local newspaper, thematic articles published in the national media and press releases of major activities (new grants, significant events, personal accomplishments, etc.).

7. Insufficient office and laboratory space for expansion: Since the creation of HCMR and the move to the new buildings in Crete (2003), IMBBC (and its two predecessor institutes), researchers and technical staff have tripled! In addition, in 2018 we were forced to move out of our extensive facilities in Agios Kosmas, Attica. Our offices and laboratories moved to spaces originally occupied by the administration in Anavyssos, while the research activities of our Agios Kosmas staff were temporarily moved to Crete. Therefore, not only is there an urgent need for new office and laboratory space for existing activities, but the development of promising new research directions necessitates new facilities and the construction of an aquaculture research facility in Anavyssos, towards which, fortunately, some funds were allocated recently. In addition, in 2021 and 2022, funding was acquired as a contribution from the Greek Recovery and Resilience budget for the construction of new office and laboratory buildings both in Crete and in Anavyssos.

8. Lack of a Data Management Plan: A Data Management Plan (DMP) describes the data management life cycle for the data to be collected, processed and/or generated by each project. As part of making research data Findable, Accessible, Interoperable and Re-usable (FAIR), a DMP should include information on (a) the handling of research data during and after the end of each project; (b) what data will be collected, processed and/or generated; (c) which methodology and standards will be applied; and (d) whether data will be shared/made open access and how data will be curated and preserved during and after the end of the project. A DMP is a key element of good data management and is something required both by the evolving practices of contemporary multidisciplinary and highly collaborative research, as well as by increasingly more funding agencies.

9. Limited influence in the EU planning for research and innovation: While Greece is a minor player in the EU 27 state research ecosystem, without a strong EU lobby presence or power, nonetheless Greek researchers have a very good track record in successful bids for EU grants. IMBBC in particular has coordinated or been a partner in almost all of the major EU research projects relating to marine aquaculture, genomics and genetics. Unfortunately, Greece has not yet developed the necessary network and procedures that would allow its scientists to provide guidance to its National Representatives, in order to influence decision-making at the EU level.

Threats

1. Bureaucracy and inefficient administration: The recent law on public procurement and the inclusion of the research centers under the Public Accounting system of the central government has created an extremely lengthy and bureaucratically rigid system regarding

the implementation of research projects. This, in combination with the admittedly less than efficient HCMR administrative system, has led to the following detrimental results: (a) difficulties in carrying out the contracted scientific part of the projects; (b) the loss of well-deserved and hard-won project funding for the institute due to exacting bureaucratic auditing procedures; (c) wasted time and effort on the part of the researchers who are obliged to deal with bureaucratic procedures far from their expertise, rather than the scientific issues of their research domains. It is not surprising that disappointment and frustration are now widespread among the research personnel.

2. Ageing of facilities and equipment: While IMBBC does possess large state-of-the-art facilities and technological platforms, the condition of the buildings and facilities, now more than 20 years old, is steadily deteriorating; many of our expensive core instruments (*e.g.* chromatographs, sequencers, micro-CT scanner, etc.), are old and need to be replaced in the near future. As previously mentioned, funds for maintenance and upgrading have not been made available by the State; therefore, adequate funding must be found soon, otherwise important facilities of the institute may become dis- or non-functional in the very near future. In addition, over the last few years we have experienced significant problems with our seawater supply (from boreholes), due to the ageing of the wells after 15 years of continuous operation. We are currently in the process of drilling two new boreholes (a very costly process), by using money from our service contracts and the IMBBC Overheads account (see Section 3.1 Policies and Practices for Financial Management). The recently acquired funds from the State will be used to fund the construction of a new filtration system for the seawater supply, which we hope will solve or ease the problem, in combination with the drilling of these new boreholes.

3. Ageing of personnel and few new permanent positions: A significant number of the permanent researchers and technicians will retire within the next ten years (See Section 2.5 Personnel). Unfortunately, many of them will not be replaced when they retire, because they do not hold what is considered to be an "organizational" position (as accounted in the Presidential decree establishing the HCMR) that allows the institute to recruit a new researcher/technician once someone has retired. This means that once these staff members retire, their positions will simply cease to exist, with no possibility of new recruitments. It is important that the status of all permanent researchers and technicians is converted to "organizational" by the State, so that they will not be lost upon retirement. Then, new positions must be created so that we can hire staff to be involved in new research directions and also to overlap with existing personnel is, since a period of training for the new staff is needed before the more experienced member has retired. Currently, the institute cannot recruit new permanent researchers or technicians either for existing or new research directions and depends on the State to allocate new position(s), something that so far has been done erratically. All in all, four new positions for researchers were allocated to the institute during the last 15 years (in 2018-19), and seven new positions for technicians to be filled during 2022.

4. Low morale: Increasing bureaucracy and the very strict financial management rules for project management imposed by the new Greek law, combined with the chronic administrative inefficiencies of HCMR, consumes much of the productive time of researchers, and has a negative impact on their morale and their productivity.

5. Difficulties in recruiting researchers from abroad: The low salaries and the existing recruitment process, which requires applicants to first have their academic degrees recognized by the Hellenic National Academic Recognition and Information Centre (HNARIC, *ΔΟΑΤΑΠ* in Greek), discourages people from considering the recruitment of

foreign or Greek scientists who have obtained their education and training abroad. The procedures of HNARIC validation are both lengthy and complex, and in addition certain titles/degrees cannot be recognized if an equivalent field of study does not exist in a Greek University. Furthermore, there is a strong tendency in Greek research organizations to open positions for post-docs who are already working for them, so that scientists applying from abroad have very little chance of being selected.

Opportunities

1. Becoming an essential partner for marine aquaculture research: Aquaculture is an ever-expanding industry, of steadily increasing importance for the supply of healthy and sustainable food. Greece is a pioneer in marine aquaculture and is currently the No. 1 marine fish producer in the EU. Therefore, there is a strong opportunity to further enhance synergies not only with the aquaculture industry in Greece, but also with Europe and the Middle East. Furthermore, due to the well-established expertise and international reputation of IMBBC researchers in this discipline, encompassing the entire production process from reproduction to final product quality, IMBBC is a much sought-after partner for many consortia that target research proposals relevant to fish farming, especially marine-based.

2. Development of novel research directions for the Blue Economy: The Blue Economy has triggered an increased tendency towards the development of innovative technological advancements that can support the intensified exploration of marine resources. In addition, the implementation of the Marine Spatial Planning EU Directive taken in conjunction with the newly established UN strategy on the "Decade of Ocean Science for Sustainable Development (2021-2030)", which calls for adaptation strategies and science-informed policy responses to global change, facilitate this "seascape" of IMBBC activities and bring new opportunities for research and know-how, and goods and services either developed or under development by the institute. Integrative approaches for biodiversity and environmental health assessment, the diving tourism industry, offshore multi-use platforms, bio-prospecting for natural products from marine organisms, as well as the design of new marine integrated observatories give IMBBC an advantageous position from which to thrive in the future.

3. Establishment of a fully operational Research Infrastructure (RI) node: By leading the National Research Infrastructure (RI) "Centre for Marine Biological Research, CMBR" and participating in several other EU and national RIs (see Section 3.5 Partnerships and Strategic Alliances), IMBBC is currently organizing the access of users to its facilities and services. It will soon become a fully operational RI node with an approved access policy and governance plan, and services and products tailored to the needs of the users, accessible through a single web portal. In this way, IMBBC is expected to increase its contribution to the scientific community and attract revenues, which will be directed to the sustainability of its infrastructure and the enhancement of its research activities. Furthermore, the institute has the advantage to be integrating the development of infrastructures needed for the four EU and national RIs in which it participates, in its single core facility. This will produce a multiplier effect by the use of the same human resources and infrastructure to addresses the needs of multiple users.

4. Development of more integrative and collaborative research: At the global scale, activities on marine biodiversity and ecosystem research are moving at pace towards more integrative approaches combining the conventional (*e.g.* taxonomy, ecology and biogeography) with cutting-edge (*i.e.* -omics) disciplines. This places the research and

innovation activities of the institute at the forefront of novel approaches, such as ecosystems biology. Moreover, IMBBC operates in the Eastern Mediterranean, an ecoregion of high ecological importance due to its susceptibility to environmental change resulting from the ongoing global climate change, as well as being a hot spot of biodiversity with the largest part of its species remaining unexplored. Alterations to coastal and deeper marine ecosystems, biodiversity shift and the introduction of non-indigenous species are ongoing phenomena that render the specific geographic location a testbed for current processes and future scenarios. With an operational range extending to all Greek seas (Aegean, Ionian and the Cretan Sea) and access to significant infrastructure (crewed and smaller research vessels, remotely operated underwater vehicles and a scientific diving unit), IMBBC can extend its role as a leader of and partner to international research initiatives towards the assessment of change in the global oceans, as well as in the area of marine biodiscovery-bioprospecting-biotechnology in Greece, and help to accelerate the valorization of marine biological resources in the Eastern Mediterranean.

5. Influencing the regional and national science policy: IMBBC has an opportunity to influence national science policy due to its active participation in the national and local committees and councils in charge of strategy development for science and innovation. Existing connections of HCMR both at the regional and central government level are also excellent, and these can certainly be used to support the growth of all three institutes.

6. Stronger interactions with HCMR's two other institutes: Recent initiatives have created a more conducive environment for collaborative work among all three HCMR institutes. The existence of complementary expertise and facilities, and the recent use of genomic tools in a variety of research disciplines make collaboration among the HCMR institutes a win-win proposition and will expand the research activities and scope of our researchers further, promoting in this way the reputation of all three institutes.

7. Increased public awareness of the role of IMBBC: The increasing public awareness of the importance of climate change on our lives and future prosperity along with the recent prominence of the Blue Economy has created a great deal of interest in the marine environment and biodiversity. The proclamation by the United Nations of the "Decade of Ocean Science for Sustainable Development for 2021-2030" envisages considerable advances and increased awareness of Ocean Literacy in all sectors of society, from education and school curricula, the public at large and informed decision-makers. We shall continue our outreach efforts to bring our research activities closer to the wider public, by means of our website and social media posts and publications in the mainstream media. The institute's participation in an EU Blue school project enables us to continue to promote our educational activities for primary and secondary students, in order to familiarize the public with our role in studying our marine environment and producing knowledge that helps in the sustainable exploitation of the plentiful marine re-sources of our seas. This will enhance our reputation and encourage the support of the institute by the local and national government.

b. Summary of the actions to maintain and augment the scientific excellence of the Institute

In order not only to maintain but also to augment the scientific excellence of the IMBBC, a wide range of actions need to be taken. Those are organized under existing, as well as novel areas that we define them as eight pillars of excellence as follows:

Strategic Plan

The formulation of a strategic plan is of pivotal importance to guide the development of the institute. Each researcher is setting his/her own plan of developing his/her activities in a horizon of 3-5 years, and this drives the collective effort to maintain and augment the scientific excellence of the institute. Then, through interactions between the researchers within and between Research Groups, discussions within the Scientific Council of the Institute (SCI, see later in Section 2.4) and between the SCI and the director, the necessary directions that the institute needs to take and the bottlenecks that need to be overcome are identified. It is very important to always consider and be prepared for the diversification of the institute's research (always within the framework of institute's mission and scope of activities) with new directions to address the new global research challenges. Also, our strategic plan should include not only research field considerations, but also research practices (data management and availability) and actions for the improvement of personnel performance.

Then the steps that need to be taken should be described and implemented as best as possible, given the realities of our specific environment (country-wise and public sector-wise). The institute's evaluation and recommendations provided by the current evaluation committee will assist us in assessing IMBBC's current goals, and guide our plan based on our success stories and expected needs of the future. Furthermore, the diversification of research (within the framework of the scope of the institute) with new directions to address the new global research challenges is also of importance.

Collaborations

There is no doubt, that the current research environment and funding policies encourage collaborative work among research centers throughout Europe and the world. Therefore, a very significant action to maintain our scientific excellence is to continue and expand our network of collaborators. Starting from within HCMR, we need to **promote collaborations between the Research Groups of IMBBC**, in order to take full advantages of the available expertise, equipment and facilities. It is essential to build and sustain a highly collaborative environment with continual communication among researchers. Such collaborative efforts, could better address national and EU proposal calls. A step to this direction could be the establishment of shared research or working facilities that bring together researchers from the two groups (*e.g.* open labs and offices) to promote scientific interactions in an informal way. Then, **joining forces with the other two institutes of HCMR in proposal preparation**, will allow us to carry out the interdisciplinary research required by the larger consortia, especially in the EU level, in domains such as climate change, blue growth, marine biodiversity and sustainable seafood production.

The maintenance of existing collaborations and the **creation of new collaborations with top ranking national and international research centers** is of pivotal importance, enhancing further our ability to carry our interdisciplinary research. Such collaborations could be achieved by establishing even stronger interactions with the local scientific community, the University of Crete (UoC) and the Institute of Molecular Biology and Biotechnology (IMBB) of the Foundation for Research and Technology – Hellas (FORTH) in Crete, through networking activities such as joint meetings, conferences, collaboration and proposal submissions, teaching at both undergraduate and graduate courses and hosting more students at IMBBC's laboratories to address common scientific questions with in a multifaceted approach.

There is an increased effort to carry out more genomic work in the Fish Health laboratories. This has been approached with internal and external collaborations with groups with expertise in the field and with the participation of staff members in online training programs (bioinformatics). Also, active collaboration exists between IMBBC and the Industrial Biotechnology Lab, Chemical Engineering School of the National Technological University of Athens (NTUA) that has provided new research directions and funding (Dr. A. Gioti). Another example is the long-term collaborations of the Environmental Microbiology Lab of IMBBC with Prof. P. Nomikou (Department of Geology and Geoenvironment, National Kapodistrian University of Athens) for the exploration and monitoring of the extreme environments of the Hellenic Volcanic Arc and the Group of Dr. N. Kyrpides (Joint Genome Institute, Department of Energy, USA) regarding the metagenomic exploration of the Hellenic Volcanic Arc. Also, through participating in the first long-term marine biodiversity observation network created by EMBRC-ERIC (European Marine Biological Resource Centre), the IMMBC is pioneering in marine biological observation. Similarly, with the European Marine Omic Biodiversity Observation Network (EMO BON) we are collaborating in the study of coastal ecosystem biodiversity based on a network of 16 marine stations. This activity is also supported by our involvement in several RIs such as BIOIMAGING-GR, LifeWatchGreece and Elixir-GR. These collaborations are essential in maintaining and augmenting our scientific excellence.

Of great importance is the continuous collaboration with the aquaculture industry, through the provision of services and goods (eggs, fry, disease diagnosis, broodstock management and fish health consulting, vaccine development programs, etc.), in order to maintain relevance on applied research directions. Furthermore, active collaboration with the aquaculture industry has been established through common research projects. To this direction **Aquatic Biologicals SA**, the first spin-off company of IMBBC (and HCMR as a whole) has been established. The company develops and produces fish vaccines and maintains an R&D agreement with IMBBC. Through this agreement, but also through the participation of IMBBC in the shareholders of the company, the research group opens paths to new research agreements with the aquaculture industry and strengthens its scientific excellence. Also, the laboratory of Fish Nutrition and Omics Technologies of our Nutrition and Biochemistry facilities, has a significant analytical infrastructure for the detection of chemical substances (UPLCs- ESI MS/MS –QTOF and MALDI-TOF) and operates according to the ISO/IEC 17025:2005 standard (ESYD -No. 1064). Through targeted national and international cooperation in competitive RTD projects, the scientific excellence is focusing in enhancing the links between applied research and industrial applications. This is achieved with testing and evaluation of the nutritional quality and effects of novel dietary ingredients, supplements and bioactive compounds on growth performance, quality and health in fish larvae, juveniles and adults. The research excellence involves investigation of the molecular and physiological mechanisms that underlie, control and regulate fish

appetite, growth, fat deposition and disease resistance using novel techniques from the field of proteomics and metabolomics.

Finally, **a Memorandum of Understanding was recently signed with the Hellenic Aquaculture Producers Organization (HAPO)** to provide support in (a) promoting of sustainable and viable aquaculture activities, in particular with regard to environmental protection and the reduction of environmental impacts, b) optimizing the quality of aquaculture products, c) strengthening of consumer confidence in Greek aquaculture products and the support of businesses in the development of mechanisms and actions to inform consumers, d) improving the competitiveness of Greek aquaculture businesses, and e) strengthening synergies between scientific research and business action. In the same framework, we have also established a long-term collaboration with AB Vassilopoulos SA – a major Greek supermarket chain- concerning the evaluation of quality & safety of aquatic products.

Cutting edge research and state-of-the-art methodology

IMBBC strives to conduct cutting-edge research, and employ as well as develop state-of-the-art methodologies. To this aim the advancement of existing research directions is needed, along with the development of new research directions with interdisciplinarity playing a pivotal role.

For the **AQUA Research Group**, and in order for IMBBC to maintain its scientific excellence, a continuous effort is needed to undertake the most relevant research for the Greek and Mediterranean aquaculture industry. Development of new rearing methods and technologies for the industry (automations, smart monitoring devices, etc.), use of the most modern scientific methods to answer questions relevant to growth, reproduction and health (omics technologies, epigenetics, etc.) and investigations for new fish species domestication are some of the areas than we need to focus for the future. Furthermore, new research directions could also include modeling, precision farming and automatic monitoring; the development and evaluation of novel chronic stress indicators in fish, as well as use of novel equipment for the determination of metabolic rate in fish, the set-up of cell-based bioassays, and the combination of established and new methodologies and equipment, that could give better opportunities to maintain scientific excellence and competitiveness, as well as additional opportunities for new services/products.

Given the recent lack of infrastructure to perform *in vivo* trials caused by the loss of our Agios Kosmas aquaculture rearing facilities, but also due to the increasingly stricter requirements for animal research, we focused recently into processes that can be implemented *in vitro*. For this purpose, the development of fish immune cell lines is envisaged to provide the scientific community with new research tools facilitating the implementation the 3Rs goals and the large-scale screening for new antimicrobials and immunostimulating compounds.

For the **MB&B Research Group**, the integration of existing expertise under a multidisciplinary framework in addressing various scientific questions has become common practice, where traditional approaches are combined with state-of-the-art methodologies to decipher biological aspects of various organisms. For example, we investigate the biology of various marine sponges (*Spongia officinalis*) through the combination of traditional taxonomy (*e.g.* morphology) and genetics, also integrating transcriptomics, metabolomics and manipulative experiments. We also expand further not only in the sponge Phylum, but also in the study of the adaptations of various marine species to abrupt changes -such as

climate crisis and human mediated pressure/change- under the integrated framework of seascape genomics involving the interaction of geneticists, ecologists, oceanographers and GIS experts.

Also promising novel research directions are in the field of genomics and marine biodiversity of marine fungi, mycoremediation and microbial epigenetics. This is a poorly studied field in Greece, and certainly one worth expanding. Furthermore, new expertise on microbial bioinformatics (comparative genomics and molecular evolution), analysis of methylation patterns from Oxford Nanopore data, fungal microbiology and genetics will be extremely important for supporting our research directions. We have also initiated the creation of the first microbial strain collection from the extreme environments of the Greek Seas for research into their value for biotechnological applications. To this effect, our research has expanded to the deep subsurface in order to unlock the past and future of one of the most active volcanoes in the Eastern Mediterranean, the Santorini Volcano Complex. Dr. P. Polymenakou is responsible of the microbiology of the ECORD-IODP mission 398, whose objective is to acquire a better understanding on how marine ecosystems respond to volcanic eruptions. The mission that will be carried out between December 2022 – February 2023 on the JOIDES Resolution research vessel (the acronym is short for Joint Oceanographic Institutions for Deep Earth Sampling) is part of the International Ocean Discovery Program (IODP). Having been studying our oceans for the past 50 years, the IODP is one of the biggest programs of its kind in the world.

A recent area of interest worldwide, and one that IMBBC will develop further as a research direction is Ocean Literacy, which is now largely accepted worldwide for use in both formal (schools, research institutes and universities) and informal (aquaria, museums, environmental centers, etc.) education settings. To this direction, IMBBC is co-chairing the Ocean Literacy Working Group of the European Global Ocean Observing System (EuroGOOS), is a founding member of the Mediterranean Working Group of the European Marine Science Educators Association (EMSEA), and also a founding member organization of EU4Ocean Coalition and Platform, in collaboration with the Department of Primary Education, Democritus University of Thrace, and a member of EMBRC Communication Panel.

Finally, although applied research is a prime focus of IMBBC, especially of its AQUA Research Group, we also believe that IMBBC will benefit from giving a stronger emphasis on fundamental research, which will allow us to broaden our options of funding calls *e.g.* from Pillar 1 “Excellent Science” of Horizon Europe (ERC grant, MSCA actions and Infrastructure).

Institute visibility

An important action to maintain and augment the scientific excellence of the institute is to increase its visibility through scientific publications in Q1 scientific journals with a high impact factor, research dissemination in workshops and conferences, education and teaching, and increasing public awareness.

To this effect, a large number of IMBBC’s personnel teaches in both undergraduate and postgraduate university courses and supervises students of all levels (BSc, MSc and PhD) from Greece, Europe and the world, who undertake their Thesis or Dissertation research, or practical training internships in our facilities. Also, IMBBC personnel participates in the most important international conferences, while dissemination and public awareness is conducted through specialized actions and citizen science projects.

Infrastructure maintenance and upgrade

IMBBC possesses valuable infrastructures and equipment that put it at the forefront of marine research. In order to maintain and improve its position, the maintenance and upgrade of its existing equipment along with the purchase of new equipment when deemed necessary is of great importance. Therefore, several proposals are being submitted in order to increase the funding of our research activities and to maintain and purchase equipment. This is necessary because, unfortunately, there is no provision in the State-provided budget for maintenance and upgrading of our facilities and equipment, so this responsibility is born by the researchers themselves. More details as to this important restriction in our research capacity is provided later in **Section 1.4c**, under **Infrastructure**.

IMBBC has built a High-Performance Computer (HPC) named "**Zorbas**". Up to date, IMBBC and "**Zorbas**" focus mostly on non-model organism Next Generation Sequencing data analysis, environmental -omics and large-scale ecology and biodiversity data analysis. Funding for establishing the IMBBC HPC has been received by the MARBIGEN (EU REGPOT) project, LifeWatchGreece and CMBR (Centre for the study and sustainable exploitation of Marine Biological Resources) and some Research Infrastructures (ESFRIs). Hardware upgrade and maintenance (**see HPC related explanation in Section 1.4c,** under **Infrastructures**) is an extremely important factor for maintaining and also augmenting IMBBC's bioinformatics capacity and potential to expand its activities.

With regard to Marine Biotechnology and Bioanalysis, the acquisition of a cutting-edge High-Resolution Mass Spectrometry (HRMS) system would offer tremendous potential to augment scientific excellence of IMBBC not only in the exploration/understanding of marine life, but also in the discovery/exploitation of value-added marine-derived products. An HRMS platform dedicated to metabolomics analysis will complement our already established research capabilities in marine genomics. More importantly, it will help to establish a core of excellence focused on metabolomic phenotyping and bioprospecting of marine biological resources.

Increase space availability and allocation

An important aspect for a fruitful and collaborative environment is space availability, *i.e.* having enough office and laboratory space, so that new staff and new equipment can be hosted and have enough space for laboratory work especially in delicate and contamination sensitive/prone cases. Due to the significant expansion of IMBBC, but also the loss of lab and office space after moving from our Agios Kosmas facilities, the construction of new buildings and aquaculture rearing facilities is critical. Fortunately, we have acquired funding for new buildings both in Crete and Anavyssos, and once these are put in operation, they will enhance our research capacity and enable us to continue develop and maintain our scientific excellence (**See more in Section 1.4c,** under **Infrastructure**).

Improve administration and financial management

The improvement of the administration and financial management of HCMR is of crucial importance for the center's continuity and existence, as well as its interactions with foreign bodies, such as national and international universities and research centers, and finally for the center's research potential. Although not fully dependent on HCMR itself, but mainly

on the State's laws and the supervising ministry's administration, there are things than could and should be changed by the administration of HCMR, in order to improve the working environment and effectiveness/efficiency of our research staff and reduce bureaucratic obstacles. You can see more on that aspect in **Section 3.a Policies and practices for financial management**.

Personnel recruitment, competency and improvement

Personnel recruitment in the form of researchers, post-docs and permanent staff of particular expertise in accordance to the institute's strategic plan is extremely important given the current personnel's age and in order to support novel directions and attract funding. Some of the expertise that is currently missing from the IMBCC and we feel it is fundamental for accomplishing its mission include quantitative genetics and genomics, phytoplankton physiology and biomass production, and stress physiology of fish.

Besides the recruitment of new personnel, an action of great importance is the state-of-the-art training for all personnel. Continuous training in new techniques and modern methodologies (*e.g.* participation in conferences, workshops and training of new techniques) will enable the maintenance of high profile of the existing research and technical personnel by continuous knowledge updating.

c. Needs and assumptions for carrying out the envisioned plan

IMBBC has produced significant new knowledge in the area of marine biology, genetics, genomics, biodiversity and aquaculture. Some have direct relevance to practical applications, such as fisheries management, conservation policies and of course the aquaculture industry. The institute has embraced the new tools and opportunities that come with Next Generation Sequencing technologies, and has developed the bioinformatics expertise and hardware capacity necessary to undertake, manage, analyze and interpret the massive data quantities that result. The ever-decreasing sequencing cost together with the ever-broadening application spectrum, such as environmental DNA biodiversity monitoring, ensure the ongoing data avalanche is not only here to stay, but also to increase further. Therefore, an important need is that of finding a way of infrastructure maintenance and upgrade, as well as purchase of new equipment, when necessary, along with the recruitment of new researchers and support personnel. Unfortunately, public funding for facility maintenance and equipment purchase is scarce (if at all), and we need to find other ways to ensure the sustainability of our research activities, beyond competitive grands. This will allow IMBBC to function in a more independent way and progress in accordance with a strategic plan/framework.

- **Infrastructures**

Maintenance and upgrade of facilities

The institute is facing two major problems in terms of infrastructures. The first one is the **loss in 2019 of the entire laboratory and office building, and the aquaculture facilities** we had in the area of Agios Kosmas (Athens), due to the reclaiming of the area by the State, in order to develop it commercially. These facilities served seven permanent researchers working in the areas of nutrition, fish health and welfare, biomarkers and final product quality (**AQUA**), and included fish rearing facilities -also containing a challenge facility- for their experiments, a feed production facility with a twin-screw extruder and state-of-the art analytical laboratories. As a result, all the labs moved to the existing HCMR headquarters in Anavyssos (Attica), but **all the fish rearing facilities have been lost**! As a consequence of this loss, a significant part of IMMBC's research activities has been compromised and funding was reduced. The researchers based now in Anavyssos have been almost 3 years without any fish rearing facilities and are struggling to find alternatives to accommodate the experimental trials included in National and EU research programs.

Fortunately, plans are currently being made and funding has been acquired for the construction of a **new Aquaculture building** with Recirculating Aquaculture Systems (RAS)-based rearing facilities (**Master Plan 1**). This facility will be used for research in the area of nutrition, health and welfare, biomarkers and final product quality. So, the continued operation of the **AQUA** laboratories based in our Anavyssos campus depend on the **timely construction of this facility.** The many bureaucratic obstacles in obtaining the building permit for the planned facilities in Anavyssos need to be overcome -at times with a political intervention- so that the building construction phase can at last begin. Such facilities are indispensable in order to attract funding towards the applied research fields important for the development of the dynamic Mediterranean aquaculture sector. A relocation to the new building in a space similar to the initial would facilitate its flawless operation. Also, the re-establishment of challenge facilities for parasitic infections is also

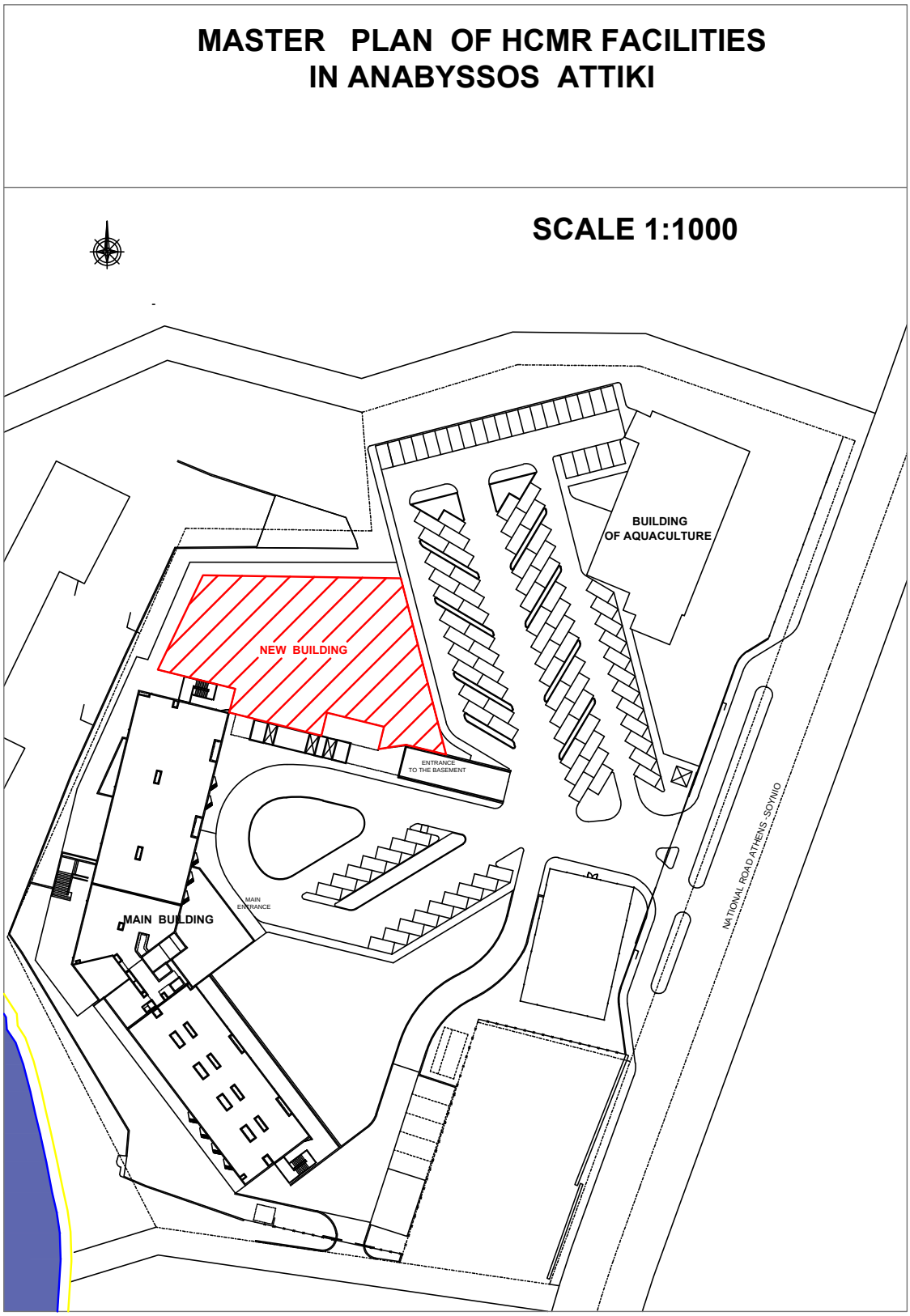
extremely important for our research and it is going to be an integral part of IMBBC's new facilities.

The second problem relates to maintenance and upgrade of our existing facilities in Heraklion, Crete. IMBBC has significant fish rearing facilities there, enabling it to carry out research at all developmental stages, and provide results that are relevant and can be quickly adapted to the Mediterranean aquaculture industry. In the AQUALABS facilities of IMBBC in Crete, fish of different species and life stages are reared for all the experiments relating to reproduction, larval rearing, nursery, behavior, physiology, reproduction, nutrition and fish health work carried out by the **AQUA** Research Group. The facilities were built in the mid 2000s and there is now a need to carry out an extensive maintenance (pipe cleaning, repair, plasters, frames, painting, insulation). More urgently, there is a need to upgrade the sea water supply and treatment system of IMBBC, as the original structure is now more than 15 years old, with almost no upgrading since. The sea water borehole supply system presents problems both with water quantity and quality, and we are now in the process of drilling new boreholes (wells) to supply the AQUALABS, that are having more and more experiments planned in the recent years, due to the loss of the rearing facilities of Agios Kosmas, Attica in 2019. Also, there is a need to convert the broodstock rearing facility and the weaning area to RAS, in order to enhance the rearing conditions of the fish, enhance biosecurity of progressively more valuable, selected breeders, and to develop new rearing procedures for commercial rearing facilities.

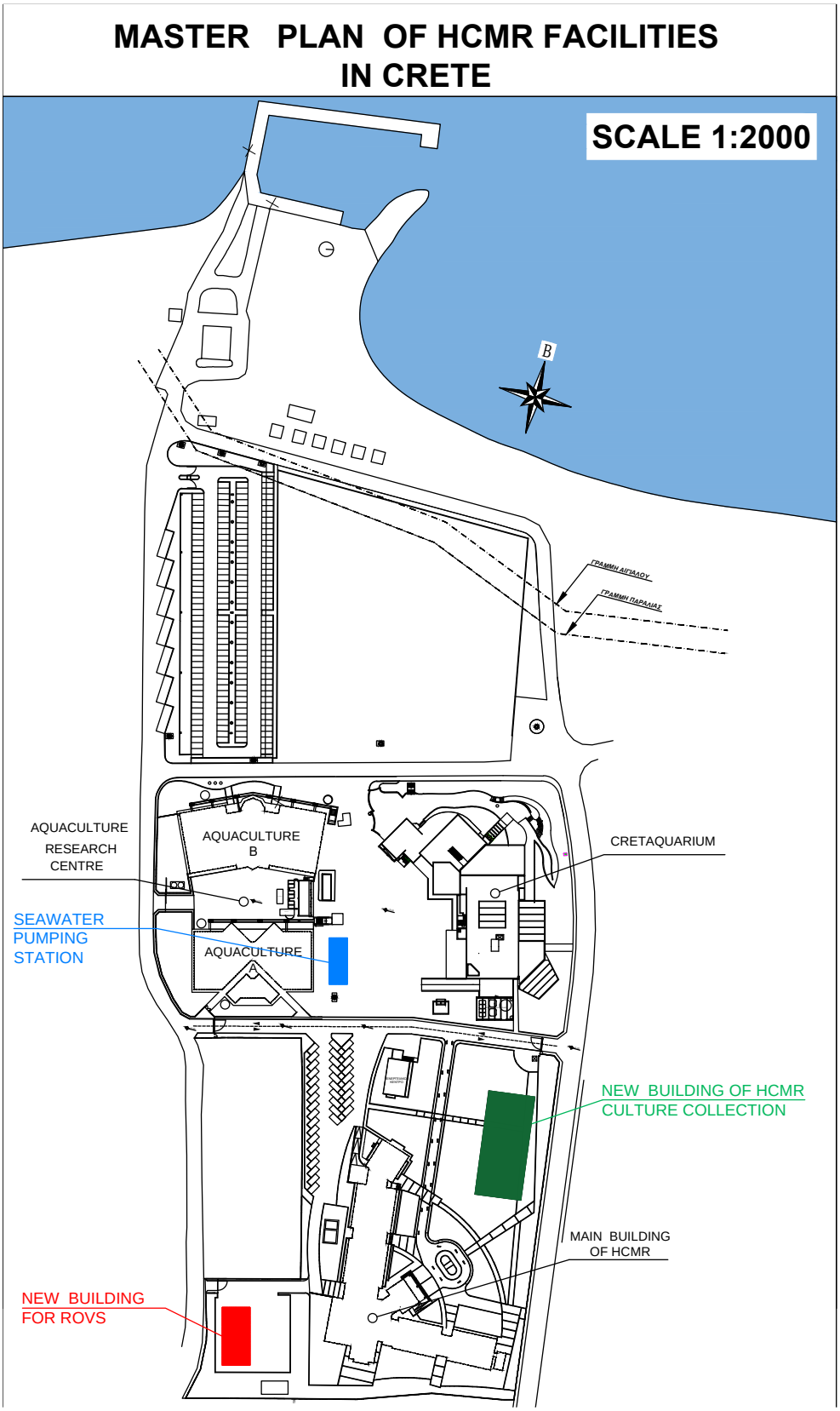
Some of the above issues regarding the necessary infrastructure for IMBBC will be addressed with the **funding we have acquired through the Recovery and Resilience Fund (RRF) of the EU**. Under the government plan for the CREATION, EXPANSION & UPGRADE OF INFRASTRUCTURES OF RESEARCH CENTRES (General Secretariat for Research and Development), **an amount of € 22,151,000 (plus VAT)** has been committed for projects concerning RIs of HCMR. Of these funds, € 5,670,000 (plus VAT) will be used for the construction of **a new 3000-m^3 office and laboratory building in Anavyssos** (**Master Plan 1**) in order for HCMR to continue fulfilling its research objectives, because of its removal from the facilities it had been granted in Agios Kosmas, Attica, and because of its continuous development course.

Also, the sum of **€ 1,667,000 (plus VAT)**, will be used for the construction of a building and equipment needed for the treatment of sea water (**Master Plan 1**) from the existing and new pumping wells at the HCMR facilities in Crete. This will significantly upgrade the biosecurity and quality of the water used for the rearing of the marine organisms that are bred and studied there. In addition, the money will be used for the procurement of RAS for broodstock maintenance, which will ensure absolute biosecurity in the management of genetically selected breeders to avoid their loss from pathogenic organisms.

Finally, another **€ 6,350,000 (plus VAT),** will be used for the construction of **a new 2,500 m^2 office-laboratory building in Crete** (**Master Plan 2**) that will serve the whole HCMR, but it will also include a **"Culture collections"** facility, mainly of microscopic organisms for advanced biotechnology applications for the exploitation of marine biodiversity. The procurement of equipment for the culture collections facilities, cryopreservation, data center and laboratory equipment, has also been included. All the above buildings and facilities are expected to be completed by 2026, but for the time being -and since 2019- the institute is **operating under severely limiting conditions**.



Master Plan 1. Additions to the Anavyssos, Attica HCMR facilities with the inclusion of a new Aquaculture rearing facility (800 m^2) and a new office/laboratory building (3,000 m^2).



Master Plan 2. Additions to the Thalasssokosmos, Crete HCMR facilities with the inclusion of a new Sea water treatment and pumping station (200 m^3/h) and a new office/laboratory building (2,500 m^2), that will include a "Culture Collection" facility.

Significant maintenance needs to be done also at the **Pilot-scale net pen aquaculture facilities** that IMBBC operates in Souda, in the western part of Crete. For example, the anchoring system, boat engines, warehouse and cages need maintenance/update/replacement due to aging while, feeding system needs improvements. There is a need for network maintenance and improvements

IMBBC has gone the extra mile for more than a decade now and established an **HPC** facility to support its tens of projects requiring data computation and data production. Beyond the hardware, a dedicated team of scientists and system administrators (https://hpc.hcmr.gr/people/) guarantee the smooth function of the system and provide user support and training. The HPC accommodates more than 200 state-of-the-art pieces of software. Supported types of analysis include: non-model organism next-generation sequencing data, environmental -omics, and up-to global scale biodiversity and ecology data crunching. While building such a facility takes an incrementally significant effort, double-digit longevity cannot be foreseen unless maintenance actions take place. "Maintenance" includes technical hardware (*e.g.* super computer components) renewal, as well as continuous software upgrade, and long-term contracts with expert personnel, as well as life-long training.

The **Underwater Biotechnological Park of Crete**, our open-sea experimental infrastructure in adjacency to IMBBC is an important testbed for field experiments, monitoring and studies. This facility hosts a seafloor observatory monitoring environmental parameters and some long-term experimental cultivations of invertebrates. It constitutes a facility with tremendous potential in basic and applied research, development and transfer of technology as well as education and training. In order to maintain this facility and the experimental settings it hosts besides the maintenance and upgrade of its equipment, both scientific and technical personnel is needed on a permanent basis. Related to that, but also involved in a multitude of projects, our **Scientific diving unit** is essential for direct access to natural marine habitats and biodiversity. Keeping this infrastructure maintained and updated to cover and expand our operational range, while at the same time ensuring safety procedures are followed, is of pivotal importance.

A new promising research direction at its onset in IMBBC is that concerned with the **exploration and exploitation of the diverse marine organisms** available in the Mediterranean. From these organisms, it may be possible to develop new products, and marine microorganisms are viewed as a promising and sustainable source of bioactive molecules. Upgrading the already existing facility for the culture of microorganisms at small (culture room/chambers, inverted microscope, turbidostats) and medium scale (photobioreactors, apparatus for collecting biomass) is a necessity.

Office & Laboratory Space

Additional office and laboratory space, needs to be secured for the permanent researchers and the hired technical staff, but also to be able to host visiting researchers and students, that spend time at IMBBC, from a few months to a few years, when they undertake their internships, postgraduate research, or collaborations with joint research projects.

One of our facilities that faces an overcrowding problem is the Genetics and Molecular Biotechnology Laboratory. The problem is particularly evident during the periods that students are hosted. Then it becomes extremely difficult for anyone working in the lab, to have adequate bench space for undisturbed and high-quality work. Moreover, such an

overloaded workspace involves the risk of contamination. Furthermore, new laboratories dedicated for eDNA analysis will support this relatively new research direction of IMBBC.

Maintenance and upgrade of equipment and purchase of new ones

Provisioning for the regular maintenance and upgrading of highly specialized and expensive laboratory equipment, needs to be secured and regularly funded, a cost which is usually not covered by the research programs, in order to avoid losing already implemented investments in infrastructures and facilities. There is also a need to purchase new analytical instruments, in situations where the old ones have reached the end of their life, *e.g.* Protein Analysis Instruments, Western Blot Imagers, Cell Counters & Viability Analysis Systems. Also, special systems equipped with new tanks and recording systems to study the behavior of marine organisms is important.

The HPC hardware maintenance and upgrade on a 5-year-cycle plan is needed since the equipment's default warranty usually lasts for up to three years, it could be extended to 5 or, in some cases, to 7 years; however, after 7 years most pieces of equipment receive no further support and are considered as having reached the end of their lifetime.

There is a need for upgrading the microscopy equipment at the Aquaculture Microbiology Laboratory, since all microscopes are good for basic routine work but are outdated when it comes to obtaining high quality pictures needed for publication purposes. This could be centrally organized for the Institute (*e.g.* designated microscopy unit).

Equipment of strategic importance is needed in order to further enhance the research capacity of HCMR (Novel RAS systems for fish rearing, TOF upgrade, extruder support through appropriate building infrastructure, etc.).

Upgrading the existing Environmental Microbiology Laboratory equipment (*i.e.* Class II Biological Safety Cabinets, incubators, microscopes and stereoscopes), purchasing and installing Sterilizable Bioreactors and Fermenters of different volumes for valuing the IMBBC microbial strain collection in industrial application is necessary.

Current advances in underwater technology such as small and affordable remotely operated vehicles and diver propulsion vehicles can allow the expansion of our research in the field of invertebrate marine biology to the mesophotic zone, an environment that remains understudied worldwide and particularly in the Eastern Mediterranean and is proven rich to new biodiversity, often with significant ecological or biotechnological interest.

- **New Researchers and Support personnel**

At IMBBC, **the vast majority of the scientific and technical staff consists of temporary, on-contract personnel (>70%**, see Section 2.5 Personnel**)** hired from monies from competitive grants, contract services and the small economic activity of the institute (*i.e.* Souda net pen aquaculture facility). Research funding in Greece does not have a steady flow as Calls for Proposals follow cycles and the response of the funding agencies in evaluating the scientific and financial reports of the projects is very slow. As an example, the mid-term report and financial statement of the project MAGIATIKO-KOTIGIAMA (GSRT-EPANeK) was submitted in March 2021, and as of today (28/3/2022) the evaluation process has not been completed, and we do not know when the second budget installment will be given to us, while the project finishes in June 2022! Meanwhile, work must be done,

deliverables submitted, personnel paid and consumables purchased. These problems of the Greek research funding system, result in severe cash flow problems for the institute and center, and **it is very difficult to maintain our contracted personnel, even though significant effort and money have been invested to train them.** For example, all the technical work in the Bioanalysis and Biotechnology Lab is carried out by non-permanent staff. Such technicians receive extensive training in order to acquire all necessary knowledge/skills and become capable of applying delicate lab protocols for the analysis of various biomolecules in complex biological extracts. This expertise may be lost every time the contract of the technician is over, if a new research project is not acquired. The specific laboratory requires at least one technician (Biologist or Chemist) on permanent contract to support current needs and help extending the turnover of provided services within and outside IMBBC.

Therefore, it is imperative that we convince the State to (a) provide more permanent positions for **scientific and technical staff for the research institutes and center,** according to their performance over the years in attracting competitive grants and/or (b) **provide some long term funding projects (5-7 year)** ,which will be renewed again based on the performance and excellence of the institute, and will cover some of the permanent research activities that take place, such as regular marine sampling campaigns, maintenance of fish broodstocks of different species to provide eggs and juveniles for our aquaculture research, maintenance and upgrading of our HPC (**Zorba**), as well as the DNA sequencing facility and the analytical instruments for feed and nutrient evaluations.

There is **a need for new researchers to be recruited**, both in existing research directions (*e.g.* nutrition, larval rearing, reproduction, *etc.*), but also for new directions that are becoming important in recent years (RAS technologies, smart aquaculture, microalgae production, etc.). Unfortunately, **the institute has no ability to recruit new researchers** and depends on the Ministry of Development & Investment to allocate new position(s). Moreover, the current group of researchers is aging, and unfortunately most of them will not be substituted when retired. Of the 25 permanent researchers of IMBBC, only 10 hold what is considered an "organizational" position (outlined and accounted in the Presidential decree establishing the HCMR), which allows the institute to recruit a new researcher once someone is retired. This means that **once the other 15 researchers retire, their positions will cease to exist and no new researchers will be recruited**. Thus, any further delay of the ministry to announce new positions will greatly compromise the future of IMBBC's research and vision, as described in Threats. Furthermore, some research directions have no permanent technical and scientific support personnel, operating only with post-doctoral staff under contracts for the period of project implementation. These personnel (trained to perform specific tasks) often change jobs creating delays and additional cost for the institute. For the work carried out in the **Production Technologies research direction, four research positions are needed**, a researcher for precision farming (image processing, welfare assessment), a researcher for modeling (physiological modeling tools development), a specialized research scientist for algorithm building, data management etc. and a specialized research scientist or research technician for hatchery management. Also, there is a need for **new research position at the in the rapidly growing field of Fungal Biology and Biotechnology** and new personnel to support the microbial strains collection and metagenomic analysis of the extreme environments.

As mentioned above, we need to **acquire more support personnel, since of the ~70 staff scientists and technicians of IMBBC, 53 are under temporary contracts** and, therefore, depend on the research funding acquired by our researchers. In addition, most of the

permanent staff do not hold "organizational" positions, and -as the situation was described earlier for researchers- their positions will cease to exist once they retire. So, **an adequate number of permanent support personnel is necessary for the efficient function of the research structure.** Furthermore, there is a significant number of very experienced young researchers with highly recognized expertise which are being employed for several years (>10-15 years) under non-permanent contracts and insecure employment terms. In order to avoid losing these well-trained personnel, it is necessary to replace each position that is lost due to retirement of older personnel, as well as to create new positions in existing and new scientific fields, which are continuously and dynamically evolving. Such actions will ensure future competitiveness in the world-wide research field and the long-term viability of the Institute. Similarly, the **Fish quality and safety direction lacks a permanent technician** to oversee the taste panel activities. Given the fact that very specific knowledge and operational procedures are required and that its use has strong time-schedule fluctuations it is difficult to keep it operational. Its operation is based on a contract-person that at times is inadequate to cover the whole work load and sometimes has workload that cannot cover its contract.

Also, **permanent positions are needed for operating the DNA sequencing platform** and specifically to unclog next generation sequencing pipeline. The research direction of bioinformatics supports a great number of research projects and needs, **but lacks permanent technical staff**. This leads to higher risk of not completing successfully the relevant projects rendering the recruitment of bioinformaticians to conduct analysis of accumulating NGS/omics data highly desired. A **new permanent researcher position in Quantitative Genetics/Genomics** is needed to assist the broader Greek industrial needs and modern trends in the fields of selective breeding and genomic selection. Today, there are only two professors with this profile in Greece (at Patras and Thessaloniki). Biodiversity research at IMBBC needs to be strengthen by opening positions for new researchers, and facilitating collaboration with collaborative university faculty members (the administrative/ bureaucratic procedure is still unclear and time-consuming).

Establish employment conditions to attract highly qualified personnel. For example, in order to keep the HPC system administration and the information technology and communication team, and given the private sector competition, offers must be made as attractive as possible, *e.g.* with long-lasting contracts and career development working conditions. Researchers would preferably have an interdisciplinary background as to drive cross institute research themes (*e.g.* oceanography and molecular biodiversity). Some desired expertise includes data scientists, data analysts capable of handling and carrying out statistics analysis on large scale data. Furthermore, data stewards and data curators to assist (a) properly-metadata-annotation data sharing (*e.g.* via deposition with public databases), (b) promote open data practices (c.) enrich, mobilize and share existing IMBBC datasets. Of great importance is the recruitment of a number of Project Administrators with a scientific-background to support a small number of projects each *e.g.* the hiring of personnel aware of scientific practices (*e.g.* laboratory work) and with administrative/management skills could help bridging communication gaps between administration and scientists, and among administration departments (especially on specific project needs such as contract duration, salary level and renewals).

Increasing our personnel focused on Ocean Literacy activities and relevant research will allow improved monitoring of impact and expansion in reach. Promotion of Ocean Literacy will further help to empower citizens of diverse societies and cultures to use their acquired knowledge of the ocean and awareness of ocean-related issues to communicate

about the ocean in a meaningful way and make informed decisions for their lives that will impact on their future wellbeing.

The Aquaculture Microbiology laboratory is supported by two permanent staff members (one researcher and one technician). Most of research and technical work is also supported by students at both graduate and postgraduate level. Some of the students have gained significant experience and have become essential members of the team. There should be a **provision that in exceptional cases, students following the completion of their studies can remain at the Institute with a fixed contract** even when resources are not available at the laboratory. These positions can be financially supported by the Institute following expression of interest by the scientific responsible of each lab and thorough evaluation of the application by a designated committee of the Institute considering the overall research strategy.

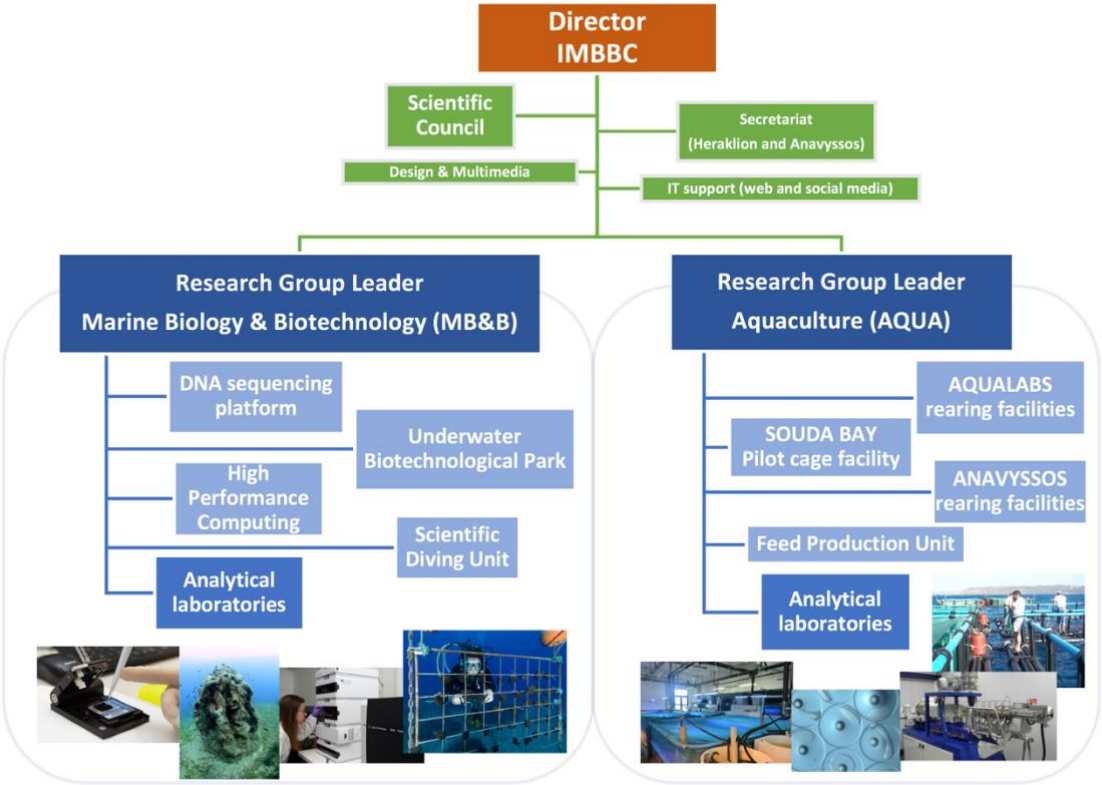
- **Other**

Recently, a new law obliges all public research institutes to abide by the financial management rules of the central government of the State. Unfortunately, these rules provide no flexibility and are not suited for the type of work done by research institutes, that have variable activities, unforeseeable changes during the course of just a few months in implementing a research project. Research, by definition, cannot be performed under restricting regulations and strict scheduling, and a high degree of flexibility must be ensured. Deviations from the "initially approved plan" are the rule in research, since the nature of our work is to search and test new methods and technical solutions. So, it is extremely important that the State realizes this and make some amendments to these laws, so that some activities of the research institutes will be excepted from the strict central government bureaucracy.

There should be plans for continuous training of personnel and young researchers to state-of-the-art methodologies and new policies and procedures. One area that must be set as a priority is data management practices. Also, more effort must be made in promoting communication actions with the public, but also the scientific community and funding agencies, as we believe this would increase our exposure and improve our reputation, making it easier for us to attract future funding or support.

2 Organizational Structure

2.1 Institute Organogram



According to the Presidential Decree for the establishment of the ICMR, the "Director" is the head of each Institute. The Director of an Institute is appointed by decision of the Minister of Development and Investment. The selection procedure and his/her qualifications are provided for in Articles 14 and 16 of Law No. 4310/14, and is done by a seven-member independent committee. The position of the Director of the Institute is full-time with a four-year term (and a maximum of two terms after going through the same selection process again), although he/she may perform research tasks in the same research center.

The Director of the Institute has the following duties, which are specified in the Internal Regulations of HCMR:

α) Supervision of the services and staff of the institute,

b) Responsibility for the operation of the institute, preparation and submission of the Institute's research and development program to the HCMR Board of Directors, preparation of the annual budget, and convening of the Institute's Assembly,

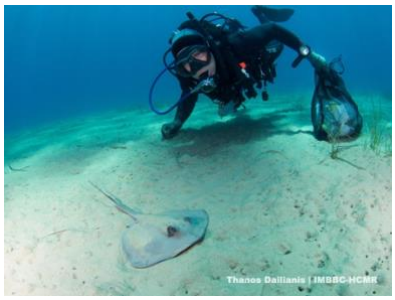
c) Participation in the Board of Directors of HCMR, the decision-making body of the center.

The Scientific Council of the Institute (SCI, see later section) is an advisory body to the Director on all issues relevant to the Institute and supports the Director in his duties. AS mentioned previously, IMBBC has two Research Groups (referred to as Sectors, or "Τομείς" in Greek): the **MB&B** and **AQUA** Research Groups. Each Research Group is then separated into a number of Research Directions that operate a number of Facilities, which in turn may have a number of different laboratories.

2.2 Research Groups

Marine Biodiversity and Biotechnology, MB&B

The **MB&B** Research Group carries out research in the fields of genetics/genomics, bioinformatics, bioanalysis and biotechnology, marine biodiversity, and marine ecology and ecosystem management. More specifically, our research focuses on a) population genetic and genomic studies to assess stock structure of commercial fish species, genetic diversity and connectivity of species of interest, and to study the genetic basis of adaptation in new environments, b) aquaculture genomics for the development of molecular markers and genetic tools for genetic maps, and Quantitative Trait Loci (QTL) analyses and parentage analyses for breeding programs in the industry c) functional and comparative genomics and d) development of bioinformatic pipelines. We also employ current approaches to assess biodiversity and ecosystem functioning in the marine realm, integrating field observation, documentation and collection, taxonomy, experimental setups, genetics/genomics and modeling.



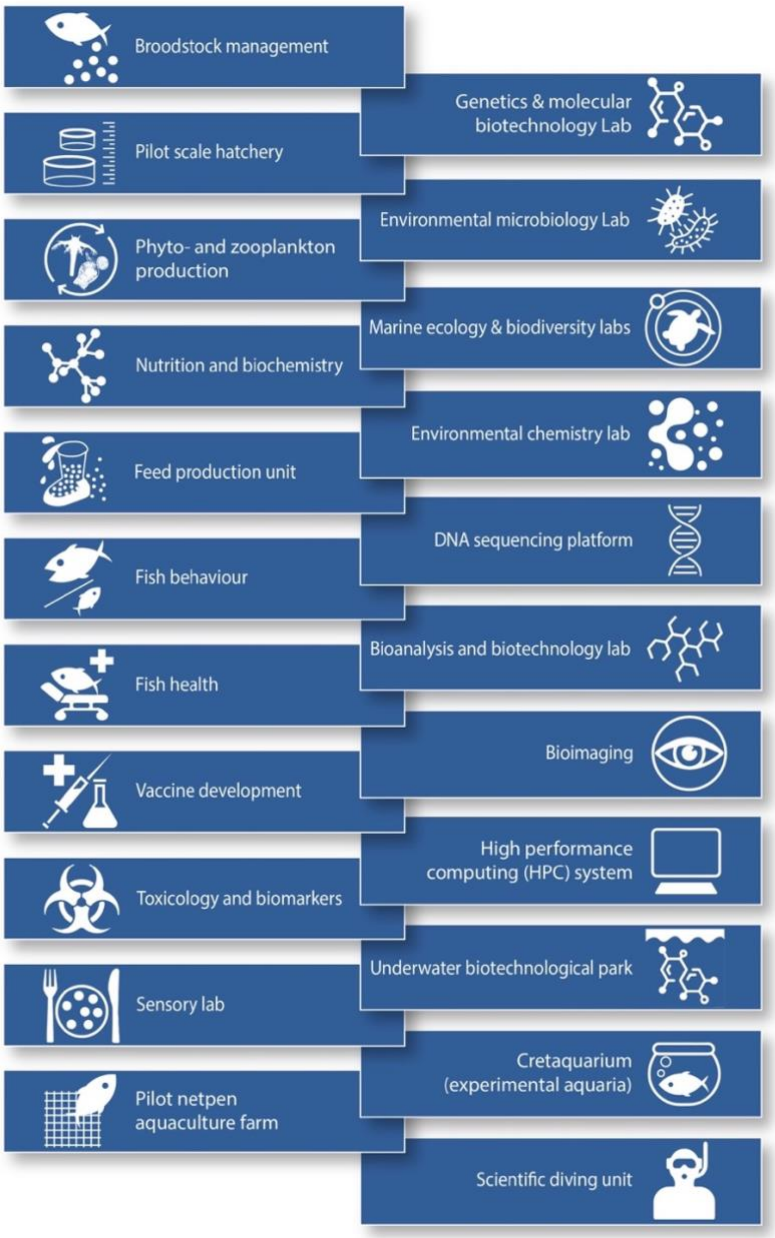
During this period, **MB&B** had **12 permanent researchers**, **33 staff scientists and technicians**, **15 post-doctoral researchers**, 3 PhD students on contract out of a total of **14 PhD that carried their Dissertation research** at IMBBC, **26 MSc students** carrying their Thesis research at IMBBC and had a total of **81 undergraduate students** doing their Thesis or BSc/MSc students doing their practical training at our laboratories.

Aquaculture, AQUA

The Aquaculture (**AQUA**) Research Group carries out research in the fields of fish biology, reproduction, ethology, nutrition and metabolism, and pathology of all developmental stages (larvae to harvestable size), and final product quality improvement and evaluation. Beyond the widely farmed species in the region (European sea bass and gilthead sea bream), we have always put great emphasis on species diversification (*e.g.* red porgy, common dentex, sharpsnout seabream, shi drum, meagre, greater amberjack, Atlantic bluefin tuna and wreckfish), in order to develop a profitable and sustainable aquaculture industry. In collaboration with **MB&B** we also work on the genetics of already cultured or potentially cultivable aquatic organisms and the use of genetics and epigenetics to develop improved strains and broodstock management methods. Work also focuses on the improvement of production methods and the development of smart farming systems.

During this period, **AQUA** had **13 permanent researchers**, **35 staff scientists and technicians**, **4 post-doctoral researchers**, 4 PhD students on contract out of a total of **16 PhD that carried their Dissertation research** at IMBBC, **19 MSc students** carrying their Thesis research at IMBBC and had a total of **39 undergraduate students** doing their Thesis or BSc/MSc students doing their practical training at our laboratories.

2.3 Research Facilities and Support Units



Snap shot of the Research Facilities and Support Units of IMBBC as outlined in the website of the institute (https://imbbc.hcmr.gr/infrastructures/facilitiesimbbc/). The left column presents the facilities that support mainly the **AQUA** Research Group, and the right column those that support mainly the **MB&B** Research Group.

IMBBC operates a wide range of state-of-the-art facilities for Aquaculture, Genomics, Marine Ecology and Biodiversity, which form part of European and national RIs. These are available not only to internal (both IMBBC Research Groups and the other two HCMR Institutes) but also to third parties from academia and industry. Below is a general description of the facilities with links to the respective web sites of the infrastructure, services and personnel.

Broodstock management - HERAKLION (Dr Constantinos C. Mylonas)

The facilities include tanks of various volumes (3 x 35 m^3, 7 x 15 m^3, 2 x 10 m^3, 8 x 5 m^3 and 14 x 2 m^3) for the maintenance of breeders of different species. All but the smallest tanks can operate either in flow through or recirculation mode, and are equipped with temperature and photoperiod control using LED lights. The species maintained include European sea bass, gilthead sea bream, shi drum (*Umbrina cirrosa*), meagre and greater amberjack. Eggs are maintained in temperature-controlled egg incubators, and larvae can be maintained until the end of yolk absorption.

A wet lab is used for the sampling (blood, gonadal biopsies and tissue extraction) and the initial evaluation of gamete and egg quality obtained from various experimental and production broodstocks. Light compound and stereo microscopes are used to evaluate the quality of oocytes, in order to monitor the stage of oogenesis and select females for hormonal spawning induction. A computer assisted sperm analysis (CASA) system is available for the evaluation of sperm quality, looking at sperm motility characteristics.

Supporting the facility is an analytical laboratory equipped with a variety of equipment for the study of reproductive biology and endocrinology. Hormonal analyses are done using ELISAs, and include the sex steroid hormones, gonadotropins and gonadotropin releasing hormone agonists (GnRHa). Histological evaluations are done using methacrylate resin and various stains. Controlled temperature incubators are used for the evaluation of egg and larval quality using the micro-titre plate method. A spectrophotometer is used to monitor water quality in the broodstock tanks. The lab is also equipped for the production of polymer-based, controlled-release devices for GnRHa, used for the induction of spawning and enhancement of sperm production (EVAc implants and PLGA microspheres).

Very limited research is undertaken by other institutes or universities, since maintaining breeding populations requires many years of rearing, and it is not easy to accommodate requests for research from outside users, unless they are partners in our own projects.

Pilot scale hatchery - HERAKLION (Dr. Nikos Papandroulakis)

A pilot scale facility for larval rearing is operated at the institute, including a plankton production unit. A Mesocosm hatchery, applying semi-intensive methods, with 6x40 m^3 tanks, together with an intensive hatchery with closed water systems, 8 of 2×0.5 m^3 tanks and 3 of 3×2.0 m^3 tanks, are available. Feeding is performed using an automated system developed at the lab. A pre-growing zone with 18x10 m^3 tanks is included.

The facility serves for the definition of species-specific hatchery methodologies, the feeding requirements, and the optimal environmental parameters (light, temperature, tank hydrodynamics, etc.) for the larvae. The effect of the larval rearing conditions on the subsequent performance of the fish represent a major objective of the activity.

The facility is used for experimental larval rearing by the Biology Department of the (UoC), for training students and Thesis implementation. It is also part of the European Research Infrastructure AquaExcel (https://www.aquaexcel2020.eu).

Phyto- and zooplankton production - HERAKLION (Drs. Nikos Papandroulakis & Frédéric Verret)

This is a dedicated live food chain production laboratory producing microalgae, rotifers, and *Artemia* spp., mainly for the larval rearing experiments and operations of the AQUA Group. More recently, research is also taking place in the area of diatoms, a prominent group of unicellular eukaryotic microalgae producing a wide range of natural compounds including various pigments (*e.g.* fucoxanthin and carotene) and lipids (*e.g.* polyunsaturated fatty acids) with increasing demand in the cosmetic, nutraceutical and aquaculture industry. Different diatom species are cultivated including well established species with high potential in compounds production, but also local species isolated during sampling expeditions in various Greek seas and coast with the aim to mine and exploit the local diatom natural diversity.

Microalgae for the larval rearing experiments are produced, starting from pre-cultures, in classical plastic sacks or in photobioreactors at high density cultures (200-300 million cells ml^{-1}). Vertical-tubular and flatbed reactors are used. Currently there are 1 flatbed reactor of 1200-L and 1 Vertical-tubular of 1800-L (dark phase included). The photobioreactors use natural light, taking advantage of the conditions in Crete. A local strain of marine *Chlorella* spp. is mostly used although *Tetraselmis* spp. or *T-Iso* are also cultured.

Zooplankton, both rotifers (*Brachionus* spp.) and *Artemia* spp. are produced at an industrial scale with standard techniques. Two rooms, with controlled water temperature, are used,

with 12 tanks for the rotifers (8x1.6 m^3 for culture and 4x0.8 m^3 for enrichment) and 10 for the *Artemia* (3x0.5 m^3 for the hatching of cysts and 7x0.8 m^3 for culture).

Diatom cultivation is undertaken at two levels. At the first level, diatoms are cultured in a recently build and dedicated culture room under controlled light intensity and photoperiod, controlled temperature, and in near-axenic condition. In this environment, small volume cultures (*i.e.* 30 mL) of all the available strains are replicated every month and constitute the diatom culture collection. In addition, large active cultures (300 mL - 10 L) are undertaken to conduct molecular and biochemical analyses aiming to determine their qualitative and quantitative potential in compounds production and characterize the evolution and activity of their biosynthetic genes and pathways. In the future, strains presenting high potential in compounds production will be selected for cultivation in large photobioreactors as described above for *Chlorella* and *Tetraselmis*. In photobioreactors, diatoms are cultivated in non-axenic condition under natural light and relaxed temperature control in order to facilitate and optimize the cost-efficiency of their production.

The facility makes available biomass and samples of different species cultured at the Biology Department of the UoC, the Pharmacy Department of the National and Kapodistrian University of Athens and laboratories at the Agricultural University of Athens.

The first level of diatom cultivation is open to external users presenting a minimum expertise in microalgae cultivation or for those aiming to gain such expertise. Its operation has led to the following services and uses:

- Provide diatom strains (*e.g.* to IMBBC researchers to assist their research projects such as sponge feeding and antifouling experiments),
- Conduct environmental perturbation of diatom populations (*e.g.* for visiting researchers from Stazione Zoologica Anton Dohrn, Italia, within the frame of EMBRC-A+ visit),
- Provide diatom biomass to researchers aiming to assess the potential of using purified diatom silica frustule as mesoporous particles for enzyme immobilization and activation.

Nutrition and biochemistry - ANAVYSSOS & HERAKLION & (Drs. Eleni Fountoulaki & Stavros Chatzifotis)

Extensive fish rearing facilities and analytical laboratories are maintained at IMBBC, currently only in Crete (AQUALABS), with plans and funding available for a new facility

in Anavyssos, supporting the nutrition work undertaken by five permanent staff researchers. At the AQUALABS, the rearing facilities include:

- 44 indoor tanks (0.05, 0.2, 0.5 and 17 m^3) some connected with Recirculating Aquaculture Systems (RAS), in which the abiotic conditions are controlled,
- 6 outdoor tanks of 5 m^3,
- Self-feeders connected with sensors which record the fish feeding activity,
- Digestibility tanks for the determination of nutrient digestibility coefficients for aquafeeds and feed ingredients.

Currently, IMBBC is in the process of licensing a new indoor facility of 700 m^2 in Anavyssos, where modern Recirculating Aquaculture Systems (RAS) will be built to further support its expanding research activities.

To support the nutrition and growth trials the analytical laboratories in Crete are equipped with analytical equipment such as nitrogen analyser, Bomb calorimeter, Spectrophotometer, Speedvac, Fibertec, Centrifuge, Biochemical analyser, Lyophilizer, HPLC, HPTLC, Leco protein analyser, Spectrophotometer, Speedvac, Fibertec, Centrifuge, Biochemical analyser, Lyophilizer.

The IMBBC analytical facilities in Anavyssos are fully equipped with the most advanced scientific instruments for the determination of a large number of measurements in feeds, raw materials, food additives and fish tissues. These include Spectrophotometers, Digestion and Distillation Units (Kjeldahl method), Soxhlet, Hydrolysis system, Centrifuges, Nitrogen analyser, Bomb calorimeter, Biochemical analyser, Fibertec, are the main instruments used and enable us to determine the gross nutrients and various physiological responses in fish. In addition to that, we operate modern analytical instruments such as GC-MS, GC-FID, HPLC-MS, HPLC, HPTLC coupled with various types of detectors according to different specific analytical needs.

Nutrient requirements such as vitamins, essential amino acids, ω3 and ω6 fatty acids, fish quality and freshness of various fresh and processed forms (fish and seafood added value products), as well as detection of veterinary drug residues, and evaluation of fish welfare indicators, can be performed by our specialized personnel to cover specific needs of our collaborations with EU, national and international research projects, as well as providing services for the aquaculture industry.

Feed production unit - ANAVYSSOS (Dr. Ioannis Nengas)

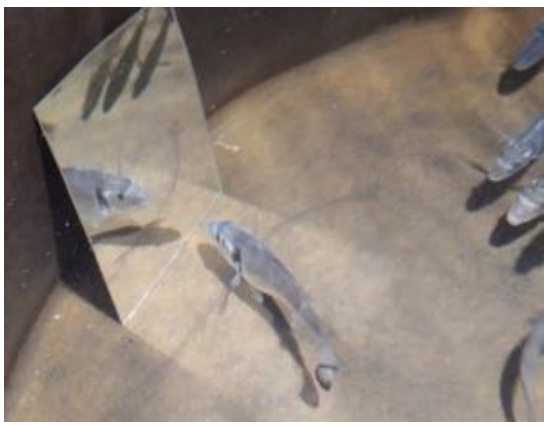
In order to be fully independent in carrying out research in nutritional requirements, feed ingredient evaluation, feed formulation and sustainable aquafeeds, we operate a feed production unit. This consists of modern laboratory scale equipment for the production of small batches of experimental feeds under controlled processing conditions. The feed line consists of a twin-screw extruder coupled with a pre-conditioner. The system includes a grinder, mixer and a dryer with controlled temperature. Finally, the produced feeds can be fat coated in a vacuum coater for efficient and homogeneous lipid absorption. Utilising the vacuum coater, is possible to coat any liquid dietary supplement of interest. The capacity of the system can reach about 30 kg per day of crumbles or pellets of all commercial sizes from 1 to 5 mm. Our feed production unit also runs a press pellet system for applications where the temperature during production has to be low, when using thermo sensitive ingredients

This facility allows our researchers -as well as industrial stakeholders- to produce and test experimental aquafeeds using different formulations, feed ingredients and processing parameters. By using this facility, IMBBC collaborates closely with the aquafeed and aquaculture industry either, under the framework of International and national research programs, or through direct contracted work.

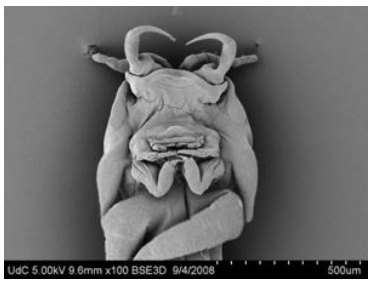
Fish Behavior – HERAKLION (Dr. Ioannis Papadakis)

In this facility we carry out research on the ontogeny and plasticity of the organs, the optimization of rearing protocols and the study of different behavioral patterns. The facilities in include some of the tanks used for the nutrition studies, and are equipped with:

- 12 indoor tanks (0.5 and 17 m^3) connected with RAS,
- 6 outdoor tanks 5 m^3,
- Self-feeders connected with sensors which record the fish feeding activity,
- Cameras and video recording system which are placed above the rearing tanks and/or in the water column, recording fish activity,
- Oxygen monitoring and automatic adjustment,
- Two dry labs equipped with microscopes and PCs for video and image analysis.



Fish Health –ANAVYSSOS & HERAKLION (Drs. George Rigos, Morgane Henry & Pantelis Katharios)



These facilities are spread in both Crete and Anavyssos, and are suitable for a full range of bacteriological, parasitological and viral detection procedures for fish diagnosis. Pathogen identification using a wide range of detection tools complemented by other labs of the institute (*e.g.* the micro-CT) or other collaborating labs (Electron Microscopy Lab of the UoC). The capacity of the Fish Health group includes also the assessment of the *in vitro* efficacy of antibacterial agents, but also in vivo evaluation of herbal extracts and natural products.

The Aquaculture Microbiology lab curates a large collection of bacterial pathogens from the Greek Aquaculture industry. Fully characterized pathogens from the lab collection are being shared with researchers in Greece (University of Patras, Aegean University) and abroad (University of Copenhagen, DTU, Czech Academy of Sciences) upon request for experimental work. It is fully equipped with BSLII cabinets, cooling incubators, genetic analyst, bioreactor Eppendorf BIOFLO 320, PCR, centrifuges, etc.

A separate histology lab with stereoscopy and digital microscopy is also included, supported by Image Analysis processing. Histology equipment include a rotary tissue processor multi-station (histokinette), embedding stations, rotary microtomes, water baths, slide warmer plates, portable bench top fume hoods and staining systems.

The facilities also include an intra-discipline Chromatography lab for the detection of veterinary drug residues and the conduction of pharmacological studies for determining drug kinetics. Consumer safety is assessed here with the establishment of drug withdrawal times coupled with other intra-lab methodologies such as bacterial measurements, detection of zoonotic parasites and so on.

Also, a fully equipped Fish Immunology Lab operates Laminar flow hood, cooling incubators, microplate spectro-photo-lumino-fluoro-meter, microplate washer, inverted microscope, centrifuge, cell counter) and studies the effects of nutritional, environmental and therapeutic stimulants on the non-specific immune system. Innate and adaptive immune parameters can be assessed in fish sera and tissues ex vivo. Primary cell culture and cell lines can also be used to assess the effects of chemicals *in vitro*.

Vaccine development – HERAKLION (Dr. Pantelis Katharios)

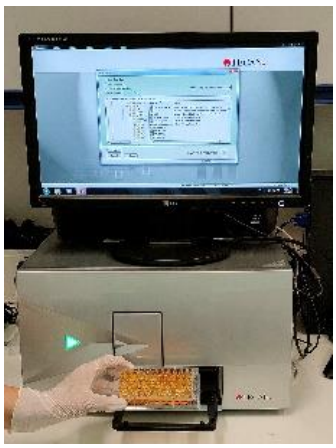
The Autogenous Vaccine Unit, is dedicated to the development of prevention tools for bacterial diseases in aquaculture. The unit has a compartmentalized area operating using HEPA filters and is fully equipped for the experimental production of inactivated bacterial

vaccines. The equipment includes BSL-II laminar flow cabinet, cooling refrigerator, high shear mixer and a bioreactor Eppendorf BIOFLO 320. Vaccine development process is ISO9001 certified since 2019. The Unit conducts also R&D for phage therapy products. Bacteriophages or phages are highly host-specific viruses of bacteria that can be used as a biocontrol method for pathogenic bacteria.

The commercialization of the activities of the Fish Vaccine Unit is made through the newly established spin-off company, **Aquatic Biologicals SA** (www.aquatic–biologicals.com).

Toxicology and biomarkers – ANAVYSSOS (Dr. Efthimia (Efi) Cotou)

This laboratory is dedicated to the identification of suitable biomarkers and development of cost- effective bioassays & micro biotests for the evaluation of bioactive properties and toxicity levels of feed ingredients and feeds as well as effects on nutritional status, growth performance, metabolic functions and health status of farmed species and their environment.

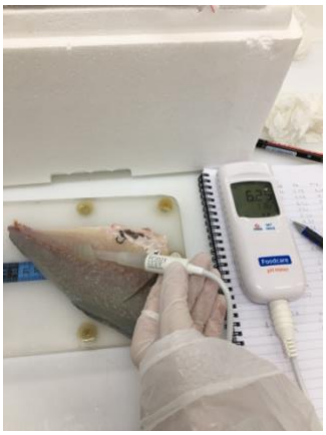


Diagnostic services based on well-established biomarkers and bioassays are provided to other researchers, aquaculture sector, regulatory authorities and environmental agencies. Its facilities include: (a) a cell culture & bioassay room of biohazard level II, where transfected mammalian cells or fish cell lines are cultured for cytotoxicity, toxicity and estrogenicity assays. It is mainly equipped with a biosafety cabinet, a humid CO_2 incubator, an incubator, an orbital incubator, a water bath, a bench centrifuge, a refrigerator, a freezer (-20°C), a deep freezer (-80°C), a cell counter, an inverted microscope, a liquid N_2 container, a sterilizer, (b) two biomarker assays rooms, where biochemical biomarker responses (enzymes activities), gene expression & protein analysis are performed. They are mainly equipped with a chemical hood, a laminar flow hood, tissue extraction homogenizers (polytron & glass Teflon), a multi cell microplate spectro-fluo-photometer, a luminometer, two bench top refrigerated centrifuges, a peristaltic pump, a refrigerator, a freezer (-20°C), a deep freezer (-80°C), a benchtop pH meter, electrophoresis apparatus for RNA/DNA & proteins (1D & 2D), DGGE & Western plotting, a thermo-cycler (PCR), a gel documentation imager system, a genetic analyzer etc.

Sensory laboratory – ANAVYSSOS (Dr. Kriton Grigorakis)

A fully equipped sensory lab with preparation room and taste panel room with booths for 8 panelists is available for supporting the fish quality and safety research direction. The preparation room is equipped with ovens, steam cookers and a thermal chamber. Additionally, controlled refrigeration (achieving required refrigeration temperatures), for

seafood freshness/ post-harvest experimentations, is obtained by a professional refrigeration chamber.



The tested fish food is prepared according to standard protocols and stored until tested. A wide variety of methodologies is employed depending on the aim of the study. For example, different analytical methods are used to detect differences or describe sensory properties of fish / seafood, such as Similarity/Difference Tests (paired comparison, duo-trio, triangle test), Rating or Ranking techniques, Fast-track descriptive methods (CATA, RATA) and Descriptive Analysis.
Also, hedonic methods are used to explore consumer likes and preferences. Analytical techniques are also part of the laboratory routines for examining the biochemical basis of sensory quality. Thus, volatile aroma compounds analysis is conducted with GC-MS to determine the compounds characterizing the aroma of seafood. Physico-chemical and microbial freshness is examined in respective infrastructures (available within Nutrition and Biochemistry, and Fish health facilities) to make correlations with sensory freshness.

Pilot net pen aquaculture farm – CHANIA (Dr. Nikos Papandroulakis)

IMBBC is the only research institute in the European Union that operates a fully functional a pilot aquaculture net pen cage farm, operating since 2000. Currently the unit consists of 16 rectangular cages 6x6 m and 4 circular cages of 12 m diameter. Part of the energy requirements are covered by photovoltaic cells and a wind turbine. The operation of the unit is served by two boats, a floating platform and a storage hut. The farm is certified as an aquaculture facility from the national veterinary authority (code GR94FISH0001) and is part of the European Research Infrastructure AquaExcel.

Over the years, a variety of fish species have been reared there, including European sea bass, gilthead sea bream, meagre, red porgy and greater amberjack. The farm serves the implementation of research projects aiming at understanding the effect of different husbandry parameters on fish performance and development of appropriate practices. Feed performance as well as behavior studies are carried out in collaboration with IMBBC researchers, other institutions or private companies. More recently aspects of multitrophic integrated aquaculture are also tested, using sponges as both a potential product and as purifying organisms.

The study of fish motion during standard rearing conditions and during stress, using video captures and hydro acoustics, targets to develop methods – indicators for monitoring and management of farmed populations during the production process. Specific algorithms developed at the Production Technologies laboratory of IMBBC are used for behavior tracking and welfare prediction systems. Furthermore, tools are developed and tested for better management, such as remotely

operated vehicles (ROV) for safety monitoring and fish size estimation cameras using stereoscopy.

The facility is used for experimental work, for testing equipment while is making available samples of different species reared for different institutions including the Biology Department of the UoC, the School of Electrical and Computer Engineering and the Department of Environmental Engineering from the Technical University of Crete, the School of Engineering of the Hellenic Mediterranean University, the Department of Marine Science of the University of Aegean and the Food Science and Human Nutrition Department of the Agricultural University of Athens.

Genetics & Molecular Biotechnology Laboratory – HERAKLION (Dr. Costas Tsigenopoulos)

This is a state-of-the-art laboratory, which supports the genetic and genomic research conducted in HCMR. In addition to the research going on by IMBBC researchers, the lab also supports research of other academic institutions of Greece and abroad, accommodating PhD and MSc students, as well as users of Transnational Access (TA) projects. The lab is coupled with the DNA Sequencing facility of IMBBC and participates in the national and European RIs CMBR, EMBRC-ERIC, and AQUAEXCEL.

The main equipment includes series of basic thermal cyclers (Biorad PCR machines), Real Time thermal cyclers (Mic & Biorad), Robotic workstation (QIAcube for automated purification of DNA, RNA, or proteins), Photometers (QuantiFluor™-ST, Nanodrop 1000, and other), an Agilent 2100 Bioanalyzer, TissueLyser, Laminar flow cabinet (Telstar Bio-IIa), a Gel electrophoresis and gel documentation system.

This laboratory is currently the primary contact-point and driving power-supply for several research directions at IMBBC through its well-trained personnel and well-equipped technological level, such as

- Population genetics and phylogeography: genetic data are generated and used to address processes related to genetic stock structure, biological invasions, adaptation, genomic responses to climate change and speciation,
- Aquaculture Genetics: we employ molecular markers and genetic tools for parentage assignment, the production of genetic maps, and Quantitative Trait Loci (QTL) identification for breeding programs in the aquaculture industry
- Environmental genomics: using markers from high-throughput DNA sequencing, we assess marine biodiversity and monitor its changes in space and time, and explore its biotechnological potential,
- Functional & Comparative Genomics: we aim to unravel the function and the regulation of genes and other parts of the genome, as well as to gain insight into evolutionary, biochemical, genetic, metabolic, and physiological pathways.

These enabled us to address scientific challenges, collaborate and publish with the other two HCMR institutes (IO and IMBRIW) and Greek universities in the areas of biodiversity, systematics and fisheries management as well as to develop new research directions under

the interdisciplinary framework of seascape genomics that couples ecology, oceanography and geography with genetic tools.

Environmental Microbiology Lab – HERAKLION (Dr. Paraskevi Polymenakou)

The Environmental Microbiology Laboratory of IMBBC is designed to investigate microorganisms including Bacteria, Archaea and Fungi from a wide range of marine environments in the context of their diversity, ecology and biotechnology potential. We focus mostly on the exploration of the unique Mediterranean Sea, which is one of the most diverse environments on Earth. We follow a multidisciplinary approach, using state-of-the-art technologies, molecular-based methods, traditional culture-based methods and computational biology to study the full spectrum of microbial diversity and corresponding key processes.

Our activities include the following:

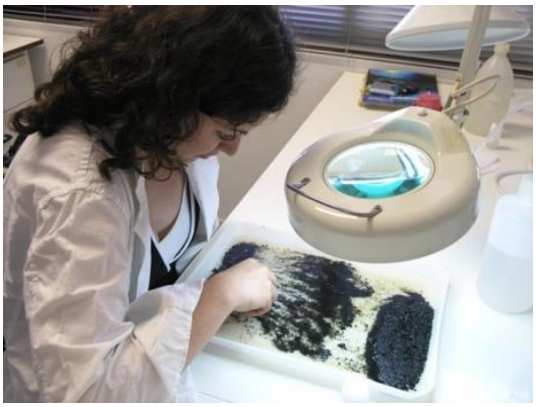
- Life in Extreme Environments: Exploring Volcanologically Active Marine Environments and Submarine Caves and Lakes
- Hypersaline Microbial Mats
- Marine Fungi
- Coastal Lagoons
- Water Microbiology

Finally, through European and national research projects, we have initiated the HCMR-IMBBC microbial strain collection from extreme and highly oligotrophic environments. Our strain collection is continuously being enriched with isolates from various marine environments from the E. Mediterranean Sea including the extreme environments of the Hellenic Volcanic Arc for further exploitation into different biotechnological sections. In addition, the Microbiology Lab is used for studying Fungi either as marine taxa symbionts *(e.g.* of sponges) or as free-living organisms. Expertise in culturing and genetically manipulating Fungi is combined with access to global sampling isolates through collaborations and computational mining of multi-omic data.

Marine Ecology & Biodiversity Laboratories – HERAKLION (Dr. Panayota (Yolanda) Koulouri & Dr. Thanos Dailianis)

These two laboratories are involved in the assessment of biodiversity and ecosystem functioning in the marine realm, collection of biological samples, analysis and modelling at all levels of biological diversity -from prokaryotes to megafauna, from the individual to habitats and ecosystems, and from local to global scale of observation. They are also involved in the integration of the latest methods on marine biodiversity data management, analysis and dissemination by proper work flows and virtual research environments, advanced scientific knowledge and development of novel scientific and technological

approaches and products. Habitat mapping is studied with Side Scan Sonar, underwater Drone (BlueROV2), underwater photography and video equipment.



They are also involved in the ecology and ecosystem management and the sustainable management of natural resources including evaluation and monitoring of fundamental biotic and abiotic factors controlling marine ecosystem processes, biodiversity dynamics, climate change, pollution, conservation and sustainable management of coastal resources and habitats and the development of innovative environmental technology. They use bioinformatics and biodiversity informatic, dealing with the analysis of genetic, genomic and other structural data, the management and analysis of biodiversity data, the support of holistic approaches to ecosystem biology and the data-mining from scientific literature.

Apart from the use of common microscopes and stereoscopes for sorting benthic/environmental samples and identifying organisms, the labs are also equipped with still and video facilities and image analysis software. The labs also work together with the **micro-CT scanner** facility (see Bioimaging facility), in order to create virtual models without destroying the original organism. The micro-CT scanner can be used to scan both hard- and soft-bodied organisms, but also fossils, materials and other small-sized structures.

The laboratories also operate a wet lab with experimental aquaria, which consists of 12 units of different sizes ranging from 216 to 810 l of water. The system is designed for ex situ experimentation with marine invertebrates using automated subsystems that can regulate temperature, salinity and pH. A main challenge is the establishment of specific techniques for efficient small to medium culture of marine invertebrates with biotechnological potential. Furthermore, some of the aquaria can be used as holding tanks and/or quarantine tanks for marine organisms of scientific interest prior to experimentation or deployment at the Underwater Biotechnological Park.

Environmental Chemistry – HERAKLION (Dr. Panayota (Yolanda) Koulouri)

The Environmental Chemistry labs are fully equipped to carry out in-house a wide spectrum of integrated research activities, for the benefit of all HCMR institutes and departments

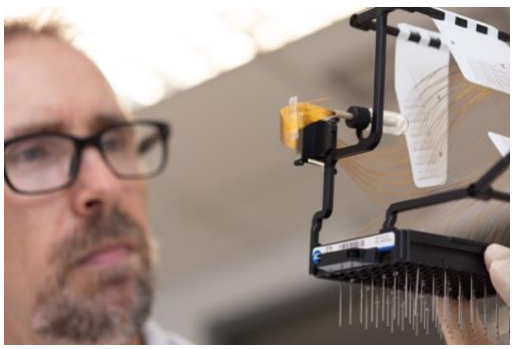
located in the Crete Centre. They also provide a full range of services for the different needs of local authorities and the tourist industry.

This Support Unit carries out measurements and analyses of organic carbon, chloroplastic pigments (chlorophyll a and phaeopigments) and nutrients in the water column, using up-to-date instrumentation such as fluorometer, spectrophotometer, centrifuge, centrifugal ball mill, laboratory drying oven, CHNS 2400 elemental analyzer and a 5-Channel nutrients analyzer.

In addition, it is involved in the investigation of marine pollutants with the sensitive equipment needed for the accurate measurement of organic compounds (*e.g.* pesticides, aliphatic and aromatic hydrocarbons, algal pigments, amino acids) using Gas Chromatography-Mass Spectrometry and High-Pressure Liquid Chromatography systems. One of the labs is also equipped with a mechanical sieve shaker, a large water bath for pipette analysis, incinerators and ovens for processing of sedimentological material (grain sediment analysis).

DNA Sequencing platform – HERAKLION (Dr. Elena Sarropoulou)

The DNA Sequencing facility of IMBBC includes the following DNA sequencing equipment:



The Illumina SBS (Sequencing By Synthesis) technology produces short reads with low error rates, typically around 1%. The MiSeq system has a maximum output of 15Gb when paired-end 2 x300 bp sequencing is performed. It is suitable for amplicon and other targeted sequencing, genome DNA sequencing (de novo & resequencing) for small to medium-sized genomes, metagenomic studies with few samples, smallRNA/microRNA sequencing; transcriptome sequencing with few samples and quality control of libraries before larger-scale sequencing.

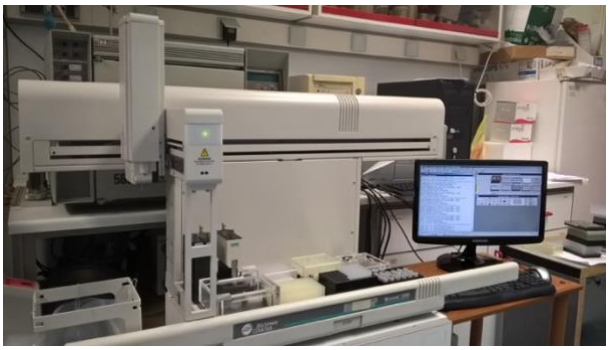
Oxford Nanopore MinION is a powerful, portable sequencing device that delivers cost-effective and real-time access to up to 30 gigabases of long-read sequencing data. The current (early 2020) sequencing error rate is around 10 % and the record longest read is 2.27 Mbases, but the technology is evolving rapidly, and yield and accuracy are continuously improving.

The ABI 3730 sequencer has 48 capillaries, 36 cm long, and it is suitable for Sanger sequencing and fragment analysis (microsatellites).

The DNA Sequencing facility is coupled with the Genetics and Molecular Biotechnology lab of IMBBC is part of the following national and European RIs CMBR, EMBRC-ERIC, and AQUAEXCEL.

Bioanalysis and Biotechnology Laboratory - HERAKLION (Dr. Emmanouil Mandalakis)

Biomolecules are the fundamental building blocks of all living organisms and play indispensable roles in almost every aspect of marine life. At the same time, marine biomolecules and biomass present increasing interest for biotechnological and biomedical applications. In this context, the Bioanalysis and Biotechnology Lab employs advanced techniques, such as tandem mass spectrometry, Ultra-High-Performance Liquid Lhromatography and microplate-based spectrophotometric methods, to perform qualitative/quantitative analysis of numerous biomolecules in various biological matrices and assess some of their basic bioactivities. By using bioanalysis as a main tool, research is conducted towards the valorization of marine biological resources. The laboratory is equipped with the knowledge, technical expertise and instrumentation required for the detection of marine biomolecules and the exploration of their potential biotechnological applications. Some indicative research activities are:



• Investigation of bioactive metabolites of marine organisms/microorganisms

• Study of the bioremediation and bioproduction potential of marine sponges

• Biotoxins detection in marine species for seafood safety and valorization of toxic biomass

• Determination of steroid hormones and other biomarkers of health status and physical fitness in farmed fish

• Targeted proteomic analysis for evaluating specific biological processes and functions in marine organisms

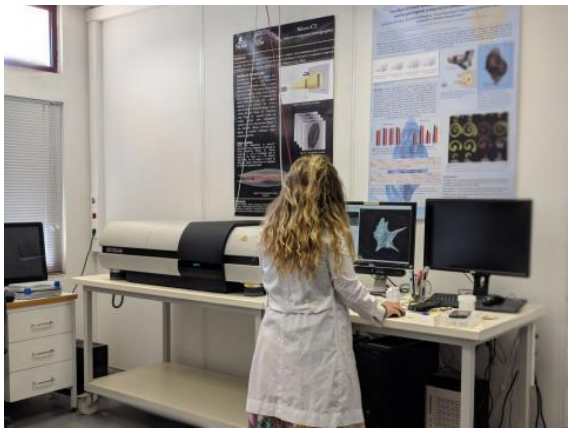
• Analysis of photosynthetic pigments (chlorophylls/carotenoids) for investigating antioxidants production in microalgae and for assessing the trophic status of marine ecosystems

The Lab is equipped with miscellaneous instruments and laboratory equipment that are necessary for sample processing and the analysis of biomolecules. These include:

- A triple quadrupole mass spectrometer hyphenated with an Ultra High-Performance Liquid Chromatography system (Agilent 6460 QQQ Triple Quad LCMS with Agilent 1290 Infinity II UHPLC)
- A High-Performance Liquid Chromatography system (Agilent 1260 Infinity HPLC)
- A gas-chromatography mass-spectrometry system (HP 6890 Series GC with HP 5972 A MS)
- A gas chromatograph with ECD/TCD detectors (Hewlett–Packard HP 5890 II Series GC)
- An Absorbance/Fluorescence microplate reader (Tecan, Infinite 200 PRO)
- A cuvette-based fluorometer (Hitachi, F-2000)
- A modern centrifugal vacuum evaporator (Genevac, EZ-2 Plus Evaporator)
- A robotic liquid handling workstation (Beckman Coulter Biomek 2000)

Bioimaging – micro-CT scanner – HERAKLION (Dr. Thanos Dailianis)

Micro-computed tomography (micro-CT) is a non-destructive imaging technique, which uses x-rays for the rapid digitisation of specimens in three dimensions. The ability of micro-CT to visualise the internal and external features of an object makes this technique a useful tool for a variety of biological research fields such as taxonomy and systematics, developmental research and functional morphology. IMBBC has a Skyscan 1172 micro-CT scanner (Bruker, Belgium), which can be used to scan both hard- and soft-bodied organisms, but also fossils, materials and other small-sized structures.



The scanner uses a tungsten X-ray source with an anode voltage ranging from 20 to 100 kV, 11 MP CCD camera (4000 × 2672 pixel) and a maximal resolution of < 0.8 μm/pixel. The maximum object size that can be scanned is 50mm in diameter. The scanning duration depends on the sample size and the selected scanning parameters (resolution, averaging frames, etc).

This Micro-CT is offered as a service το researchers from outside organizations, including including the UoC (Biology Department, School of Mineral Resources Engineering, Greece), the National and Kapodistrian University of Athens (Faculty of Biology, Greece) and the Aristotle University of Thessaloniki (School of Dentistry, School of Medicine, Greece), Museum and Art Gallery of the Northern Territory (Darwin, Australia), Plymouth Marine Laboratory, University of Maine, Natural History Museum of Crete, Zoological Museum of the University of Athens, the Institute of Molecular Biology and Biotechnology (IMBB) of the Foundation for Research and Technology – Hellas (FORTH), University of Minho (Portugal), University of Tel Aviv, and the Agricultural University of Athens .

High-Performance Computing – HERAKLION (Dr. Evangelos Pafilis)

"Zorbas" is the IMBBC's High-Performance Computing (HPC) cluster, dedicated to bioinformatics applications for non-model species and ecological data analyses. Equipped with ~400 cores, >5TB RAM, 1,5TB of which available on a single node, "Zorbas" hosts more than 200 state-of-the-art software suites. Among others supported types of analysis

include: non-model organism next-generation sequencing data, environmental -omics, and up-to global scale biodiversity and ecology data crunching. Web-based interfaces like the RvLab (https://rvlab.portal.lifewatchgreece.eu) provide user-friendly and seamless access to the HPC system. Upon request, command-line access is also possible (https://hpc.hcmr.gr/docs/getting-started/).

Ongoing efforts translate a more-than-a-decade long of bioinformatics data processing in containerized pieces of software (Singularity and Docker based) as well as reusable pipelines (in snakemake). The dedicated IMBBC HPC portal https://hpc.hcmr.gr/ contains the most up-to-date information about the IMBBC HPC system on how to make the best use out of it for your research purposes. A detailed documentation covering basic to advanced topics of working in an HPC is available (https://hpc.hcmr.gr/docs/). Logistics for gaining access to the IMBBC HPC is described at: https://hpc.hcmr.gr/docs/getting-started/.

Analyses at IMBBC HPC cover most of the -omics levels from DNA (like genomics and metabarcoding) and RNA (transcriptomics) to phenomics and community ecology. In addition, a dedicated helpdesk service is available to address software and hardware requests as well as maintenance operations.

The IMBBC HPC ("Zorbas") in numbers:

- 19 worker nodes/4 computing partitions
- 420 Intel Xeon cores
- 5TB total RAM
- 1.5TB RAM on a single node
- 40Gbps Infiniband interconnection
- 12.5 Tflops peak performance
-

Applications/Analyses include Read pre-preprocessing, De novo assembly, Gene annotation, Variant discovery, Mapping, Differential Expression, Orthology analysis, Phylogenomics, Population genomics, Metabarcoding, Biodiversity index calculation, Ecological data analysis.

Usage/Services so far include more than 80 users (Greece, Italy, Spain etc), with 2 HPC system administrators specialized on bioinformatics applications and ~20000 submitted jobs in 2019.

By ensuring that hardware and software (and subsequent data analysis) perform uninterruptedly and in an orchestrated resource-sharing manner, the IMBBC HPC facility supports project from both the MB&B and AQUA Research Groups of IMBBC, but also from the other two institutes of HCMR, the (IO and IMBRIW).

Beyond HCMR, the HPC unit has been offering support to a number of outside collaborators from organizations such as the IMBB of FORTH (Crete), Department of Biology, UoC, the National Technical University of Athens, Oran University Algeria, University of Padova, IRTA Sant Carles de la Ràpita (Catalunya, Spain), and University of Göteborg, Sweden.

Underwater Biotechnological Park – HERAKLION (Dr. Panayota (Yolanda) Koulouri & Dr. Athanasios (Thanos) Dailianis)

The Underwater Biotechnological Park of Crete (UBPC) is an applied research infrastructure established in 2015. It occupies a seafloor area of 2.5 hectares at depths between 18 and 22 m in the Gulf of Heraklion, Crete, one nautical mile from the coast. Its main objectives are:

- the continuous monitoring of coastal environmental parameters,
- the experimental cultivation and study of marine biological resources,
- the development and testing of methods in fisheries management and marine ecotourism.

The underwater experimental facility is fully supported by the scientific diving unit operated by IMBBC. At the core of the experimental area, an underwater observatory is continuously monitoring environmental parameters, comprising three autonomous oceanographic instruments (ADCP, CTD, fluorometer) deployed on the seafloor and an array of temperature loggers deployed along the water column.

Equipment on the seafloor observatory operating at the core of the underwater experimental facility include:

- SonTek Acoustic Doppler Profiler (water velocity; 24 cells, 1 m cell size; wave height)
- SAIV SD208 CTD (conductivity, temperature, dissolved oxygen)
- Turner Designs C3 Fluorometer (in-vivo chlorophyll sensor, turbidity sensor, fluorescein sensor)
- Onset HOBO Pro v2 U-22 temperature loggers (temperature along the water column, array of 6)

Current research activities at the UBPC include the long-term operation of an experimental sponge farm, as well as the evaluation and demonstration of innovative artificial reefs, as part of the technological concept ‘Recreational diving oasis with artificial reefs’ developed in IMBBC. Both projects are consistently monitored and upgraded since 2015. Moreover, UBPC supports hosted research projects and collaborations that are benefitted from the easy access to the facility and the existence of environmental data time-series.

Cretaquarium experimental aquaria – HERAKLION (Dr. Aspasia Sterioti)

The Cretaquarium is a public aquarium that belongs to the HCMR. The head of aquariology (Dr. A. Sterioti) and the coordinator of animal health (Dr. P. Katharios) are permanent researchers of IMBBC, and as of March 2022 the overall Director of the aquarium is also an IMBBC researcher (Dr. I. Papadakis). The focus of the Cretaquarium on Mediterranean biodiversity offers the ideal infrastructure for conducting marine research concerning living organisms. The aquarium's facilities include tanks in varying sizes with controlled conditions for observing the life cycle and behavior of the hosted species along the visitors' route as well as the quarantine areas. A very large part of this infrastructure is dedicated to the quarantine areas placed at the basement of the building. It is divided into cold (8-19°C) and warm water (19-25°C) areas, with autonomous tanks of 150 l and 300 l capacity (forage water) and controlled lighting conditions. These tanks, additionally to their main purpose in supporting the aquarium exhibition (animal adaptation and de-parasitization, production and maintenance of living feeds, the development of stocks of fish to an appropriate size, reproduction of animals, etc.) are often used for experimental research on organisms with economical and/or ecological interest.

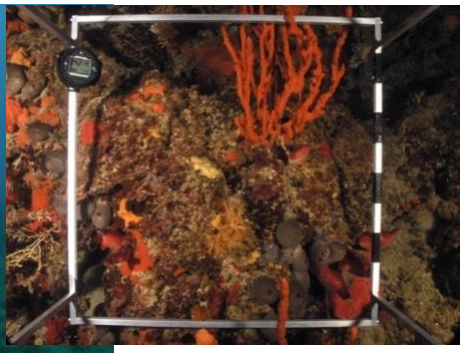
Significant part of the research activities concerns the allochthonous species introduced to the Mediterranean Sea, with emphasis on those whose arrival is linked to climate change and those which have an impact on local food chains. Special efforts are also made to take care of and study endangered and protected species such as invertebrates (marine snails, sea urchins, sea cucumbers, etc.), fish and sea turtles.

A set of experimental tanks hosted in Cretaquarium have been set up for the implementation of indoor controlled ecological experiments, mainly focused on climate change experiments ensuring the accurate control of seawater temperature and pH. The experimental system is semi-closed and supplied with seawater pumped from the sea at 2 m depth and left to settle in a sedimentation tank. The supernatant seawater is UV filtered (AstraPool Heliox UV LP) before being supplied in the experimental tanks. Temperature and pH are controlled using an Aquarium Computer Complete Set GHL controller Profilux 4 equipped with individual temperature and pH electrodes for each experimental tank.

Scientific diving unit – HERAKLION (Dr. Thanos Dailianis)

Diving provides direct access to shallow marine ecosystems, allowing for census and sampling of marine biodiversity, measurements of environmental parameters, and the conduction of experiments. A highly skilled team of diving scientists operates at IMBBC, supported by a dedicated facility with a tank-filling station, small vessels, diver propulsion

vehicles (DPVs), portable remotely-operated vehicles (ROVs), and underwater photographic equipment. The facility currently supports approximately 150 person-dives per year and a multitude of research projects and initiatives requiring diving-supported research. It commonly hosts visiting diving scientists who collaborate in joint expeditions, as part of trans-national access networks (*e.g.* Assemble+) or personal scientific collaborations. As part of HCMR, IMBBC participates in the European Scientific Diving Panel (ESDP), an operational platform to advance underwater scientific excellence and to promote and implement a practical support framework for scientific diving related activities.

2.4 Scientific Council

List the Institute's Scientific Council members active during the period and report on its regular processes (frequency and topic coverage of the meetings)

The Scientific Council of the Institute (SCI) is an advisory body to the Director, supporting the Director in his/her duties. In IMBBC, the SCI consists of five (5) members (a number which depends on the number of permanent researchers and research assistants of the institute), and its members can be the institute's Permanent Researchers of A' (Research Director) or B' (Principal Researchers) degree, as well as collaborating university professors. The members of SCI are elected by secret ballot by all the researchers for a term of office of two years. After its formation in a body, the members of the SCI elect by secret ballot its president. In the SCI, an elected representative of the scientific, technical and administrative staff is also participating, but without the right to vote, whereas the director of the institute participates in its meetings, but also does not vote. If the director suggests a topic for discussion, this must be included in the agenda. If the director of the institute disagrees with the opinion of the members of the SCI, which gathers a simple majority of all its members, the director is obliged to submit the matter to the HCMR's Board of Directors for the resolution of the dispute, in the presence of one of the dissenting members of the SCI.

- The SCI exercises the following powers, as well as any other powers provided by Law 4386/16:
- Assists the Director of the Institute in the exercise of his/her responsibilities.
- Monitors the research and development programme of the Institute and submits its opinion and criticism to the Director of the Institute and to the Board of Directors of the Centre.
- Contributes to the formulation of the strategy, organization chart and human resources policy.
- Assists the Director of the Institute in the preparation of opinions on specific questions submitted by the Board of Directors of HCMR.
- Gives its agreement on the calls for new researcher positions.
- Appoints the evaluation and advisory committees for the filling of new researcher positions and the promotion of researchers

During the review period of 2018-2021, there were three different SCIs, with the following composition:

2016 – 2018	**Position**	**Research Group**
Dr. C.C. Mylonas	President, Researcher A	Aqua
Dr. G. Rigos	member, Researcher A	Aqua
Dr. C. Dounas	member, Researcher A	MB&B
Dr. G. Kotoulas	member, Researcher A	MB&B
Dr. C. Tsigenopoulos	member, Researcher A	MB&B
2018 – 2020		
Dr. C.C. Mylonas	President, Researcher A	Aqua
Dr. K. Grigorakis	member, Researcher A	Aqua
Dr. C. Dounas	member, Researcher A	MB&B
Dr. G. Kotoulas	member, Researcher A	MB&B

Dr. P. Kasapidis	member, Researcher B	MB&B
Ms V. Terzoglou	delegate of the scientific, technical and administrative personnel	

2020 – 2022

Dr. C.C. Tsigenopoulos	President, Researcher A	MB&B
Dr. I. Nengas	member, Researcher A	AQUA
Dr. P. Kasapidis	member, Researcher B	MB&B
Dr. P. Koulouri	member, Researcher B	MB&B
Dr. P. Katharios	member, Researcher B	AQUA
Ms W. Plaiti	delegate of the technical and administrative personnel	

Dr. I. Nengas replaced Dr. A. Magoulas in March 2021 when the latter was elected Director and President of the Board of Directors of HCMR.

The SCI meetings are convened on a monthly basis. In exceptional cases when serious issues arise, these meetings may be convened more frequently. The agenda of each meeting is formed based on the suggestions of the SCI members but also following requests from the Permanent Researchers and staff of the institute.

During the review period of 2018-2021, the SCI defined the following scientific fields for four new Permanent Researchers (Level C, tenure track).

- Bioinformatics with emphasis on data analysis of applied marine biology and biodiversity (2018)
  Candidates: Dr. T. Manousaki, Dr. E. Pafilis, Dr. A. Meziti
  Selected: **Dr. E. Pafilis**
- Biology & ecology of marine invertebrates with emphasis on species of biotechnological interest (2019)
  Candidates: Dr. A. Dailianis, Dr. E. Chatzinikolaou
  Selected: **Dr. A. Dailianis**
- Bioanalysis and Biotechnology (2019)
  Candidates: Dr. E. Mandalakis, Dr. D. Toubanaki (candidacy withdrawn).
  Selected: **Dr. E. Mandalakis**
- Evolutionary Genomics of fish, with emphasis on bioinformatic analysis (2019)
  Candidates: Dr. T. Manousaki
  Selected: **Dr. T. Manousaki**

During the review period, the SCI defined also the following scientific fields and proposed to the Board of the HCMR Directors, the Committee Members that would evaluate the applications for promotion or appointment to a Permanent Researchers.

From Level B' to A' Researcher (promotion)

- Aquatic Pathobiology (2021)
  Promoted candidate: **Dr. P. Katharios** (AQUA)
- Aquatic Nutrition & Physiology (2021)
  Promoted candidate: **Dr. I. Kotzamanis** (AQUA)
- Functional and comparative genomics of cultured fishes with emphasis on growth and development (2021)
  Promoted candidate: **Dr. E. A. Sarropoulou** (MB&B)

From Level C' to B' Researcher (open procedure, promotion or selection of new researcher)

- Fish immunology and effects of nutrition, stress, pollution and diseases (2021)
  Candidates: Dr. H. Morgane, Mrs I. Ali Oglou

Selected: **Dr. H. Morgane** (AQUA)

- Developmental biology and behavior of farmed fish (2021)
  Candidates: Dr. I. Papadakis, Mrs I. Ali Oglou
  Selected: **Dr. I. Papadakis** (AQUA)
- Environmental Microbiology with specialization in extreme ecosystems (2021)
  Candidates: Dr. K. Chatzikyriakidou, Dr. P. Polymenakou, Mrs I. Ali Oglou
  Selected: **Dr. P. Polymenakou** (MB&B)

During this period, the SCI applied to the Board of Director to award the title of Emeritus Researcher to **Dr. Pascal Divanach**, who was the head of the Department of Aquaculture of the IMBC from 1994 to 2003 and was the Director of the Institute of Aquaculture of HCMR (2003-2012). He was also the scientific director of the Cretaquarium of HCMR and his contribution to the design, implementation and scientific and operational support of the project was fundamental. Unfortunately, Dr. P. Divanach passed on in April 2021, after a year-long battle with cancer.

The SCI organized for the first time in IMBBC, two General Assemblies. In the first one on June 24th 2021, the Director Dr. C.C. Mylonas presented last year's developments, the future plans for the research projects, the effort for increased dissemination to the public and the strategic goals of IMBBC. Then, the SCI president (Dr. C. Tsigenopoulos) referred to the main issues that occupied the SCI before getting into the update and the discussion on various issues of the institute and the research center based on an agenda formed after an open call to all personnel. The second General Assemblies took place on December 13th and 14th 2021, and included 55 short (5 min) talks from almost all PhD holders in IMBBC, and was attended by the majority of the IMBBC staff; this permitted all personnel to have a clear idea of all the researchers' profiles and the research being carried out currently at IMBBC.

2.5 Personnel

Fill in the following tables with the corresponding information.

Table 2-1: Permanent Researchers

	Researcher Name	Position [1]	Year joining the Institute	Year departing from the Institute	Year(s) of promotion [2]
1	Mylonas, Constantinos (Dinos) C.	A	1999 (C)	2031	2003 (B) 2007 (A)
2	Magoulas, Antonios	A	1994 (B)	2024	2003 (A)
3	Chatzifotis, Stavros	A	2006 (C)	2033	2012 (B) 2016 (A)
4	Fountoulaki, Eleni	A	2007 (C)	2026	2012 (B) 2017 (A)
5	Tsiggenopoulos, Constantinos (Costas)	A	2006 (C)	2038	2012 (B) 2016 (A)
6	Grigorakis, Kriton	A	2006 (C)	2038	2012 (B) 2018 (A)
7	Papandroulakis, Nikolaos (Nikos)	A	2000 (*ΕΛΕ* C)	2032	2006 (R B) 2012 (A)
8	Kotzamanis, Ioannis	A	2006 (C)	2031	2012 (B) 2021 (A)
9	Katharios, Pantelis	A	2007 (C)	2040	2016 (B) 2021 (A)
10	Rigos, Georgios	A	2007 (C)	2033	2012 (B) 2016 (A)
11	Kotoulas, Georgios	A	2001 (*ΕΛΕ* B)	2026	2006 (R A)
12	Negas, Ioannis	A	1994 (D)	2031	1994 (D) 2009 (A)
13	Sarropoulou, Elena	B	2012 (C)	2039	2012 (C) 2016 (B) 2021 (A)
14	Ntounas, Constantinos (Costas), **retired**	A	1994 (B)	31/12/2021	1994 (B) 2003 (A)
15	Arvanitidis, Christos, **leave of absence**	A	2006 (B)	30/04/2019	2006 (B) 2016 (A)
16	Kasapidis, Panayotis	B	2007 (D)	2039	2007 (D) 2012 (C) 2016 (B)
17	Cotou, Efthimia (Efi)	B	2006 (C)	2029	2006 (C)

					2014 (B)
18	Papadakis, Ioannis	B	2016 (C)	2039	2016 (C) 2021 (B)
19	Polymenakou, Paraskevi (Voula)	B	2016 (C)	2042	2016 (C) 2021 (B)
20	Koulouri, Panayota (Yiolanta)	B	2006 (D)	2039	2006 (D) 2011 (C) 2016 (B)
21	Henry, Morgane	B	2016 (C)	2038	2016 (C) 2021 (B)
22	Sterioti, Aspasia	B	2006 (C)	2034	2006 (C) 2018 (B)
23	Pafilis, Evaggelos (Vaggelis)	C	2018	2045	
24	Dailianis, Athanasios (Thanos)	C	2019	2041	
25	Mandalakis, Emmanouil (Manolis)	C	2019	2042	
26	Manousaki, Tereza	C	2019	2050	

[1] This is the promotion grade as follows: D does not exist anymore, and there is no equivalent name; C is Assistant (Designated) Researcher; B is Senior (Major) Researcher and A is Director of Research. The same levels exist for Specialist Operational Researchers (*Ειδικός Λειτουργικός Επιστήμονας*, *ΕΛΕ* in Greek), which is a lower grade researcher classification that exists in Greek public research centers (PhD not required).

[2] In parentheses the promotion grade. The notation "R" is used to indicate a transition from *ΕΛΕ* to Researcher.

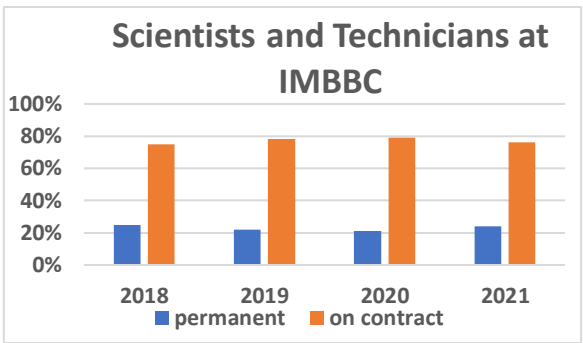
Although not indicated in the above Table, the **Permanent Researchers are separated** as (a) having "**organizational**" positions (outlined and accounted in the Presidential decree establishing the HCMR), or (b) having «**Private Law Indefinite Employment** (*Ιδιωτικού Δικαίου Αορίστου Χρόνου*, ***ΙΔΑΧ*** in Greek)». At IMBBC, we have 10 "organizational" positions and 16 *ΙΔΑΧ*. The significant difference is that once a researcher with an *ΙΔΑΧ* status is retired, its position is abolished and no new recruitment is possible. This is a significant limitation to the future recruitment of new researchers and something that IMBBC will face around the end of this decade, when eight permanent researchers will retire (shaded in yellow in Table 2-1 above).

Some further explanations need to be made in the classification of our staff in the various categories to clarify some peculiarities of the Greek system, but also because the categories of Table 2-2 in the RIview platform do not describe all different types of staff in IMBBC (and HCMR in general). Therefore, here we have modified Table 2-2 (next page), by splitting some rows in two and creating new categories (green shaded rows). As a result, the total numbers shown here, are slightly different from the numbers in Table 2-2 of the RIview platform.

Table 2-2: All Personnel (modified by IMBBC)

Personnel Totals	2018		2019		2020		2021	
	Male	Female	Male	Female	Male	Female	Male	Female
Researchers	16	7	17	8	17	8	17	8
Collaborating University Faculty	0	0	0	0	0	0	1	0
Adjunct, part-time, visiting Researchers	0	0	0	0	0	0	0	0
Staff Scientists and Technicians **permanent**	5	13	5	12	5	11	5	11
Staff Scientists and Technicians **on contract**	23	32	27	34	26	34	21	31
Post-doctoral Researchers (on contract)	8	7	8	8	9	8	10	9
PhD Students **on contract**	2	1	3	1	0	2	3	4
PhD Students **not on contract**	0	2	0	0	0	0	6	7
Administrative Personnel (permanent or on contract)	1	5	1	5	2	5	2	5
Master Students	5	5	4	3	3	4	8	13
Undergraduate Students	12	19	10	18	9	17	21	14
Other Personnel	2	1	2	1	2	1	2	1
Total	**74**	**90**	**77**	**90**	**73**	**90**	**90**	**96**

Firstly, we need to point out that in Table 2-2 in the RIview platform, for the **Staff Scientists and Technicians** there is no discrimination between permanent and on contract personnel. Since the percentage of on-contract personnel is quite significant for IMBBC (see Figure on the right), as it is also for HCMR as a whole, we modified the Table 2-2 (above) and we separated the staff in this category to **permanent** or **on contract**.



Secondly, we have split the category "**Master and Undergraduate Students**", into **Master students** and **Undergraduate students** in order to show better the number of students we train in these two categories. These numbers refer to **different students every year**, contrary to the data in all other non-student categories of personnel, where the numbers represent the personnel present in IMBBC during the specific year.

Finally, as Table 2-2 in the RIview platform included only a category of "PhD Students (**on Contract**)" we did not have another category to account for PhD students that were not on contract, but spent time at IMBBC. These students usually have contracts with their universities and spend only part of their time (months to years) to carry out either part or all of their Doctoral research. Therefore, the number of PhD students that were trained at IMBBC during the period of 2018-2021 is somewhat underestimated when looking at the RIview platform table. A better account is shown in the modified table here, where we included a row with "PhD Students (**not on Contract**)", and these students are presented individually in the appropriate section later in the report. As for Master and Undergraduate Students, the numbers for PhD Students refer to **different students every year.**

3 Administration and Management Policies and Practices

3.1 Policies and practices for financial management and Access policies to Facilities.

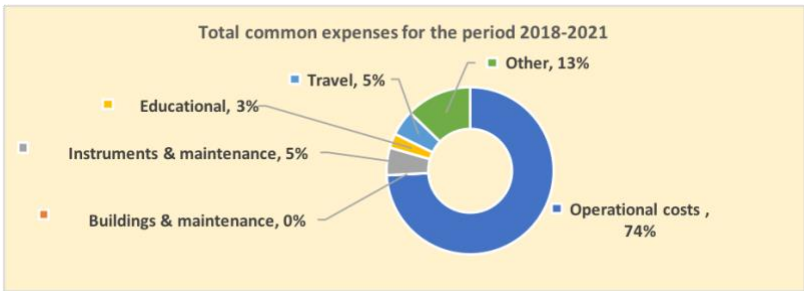
As HCMR is a public research center, its financial management is separated into two main modules. The Greek State is funding the salaries of permanent staff and a small fraction of the operating costs (*e.g.* electricity, water, telephony, etc.). Then, the so called "Special Account for Research Grants (SARG, known as ΕΛΚΕ)" is an autonomous financial department, with responsibility to manage all other income and expenses of the center (research grants, studies and private funding, and sales of products and services), so the institutes are not involved in the financial management of these funds. The SARG is staffed with specialized personnel (permanent and on contract), and its expenses and all other operating costs of the center not covered by the Greek State, are paid through the overheads on the research and service grants of HCMR. The maximum allowable overheads rate allowed by law (N4485, art. 59) is 25% of the total budget of a grant, but the actual amount varies for different funding organizations and schemes. National projects from Greece, unfortunately allow less than 10% of the grants for overheads, so **the average overhead percentage from all research and service grants for HCMR is only 10%**! This puts significant restrictions on our operations and our ability to create financial reserves to absorb cash flow problems created very often, by delays in payment from the funding organizations, especially from Greece. **Another important issue that the State must address**, if the research centers are to survive, improve and contribute to the national economy, is that although typical public organizations (*e.g.* ministries, schools, hospitals, etc.) are fully funded from the government for their operational costs, maintenance and upgrading, in the case of public research centers –such as HCMR- we are constantly forced to fund our own operations with **ever decreasing support from the State**. Instead of covering the total of our operating costs, unfortunately the State only pays for the salaries of the permanent staff -which for HCMR is only about 1/3 of the total personnel. For all the rest of the expenses, we must compete for and win a very high number of projects, to have the necessary overheads to fund all the operational needs of a growing center.

Regarding the institutes of HCMR, a small portion of overheads (around 2%) is allocated for operating and development expenses of each institute, and is credited to the **IMBBC Overheads account**. The distribution of the IMBBC common expenses (not including salary costs) paid by this account together with the operational costs paid from the HCMR overheads (**Table 4-3** in the RIview platform) is shown below for the period 2018-2021.

	2018	2019	2020	2021
Operational costs (electricity, water etc.) [1]	€ 88.799	€ 110.602	€ 91.893	€ 99.413
Buildings & maintenance	0	0	0	0
Instruments & maintenance	€ 2.143	€ 7.797	€ 5.251	€ 12.923
Educational	€ 4.377	€ 3.854	€ 1.334	€ 5.073
Travel	€ 14.531	€ 9.222	€ 987	€ 1.523
Other	€ 14.120	€ 14.678	€ 10.996	€ 27.395
TOTAL	**€ 123.971**	**€ 146.153**	**€ 110.461**	**€ 146.327**

[1] These costs are paid by the HCMR overheads.

As one can see, very little is paid by the **IMBBC overheads budget** for common expenses, mainly because this account was created only in the last 5 years and it has only recently accumulated enough funds. This year (2022) **we are going to hire for the first time a professional using this budget**, to fill the position of an IT Support service of the institute. Also, we started using this IMBBC overheads budget for important maintenance of facilities and common equipment (freezers, air conditioners, water pumps for our sea water supply, etc.), since **no funding is available from the State to cover these expenses**. Facility and equipment maintenance and upgrades have been funded so far -and from the beginning of the creation of HCMR- by money from research grants (when eligible) and mainly service grants (when available) of the researchers who are the main users of each facility or equipment. **Had the State provided money for facility and equipment maintenance**, this money could be better used by the researchers to carry out research that is not yet funded and that can open up new directions for the institute, hiring new personnel, providing scholarships to MSc and PhD students, acquiring new equipment that cannot be purchased solely from one project and carrying out preliminary research to improve the chances of submitting a competitive proposal.

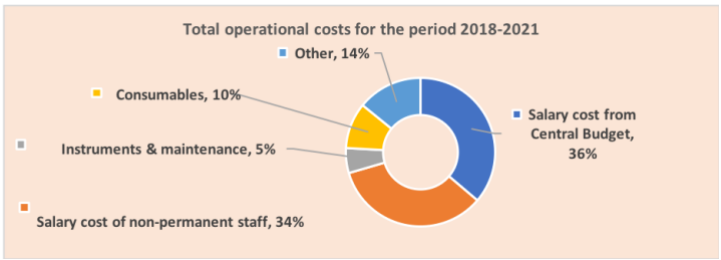


The expenditure of IMBBC during the reporting period ranged between € 3,6 and € 4,9 million (**Table 4-4** in the RIview platform), including also the salaries of the permanent staff, showing an increasing trend over the years. It is apparent that the highest cost regards personnel, with the cost of the permanent staff being 36% of the total expenditure and the cost of the non-permanent personnel being almost equal (but for a much larger number of persons) at 34% (see also Doughnut chart in next page).

	2018	2019	2020	2021
Salary cost from Central Budget	€ 1.484.225,00	€ 1.567.155,00	€ 1.586.026,00	€ 1.599.531,00
Salary cost of non-permanent staff	€ 1.193.723,69	€ 1.360.929,42	€ 1.643.815,80	€ 1.693.490,68
Instruments & maintenance	€ 64.512,55	€ 169.650,96	€ 292.950,28	€ 407.758,55
Consumables	€ 361.088,22	€ 382.114,95	€ 438.530,22	€ 538.417,95
Other	€ 546.153,59	€ 641.026,21	€ 500.127,72	€ 740.763,79
TOTAL	**€ 3.649.703,05**	**€ 4.120.876,54**	**€ 4.461.450,02**	**€ 4.979.961,97**

The new law for research activities (N4485) obliges all public research institutes to abide by the financial management rules of the central government. Unfortunately, these rules provide no flexibility and **are not suited for the type of work done by research institutes**, that have variable activities, and unforeseeable changes during the course of just a few months in implementing a research project. Research, by definition, cannot be performed

under restrictive regulations and scheduling, and a high degree of flexibility must be allowed by the funding agencies and the national financial management laws.



Deviations from the "initially approved plan" are customary in implementing research projects, since the ability to improvise is imperative during searching and testing new methods and technical solutions. However, **government bureaucracy tends to oblige all things to be pre-planned**, when the needs of a successful innovation are to be flexible, and able to act fast and improvise. Trying to abide by every financial and administrative rule and regulation is often an impossible task, while **it always takes valuable time and energy from the researchers**, whose expertise and role is to carry out research, teach new scientists, and publish and implement their findings. Instead, **valuable time and effort is wasted**, **disappointment and frustration are widespread among the research personnel**, and loss of well-deserved and worked-for moneys for the institute result from strict auditing procedures that should have been better created and planned for the financial management of research projects. So, it is important that new auditing procedures are put in place, which will be better in line with the nature of research and its peculiarities. **Auditing should focus more on the work outcome and deliverables** vis-à-vis the approved proposal and be more similar to financial management in the private economy than the central government.

We propose that funding of research should become more similar to a model of loose subcontracting, where at the proposal stage a price for the research is determined by an indicative cost analysis, in order for the reviewers to evaluate and determine if the requested budget is justified. Once approved, **the rules should only be limited to avoid fraud and illegal activities**. All other aspects should be allowed **full flexibility**, as long as the research goals are achieved, since for any public organization, such as HCMR, systems are already in place to assure that fraud and illegal activities are extremely difficult to occur.

Access fees to the IMBBC facilities do not apply for internal users, while for external users these apply mainly in the context of the EU Transnational Access projects to RIs. In recent years, with the participation of several facilities of IMBBC in national and European RIs, a new financial management scheme and access policy is under preparation. This scheme includes fees for the use of the facilities and services (calculated with the assistance of an auditor), and different fee categories for internal, academic external and private sector external users. Each facility will have its own financial account where the fees will be collected and used for its operation. An Access Policy, in the framework of the national RI "CMBR" is under preparation. This Policy envisions a single-entry point to the research facilities through a web portal (under preparation). An Access Officer will receive the requests and direct them to the person in charge of the respective facility. This access policy scheme has been already applied in IMBBC in the framework of EU projects that support Transnational Access, such as the projects EMBRIC and ASSEMBLE PLUS, which are based on the European RI EMBRC-ERIC and the EU projects AQUAEXCEL, AQUAEXCEL2020 and AQUAEXCEL 3.0 for aquaculture research.

3.2 Management of the Human Potential

There is no separate IMBBC policy in this aspect, and we follow what is established for the HCMR as a whole. The HCMR implements Greek and European legislation and respects principles of transparency and equality treatment. We can separate personnel recruitment between Permanent Researchers (tenure track) and Other contracted personnel -which includes Post-doctoral Researchers and technicians. For Permanent Researchers the subject area to be advertised is decided by the Scientific Board of the Institute after consultation with the director. The position is approved by the Board of Directors of the HCMR, it is announced on the center's website and in at least two national newspapers, and then an **Evaluation Committee** is appointed, consisting of five Permanent Researchers including the director of the institute. A three-member sub-committee (**Recommendation committee**) including the director of the institute evaluates the candidates and recommends the most appropriate candidate. Then the Evaluation Committee meets, may interview the candidates if necessary and makes their decision.

For **Other contracted personnel** recruitment --which includes Post-doctoral Researchers and technicians-- specific criteria are decided for the evaluation, based on the requirements of the research project that will be paying the personnel. It is important to note here, that when it comes to this category of personnel, there have been no permanent staff positions opened in the last 15 years, and only in 2021, **seven new permanent Technical Staff positions** have been allocated to IMBBC and we expect to have the evaluation for these positions within 2021. Therefore, new staff has been hired exclusively from competitive research grants, and also from on-going contract research activities and the production and sale of juveniles and edible fish.

The selection of **Technical Staff** is carried out following an open call/announcement, which is posted on the HCMR website and in DIAVGEIA, ensuring the principle of transparency. The eligibility criteria of the candidates correspond exclusively to criteria of academic, professional and scientific evaluation. Regarding the grading of the qualifications of the candidates, the Supreme Council for Personnel Selection (*ΑΣΕΠ* in Greek) standard is followed. Also, an interview is provided as a selection criterion, only where it is absolutely necessary. Elements that will be evaluated are determined in an objective and transparent way, based on the requirements of each research program. Nominations are evaluated by a three-member Evaluation Committee and each candidate has the right to submit an appeal, which is examined by a separate, annually appointed Appeals Committee.

Regarding a policy for **newly recruited Permanent Researchers**, unfortunately there is no start-up funding, or other types of financial support, since the institute until only recently did not have any separate budget, and all overheads went to Special Account for Research Grants (*ΕΛΚΕ*), which took care of all the financial management of the research activities and services of HCMR's institutes. Therefore, new researchers could only expect to be given office space and the ability to work in a lab, and have to immediately become active in proposal writing and solicitation of funds, in order to start their own line of research. We believe it is essential that such support policy is put in place now that the institute has its own budget, in order to enable the new researchers to start working and accumulating data in preparation for submission of proposals.

3.3 Measures for promoting Equality, Diversity and Inclusion

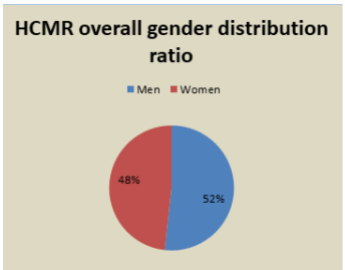
There is no separate institute policy for these aspects, and we follow what is established for the HCMR as a whole. The HCMR aims to provide equal opportunities for new staff and equality in the workplace. For this purpose, a **Gender Equality Plan (GEP)** has been recently established (2022), in order to ensure fair access and equality for all staff categories (research, managerial, technical, administrative and support staff). The GEP is in accordance to Greek and European laws and does not only limit equality to gender bias, but also considers other inequality grounds such as disability, age, sexual orientation, religion or ethnicity, etc.

The HCMR GEP legitimizes and protects every strategy aiming to achieve gender equality within the Center and implements the following actions:

i. Encouraging balanced gender representation in job applications through gender-neutral vacancy descriptions.

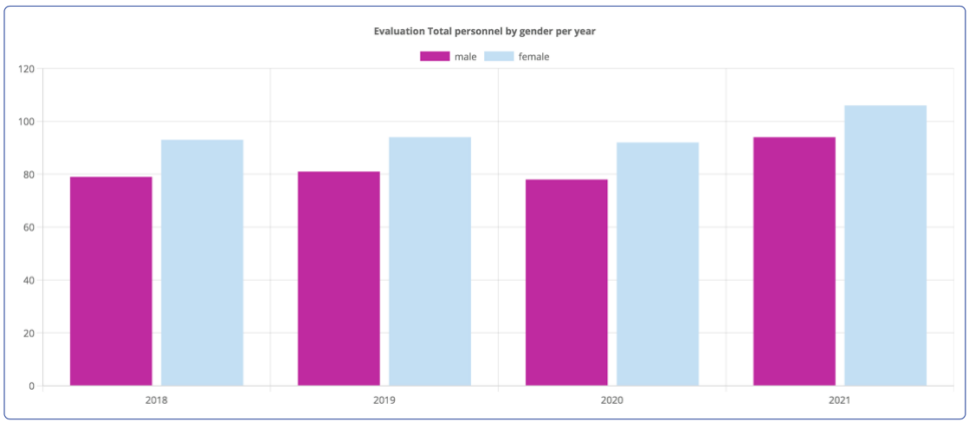
ii. Ensuring gender balance in decision-making processes and bodies, by inclusivity in decision-making by not allowing gender discrimination enabling women to participate in the process.

iii. Integrating the gender dimension in research and innovation content.



As shown on the right, HCMR has managed to achieve a balanced gender representation in its personnel **(Source: HCMR's GEP)**

Also, as shown below, IMBBC had more female than male personnel during every year of the reporting period.



Regarding the remuneration/pay, for the Researchers the law 4472/2017 is applied. For the rest of the staff (special scientific and technical staff, administrative staff and other support staff) whether employed on a permanent contract or on a fixed-term contract, the amount of remuneration is set by the Law 4354/2015, so as to avoid any discrimination.

3.4 Policy and Regulations enforcing Ethics in Research and Scientific Integrity

For these aspects, there is no separate institute policy, and we follow what is established for the HCMR as a whole.

Ethics Committee

The HCMR's Ethics Committee was established just recently (2021) in accordance with Law 4521/2018 (articles 21-27) in order to provide, at an ethical level, a guarantee of the reliability of the research projects carried out at the HCMR. The Ethics Committee checks whether a research project is carried out with respect for fundamental human rights, the autonomy of the persons involved, their privacy and personal data, and the care of the natural and cultural environment. It also monitors compliance with generally accepted principles of research integrity and the criteria of good scientific practice. In addition, the mission of the Ethics Committee is to assist in the harmonization of HCMR's research practices with the legislation, rules and regulations of the European Union and international law.

Personal Data Protection Policy (GDPR)

The HCMR has complied fully with the current legislation (European Data Protection Regulation and Law 4624/2019 on Personal Data) and implements a comprehensive program for the Protection of Personal Data, in order to fully ensure the protection of employees, associates and all stakeholders. HCMR cooperates with a private company that advises and trains the person in charge of personal data protection in matters of data protection and information security, in order to more effectively inform and comply with the Organization. Two meetings are already scheduled (distance learning) for training at 05/04/2022 and 07/04/2022.

It is also worth mentioning that during the Ocean Sampling Days (OSD) campaigns, which are supported by the European Marine Biological Resource Centre (EMBRC-ERIC) Research Infrastructure, through the ASSEMBLE Plus project, and are operated by IMBBC, special attention is paid to GDPR policy. The GDPR compliance is ensured at every stage of data processing, through the ASSEMBLE Plus Privacy Policy presented at http://www.assembleplus.eu/about/privacy-policy.

Scientific Data Management Plan

We do not have an HCMR-wide plan so far, but as per the requirements of the EU funding agencies, we have initiated a process of storing our data in repositories that are usually created by the program coordinating organizations. However, it should be mentioned that IMBBC hosts the **LifeWatchGreece Research Infrastructure (RI)**, which is open to all potential users, from researchers and students to entrepreneurs and policy makers, and stores biodiversity data and information from all biology-related disciplines. The purpose of the RI is to be compliant with European Commission's policy for OPEN and FAIR scientific data. The "Background Information Document on LifeWatchGreece Research Infrastructure Data Policy and Data Sharing Agreement" is available at: https://www.lifewatchgreece.eu/sites/default/files//documents/D1.2%20Policy%20Background%20Doc_En.pdf

This document provides information on datasets, metadata, data sharing, licenses and copyright issues concerning biodiversity data. This document declares that LifeWatchGreece RI uses Creative Commons as a legal instrument to define the usage rights of the data. Creative Commons are legally binding, simple to use, globally accepted and its licenses are both human-readable and machine-readable, the latter being especially important in the digital age. Furthermore, the submission of data to the LifeWatchGreece Research Infrastructure database has as a prerequisite the agreement with the rights and obligations of the Data Provider, as well as with the terms of operation of LifeWatchGreece RI, as presented at:

https://www.lifewatchgreece.eu/sites/default/files//documents/D1.2%20Data%20Sharing%20Agreement_En.pdf.

Finally, in the framework of the project "Centre for the study and sustainable exploitation of Marine Biological Resources (CMBR), which is a research project of IMBBC for the period 2018-2021, a data management plan has been created, and the experience gained could be used to develop such a plan for the whole HCMR. The Data Management Plan (DMP) can be considered as a "living' document", although it was created at the beginning of the research project, and it was updated as the project progressed. The DMP contains information on the suggested policies, standards, and sustainability activities related to the created data, to ensure the management of knowledge in the project is maintained following the FAIR principles. The DMP describes the data and metadata standards, data availability and licenses, data curation and preservation methods, as well as the rights and duties of data providers and data holders.

Experiments with Animals

Animal experimentation is taking place at the aquaculture facilities of IMBBC (AQUALABS) in Heraklion, Crete and during part of the reporting period at the facilities of Agios Kosmas (**no longer in operation since the summer of 2019**). The AQUALABS are registered facilities at the National Veterinary Authority under the registration number EL91-BIObr-03 for experimental animal production and EL91-BIOexp-04 for experimentation with animals. Designated personnel involved in animal experimentation hold a degree accredited by the Federation of European Laboratory Animal Science Associations (FELASA) on the "Care and use of laboratory animals" for persons carrying out procedures in animals, designing procedures and projects, taking care of animals and killing animals. The number of animals used for experiments in the IMBBC facilities is submitted annually to the Directory of Animal Protection and Veterinary Drugs of the Ministry of Rural Development and Food, and experimental fish by-products are collected by a waste management company and discarded by incineration.

Experiments conducted at the AQUALABS comply with the Presidential Decree 56/2013, which is the Greek national law governing animal experimentation, in accordance with the EU Directive 2010/63. A biologist with a FELASA degree has been appointed as the person responsible for the application of the directive, whereas a designated veterinarian has been appointed in charge of the welfare and treatment of animals. A committee, which involves a senior researcher, a veterinarian, a fish pathologist, a statistician, and a representative of the Veterinary Office of the Region of Crete has been assigned for the evaluation and approval of all experimental protocols conducted at IMBBC. After approval of the protocols, their non-technical project summaries (NTS) are submitted to the ALURES NTS EU database.

3.5 Partnerships, strategic alliances

- *Describe Partnerships or Strategic Alliances of the Institute with other Greek or foreign Research Centers, Universities, Companies, and the content of collaboration (add also links to corresponding web sites).*

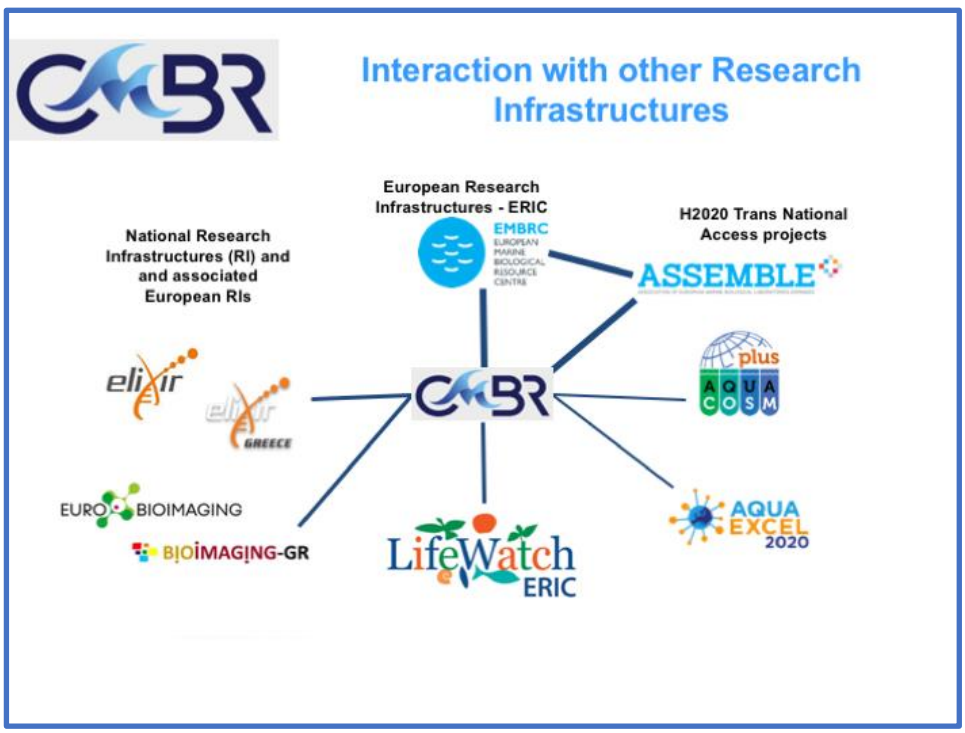
The Reproduction and Physiology laboratory (**AQUA**, Dr. Mylonas, C.C. and Fish Behavior Laboratory, AQUA, Dr. Papadakis, I.) has established a collaboration with the **New Zealand Institute for Plant and Food Research** (Nelson, NZ) in the area of fish reproduction and larval rearing ontogeny, in 2019. The collaboration began with exchange visits of the IMBBC researchers and of Dr. Matthew Wiley, a joint publication of a review article, and more recently with a signing of a subcontracting agreement in the area of larval rearing and early ontogeny. The next visit to NZ will take place in October-November 2022. This partnership has created an opportunity for IMBBC to disseminate its expertise to an important institute abroad, but one with a limited expertise in the area of aquaculture. Also, post-docs trained at HCMR, had the opportunity to compete for opening positions in the NZ institute, further establishing important links for IMBBC. A collaboration has also been established with the **Institute of International Marine Centre (Sardinia, Italy)** on evaluating larval rearing protocols in emerging aquaculture species.

A recent strategic alliance was initiated in 2021, with the preparation of a Memorandum of Understanding (MOU) with the **Hellenic Aquaculture Producers Organization (HAPO)**. The objective of the MOU is (a) the promotion of sustainable aquaculture activities, particularly with regard to environmental protection; b) the optimization of the quality of aquaculture products; c) the strengthening of consumer confidence in Greek aquaculture products and the support of businesses in the development of mechanisms and actions to inform consumers; and d) the improvement of the conditions for the placing on the market of Greek aquaculture products and the improvement of the quality of these products. Through this alliance, IMBBC can influence the aquaculture producers in Greece, provide expert opinions on production processes, and ensure the collaboration of these companies in research proposals and projects of interest to IMBBC researchers.

After an initiative from the director of IMBBC, an MOU has also been signed in 2021with the **Natural History Museum of Crete (NHMC, University of Crete)**, where HCMR samples will be deposited to the NHMC collections. This will allow appropriate sample's storage and archiving as well as access and acquisition of time-series data by the scientific community. The NHMC, a member of the Consortium of European Taxonomic Facilities (CETAF, https://cetaf.org/), due to the richness of its collections, has been appointed as the national representative in the **European Distributed System of Scientific Collections (DiSSCo) consortium** and leads the Greek consortium. At the same time, the HCMR is the country's representative in the **European research infrastructure LifeWatch ERIC**, also a member of ESFRI, which collaborates with DiSSCo and which develops tools and services for the management and communication of multi-level biodiversity monitoring data, while providing access to our HPC. As regards the mainstream biodiversity approaches in modern biology, HCMR participates in the Biodiversity Focus Group of **ELIXIR EU (ESFRI)**, and coordinates in its Greek node the support of marine biodiversity needs. The coordination between these key infrastructures, in which NHMC and HCMR participate, places the country at the European forefront of biodiversity recording, mapping and monitoring. These are necessary conditions for national policy planning, decision-making and sustainable development of the country, while supporting and implementing of European policies.

As a strategy for the development of IMBBC, it was sought, among others, to operate the Institute as a research infrastructure open to other research centers and universities. This is the reason for the creation of the CMBR RI. Recent integration into **European infrastructures and programs (AQUAEXCEL, EMBRC, EMBRIC, ASSEMBLE PLUS)** ensures a continuous flow of researchers from abroad, hosting research, attracting collaborations, and projecting the Institute into an international environment. The IMBBC has now strong relationships with **LifeWatch ERIC** from the time Dr. C. Arvanitidis (a Permanent Researcher of IMBBC) was elected as the CEO of the ERIC. Through this connection, IMBBC has a great number of options to participate in organizations, projects and initiatives as either an independent partner or Third Lead Partner (TLP). Participation in Genomic Observatory projects such as EOSC Future would have been unthinkable for IMBBC without its collaboration with ERICs such as **LifeWatch** and European Marine Biological Resource Centre (**EMBRC)**. The EMBRC RI, https://www.embrc.eu/) and **ASSEMBLE Plus** (http://www.assembleplus.eu/) projects constitute **two of the most strategic alliances of the institute**. Through these collaborations, IMBBC has been as a well-known and respected marine research institutes in Europe. Also, these collaborations are promoting the involvement of IMBBC in research proposals. More specifically, the e-infrastructure group of EMBRC hosts monthly meetings where new ways to promote and further enhance this collaboration are being discussed. In addition, the LifeWatch ERIC RI, acts as an interlink between EMBRC and other European RIs, and in many cases this strengthens the role of IMBBC. Furthermore, through the collaboration with EMBRC-ERIC, IMBBC implements and manages the EMBRC genomic observatory, the European Marine Omic Biodiversity Observation Network (EMO BON). The EMO BON is a core project of the EMBRC that focuses on studying coastal biodiversity in the long term.

Our institute is also a partner node of **BioImaging-GR**, which is a distributed research infrastructure for open-access, high-end biological imaging providing a range of imaging methods to many scientists in research institutes in Greece and neighboring countries (https://bioimaging.gr/index.php/en/partners-en).



Another successful and long-term collaboration is with the **Flanders Marine Institute (VLIZ)**, in the framework of Data Management practices (curation and submission). As an example, IMBBC along with VLIZ and the Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS) have organized a hands-on workshop in 2020 on data formatting, quality control (QC) & publishing as part of the EMODnet Biology project (phase 3), with the intention to provide training to current and future data providers on how to format and submit their data to the project (https://www.emodnet-biology.eu/news?p=show&id=8425).

Drs. D. Tsaparis, Dr. P. Kasapidis and G. Kotoulas of IMBBC collaborate with the Molecular Ecology & Conservation Genetics Lab of the **University of Ioannina** (Assoc. Prof. Sotiropoulos K., Department of Biological Applications & Technology), promoting genetic research and conservation of several threatened species or populations of the Greek fauna. Training of BSc and PhD students in IMBBC facilities was also achieved in the context of this collaboration, resulting in publication of the results in peer-reviewed journals. Furthermore, Dr. Tsaparis collaborates with Prof. Stelios Katsanevakis (**University of the Aegean, Department of Marine Sciences**) for the study of marine invasive species and their impact on Mediterranean marine ecosystems, resulting so far, in one common publication. Dr. A. Antoniou collaboration with the **Molecular Systematics Laboratory of NHMC, UoC** (Prof. Nikos Poulakakis) permits expertise exchange in the fields of phylogenomics, population genomics, adaptation and hybridization addressing interesting evolutionary questions inspired by a wide range of natural systems. This collaboration has produced many publications, five of them from 2018 up to date.

Members of the Functional Genomics research direction (A. Gioti, A. Magoulas & G. Kotoulas) have established a collaboration for the omic study of mycoremediation with the IndBioCat team (Prof. Evangelos Topakas) of the **Chemical Engineering School at NTUA** since 2019. Dr. A. Gioti has been co-supervising the NTUA PhD candidate Romanos Siaperas in bioinformatics, and G. Kotoulas is a member of his PhD committee. The collaboration has provided so far two publications and one oral presentation by R. Siaperas in an international event.

Dr. T. Dailianis and Prof. Vasilis Gerovasileiou participate in international panels of experts on the conservation and management of sensitive marine species. In particular, the **ongoing preparation of the IUCN Red List of sponges in the Mediterranean** is an important initiative launched in 2018 and is the first time that members of the Phylum Porifera are assessed for their vulnerability. IMBBC **hosted the 1st IUCN Red List Assessment Review Workshop: Mediterranean Porifera** (25-28/11/2019, Heraklion, Greece),

Link: https://www.iucn.org/news/mediterraneo/201911/marine-conservation-experts-meet-prepare-1st-red-list-assessment-sponges-mediterranean.

Moreover, Drs. T. Dailianis and V. Gerovasileiou participate in **the panel of experts of the FAO GFCM Regional Research Programme** on the coordination of research regarding the endangered Mediterranean red coral *Corallium rubrum*, launched in 2020.

The HCMR participates in the **European Scientific Diving Panel** (ESDP, http://ssd.imbe.fr), an operational platform to advance underwater scientific excellence and to promote and implement a practical support framework for scientific diving related activities. The ESDP currently operates under the European Network of Marine Research Institutes and Stations (MARS). From IMBBC, Dr. T. Dailianis and Mrs. W. Plaiti participate to the regular meetings of the panel representing Greece.

IMBBC is an active member and co-chair of the **Ocean Literacy Working Group of the European Global Ocean Observing System (EuroGOOS)**, which has launched a long-

term UN Ocean Science Decade Action Program not only to support, but also to promote Ocean Literacy (OL) and thus to bring considerable added value to achieving the seven societal outcomes for sustainability in society, reaching out specifically to policy-decision-makers, NGOs, scientists, interested stakeholders and more generally to the public at large. Collaboration with the **European Marine Science Educators Association (EMSEA) and the Department of Primary Education, Democritus University of Thrace** brings considerable expertise in Ocean Literacy, while we have been heavily involved both in activities and publications regarding the development of the adaptation of OL principles and concepts to the specificities of the Mediterranean Sea. The Mediterranean Sea, an important global biodiversity hotspot, has been described as being under siege due to multiple human pressures. Ocean Literacy should be established across all Mediterranean countries in order to prepare the future generations of Mediterranean Sea-literate citizens.

IMBBC has been involved from its creation in teaching at both undergraduate and postgraduate levels in collaboration with various Greek and European Universities. Cooperation with the **Biology Department (UoC)** has been especially developed, both in their undergraduate and post-graduate programs. This is in the form of support of teaching offered by IMBBC researchers in the (a) **ERASMUS Mundus (ERASMUS +) Joint Master Degree "AquaCulture, Environment and Society"**, (b) postgraduate inter-institutional program **"Environmental Biology - Management of Terrestrial and Marine Biological Resources"**, (c) postgraduate program in "**Bioinformatics**". Regarding the **ERASMUS** Mundus Joint Master Degree **ACES**, this collaboration is supported by the involvement of Dr. P. Katharios in the academic and administrative activities of these programs including teaching, module organization, hosting and supervising of students in the lab. The majority of Permanent Researchers in the Research Group AQUA provide lectures in their specialty in this program, and accept students for their internship and some for the Thesis research.

Also, Dr. Aglaia Antoniou is co-lecturing undergraduates of the Biology Department of the UoC in the course on Computational Methods. Furthermore, recent contacts with French Engineering schools have directed many high level and motivated students to turn to HCMR to perform their 5-month, end of studies training period. IMBBC has also been hosting quarterly research projects (Rotations) of postgraduate programs of the Department of Biology, providing scholarships to doctoral candidates, hosting the annual workshop on the progress of postgraduate students and doctoral candidates, etc. In addition, we participate in the organization of talks at the '**Darwinian Mondays**', which is open to the general public and is hosted by the Museum of Natural History of Crete (MNHC).

Finally, IMBBC organizes and lectures in a **European Molecular Biology Organization (EMBO)** advanced course in training postgraduate students, Post-Docs and faculty on computational molecular evolution since 2010 (**CoME course**). A long term collaboration has also been achieved on delivering the same course under both **Wellcome Trust and the European Bioinformatics Institute (EBI)** since 2011 (CoME, https://coursesandconferences.wellcomeconnectingscience.org/event/computational-molecular-evolution-20190513/, https://coursesandconferences.wellcomeconnectingscience.org/event/computational-molecular-evolution-20220718/).

The involvement of IMBBC in these series of advanced courses provides early-career stage researchers training and with the theoretical knowledge and practical skills to carry out molecular evolutionary analyses on sequence data, offering a unique opportunity for direct interaction with some of the world-leading scientists and authors of famous analysis tools

in Evolutionary Bioinformatics. This series of courses cover the demand for such training, which is growing as the sequence databases and researchers' awareness of the important insights that can be gained from phylogenetic and molecular evolutionary techniques and provides a stable hub on computational molecular evolution training in Greece and the Eastern Mediterranean, increasing its visibility and research potential.

3.6 Scientific exchanges and collaborations

- *Describe the regular scientific exchange activities within the Institute during the period (i.e. Internal Seminars, Horizontal Thematic Seminars, Retreats, Invited Speaker Lectures, others). Provide a list of Invited Speakers (or web site link to the Invited talks).*

A series of lectures have been launched since 2018 that include either presentations of the activities and research interests of the local researchers or invited talks from visiting scientists (see Table below for a complete list). This activity has led to a total of 7 talks for 2018 (October to the end of the year) and 19 for 2019. The COVID 19 pandemic has dramatically impacted this activity of the institute slowing down this effort. Especially in 2020 out of the 5 talks in total, 4 took place until early March when the first lock-down of the country was initiated. In 2021, 9 talks were given all within the summer months (June-September) which were again stopped in the autumn/winter months following the rise of the country's cases and restriction measures.

Although the pandemic has impacted remarkably this important activity of the institute, at the same time it pushed towards using web tools for scientific interactions (*e.g.* Zoom, Microsoft Teams, etc.) enabling the interaction with researchers from the Greek Diaspora. This has led to the invitation of talented young researchers from the Greek Diaspora (*e.g.* **Dr. Constantina Theofanopoulou from Rockefeller University, NY**) that were attended not only from IMBBC but also from other research centers and universities across Greece.

Date	Speaker	Title	Category
16/12/21	Ivana Buselic	Transcriptomic approach to environmentally friendly farming of European sea bass in the Adriatic Sea, using alternative protein sources	Visiting researcher
29/9/21	Valeria Di Dato	Fundamental pathways in metazoans: unexplored pathways in diatoms. New frontiers in genomics of marine micro-organisms	Visiting researcher
16/9/21	Xavier Buñuel	Assessing herbivory in a global change era: Linking behavioral interactions to ecosystem function in the Mediterranean Sea	Visiting researcher
27/7/21	Chiara Conte	The investigation of seagrass holobiont across different seagrass species and environmental conditions	Visiting researcher
15/7/21	Vassia Koutsouveli	Physiological and evolutionary questions in sponges	Visiting researcher

14/7/21	Costas Billis	Using transcriptomics data in Ensembl	Visiting researcher
13/7/21	Constantina Theofanopoulou	Universal nomenclature for oxytocin-vasotocin ligands and receptors: insights on whole genome duplication scenarios	Visiting researcher
30/6/21	Liron Goren	Macrofauna Inhabiting Massive Demosponges from Shallow and Mesophotic Habitats Along the Israeli Mediterranean Coast	Visiting researcher
4/6/21	Giorgio Mancinelli	Stable isotope analysis in trophic ecology	Visiting researcher
1/6/21	Giorgio Mancinelli	Caught in the middle: the invasive portunids *Callinectes sapidus* and *Portunus segnis* in the Mediterranean Sea	Visiting researcher
28/7/20	Miguel Desmarais	The emerging role of bioinformatics in environmental engineering	Visiting researcher
5/3/20	Jorune Sakalauskaite	Shell Palaeoproteomics - from biomineralization to characterization of fossil proteins in archaeological shells	Visiting researcher
19/2/20	Vasilis Papadogiannis	Looking for the origin of vertebrate senses	Visiting researcher
14/2/20	Dimitra Mavraki	Introduction to the concept of 'Data FAIRness	Visiting researcher
6/2/20	Fotis Tsetsos	Utilizing human genomic data to gain insights on medical traits and population history	Visiting researcher
13/12/19	Vasilis Gerovasileiou	Shedding light on the "Dark Habitats" of the Eastern Mediterranean Sea	Visiting researcher
6/12/19	Sandra Ramos	Control of reproduction in the grey mullet (*Mugil cephalus*) based on the use of recombinant gonadotropin hormones	Visiting researcher
5/12/19	Elisavet Kaitetzidou	Molecular characterization and annotation of paralogous and orthologous genes in teleost early developmental stages	Visiting researcher
29/11/19	Evangelos Pafilis & Haris Zafeiropoulos	PREGO (Process–environment–organism): building a knowledge base associating the different types of ecosystems with the microorganisms they contain the biological/environmental processes the latter are involved with	Visiting researcher

22/11/19	Potirakis/Ninidakis/Pafilis	Zorbas: the HPC cluster for biological analysis in IMBBC, HCMR	Visiting researcher
6/11/19	Simona Georgieva	Biodiversity and population connectivity of sparid fish parasites in the Mediterranean Sea	Visiting researcher
25/10/19	Francisco Sedano	Comparing benthic communities between artificial structures and natural hard habitats. Crete and Algeciras Bay (Spain) as case studies.	Visiting researcher
18/10/19	Federica Montesanto	Ascidians hunters: integrated taxonomy unveils invasive and cryptic ascidians (Ascidiacea, Tunicata) within the Mediterranean Sea and beyond	Visiting researcher
16/10/19	Jonathan (Yoni) Belmaker	Do Lessepsian invasives impact indigenous fish communities?	Visiting researcher
9/10/19	Chiara Conte	Investigating the seagrass microbiome of monospecific and mixed meadows: a study of the potential seagrass holobiont responsiveness to the ecological competition	Visiting researcher
27/9/19	Ilias Lagkouvardos	Integration of global amplicon sequence data, a step towards estimation of global microbial diversity	Visiting researcher
19/9/19	Annekatrin Enge	Distribution and ecology of (alien) benthic foraminifera in shallow-water habitats of Crete	Visiting researcher
13/9/19	Fred Verret	RNA silencing in diatoms (RADIO-HFRI)	IMBBC researcher
1/8/19	Cibele de Sotero Caio	Local adaptation in habitats under anthropogenic stress	Visiting researcher
26/7/19	Enrico Daniso	Detection of Novel ingredients in aquafeed	Visiting researcher
12/7/19	Panagiotis Kasapidis	Invasion genomics of two Lessepsian fish migrants, *Siganus rivulatus* and *S. luridus*	IMBBC researcher
21/6/19	Matej Medvecky	Demonstration of a bioinformatics pipeline for bioprocess-oriented targeted proteomics	Visiting researcher
15/6/19	Sébastien Villéger	Exotic herbivorous fish in Mediterranean ecosystems: biological causes and ecological consequences of an ongoing invasion	Visiting researcher

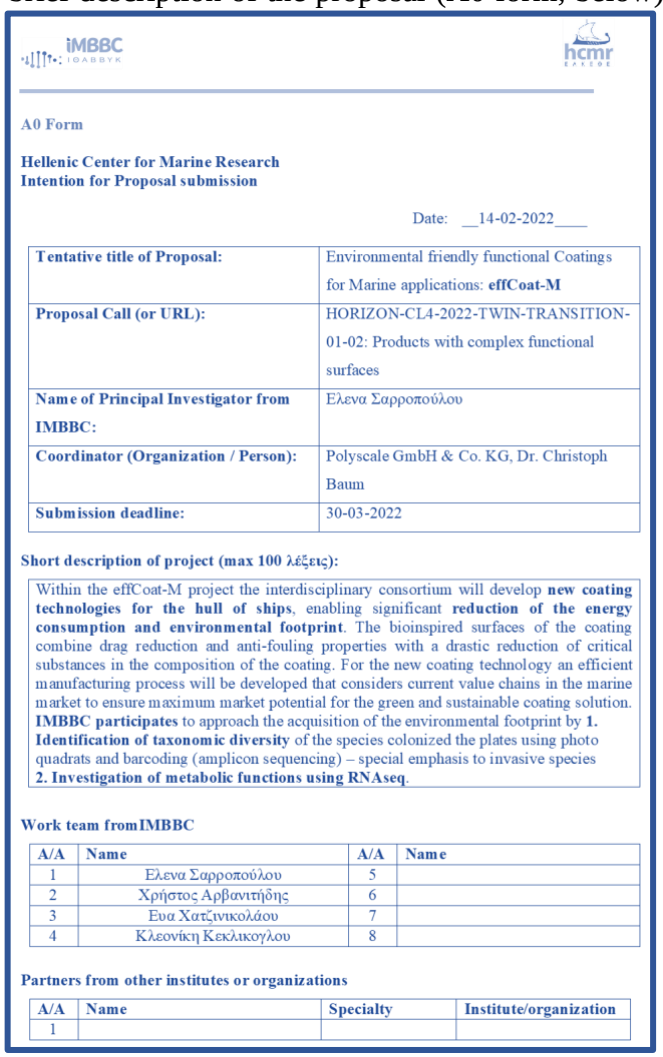
31/5/19	Anna Maitz & Kimani Kitson-Walter	Impact of *Halophila stipulacea* on the availability of benthic diatoms, an important food source for benthic feeders	Visiting researcher
10/9/19	Bonaldo Alessio	Fish Nutrition work for the improvement of Mediterranean Aquaculture	Visiting researcher
20/11/18	Valeria Di Dato	Animal-like prostaglandins in marine microalgae (Eicosanoid metabolites in *Skeletonema marinoi*)	Visiting researcher
30/10/18	Laura Núnez Pons	"Unus pro omnibus, omnes pro uno": Marine Symbiosis for health, stress and disease	Visiting researcher
26/10/18	James Morris	Offshore mollusc aquaculture: its potential ecosystem services and environmental impacts	Visiting researcher
17/10/18	Imants (Monty) G. Priede	Deep-Sea Fishes - Discovery, Evolution and Exploitation	Visiting researcher
16/10/18	Christian Galasso	Sustainable and high-efficient production of *Tetraselmis suecica* as innovative product with high biological value for cosmeceutical market	Visiting researcher
12/10/18	Isabel Cunha	Cement protein genes in stalked barnacles offer insights into the comparative analysis of barnacles' adhesion mechanisms	Visiting researcher
4/10/18	Gloriana Cardinaletti	Identification of Gilthead seabream chitinase genes and effect of insect meal diet on fish welfare status	Visiting researcher

- *Describe the means of promoting collaborations **between the Research Groups within the Institute**. Provide a list of publications resulting from collaborations within the Institute.*

A number of actions have been initiated in the last two years, to enhance the understanding of the work done by all researchers and to foster interactions and collaborations between researchers in the different Research Groups, Laboratories and Institutes of HCMR. A General Assembly is organized once a year, with brief presentations of all researchers (permanent, collaborating, postdocs and PhD candidates). The objective is to let all the staff know of the capabilities of the different laboratories in terms of facilities, equipment and analytical techniques.

Secondly, when a new article is published by a researcher from IMBBC, an announcement is sent by email to all staff (researchers and technicians) together with the pdf file, in order to (a) acknowledge the achievement of the authors and (b) make known to the whole institute of the type of work undertaken, technique used and equipment available. This helps in making researchers think about ways that they can take advantage of the expertise and equipment used by their colleagues and fosters the creation of collaborative work.

Also, when a researcher is planning to prepare or participate in a proposal, there is a requirement to submit to the director a brief description of the proposal (A0 form, below) with basic information about the scope and partners of the proposal. The purpose of this A0 form submission is mainly to give the opportunity to the director to suggest potential partners from **within the institute** (but also among the other two institutes), that would enhance the collaboration between our researchers and may enhance the competitiveness of the proposal. Due to his position and his involvement in the Board of Directors of HCMR and his interactions with the other institute directors, the IMBBC director has a "bird's eye view" of the different expertise and activities that occur both in the institute and the center.



iMBBC ΙΩΑΒΒΥΚ hcmr ΕΛΚΕΘΕ

A0 Form

Hellenic Center for Marine Research
Intention for Proposal submission

Date: __14-02-2022____

Tentative title of Proposal:	Environmental friendly functional Coatings for Marine applications: **effCoat-M**
Proposal Call (or URL):	HORIZON-CL4-2022-TWIN-TRANSITION-01-02: Products with complex functional surfaces
Name of Principal Investigator from IMBBC:	Ελενα Σαρροπούλου
Coordinator (Organization / Person):	Polyscale GmbH & Co. KG, Dr. Christoph Baum
Submission deadline:	30-03-2022

Short description of project (max 100 λέξεις):

Within the effCoat-M project the interdisciplinary consortium will develop **new coating technologies for the hull of ships**, enabling significant **reduction of the energy consumption and environmental footprint**. The bioinspired surfaces of the coating combine drag reduction and anti-fouling properties with a drastic reduction of critical substances in the composition of the coating. For the new coating technology an efficient manufacturing process will be developed that considers current value chains in the marine market to ensure maximum market potential for the green and sustainable coating solution. **IMBBC participates** to approach the acquisition of the environmental footprint by **1. Identification of taxonomic diversity** of the species colonized the plates using photo quadrats and barcoding (amplicon sequencing) – special emphasis to invasive species **2. Investigation of metabolic functions using RNAseq**.

Work team fromIMBBC

A/A	Name	A/A	Name
1	Ελενα Σαρροπούλου	5	
2	Χρήστος Αρβανιτήδης	6	
3	Ευα Χατζινικολάου	7	
4	Κλεονίκη Κεκλικογλου	8	

Partners from other institutes or organizations

A/A	Name	Specialty	Institute/organization
1			

In the following page, there are some examples of collaborations **between the two Research Groups of IMBBC**, the Marine Biology & Biotechnology (**MB&B**) and the Aquaculture (**AQUA**) Research Groups.

IMBBC's HPC facility (http://hpc.hcmr.gr/) is a unit that supports research across the broad spectrum of marine biology, with a focus on non-model, marine organism sequence analysis and biodiversity studies. By ensuring hardware and software (and subsequent data analysis) performs uninterruptedly and in an orchestrated resource-sharing-manner, **the HPC facility supports projects within both the MB&B and AQUA Research Groups**. The HPC impact is evident from the fact that 21 out of the 92 IMBBC projects of the 2018 – 2021 period (*i.e.* 23%), received computational analysis support by the HPC facility, resulting so far to 12 out of the 90 IMBBC publications, or 13,3%. A detailed listing of all IMBBC HPC supported publications is available at: https://hpc.hcmr.gr/publications.

The Reproduction and Physiology laboratory (**AQUA**, Dr. C.C. Mylonas) has initiated a new area of research with the Functional and Comparative Genomics team (**MB&B**, Dr. E. Sarropoulou), in the area of epigenetics in fish reproduction. This collaboration began in 2018 in the framework of an EU H2020-funded program (MedAID). Another collaboration was with the laboratory of Bioanalysis and Biotechnology (**MB&B**, Dr. E. Mandalakis), that resulted in the development of a new LC, MS-MS method for the analysis of a suite of steroid hormones related to stress and reproductive physiology in fish (H2020-funded programme, NEWTECHAQUA).

The laboratory of Fish Behavior (**AQUA**, Dr. I. Papadakis) has initiated a new area of research with the Functional and Comparative Genomics team (**MB&B**, Dr. E. Sarropoulou), in the area of study of fish vision. Another collaboration is with the laboratory of Bioimaging (**MB&B**, Kekliloglou, N.), which resulted in the improvement of the method that had been developed for the analysis of the digestive system in fish larvae.

The Laboratory of Nutrition and Biochemistry (**AQUA**, Dr. E. Fountoulaki and Dr. I. Nengas) is involved in three research programs with **MB&B**. The collaboration is within the framework of one EU H2020-funded program (FutureEUAqua) with the Genetics & Molecular Biotechnology Laboratory (**MB&B**, Dr. C. Tsiggenopoulos) and two ESPA, EPALTH program with the Functional and Comparative Genomics team (**MB&B**, Dr. E. Sarropoulou) and Bioanalysis and Biotechnology laboratory (**MB&B**, Dr. M. Mandalakis).

Dr. J.B. Kristoffersen (**MB&B**) is working with the PhD student Miss M.C. Cascarano of the Fish Health laboratory laboratory (**AQUA**, Dr. P. Katharios) on the genomic characterization of *Epitheliocystis*. This collaboration began in 2018 where Miss Cascarano was trained in the construction and sequencing of genome libraries as part of her PhD thesis on "*Epitheliocystis* disease in fish, epidemiology, pathology and genomic characterization of the causative agents".

The Fish Health laboratory (**AQUA**, Dr. P. Katharios) has initiated a new area of research with the Bioanalysis and Biotechnology laboratory (**MB&B**, Dr. E. Mandalakis) that has resulted in the development of new methods of *in vitro* analysis of antibacterial effects of various substances/organisms including bacteriophages and essential oils of aromatic plants. Another collaboration is with the Functional and Comparative Genomics team (**MB&B**, Dr. E. Sarropoulou) and has resulted in the genomic sequencing of microorganisms of interest including pathogenic bacteria and bacteriophages. Finally, there is an active collaboration with the Bioimaging Unit (**MB&B**, Mrs. N. Keklikoglou), which has resulted in the development of new methods for the imaging of parasites and fish disease lesions using the micro-CT equipment together with other bioimaging and microscopy tools. This collaboration began in 2018 in the framework of the project MOUNT (MIS 5002470), through the Operational Programme "Competitiveness, Entrepreneurship and Innovation" (NSRF 2014-2020) and co-financed by Greece and the European Union (European Regional

Development Fund). A collaboration between Dr. Christina Pavloudi (**MB&B**) and Dr. P. Katharios (**AQUA**) started in August 2018 and had as a research goal the investigation of the mass mortality event of *Pinna nobilis* populations, while in 2020 they collaborated regarding the investigation of Systemic Granulomatosis in cultured meagre, using clinical metagenomics.

The Fish Health laboratory (**AQUA**, Dr. M. Henry) has initiated a new area of research with the Functional and Comparative Genomics team ((**MB&B**, Dr. E. Sarropoulou), in the area of the regulation of immune gene expression through the use of miRNAs. This collaboration began in 2021 with the design of a Post-Doctoral project submitted to the Hellenic Foundation for Research & Innovation (HFRI or ΕΛΙΔΕΚ in Greek) (FishCellBoost). Dr. M. Henry also collaborated with Dr. E. Mandalakis, E. & Dr. C. Tsigenopoulos (**MB&B**) to perform immunological analyses on fresh samples collected from experiments run in the fish rearing facilities of the AQUALABS in Crete.

The Production Technology team (**AQUA** Dr. N. Papandroulakis) has initiated in 2019 a collaboration with Dr. T. Dalianis and Dr. E. Mandalakis (**MB&B**) for the use of sponges as a secondary species of culture in an IMTA concept. This resulted in a collaboration within the HFRI-funded projects SPINAQUA and MACCIMO, with the first targeting the evaluation of integrated aquaculture with sponges for bioremediation and bioproduction, and a recent publication provided in the list of articles below. The collaboration has resulted in the deployment of an experimental sponge cultivation within IMBBC's Pilot net pen aquaculture facility and its monitoring for the past 2 years, as well as on-site experiments investigating sponge bioremediation capacity. The Production Technology team has also initiated a collaboration with Dr. C. Tsigenopoulos and Dr. E. Sarropoulou (**MB&B**) for the genetic implication in the performance of reared fish species through two projects (PERFORMFISH and AMBERJACK)

Dr. F. Verret F (**MB&B**) provides diatom species in active cultures (*i.e. Phaeodactylum tricornutum*) to Dr. N. Papandroulakis (**AQUA**) for microalga antifouling experiments.

The Functional and Comparative Genomics team (**MB&B**, Dr. C. Tsigenopoulos) has continued fruitful collaborations with fellow researches from **AQUA** and more specifically with Drs. C.C. Mylonas and N. Papandoulakis for European sea bass, meagre, and greater amberjack genetic studies as part of national and EU-funded projects, as well as on different sparid species. Collaboration also exists with other researchers of **AQUA**, namely Dr. G. Rigos for parasite genomics, and Dr. I. Nengas for Genome-by-Feed selection breeding experiments.

Dr. A. Sterioti is a Permanent Researcher of IMBBC (**AQUA**) and at the same time she is the head Aquariologist for the Cretaquarium. As such, she has collaborations with both **AQUA** and **MB&B**.

List of articles resulting from collaborations between the Research Groups MB&B and AQUA of IMBBC for the reporting period (2018-2020):

1. Anastasiou, T.I., Mandalakis, M., Krigas, N., Vézignol, T., Lazari, D., Katharios, P., Dailianis, T., Antonopoulou, E., 2019. Comparative Evaluation of Essential Oils from Medicinal-Aromatic Plants of Greece: Chemical Composition, Antioxidant Capacity and Antimicrobial Activity against Bacterial Fish Pathogens. Molecules 25, 148. https://doi.org/10.3390/molecules25010148

2. Aslam, M.L., Carraro, R., Sonesson, A.K., Meuwissen, T., Tsigenopoulos, C.S., Rigos, G., Bargelloni, L., Tzokas, K., 2020. Genetic Variation, GWAS and Accuracy of Prediction for Host Resistance to Sparicotyle chrysophrii in Farmed Gilthead Sea Bream (Sparus aurata). Frontiers in Genetics 11, 594770. https://doi.org/10.3389/fgene.2020.594770
3. Katharios, P., Varvarigos, P., Keklikoglou, K., Ruetten, M., Sojan, J., Akter, M., Cascarano, M.C., Tsertou, M.I., Kokkari, C., 2020. Native parasite affecting an introduced host in aquaculture: cardiac henneguyosis in the red seabream Pagrus major Temminck & Schlegel (Perciformes: Sparidae) caused by Henneguya aegea n. sp. (Myxosporea: Myxobolidae). Parasites & Vectors 13, 27. https://doi.org/10.1186/s13071-020-3888-7
4. Kokkari, C., Sarropoulou, E., Bastias, R., Mandalakis, M., Katharios, P., 2018. Isolation and characterization of a novel bacteriophage infecting Vibrio alginolyticus. Archives of Microbiology 200, 707–718. https://doi.org/10.1007/s00203-018-1480-8Koutsouveli, V., Manousaki, T., Riesgo, A., Lagnel, J., Kollias, S., Tsigenopoulos, C.S., Arvanitidis, C., Dounas, C., Magoulas, A., Dailianis, T., 2020. Gearing Up for Warmer Times: Transcriptomic Response of Spongia officinalis to Elevated Temperatures Reveals Recruited Mechanisms and Potential for Resilience. Front. Mar. Sci. 6, 786. https://doi.org/10.3389/fmars.2019.00786
5. Makridis, P., Kokou, F., Bournakas, C., Papandroulakis, N., Sarropoulou, E., 2021. Isolation of Phaeobacter sp. from Larvae of Atlantic Bonito (Sarda sarda) in a Mesocosmos Unit, and Its Use for the Rearing of European Seabass Larvae (Dicentrarchus labrax L.). Microorganisms 9, 128. https://doi.org/10.3390/microorganisms9010128
6. Mandalakis, M., Anastasiou, T.I., Martou, N., Keisaris, S., Greveniotis, V., Katharios, P., Lazari, D., Krigas, N., Antonopoulou, E., 2021. Antibacterial Effects of Essential Oils of Seven Medicinal-Aromatic Plants Against the Fish Pathogen Aeromonas veronii bv. sobria: To Blend or Not to Blend? Molecules 26, 2731. https://doi.org/10.3390/molecules26092731
7. Mladineo, I., Hrabar, J., Smodlaka, H., Palmer, L., Sakamaki, K., Keklikoglou, K., Katharios, P., 2019. Functional Ultrastructure of the Excretory Gland Cell in Zoonotic Anisakids (Anisakidae, Nematoda). Cells 8, 1451. https://doi.org/10.3390/cells8111451
8. Mladineo, I., Hrabar, J., Vidjak, O., Bočina, I., Čolak, S., Katharios, P., Cascarano, M.C., Keklikoglou, K., Volpatti, D., Beraldo, P., 2020. Host-parasite interaction between parasitic cymothoid Ceratothoa oestroides and its host, farmed european sea bass (Dicentrarchus labrax). Pathogens 9, 1–19. https://doi.org/10.3390/pathogens9030230
9. Oikonomou, S., Tsakogiannis, A., Kriaridou, C., Danis, T., Manousaki, T., Chatziplis, D., Papandroulakis, N., Mylonas, C.C., Triantafyllidis, A., Tsigenopoulos, C.S., 2021. First linkage maps and a pilot QTL analysis for early growth performance in common dentex (Dentex dentex) and sharpsnout seabream (Diplodus puntazzo). Aquaculture Reports 21, 100855. https://doi.org/10.1016/j.aqrep.2021.100855
10. Papadaki, M., Kaitetzidou, E., Mylonas, C.C., Sarropoulou, E., 2020. Non-coding RNA Expression Patterns of Two Different Teleost Gonad Maturation Stages. Mar Biotechnol 22, 683–695. https://doi.org/10.1007/s10126-020-09991-2
11. Papadaki, M., Mandalakis, M., Anastasiou, T.I., Pouli, M., Asderis, M., Katharios, P., Papandroulakis, N., Mylonas, C.C., 2021. Histological evaluation of sex differentiation and early sex identification in hatchery-produced greater amberjack

(*Seriola dumerili*) reared in sea cages. Fish Physiol Biochem 47, 1777–1792. https://doi.org/10.1007/s10695-021-01007-7

12. Pauletto, M., Manousaki, T., Ferraresso, S., Babbucci, M., Tsakogiannis, A., Louro, B., Vitulo, N., Quoc, V.H., Carraro, R., Bertotto, D., Franch, R., Maroso, F., Aslam, M.L., Sonesson, A.K., Simionati, B., Malacrida, G., Cestaro, A., Caberlotto, S., Sarropoulou, E., Mylonas, C.C., Power, D.M., Patarnello, T., Canario, A.V.M., Tsigenopoulos, C., Bargelloni, L., 2018. Genomic analysis of Sparus aurata reveals the evolutionary dynamics of sex-biased genes in a sequential hermaphrodite fish. Commun Biol 1, 119. https://doi.org/10.1038/s42003-018-0122-7
13. Samaras, A., Dimitroglou, A., Kollias, S., Skouradakis, G., Papadakis, I.E., Pavlidis, M., 2021. Cortisol concentration in scales is a valid indicator for the assessment of chronic stress in European sea bass, Dicentrarchus labrax L. Aquaculture 545, 737257. https://doi.org/10.1016/j.aquaculture.2021.737257
14. Sarropoulou, E., Kaitetzidou, E., Papandroulakis, N., Tsalafouta, A., Pavlidis, M., 2019. Inventory of European Sea Bass (Dicentrarchus labrax) sncRNAs Vital During Early Teleost Development. Front. Genet. 10, 657. https://doi.org/10.3389/fgene.2019.00657
15. Santi, I., Kasapidis, P., Psarra, S., Assimakopoulou, G., Pavlidou, A., Protopapa, M., Tsiola, A., Zeri, C., Pitta, P., 2020. Composition and distribution patterns of eukaryotic microbial plankton in the ultra-oligotrophic Eastern Mediterranean Sea. Aquatic Microbial Ecology 84, 155–173. https://doi.org/10.3354/ame01933
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- *Describe the means of promoting interdisciplinary collaborations **with Groups of other Institutes of the Center or Partner organizations**. Provide a list of publications resulting from such collaborations.*

Beginning in 2021, an effort has been initiated to develop **Thematic Groups** between the three institutes of HCMR. The objective of these groups is to bring together and coordinate the activities of the institutes in a specific area that is of interest to the researchers, from a complementary point of view. For example, the area of Aquaculture is of interest to all three institutes from a different perspective. IMBBC is involved with the methods of producing fish in culture, the IO-HCMR is involved in studying the interactions of aquaculture and the environment, while the IMBRIW-HCMR is interested in the relations between fisheries and aquaculture, and the management of common resources. Other Thematic groups include Biodiversity and Climate Changes, which again are areas of interest to all three institutes. The Thematic Group will consist of one member (and a substitute) from each institute.

Following is a list of collaborations of IMBBC researchers with the other two institutes of HCMR or some "partner organizations". As a partner organization, we define an organization with which we maintain long term formal (*i.e.* with MOUs) or informal relations in submitting proposals together, carry out joint research projects even in the absence of direct funding, exchange techniques and share laboratories, etc. We also include the collaboration we have with the Aquariology team of the Cretaquarium (Dr. Aspasia Sterioti, who is a Permanent Researcher of IMBBC, Dr. Panos Gregoriou and Dr. Chrysa Doxa who are on contract for more than 10 years).

A collaboration has been established with the New Zealand Institute for Plant and Food Research (Nelson, NZ) in the area of fish reproduction (**AQUA**, Dr. C.C. Mylonas) and larval rearing ontogeny (**AQUA**, Dr. I. Papadakis), starting in 2019. The collaboration began with exchange visits of IMBBC researchers, and of Dr. Matthew Wiley, a joint publication of a review article, and more recently with the signing of a subcontracting agreement in the area of larval rearing and early ontogeny. This partnership has created an opportunity for IMBBC to disseminate its expertise to an important institute in NZ, and to promote its reputation around the world. Our next visit to New Zealand is scheduled for the Fall of 2022, where we will join a team of colleagues from Australia (Dr. Avigail Elizur) and Japan (Drs. Keitaro Kato and Goro Yoshizaki) for a mini symposium.

Another collaboration has also been established between IMBBC and the Institute of International Marine Centre (IMC Sardinia, Italy) developing reproductive maturation methods (**AQUA**, Dr. C.C. Mylonas) and larval rearing protocols (**AQUA**, Dr. I. Papadakis) in species with aquaculture interest. Since 2020, Dr. C.C. Mylonas is an official member of the Scientific Committee of the IMC, which plays a role in promoting the Foundation's activities in national and international scientific venues; it also has a consultancy and reference function for the Director and the Management Committee, in relation to the development of the program lines and annual activity program. So far, two researchers from IMC have spent time at HCMR and were trained in relevant methods and techniques, and the researchers from HCMR have given seminars in a special workshop organized by ICM.

The Fish Nutrition and Feeding team (**AQUA**, Dr. E. Fountoulaki and Dr. I. Nengas) has initiated a collaboration with the IMBRIW-HCMR, in the framework of an ESPA, EPALTH research project and with Dr. P. Karachle on the utilization of invasive species as fishmeal for aquaculture feeds.

The Nutrition and Biochemistry laboratory (**AQUA**) has initiated a collaboration with the Dr. A. Machias and Dr. K Tsagarakis from IMBRIW-HCMR within the frame of VIOAXIOPOIO Project, with the objective of using the fishery discards as fish meal sources for aquafeeds. Another collaboration involves the Università degli Studi di Torino, Italy, UNITO, Department of Agricultural, Forest and Food Sciences, as well of the Biological Department, Aristotelian University, Greece to investigate the use of insect meal in aquafeeds. Out of this collaboration a few scientific papers were published.

The Fish Health team (**AQUA**, Dr. P. Katharios) has initiated a collaboration with Dr. Paraskevi Pitta of the IO-HCMR and through the project AQUACOSM (https://www.aquacosm.eu). The collaboration is on the effect of antibiotics used in aquaculture on the microbial trophic networks in the Mediterranean Sea. The team has also a long-term collaboration with the University of Copenhagen (Prof. Mathias Middelboe) in the area of phage microbiology and phage therapy. This collaboration involves common research projects (Aquaphage-Marie Curie IRSES 2010, ProAqua-Danish National Program, etc.), but involves staff exchanges and common supervision of PhD students (Dr. Panos Kalatzis).

The Pilot net pen aquaculture facility (**AQUA** Dr. N. Papandroulakis) has initiated a collaboration with the IO-HCMR (Dr. V. Pitta) on concepts of Integrated Multitrophic Aquaculture (IMTA) providing the sea cages as testing ground.

Dr. K. Grigorakis, head of the Sensory Lab (**AQUA**) has initiated a collaboration with the IMBRIW-HCMR with two joint research projects (4Alien and FRESQO). The first project is in order to examine the quality of wild invasive fish species in Greek waters. The second collaboration is also joint with FORTH (Crete) and University of Patras, in order to invent and implement a rapid non-destructive seafood freshness method (FRESQO). Dr. Kriton Grigorakis has a long-term collaboration with University of West Attika, that covered two EU project periods and working together outside a research project within the frames of FTET visualization and development (see IP and Patent section).

The Bioanalysis and Biotechnology lab (**MB&B**, Dr M. Mandalakis) has initiated a collaboration with the IMBRIW-HCMR for the assessment of *Lagocephalus sceleratus* toxicity in the Greek seas and the valorization of its biomass. An informal collaboration began in 2017 and this was further consolidated in 2019 through the joint research project LIONHARE, which was funded by the Fisheries and Maritime Operational Program 2014–2020 of the Greek Ministry of Agricultural Development and Food. Another tight collaboration was initiated with the IO-HCMR to facilitate the quantitative assessment and taxonomic classification of phytoplankton in the marine environment, as well as in mesocosm experiments, through the analysis of carotenoids/chlorophylls (chemotaxonomy).

Dr. Aglaia (Cilia) Antoniou of the Genetics & Molecular Biotechnology laboratory (**MB&B**) has initiated a new area of research with Mr. Vasilis Valavanis, the head of GIS and Remote Sensing laboratory of the IMBRIW-HCMR, in the interdisciplinary framework of seascape genomics. They have been involved in the submission of two HFRI proposals in calls for Post-Docs (ASSET in 2020 and GRECE 2019). Furthermore, through the collaboration of Dr. A. Antoniou with the **Molecular Systematics Laboratory of NHMC, UoC** (Prof. Nikos Poulakakis), expertise exchange in the fields of phylogenomics, population genomics, adaptation and hybridization allowed us to address interesting evolutionary questions inspired by a wide range of natural systems and producing many publications, five of them from 2018 up to date.

Also, the Population Genetics & Phylogeography team (**MB&B**, Dr. C. Tsigenopoulos & Dr. D. Tsaparis) has initiated a collaboration with the IMBRIW-HCMR (Dr. M. Stoumboudi, Dr. Kalogianni, Dr. Barbieri) for studying plylogeography and conservation genetics of freshwater ichthyofauna of Greece. In addition, a new collaboration with Dr. G. Tserpes and Dr. N. Peristeraki was established for monitoring marine invasive species in the Greek Seas. Another collaboration regards research on mesopelagic fish (Dr. K. Tsangarakis) systematics, and one with the IO-HCMR to study invasive *Halophila* species (Dr. E. Apostolaki).

The Genetics and Molecular Biotechnology lab (**MB&B**, Dr. P. Kasapidis) has initiated a collaboration with the IO-HCMR in terms of the PhD Dissertation of Ioulia Santi on "Eukaryotic microbial plankton and nutrient supply in the Eastern Mediterranean Sea". The work focused on plankton biodiversity and ecology that was studied using different techniques. Another collaboration involving the two parties was within the research infrastructure project "Centre for the study and sustainable exploitation of Marine Biological Resources (CMBR)". We worked together with Dr. Paraskevi (Vivi) Pitta (IO-HCMR), Scientists to upgrade the mesocosm infrastructure of IO-HCMR and conducted a mesocosm experiment to decipher relationships among plankton groups.

Dr. E. Chatzinikolaou (**MB&B**) is currently collaborating with Mr. Manolis Ntoumas (IO-HCMR) in the implementation of the H2020 project NAUTILOS (budget IMBBC = 264.188 €, IO = 631.688 €) and the Interreg Greece-Cyprus project SocioCoast (budget IMBBC = 86.720 €, IO = 50.613 €).

A collaboration of Dr. T. Dailianis (**MB&B**) with Dr. Maria Salomidi (IO-HCMR) exists in the framework of the EU SeasERA project CIGESMED targeting the study of the endemic Mediterranean coralligenous habitats. Furthermore, Dr. Dailianis collaborates with Dr. Chris Smith (IMBRIW) in the framework of the EU H2020 project MERCES targeting marine ecosystem restoration.

The Marine Ecology & Biodiversity lab (**MB&B**, Dr. P. Koulouri) has initiated a collaboration with the IMBRIW-HCMR for different studies concerning environmental impact assessments and integrated coastal zone management. The lab has also collaborated with the IO and IMBRIW in the framework of the Strategic Action Programme for the conservation of Biological Diversity (SAP BIO) in the Mediterranean Region. The lab has also collaborated with the two other HCMR institutes and the Cretaquarium for Ocean Literacy research and activities (ERASMUS+ project). The lab has also initiated a collaboration with Dr. N. Lampadariou of the IO-HCMR during the MSc Thesis of K. Keklikoglou. This work was related with the testing of three different hard bottom samplers for macro- and meiobenthic assemblages. The collaboration began in 2013 and a research article was published in 2018.

Finally, the collaboration between the Marine Ecology & Biodiversity Labs (**MB&B**, Dr. V. Gerovasileiou) and the IMBRIW-HCMR in the frame of the Hellenic Network on Aquatic Invasive Species (ELNAIS), the Marine Strategy Framework Directive (MSFD) and DEEPEASTMED project gave a number of papers on non-indigenous and deep-water biodiversity in the Greek Seas.

The Environmental Microbiology Lab (**MB&B**, Dr. P. Polymenakou) has collaborated with the IO-HCMR (Dr. E. Apostolaki) in the field of ocean acidification and this produced one peer-reviewed publication in Marine Environmental Research.

The IMBBC's HPC (**MB&B**) facility supports projects of the IO-HCMR and the IMBRIW-HCMR. In order to accomplish that, a close collaboration with exists with Dr. Georgios

Petihakis, Dr. Paraskevi (Vivi) Pitta, Dr. Eugenia Apostolaki (IO-HCMR), and Dr. Marianna Giannoulaki, and Dr. Maria Stoumboudi (IMBRIW-HCMR) exists. The latter involves a broad range of topics from zooplankton automated image analysis, to ecological modeling and genomics sequence analysis. Beyond HCMR, the HPC unit has been offering support to a number of IMBBC collaborators, including -among others- Dr. Kriton Kalantidis (IMBB-FORTH, Department of Biology, UoC), Dr. Evangelos Topakas (National Technical Uni of Athens), as well as visitor-users from Oran University (Algeria), University of Padova (Italy), IRTA Sant Carles de la Ràpita (Catalynya, Spain) and University of Göteborg (Sweden).

List of articles resulting from collaborations between the institutes of HCMR or other Partner organizations for the reporting period (2018-2020):

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4 Financial Situation of the Institute

Tables from the RIview platform

Table 4-1: Governmental Funds

	2018	2019	2020	2021
Regular Budget	€ 1.484.225	€ 1.567.155	€ 1.586.026	€ 1.599.531
Matching Funds	€ 221.369	€ 222.423	€ 83.348	0
TOTAL	**€ 1.705.594**	**€ 1.789.578**	**€ 1.669.374**	**€ 1.599.531**

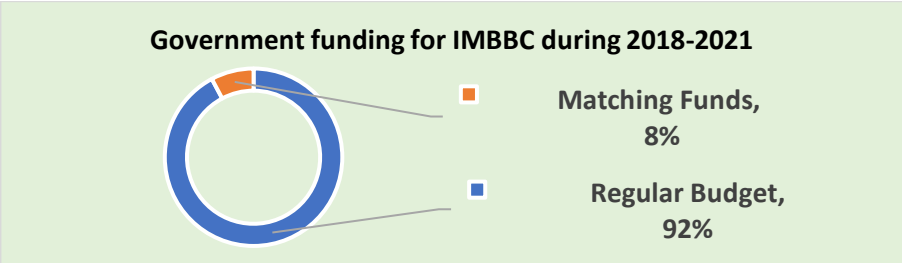


Table 4-2: Competitive Grants

	2018	2019	2020	2021
Greek Programmes	€ 1.729.317	€ 1.345.933	€ 2.125.481	€ 2.221.349
EC Programmes	€ 605.645	€ 1.479.815	€ 1.545.314	€ 447.173
Other International	0	0	0	0
Private Funding	€ 891.041	€ 584.983	€ 547.205	€ 610.149
Other	€ 141.665	€ 19.072	€ 64.379	€ 39.900
TOTAL	**€ 3.367.668**	**€ 3.429.803**	**€ 4.282.379**	**€ 3.318.571**

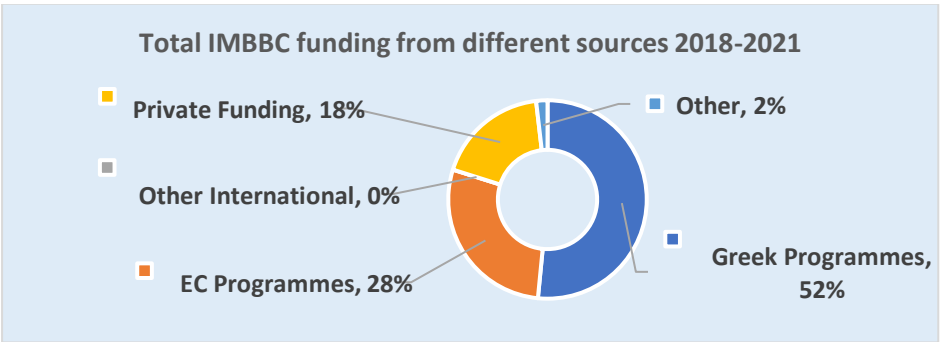


Table 4-3: Common Expenses (not including Salary Costs)

	2018	2019	2020	2021
Operational costs (electricity, water etc.)	€ 88.799	€ 110.602	€ 91.893	€ 99.413
Buildings & maintenance	0	0	0	0
Instruments & maintenance	€ 2.143	€ 7.797	€ 5.251	€ 12.923
Educational (*e.g.* invited speakers, journal subscription etc.)	€ 4.377	€ 3.854	€ 1.334	€ 5.073
Travel	€ 14.531	€ 9.222	€ 987	€ 1.523
Other	€ 14.120	€ 14.678	€ 10.996	€ 27.395
TOTAL	**€ 123.971**	**€ 146.153**	**€ 110.461**	**€ 146.327**

The common expenses come from the **IMBBC overheads budget**, which amounts to 2% of the total funding of each project of the institute. However, if the project does not allow an overhead rate of 20%, then the amount taken as overheads is divided between the HCMR and IMBCC, at a ratio of 75:25. As one can see, very little is paid by the IMBBC overheads budget for common expenses, mainly because this account was created only in the last 5 years and it has only recently accumulated enough funds.

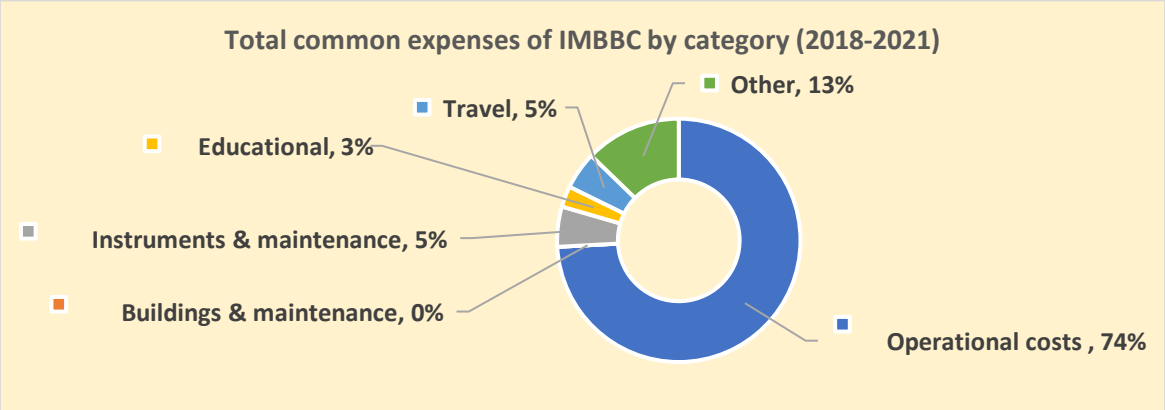
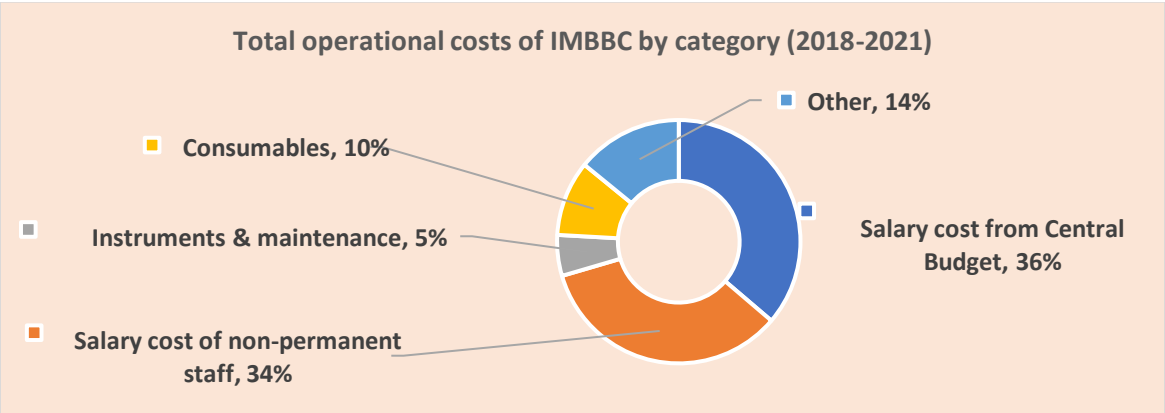


Table 4-4: Operational Costs for Facilities and Infrastructures

	2018	2019	2020	2021
Salary cost from Central Budget	€ 1.484.225	€ 1.567.155	€ 1.586.026	€ 1.599.531
Salary cost of non-permanent staff	€ 1.193.723	€ 1.360.929	€ 1.643.815	€ 1.693.490
Instruments & maintenance	€ 64.512	€ 169.650	€ 292.950	€ 407.758
Consumables	€ 361.088	€ 382.114	€ 438.530	€ 538.417
Other	€ 546.153	€ 641.026	€ 500.127	€ 740.763
TOTAL	**€ 3.649.703**	**€ 4.120.876**	**€ 4.461.450**	**€ 4.979.961**

The expenditures of IMBBC during the reporting period ranged between € 3,6 and € 4,9 million, including also the salaries of the permanent staff, showing an increasing trend over the years. It is apparent that the highest cost regards personnel, with the cost of the permanent staff being 36% of the total expenditure and the cost of the non-permanent personnel being almost equal (but for a much larger number of persons) at 34%.



5 Results & Achievements

5.1 Bibliometric Output

Table 5-1: Bibliometric Output

	2018	2019	2020	2021	Total
Journal articles	65	64	85	90	**304**
International Conference Proceedings	56	83	15	75	**229**
Other conferences	40	24	8	25	**97**
Book Chapters	2	3	2	5	**12**
Books-Monograms	0	2	1	4	**7**
Citations (cumulative after 2018) [1]	82	294	564	1104	
Mean Impact Factor	3.81	3.75	3.55	3.67	
[2] **Q1 articles**	42	49	55	55	**201**
Q2 articles	18	12	23	28	**81**
Q3 articles	4	1	5	3	**13**
Q4 articles	1	2	2	1	**6**

[1] The number represents the citations during the year and each prior year up to 2018, for only the articles of the specific year. We used the **Scopus** database for the citations, as it provides more conservative results.
[2] The number of articles published in Journals belonging to the specific Quartile.

The institute has shown a **steady increase in the production of high-quality articles**, published in the best journals of our scientific area. From a 5-year average of **50 articles per year** in the previous evaluation period (2013-2017), we have moved to an all-time high of **90 articles in 2021** with more than 67% of the articles (4-year average) being published in Q1 journals. The full citation of all journal articles, International Conference Proceedings, Other Conferences, Book Chapters and Books-Monograms are listed at the end of the self-evaluation, in **Annex I – Bibliography**.

5.2 Training and Educational Activities

Although HCMR is not an educational institution, we have chosen to actively support the provision of education to meet the needs and challenges of modern research, but also to attract collaborations and ensure the international visibility of the Institute. In addition, we contribute to the development of a critical mass of trained researchers in the country. Researchers of IMBBC supervised a total of **45 MSc theses** during the evaluation period, which corresponds to an average **of 1.76 MSc Theses per researcher**, mainly through the UoC (26), but also other Greek and European universities. In addition, there were a total of **31 PhD Dissertations** during the evaluation period, corresponding to an average of **1.25 PhD Dissertations per researcher**, with students being registered mainly through the UoC (15), followed by the Aristotle University of Thessaloniki (3), but also other European universities. Also, a total of **120 undergraduate and graduate internships** (2-6 months duration) have been carried out at IMBBC and supervised by its researchers, from young scientists from15 universities and organizations from Greece and 45 from Europe and the world.

a. PhD Programs

- Provide a short description of the activities and the number of students trained at the Institute and awarded a PhD degree during the period

The majority of PhD students are Greek and study at Greek universities, but we also have students that are registered at universities abroad, and come for part of their Doctoral research. Some students are paid during their presence at HCMR, through scholarships provided by the research projects in which they work, while others have funding from their university or other sources.

Year	MB&B females	MB&B males	AQUA females	AQUA males	Total
2018	2	2	1	0	**5**
2019	1	1	0	2	**4**
2020	0	0	2	0	**2**
2021	4	5	7	4	**20**
Total	**7**	**8**	**10**	**6**	**31**

PhD	Name of student	Title	Degree (PhD)	Year of graduation/presence in IMBBC	Supervisor from IMBBC	University	Country
PhD	Alexi Niki	Quality characterization of emerging aquaculture fish products: a multisensory and instrumental approach	PhD Thesis	2018	Grigorakis K.	University of Aarhus	Denmark
	Bounas Anastasios	Promigratory ecology, phylogeography and conservation genetics of the threatened raptor *Falco naumanni* in Balkans	PhD Thesis	2018	Kotoulas G., Tsaparis D.	University of Ioannina, Department of Biological Applications and Technology	Greece
	Christakis Christos	Study of the geo-biological mechanisms that determine microbial ecosystem structure and biogeochemical metal cycling in seafloor hydrothermal vent fields of the Santorini volcanic complex	PhD Thesis	2018	Kotoulas G., Polymenakou P.	National Kapodistrian University of Athens, Department of Geology and Geoenvironment	Greece
	Kampantais Dimitris	Utilization of microalgae in the diets of farmed fish as a source of natural pigments	PhD Thesis	2018	Kotzamanis Y.	Agricultural University of Athens	Greece
	De Mello Henrique Paolo	Reproduction of Dusky grouper and larval rearing under different feeding regimes	PhD Candidate	2019	Mylonas, C.C.	University of Sao Paolo	Brazil
	Tarifa Georgia	The biology and the breeding of sea urchin of the species *Paracentrotus lividus* (Echinodermata, Echinoidea).	PhD candidate	2018	Sterioti A.	University of Crete, Department of Biology	Greece
	Vardali Sofia	Development and validation of multi-residue methods (LC-PDA and LC-QTOF-MS) for the simultaneous determination of antimicrobial residues and some of their metabolites in edible tissue of European sea	PhD Thesis	2018	Kotzamanis Y.	Aristotle University of Thessaloniki, Department of Chemistry	Greece

PhD	Name of student	Title	Degree (PhD)	Year of graduation/presence in IMBBC	Supervisor from IMBBC	University	Country
	Daniso Enrico	Graded level of *Hermetia illucens* meal in plant protein-based diet lacking fish meal for gilthead sea bream (*Sparus aurata*, L.): gastrointestinal evaluation	PhD Thesis	2019	Sarropoulou E.	University of Udine	Italy
	Santi Ioulia	Eukaryotic microbial plankton and nutrient supply in the Eastern Mediterranean Sea	PhD Thesis	2019	Kasapidis P.	University of Crete, Department of Biology	Greece
	Stavrakidis Zachou Orestis	Investigation of the effect of high temperatures on the metabolism of cultured fish. An experimental and theoretical approach.	PhD candidate	2019	Papandroulakis N.	University of Crete, Department of Biology	Greece
	Kandyliari Katerina	Aquaculture fish byproduct analysis and study of their bioactivity	PhD candidate	2020	Papandroulakis N.	Agricultural University of Athens, Department of Food Science and Human Nutrition	Greece
	Tsertou Maria Ioanna	Non-infectious diseases of meagre	PhD Thesis	2020	Katharios P.	Aristotle University of Thessaloniki	Greece
	Arboleda Joey	Humane Slaughter Methods for Aquaculture Harvest	PhD candidate	2021	Papandroulakis N.	University of Crete, Department of Biology	Philippines
	Cascarano Maria Chiara	Epitheliocystis disease in fish, epidemiology, pathology and genomic characterization of the causative agents	PhD Thesis	2021	Katharios P.	University of Crete	Italy
	Cascarano Maria Chiara	NGS library construction and genome sequencing of epitheliocystis disease in fish	PhD Thesis	2021	Kristoffersen J.	University of Crete	Italy
	Dimitris Kanakis	Development of a method for the determination of hormones in biological samples (fish blood serum) by applying proteomic techniques using tandem mass spectrometry of high resolution	PhD candidate	2021	Kotzamanis Y.	University of Athens, Department of Chemistry	Greece
	Fakriadis Ioannis	Reproductive biology of the greater amberjack (*Seriola dumerili*) in aquaculture	PhD Thesis	2021	Mylonas C.	University of Crete	Greece
	Kotouzas Dimitris	Breeding of insects using organic agricultural wastes and exploitation of the produced insect meal in the feed of cultured fish	PhD candidate	2021	Kotzamanis Y.	Agricultural University of Athens	Greece
	Lancerotto Stefano	Use of recombinant gonadotropin hormones for the induction of gametogenesis in the greater amberjack (*Seriola dumerili*)	PhD Thesis	2021	Mylonas C.	University of Crete	Greece
	Mastoraki Maria	Insect meal in aquafeeds	PhD Thesis	2021	Chatzifotis S.	Aristotle University of Thessaloniki	Greece
	Nousias Orestis	Development and application of genetic tools aiming at the future production improvement in two new species for the Mediterranean aquaculture, the meagre (*Argyrosomus regius*) and the greater amberjack (*Seriola dumerili)*	PhD Thesis	2021	Tsigenopoulos C.	University of Crete	Greece
	Papadaki Maria	Gene regulation during gonad maturation in reared fish species	PhD candidate	2018	Sarropoulou E.	University of Crete	Greece
	Papadouli Christina	Assessment of mycotoxins effects on health and welfare of intensively farmed fish	PhD Thesis	2021	Rigos G.	University of Thessaly, Department of Ichthyology	Greece
	Smyrli Maria	Comparative study on *Aeromonas veronii* isolates as disease agent in farmed European seabass. Development of autogenous vaccines for the prevention of the disease	PhD Thesis	2021	Katharios P.	University of Crete	Greece
	Triga Adriana	Antibiotic resistance development cost in fish pathogenic bacteria	PhD Thesis	2021	Katharios P.	University of Crete	Italy
	Feborova Valeria	Faunistics and ecological aspects of the benthic polychaeta communities in the Mediterranean coast of Israel	PhD Thesis	2021	Chatzigeorgiou G.	University of Haifa, Department of Marine Biology	Israel
	Varamogianni-Mamatsi Despina	Improvement of water quality and bioproduction of natural products of high added-value through integrated aquaculture of sponges in fish farms	PhD candidate	2020 ongoing	Mandalakis M., Dailianis A.	Technical University of Crete, School of Chemical and Environmental Engineering	Greece
	Vasilaki Antigoni	Forage legumes in fish nutrition	PhD candidate	2020 ongoing	Nengas I.	University of Thessaly, Department of Ichthyology	Greece

PhD	Name of student	Title	Degree (PhD)	Year of graduation/presence in IMBBC	Supervisor from IMBBC	University	Country
	Gratsia Eirini	Ecological and molecular approaches to the study of invasive species in the Eastern Mediterranean, with an emphasis on benthic macroinvertebrates	PhD candidate	2022 ongoing	Kasapidis P.	University of Crete, Department of Biology	Greece
	Paragamian Savvas	Microbial community metabolism and its associations to ecosystem functioning and biogeochemical processes	PhD candidate	2022 ongoing	Pafilis E.	University of Crete, Department of Biology	Greece
	Zafeiropoulos Haris	Microbial communities through the lens of high throughput sequencing, data integration, metabolic networks analysis	PhD candidate	2022 ongoing	Pafilis E.	University of Crete, Department of Biology	Greece

b. MSc Programs

- *Provide a short description of the activities and the number of students trained at the Institute and awarded a master's degree during the period.*

The majority of MSc students are Greek and study at Greek universities number of students, but we also have students that are registered at universities abroad, but carry their Thesis research at IMBBC, being co-supervised by our researchers. The total number of students may appear higher than the sum of student for the two Research Groups, since some students may be working in both groups.

Year	MB&B females	MB&B males	AQUA females	AQUA males	Total
2018	1	3	4	2	**10**
2019	1	0	2	4	**7**
2020	2	1	2	2	**7**
2021	11	7	2	1	**21**
Total	**15**	**11**	**10**	**9**	**45**

MSc	Name of student	Title	Degree (MSc)	Year of graduation/presence in IMBBC	Supervisor from IMBBC	University	Country
MSc	Bernadou Emmanuella	Influence of diet and management of greater amberjack (*Seriola dumerili*) broodstock on the quality and composition of eggs during the reproductive season	MSc Thesis	2018	Mylonas C.	University of Crete	Greece
	Kotari Ioanna	Study of the evolution and expression of paralogous genes with roles during pigmentation in early developmental stages of the three-spine stickleback (*Gasterosteus aculeatus*).	MSc Thesis	2018	Sarropoulou E.	University of Crete, Department of Biology	Greece
	Montero Nardim Superio Natalia Sofia	Effect of treatment with GnRHa during mid gametogenesis on the reproductive maturation of greater amberjack (*Seriola dumerili*)	MSc Thesis	2018	Mylonas C.	ERASMUS+/ACES	Greece
	Natsidis Paschalis	A phylogenomic perspective on Sparidae (Teleostei: Spariformes) positioning within the tree of teleosts: challenges and new insights	MSc Thesis	2018	Manousaki T., Tsigenopoulos C.	University of Crete	Greece
	Pouli Marina	Histological and molecular aspects of gender differentiation in the greater amberjack (*Seriola dumerili*).	MSc Thesis	2018	Sarropoulou E.	University of Crete, Department of Biology	Greece
	Roussos Efstratios	Study of the effects of partial replacement of fishmeal by a combination of vegetable proteins and food additives on the growth and health of sea bream (*Sparus aurata*)	MSc Thesis	2018	Kotzamanis Y.	University of Thessaly, Department of Icthyology	Greece
	Zafeiropoulos Charalampos (Haris)	eDNA metabarcoding for biodiversity assessment: Algorithm design and bioinformatics analysis pipeline implementation	MSc candidate	2018	Pafilis E., Pavloudi C.	University of Crete, Department of Medicine	Greece
	Zanata Eugenio	Enhancement of spermiation in meagre (*Argyrosomus regius*) by using gonadotropin releasing hormone agonist (GnRHa) implants	MSc Thesis	2018	Mylonas C.	University of Padova	Italy

MSc	Name of student	Title	Degree (MSc)	Year of graduation/presence in IMBBC	Supervisor from IMBBC	University	Country
	Kyriakis Dimitrios	Linkage mapping in gilthead seabream with the use of ddRAD sequencing	MSc Thesis	2019	Manousaki T.	University of Crete, School of Medicine	Greece
	Lancerotto Stefano	Comparison and evaluation of three commonly used disinfectants on meagre (*Argyrosomus regius*) eggs	MSc Thesis	2019	Mylonas C.	Universita Politechnica delle Marche, Ancona	Italy
	Natsidis Paschalis	Phylogenomic analysis of teleost genomes	MSc Thesis	2019	Manousaki T.	University of Crete, School of Medicine	Greece
	Pasxali Elissavet	Effects of hydrolyzed proteins derived from alternative animal sources in the development and survival of the European sea bass	MSc Thesis	2019	Kotzamanis Y.	University of the Aegean, Department of Marine Sciences	Greece
	Pouli Marina	Histological and molecular aspects of sex differentiation in greater amberjack (*Seriola dumerili*)	MSc Thesis	2019	Mylonas C.	University of Crete	Greece
	Richardson Andrew	Insect meal in aquafeeds	MSc Thesis	2019	Chatzifotis S.	University of Crete	Greece
	Roussos Ioannis	Effects of organic and inorganic minerals on the immune system of European seabass	MSc Thesis	2019	Henry M.	National and Kapodistrian University of Athens	Greece
	Sarafidou Georgia	Assessment of genetic diversity of the bivalve *Pinna nobilis* in the Eastern Mediterranean and investigation of the degree of infection by the parasite *Haplosporidium pinnae*	MSc candidate	2019	Pavloudi C.	University of Crete, Department of Biology	Greece
	Voskakis Dimitris	Fish Size and Shape Estimation with Stereoscopic Vision	MSc candidate	2019	Papandroulakis N.	Hellenic Mediterranean University, School of Engineering	Greece
	Karli Christina	Development and optimization of environmental DNA (eDNA) methodology for the study and biomonitoring of fish fauna in the oligotrophic marine ecosystems of the Eastern Mediterranean	MSc Thesis	2020	Kasapidis P.	University of Crete, Department of Biology	Greece
	Misol Gerald Jr.	Biological and genomic characterization of a novel jumbo bacteriophage, vb_pir03 with broad host lytic activity against *Vibrio harveyi*	MSc candidate	2020	Katharios P.	ERASMUS+/ACES	Malaysia
	Magoulas Nikolaos	Management of human resources in research organizations with external funding through projects	MSc Thesis	2020	Manousaki T.	Swansea University, Department of Computer Science	UK
	Pananganan Bernadeth G.	Insect meal digestibility	Master Thesis	2020	Chatzifotis S.	University of Crete	Greece
	Spilani Loukia	Seascape genomics of marine invertebrates in coastal Crete	MSc Thesis	2020	Magoulas A., Sarropoulou E., Antoniou A.	University of Crete	Greece
	Superio Joshua	Parentage contribution of European sea bass (*Dicentrarchus labrax*) broodstocks, and correlation with fertilization success and larval survival	Master Thesis	2020	Mylonas C.	ERASMUS+/ACES	Greece
	Vasilaki Antigoni	Novel aquafeed ingredients	MSc Thesis	2020	Nengas I	University of Thessaly, Department of Icthyology	Greece
	Botsidou Petroula	Temporal variation in the sex ratio of a colonial raptor: the case of Eleonora's falcon	MSc Thesis	2021	Tsaparis D., Kotoulas G.	University of Crete, Department of Biology	Greece
	Chakkalakkal George Joseph	Identification and Characterization of piRNAs in Teleosts	MSc Thesis	2021	Sarropoulou E.	ERASMUS+/ACES	Greece
	Chertz-Bynichaki Melina	Analysis of benthic communities on artificial reefs	MSc Thesis	2021	Dailianis A., Chatzigeorgiou G.	University of the Aegean, Department of Marine Sciences	Greece
	Danis Thodoris	Genome analysis of *Lagocephalus sceleratus*	MSc Thesis	2021	Manousaki T.	University of Crete, School of Medicine	Greece
	Digenis Markos	Comparative study of hard substrate benthos in marine caves of the Karpathos-Saria protected area	MSc candidate	2021	Arvanitidis C., Gerovasileiou V.	University of Crete, Department of Biology	Greece

MSc	Name of student	Title	Degree (MSc)	Year of graduation/presence in IMBBC	Supervisor from IMBBC	University	Country
	Droubogiannis Stavros	Resistance development during phage therapy	MSc Thesis	2021	Katharios P.	University of Crete	Greece
	Eleftheriadi Klara	Genome analysis of *Sparus aurata*	MSc Thesis	2021	Manousaki T.	University of Crete, School of Medicine	Greece
	Elisavet Iliopoulou	Comparative genomic analysis of conserved non-coding sequences in teleost genomes	MSc Thesis	2021	Manousaki T.	University of Crete, School of Medicine	Greece
	Grecoletto Laura	Reproductive behavior of meagre (Argyrosomus regius) in aquaculture conditions and after GnRHa induction of spawning	Master Thesis	2021	Mylonas C.	University of Padova	Italy
	Mallick Sreeradha	Effect of temperature on the immunity and microRNAs in the European seabass (Dicentrarchus labrax)	MSc Thesis	2021	Sarropoulou E.	ERASMUS+/ACES	Greece
	Chakkalakkal George Joseph	Identification and Characterization of piRNAs in Teleosts	MSc Thesis	2021	Sarropoulou E.	ERASMUS+/ACES	Greece
	Moutsopoulou Ioli	Study of the mass mortality event of the bivalve *Pinna nobilis*	MSc candidate	2021	Katharios P., Pavloudi C.	University of Crete, Department of Biology	Greece
	Sarropoulou Polyxeni	Genetic diversity patterns of mesopelagic fish in the Greek Seas	Master Thesis	2021	Tsigenopoulos C., Tsaparis D.	University of Crete	Greece
	Terzoglou Vassiliki	Phylogeographic study of the giant red shrimp *Aristaeomorpha foliacea*, in the Mediterranean Sea	Master thesis	2021	Tsigenopoulos C., Tsaparis D.	University of Crete	Greece
	Theologi Ourania	Chemical text and association rule mining to facilitate the study of metabolic processes in hyperthermophilic microorganisms	MSc Thesis	2021	Pafilis E.	National and Kapodistrian University of Athens	Greece
	Christos Kitsoulis	Genome analysis of Pterois miles	MSc Thesis	2021	Manousaki T.	University of Crete, School of Medicine	Greece
	Papadopoulou Andromahi	Epigenomics analysis of gilthead seabream	MSc Thesis	2021	Manousaki T.	University of Crete, School of Medicine	Greece
	Chelmis Nikolaos	Genetic diversity and population structure of Balkan chamois in Greece	MSc Thesis	2021 ongoing	Tsaparis D., Tsigenopoulos C.	University of Crete, Department of Biology	Greece
	Rallis Ioannis	Comparing sampling protocols in extreme environments focused on NIS	MSc Thesis	2021 ongoing	Arvanitidis C., Chatzigeorgiou G.	University of Crete, Department of Biology	Greece
	Tasiouli Aikaterini	Parentage assignment evaluation in commercial meagre (Argyrosomus regius) stocks using different types of genetic markers	MSc Thesis	2021 ongoing	Tsigenopoulos C.	University of Crete	Greece

c. Undergraduate Students, Internships

- *Provide a short description of the activities and the number of undergraduate theses supervised, and the internships performed in the Institute during the period.*

A number of students come for the BSc Thesis research, or for practical training for 2-4 months during the last year of undergraduate school, or during their MSc studies. The majority are Greek and study at Greek universities, but we also have a great number coming from abroad.

Year	MB&B females	MB&B males	AQUA females	AQUA males	Total
2018	4	4	15	8	**31**
2019	3	5	15	5	**28**
2020	6	2	11	7	**26**
2021	6	9	8	12	**35**
Total	**19**	**20**	**49**	**32**	120

	Name of student	Title	Degree (MSc, BSc, internships)	Year of graduation/presence in IMBBC	Supervisor from IMBBC	University	Country
Practical training	Debernardis Rossella	Behavioral and Histological studies on fish and fish larvae	Practical training	2018	Papadakis I.	Polytechnic University of Marche, Department of Life and Environmental Sciences	Italy
	Delli Compagni Martina	Behavioral and Histological studies on fish and fish larvae	Practical training	2018	Papadakis I.	Polytechnic University of Marche, Department of Life and Environmental Sciences	Italy
	Digenis Markos	Effect of ocean acidification on the metatranscriptome of the gastropod *Hexaplex trunculus* - Study of benthic macrofaunal communities	Practical training BSc	2018	Chatzinikolaou E., Pavloudi C.	University of Crete, Department of Chemistry	Greece
	Dimitriadis Theodosios	The colonization of the jellyfish *Aurelia aurita* polyps on different types of substrates at Cretaquarium.	Practical training BSc	2018	Sterioti A.	Agricultural University of Athens, Department of Animal Production Science and Aquaculture	Greece
	Gonzalez Munoz Pablo	Effect of temperature on lipid requirements	Practical training	2018	Chatzifotis S.	University of Alicante	Spain
	Grizi Olga	Practical learning of Marine Aquariology. Aquarium maintenance and participation in the research projects carried out in the Cretaquarium (tropical fish rearing, embryonic development of triton *Charonia seguenzae*).	Practical training BSc	2018	Sterioti A.	University of Ioannina, Department of Biological Applications and Technologies	Greece
	Keroglidou Maria	DNA barcoding of freshwater ichthyofauna	Practical training BSc	2018	Tsaparis D.	University of Ioannina, Department of Biological Applications and Technology	Greece

	Name of student	Title	Degree (MSc, BSc, internships)	Year of graduation/presence in IMBBC	Supervisor from IMBBC	University	Country
	Laiolo Elisa	Monitoring of experimental trials, feeding, parasitic measurements	Practical training BSc	2018	Rigos G.	Università Politecnica delle Marche	Italy
	Liapi Aspasia	Behavioral and Histological studies on fish and fish larvae	Practical training	2018	Papadakis I.	Agricultural University of Athens	Greece
	Panourgia Dafni	Biochemical Analysis and aquafeed production	Practical training	2018	Nengas I.	University of Peloponese	Greece
	Pouli Marina	Finding of orthologous and paralogous genes in fish with important functional roles during fish development	Rotation	2018	Sarropoulou E.	University of Crete, Department of Biology	Greece
	Roussos Efstratios	Nutritional studies of farmed fish	Practical training	2018	Kotzamanis Y.	University of Thessaly, Department of Ichthyology	Greece
	Ruiz Orta Diego	The behavior of clownfish *Amphiprion oscelaris* and *Amphiprion klarkii* under controlled conditions at Cretaquarium.	Practical training MSc	2018	Sterioti A.	ERASMUS+/ACES	Mexico
	Sarafidou Georgia	Population genetics of Pinna nobilis from the Marine Protected Area of Karpathos	Practical training MSc	2018	Pavloudi C.	University of Crete, Department of Biology	Greece
	Skiani Evaggelia	Nutritional studies of farmed fish	Practical training	2018	Kotzamanis Y.	Aristotle University of Thessaloniki, Department of Biology	Greece
	Tommasi Ilaria	Reproduction of sea urchins *Paracentrotus lividus*.	Practical training BSc	2018	Sterioti A.	Università degli Studi di Torino, Department of Veterinary Science	Italy
	Tsoukala Katerina	Nutritional studies of farmed fish	Practical training	2018	Kotzamanis Y.	University of Thessaly, Department of Ichthyology,	Greece
	Vatougios Filippos	Nutritional studies of farmed fish	Practical training	2018	Kotzamanis Y.	University of the Aegean, Department of Marine Sciences	Greece
	Zafeiriou Alexandros	CATA and RATA sensory analysis in foods	Practical Training	2018	Grigorakis K.	University of Peloponese, Department of Food Technology	Greece
	Zafeiriou Alexandros	Biochemical Analysis and aquafeed production	Practical training	2018	Nengas I.	University of Peloponese	Greece
	Balamvanou Annita	Training in biochemical analysis of feeds and fish	Practical taining	2019	Fountoulaki E.	University of Thessaly, Department of Ichthyology	Greece
	Calloni Luca	Broodstock management	Practical training	2019	Mylonas C.	Università Politecnica delle Marche	Italy
	Kalaintzakis Ioannis	Population diversity assessment of the phanerogam *Posidonia oceanica* at the marine protected area of Karpathos-Saria	Practical training BSc	2019	Pavloudi C.	University of Crete, Department of Biology	Greece
	Kalaintzakis Ioannis	The effect of salinity on the growth of allochthonus freshwater fish of the species *Gambusia affinis* (S.F. Baird & Girard, 1853).	Practical training BSc	2019	Sterioti A.	University of Crete, Department of Biology	Greece
	Kalaitzakis Ioannis	Systematic and taxonomy of polychaetes	Practical training	2019	Chatzigeorgiou G.	University of Crete, Department of Biology	Greece
	Keisaris Sofoklis	Study on the synergistic antibacterial activity of essential oils against fish pathogens	Practical training BSc	2019	Mandalakis M.	Aristotle University of Thessaloniki	Greece
	Kopper Svenja	Broodstock management	Practical training	2019	Mylonas C.	University of Bremen	Germany
	Medvecký Matej	Development of a peptide selection tool for designing function-based targeted proteomic assays in complex microbial systems	Mobility &Training Erasmus+	2019	Mandalakis M.	University of Veterinary and Pharmaceutical Science Brno	Czech Republic
	Mela Dorothea	Study of benthic macrofaunal communities from the marine protected area of Karpathos-Saria	Practical training BSc	2019	Pavloudi C.	University of the Aegean, Department of Marine Sciences	Greece
	Orfanakis Michail	Rearing conditions of *Amphiprion* sp. (clownfish) at Cretaquarium.	Practical training BSc	2019	Sterioti A.	University of Crete, Department of Biology	Greece

	Name of student	Title	Degree (MSc, BSc, internships)	Year of graduation/presence in IMBBC	Supervisor from IMBBC	University	Country
	Pugh Sarahjane	Marine Aquariology: maintenance and growth of the Cretaquarium fauna.	Practical training MSc	2019	Sterioti A.	ERASMUS+/ACES	UK
	Rana Saverio	Broodstock management	Practical training	2019	Mylonas C.	Università Politecnica delle Marche	Italy
	Rappai Raghi	Practical learning of Marine Aquariology and the various backstage Cretaquarium activities for the maintenance and growth of its fauna.	Practical training MSc	2019	Sterioti A.	ERASMUS+/ACES	India
	Sarracino Roberta	Broodstock management	Practical training	2019	Mylonas C.	Università Politecnica delle Marche	Italy
	Tasiouli Aikaterini	An introduction to SSR data analysis from wild and cultured populations of the species Dicentrarchus labrax	Practical training BSc	2019	Tsigenopoulos C.	Aristotle University of Thessaloniki	Greece
	Valenzuala Diego	Phage isolation and characterization	Practical training PhD	2019	Katharios P.	University of Conception	Chile
	Chakkalakkal George Joseph	In silico investigations of piwi RNAs in Teleost	Practical Training	2020	Sarropoulou E.	ERASMUS+/ACES	Greece
	Diamantopoulou Christina	Practical learning of Marine Aquariology. Cretaquarium maintenance and participation in the research projects carried out at the aquarium (rearing of tropical fish, cuttlefish, dogfish, climate change effect on marine snails, etc.).	Practical training BSc	2020	Sterioti A.	University of Ioannina, Department of Biological Applications and Technologies	Greece
	Gabed Noujoud	NGS library construction and genome sequencing of diatom	Practical training	2020	Kristoffersen J.	Higher School of Biological Sciences of Oran	Algeria
	Giaglara Mathildi Eirini	Fish nutrition	Practical training	2020	Chatzifotis S.	Aristotle University of Thessaloniki	Greece
	Hobdy Anne	Rearing of clownfish *Amphiprion oscellaris and Amphiprion bicinctus* under controlled conditions at Cretaquarium.	Practical training MSc	2020	Sterioti A.	ERASMUS+/ACES	USA
	Huguet Sánchez Rocio	Fish nutrition	Practical training	2020	Chatzifotis S.	University of Alicante	Spain
	Karaiskou Victoria	Marine Aquariology: maintenance and growth of the Cretaquarium fauna.	Practical training BSc	2020	Sterioti A.	University of the Aegean, Department of Oceanography and Marine Sciences	Greece
	Lokuh Santamali	Broodstock management	Practical training	2020	Mylonas C.	ERASMUS+/ACES	Greece
	Mallick Sreeradha	Effect of temperature on the immunity and miRNAs in the early life-stage development in the European seabass (Dicentrarchus labrax)	Practical Training	2020	Sarropoulou E.	ERASMUS+/ACES	Greece
	Marquez Rodriguez Izaskun	The *Amphiprion chrysopterus* reproduction and larval rearing under controlled conditions at Cretaquarium.	Practical training BSc	2020	Sterioti A.	Kardala LHII, Akuakultura eta Elikagaien Industriak, Mutriku	Spain
	Nikolaidi Marieta	Behavioral and Histological studies on fish and fish larvae	Practical training	2020	Papadakis I.	University of Thessaly, Department of Ichthyology	Greece
	Patsiou Vasiliki	Behavioral studies about the effects of stocking density in the growth performance of gilthead sea bream (*Sparus aurata*) and European sea bass (*Dicentrarchus labrax*) juveniles.	Practical training	2020	Papadakis I.	Queen's University of Belfast	Ireland
	Procopiou Avgi	Marine benthic communities' assessment	Erasmus+ Training ship	2020	Dailianis A.	European University Cyprus	Cyprus
	Sfakianaki Maria	Behavioral and Histological studies on fish and fish larvae	Practical training	2020	Papadakis I.	University of Thessaly, Department of Ichthyology	Greece
	Superio Joshua	Broodstock management	Practical training	2020	Mylonas C.	ERASMUS+/ACES	Greece
	Alexandridis Damianos	DNA barcoding of marine fishes of the Mediterranean Sea	Practical training BSc	2021	Kasapidis P.	Aristotle University of Thessaloniki, Department of Biology	Greece
	Basilakopoulos Evangelos	Biochemical Analysis and aquafeed production	Practical training	2021	Nengas I.	University of Thessaly, Department of Ichthyology	Greece Greece

	Name of student	Title	Degree (MSc, BSc, internships)	Year of graduation/presence in IMBBC	Supervisor from IMBBC	University	Country
	Bilbao Jone	DNA metabarcoding and bioinformatics on water samples for the assessment of phytoplankton communities	Practical training PhD	2021	Pavloudi C.	University of the Basque Country (UPV/EHU), Phytoplankton Ecology research group	Spain
	Chatzibalassis Dimitris	Antibacterial activity of insect's bioactive components against fish pathogens	Practical training BSc	2021	Henry M.	Aristotle University of Thessaloniki	Greece
	Ciribilli Irene	Deciphering the functional potential of a hypersaline swamp microbial mat community using a combination of culture dependent and culture independent approaches	Practical training Erasmus+	2021	Dailianis A., Pavloudi C.	Università degli Studi di Perugia, Faculty of Chemistry, Biology and Biotechnology	Italy
	Di Dato Valeria	NGS library construction and genome sequencing of diatom	Practical training	2021	Kristoffersen J.	Stazione Zoologica 'Anton Dhorn	Italy
	Gasparis Ioannis	Biochemical Analysis and aquafeed production	Practical training	2021	Nengas I.	Agricultural University of Athens	Greece
	Gatouillat Hugo	Antibacterial activity of insect's bioactive components against fish pathogens	Practical training BSc	2021	Henry M.	Agrocampus Ouest Rennes	France
	Karafios George	Nutritional studies of farmed fish	Practical training	2021	Kotzamanis Y.	University of Patras, Department of Animal Production, Fisheries and Aquaculture	Greece
	Koutroumani Stella	Biochemical Analysis and aquafeed production	Practical training	2021	Nengas I.	University of Thessaly, Department of Ichthyology	Greece
	Laoutidis Nikolaos	Insect meal in aquafeeds	Practical training	2021	Chatzifotis S.	Aristotle University of Thessaloniki	Greece
	Le Roy Romane	Effect of climate change and ocean acidification on the feeding and predation behavior of marine gastropods.	Practical training MSc	2021	Chatzinikolaou E.	University Agrocampus Ouest (Rennes)	France
	Liolis Alexandros	First acquaintances with molecular techniques	Practical training	2021	Sarropoulou E.	Democritus University of Thrace	Greece
	Maroulasof Leonidas	Insect meal in aquafeeds	Practical training	2021	Chatzifotis S.	Aristotle University of Thessaloniki	Greece
	Martinez Martinez Alejandro	Fish nutrition	Practical training	2021	Chatzifotis S.	University of Alicante	Spain
	Paias Christos	Activities of Digestive and antioxidant enzymes in fish fed on alternative diets	Practical training BSc	2021	Cotou E.	Aristotle University of Thessaloniki	Greece
	Tselepidaki Charoula	Comparing benthic communities at three different habitats (FutureMares)	Practical Training	2021	Chatzigeorgiou G.	Aristotle University of Thessaloniki, Department of Biology	Greece
BSc	Chatzivasileiou Dimitra	Holothuria's biology: Correlation of residence time in the sand of Holothuria polii with the supply of organic matter in the sediment.	BSc Thesis	2018	Sterioti A.	University of Crete, Department of Biology	Greece
	Kostidis Constantinos	Development of analytical method for the detection of tetrodotoxin in *Lagocephalus sceleratus*	BSc Thesis	2018	Mandalakis M.	University of Crete	Greece
	Oikonomopoulou ioanna	Effect of cooking in nutritional value of gilthead sea bream and meagre	BSc Thesis	2018	Grigorakis K.	Harokopeion University of Athens	Greece
	Zafeiriou Alexandros	Development of RATA methodology for sensory evaluation of mushrooms	BSc Thesis	2018	Grigorakis K.	University of Peloponese, Department of Food Technology	Greece
	Digenis Markos	Biodiversity and environmental gradients in a marine cave of Crete	BSc	2019	Arvanitidis C., Gerovasileiou V.	University of Crete, Department of Chemistry	Greece
	Sotiriadis Sotiris	phage therapy against *Vibrio harveyi*	BSc Thesis	2019	Katharios P.	University of Crete	Greece

	Name of student	Title	Degree (MSc, BSc, internships)	Year of graduation/presence in IMBBC	Supervisor from IMBBC	University	Country
	Voulgaridi Chara	The effect of size and presence of more than one triton *Charonia seguenzae* (Aradas & Benoit, 1872) on their hunting ability on alive *Holothuria polii* (Delle Chiaje, 1823).	BSc Thesis	2019	Sterioti A.	University of Crete, Department of Biology	Greece
	Anagnostopoulou Argiro	Studying the effect of cultivation conditions on carotenoids production by marine microalgae.	BSc Thesis	2020	Mandalakis M.	University of Crete	Greece
	Igoumenakis Michael	Larval rearing of Mediterranean species	BSc	2020	Papandroulakis N.	University of Crete, Department of Biology	Greece
	Kalaintzakis Ioannis	The effect of the presence of *Entacmaea quadricolor* anemone and the fish-density on territorial/spatial behavior and on the mobility of the clownfish *Amphiprion bicinctus* at Cretaquarium.	BSc Thesis	2020	Sterioti A.	University of Crete, Department of Biology	Greece
	Karastergiou Anna	Studying the biological and chemical response of bacteria cultivated under an increasing deficit of carbon.	BSc Thesis	2020	Mandalakis M.	University of Crete	Greece
	Lazaridou Kyriaki	Factors affecting growth hormone in farmed fish	BSc Thesis	2020	Kotzamanis Y.	University of the Aegean, Department of Marine Sciences	Greece
	Charalambous Maria	Ethologic characterisation and metabolic rate of g. amberjack	BSc	2021	Papandroulakis N.	University of Crete, Department of Biology	Greece
	Gennaraki Marianna	Polychaetes communities in NMP of Karpathos - Saria	BSc Thesis	2021	Dailianis A., Chatzigeorgiou G.	Department of Biology, University of Crete	Greece
	Kouvarakis Nikos	Study on the removal of dissolved organic compounds from aquatic systems using marine sponge	BSc Thesis	2021	Mandalakis M.	University of Crete	Greece
	Lioret Arthur	Cage rearing of Mediterranean aquaculture species	BSc	2021	Papandroulakis N.	Ecole d'Ingenieurs de PURPAN	France,
	Manthos Constantinos	The rearing of *Salaria fluviatilis* (Asso, 1801) under controlled conditions at Cretaquarium.	BSc Thesis	2021	Sterioti A.	University of Ioannina, Department of Biological Applications and Technologies	Greece
	Saridaki Paraskevi	Analysis of *Vibrio harveyi* genomes	BSc Thesis	2021	Katharios P.	Agricultural University of Athens	Greece
	Tsotoulidis Panayiotis	Nutritional studies of farmed fish	Practical training	2021	Kotzamanis Y.	University of Thessaly, Department Ichthyology	Greece
	Alexandridis Damianos	DNA barcoding of marine fishes of the Mediterranean Sea	BSc Thesis	2022 ongoing	Kasapidis P.	Aristotle University of Thessaloniki, Department of Biology	Greece
COST STSM	Christou Andreas	Deciphering *Posidonia oceanica* bacterial community to advance biodiscovery in the Levantine basin	COST STSM	2021	Pavloudi C.	Cyprus University of Technology, Department of Chemical Engineering	Cyprus

d. Other Mentoring activities and actions to support career development of the trainees

- *Provide α short description of other activities, including training courses, summer schools, etc. in the Institute during the period*

Lectures and seminars

Apart from supervising the Dissertation or Thesis research of postgraduate students, several of the institute's researchers are active in giving lectures and seminars in undergraduate and graduate programs in Greece and abroad, to social events or other educational events (primary and secondary level). Specific examples follow below:

-Dr. C. Arvanitidis participates in three MSc curricula operated by (a) the Department of Biology, University of Salento, (b) the Department of Biology, UoC and (c) by the Department of Environment, Ionian University.

-Dr. S. Chatzifotis participated in seminars on fish nutrition at the UoC undergraduate and graduate courses for the years 2018-2020.

-Dr. E. Chatzinikolaou designed and implemented a series of educational activities (online, in the class and on the beach) for primary school students under the framework of the Nautilos (H2020) project Citizen Science actions focused on the plastic pollution of the oceans. More specifically Dr. E. Chatzinikolaou has established synergies with EU4Ocean, European Maritime Day - In My Country 2021, World Ocean Day 2021, European Marine Science Educators Association (EMSEA) initiatives. She also participates in the national school project CONNECT within the framework of Synergies in the H2020 project Nautilos, through the support of two thematic sections: 1) Microplastics, the invisible threat, and 2) Climate change in the oceans.

-Dr. V. Gerovasileiou has participated in "Online training course on data formatting, QC and publishing", co-organized by the Flanders Marine Institute (VLIZ), the "Istituto Nazionale di Oceanografia e di Geofisica Sperimentale" (OGS) and HCMR in the framework of "EMODnet Biology III" project, 8-19/6/2020 and to a Seminar to undergraduate students from Boston's Northeastern University at IMBBC-HCMR in Crete by Dr. V. Gerovasileiou, Dr. T. Dailianis (MB&B) and Dr. N. Papandroulakis (AQUA), 23 July 2019.

-Dr. P. Katharios has been a member of the Governing Committee of the Environmental Biology Post Graduate Course of the UoC (2019-2020), and a co-organizer of the Fish Health and Welfare module of the International postgraduate course ACES+ (2020). In addition, he has been involved in the following activities

- **2019,** Participation at the postgraduate course "Sustainable Management of Aquatic Environment" of the Agricultural School of the University of Thessaly as invited lecturer for the course "Hygiene of aquatic ecosystems".
- **2016-today**, lecturer in the Erasmus+ Joint Master Degree in Aquaculture, Environment and Society (University of Crete). Lecture and Practicals on Fish Diseases, Vaccine development and Alternative treatments.
- **2015-today,** International Course on the Care and Use of Laboratory Animals, Crete, Greece, Lecture Title: Zebrafish Diseases, Prophylaxis and Treatment.
- **2004- today**, Participation in the Post Graduate Program "Environmental Biology: Management of terrestrial and marine biological resources" of the

Department of Biology, UoC as a collaborating researcher with the lecture "Fish Diseases".

- **2010-today**, Participation in the Bachelor Course of the Department of Biology, UoC as a guest Lecturer at the course "Marine Biotechnology" with 2 lectures per year (Phage Biotechnology and Vaccine production for Aquaculture fish).

-Dr. T. Manousaki participates since 2016 actively in the MSc program of Bioinformatics of the Department of Medicine, UoC with a total of 45 hours of teaching per year.

-Mrs D. Mavraki has contributed to four workshops on FAIR data at LifeWatch & ENVRIplus International Summer School-Data FAIRness for Environmental & Earth Science Infrastructures (Italy, 2019), at the Assemble plus FAIR workshop (Belgium, 2019), at the online workshop Contributing datasets to EMODnet Biology (2020) and the online workshop ENVRI Community International School on Services for FAIRness (2021).

-Dr. C.C. Mylonas has conducted 14 seminars in total for the period 2018-2021. From those, six were held at the University of Crete, Department of Biology either for the Joint Master's Program in "Aquaculture, Environment and Society (ERASMUS MUNDUS, ACES)" or for the graduate seminar series of the department. In 2018, he gave lectures at the graduate seminar series of the Department of Biology, University of Cyprus, at the Scientific School Aquaculture RISE of the International Marine Center in Sardinia, Italy, at the undergraduate course "Aquaculture" of the Department of Aquaculture, University of Bologna and at the Course "Advances in Fish Reproduction and Their Application to Broodstock Management" of the Mediterranean Agronomic Institute of Zaragoza, CIHEAM, Spain. In 2020 he gave again a lecture at the graduate course "Aquaculture" of the Department of Aquaculture, University of Bologna and a webinar on the EASTalk Webinars Series of the European Aquaculture Society. Finally, in 2021 he repeated the webinar and held a lecture for the undergraduate course "Aquaculture" of the Faculty of Veterinary Medicine and Animal Science at the Swedish University of Agriculture Sciences.

-Dr. I. Papadakis was an invited speaker at the Scientific School Aquaculture RISE in Italy (2018) and in the New Zealand Institute for Plant & Food Research, New Zealand (2019).

-Dr. N. Papandroulakis hosted a group of students from NorthEastern University (in 2019) and offered lectures together with Dr. Thanos Dalianis and Dr V. Gerovassiliou.

-Dr. V. Polymenakou is a lecturer at the undergraduate classes "Geobiology" at the Department of Geology and Geoenvironment, National and Kapodistrian University of Athens since 2021 and "Marine Biotechnology", Department of Biology, UoC since 2010.

-Dr. G. Rigos has conducted lectures (8 hours in total) in the Joint Master Degree, AquaCulture, Environment and Society (ACES), CIHEAM – Mediterranean Agronomic Institute of Zaragoza, (Spain) and the MSc program "Mediterranean Aquaculture" of the Department of Ichthyology & Aquatic Environment, University of Thessaly (Greece).

Workshops

IMBBC conducted multiple Bioinformatics seminars where prestigious researchers presented to an audience from the whole country during the summer period. This activity was opened to the whole Greek community and will continue when limitations due to the pandemic will be lifted.

-Dr. A. (Cilia) Antoniou co-organizes and lectures at the **EMBO Advanced Practical Course on Computational Molecular Evolution (CoME**) that is hosted in IMBBC, HCMR every two years. During 2018-2020 two such courses were funded after successful applications to EMBO respective calls. However, the 2020 course was canceled due to the pandemics. This hands-on computational course aims to provide early-career stage researchers with the theoretical knowledge and practical skills to carry out molecular evolutionary analyses on sequence data. In addition, the course offers a unique opportunity for direct interaction with some of the world-leading scientists and authors of famous analysis tools in Evolutionary Bioinformatics. The demand for such training is large and growing, as are the sequence databases and researchers' awareness of the important insights that can be gained from phylogenetic and molecular evolutionary techniques. The course intensifies collaboration between early career stage biologists and bioinformaticians. The course is also suitable for established researchers and instructors who would like to refresh their memory of modern statistical methods for phylogenetic analysis of genomic sequence data and to interact with developers of such methods.

-Dr. A. Gioti has been elected (2019-2021) as member of the **Board of Directors of the Hellenic Bioinformatics (HBio) society**, whose aim is to strengthen bioinformatics training in Greece, among others. To that end, Dr. A. Gioti co-organized an online "bridge" event for the HBio society.

-Mrs N. Keklikoglou organized a micro-CT workshop on 29 October 2019 in HCMR (Heraklion, Crete) for micro-CT users during the BIOIMAGING-GR project. The invited speakers presented their work which was relevant with tomographic data providing tips and tricks to the audience about the creation of a micro-CT dataset and the post-processing steps (*e.g.* 3D analysis, segmentation).

Mentoring activities

-Dr. C.C. Mylonas, participates in the **European Aquaculture Society's "Adopt a student" program**. Under this program, accomplished researchers are matched with post-graduate students that have similar professional interests, in order to help them with decisions relevant to their education, research, interviews and career development.

The students below **have not spent any time at IMBCC**, but our researchers were co-supervisors or have participated in their evaluation committee as external members.

	Name of student	Title	Degree (PhD, MSc, BSc)	Year of graduation/study	Name of IMBBC Researcher/Postdoc	Role of Researcher/post doc	University	Country
PhD	Biancarosa Irene	Insects reared on seaweed as novel feed ingredients for Atlantic salmon	PhD	2020	Henry, M.	President of Evaluation Committee	University of Bergen	Norway
	Chatziantoniou Andromachi	Investigating the feasibility of environmental monitoring of aquaculture farms using satellite data for the sustainable development of the sector	PhD cand	2020	Papandroulakis, N.	PhD Co-supervisor	Dep of Marine Science, University of Aegean	Greece
	Toomey Lola	Unlocking the wild potential: integration of geographic differentiation in domestication processes to facilitate fish aquaculture diversification	PhD	2020	Tsigenopoulos, C.	PhD external evaluator	Universite Lorraine a Nancy	France
	Dourou Marianna	Studies on the growth of marine microalgae strains cultivated on fish farm effluents and production of high added value products"	PhD (completed)	2021	Kotzamanis Y.	PhD Co-supervisor	Department of Biology University of Patras	Greece
	Oikonomou Stavroula	Uses and Applications of genetic and genomic approaches in Improvement programs of farmed fish	PhD	2021	Tsigenopoulos, C.	PhD Co-supervisor	Aristotle University of Thessaloniki	Greece
	Ramos Júdez Sandra	Control of reproduction in the flathead grey mullet *Mugil cephalus*. Broodstock management, hormonal therapies and transcriptomic signature	PhD	2021	Tsigenopoulos, C.	PhD external evaluator	Universitat Autonoma de Barcelona	Spain
	Digenis Markos	Biodiversity of sea caves in the Eastern Mediterranean Sea	PhD Thesis	2021 ongoing	Dailianis, T.	PhD Co-supervisor	Ionian University, Department of Environment	Greece
	Feborova Valeria	Faunistics and ecological aspects of the benthic polychaeta communities in the Mediterranean coast of Israel	PhD Thesis	2021 ongoing	Chatzigeorgiou G.	PhD Co-supervisor	Department of Marine Biology, University of Haifa	Israel
	Tampou Anna	Organic Aquaculture	PhD	PhD candidate	Nengas, I.	PhD Co-supervisor	University of Thessaly, Dept Icthyology	Greece
	Asimaki Mado	Fish nutrition with processed animal protein originated from insects	PhD cand	PhD ongoing	Henry, M.	PhD external evaluator	Agronomic University of Volos	Greece
	Loufi Katerina	The use of copepods during greater amberjack (*Seriola dumerili*) larval rearing procedure	PhD cand	PhD ongoing	Papadakis I	PhD Co-supervisor	Department of Biology University of Patras	Greece
	Vallecillos Quijada Antonio	New challenges in genetic selection to improve the competitiveness of the aquaculture sector	PhD cand	PhD ongoing	Tsigenopoulos, C.	PhD external evaluator	Universidad Politécnica de Cartagena	Spain
	Siaperas Romanos	Discovery of biocatalysts of industrial interest in marine fungi using omic technologies	PhD cand	PhD ongoing	Gioti A.	PhD Co-supervisor (with G. Kotoulas at IMBBC)	NTUA, Chemical Engineering School	Greece
	Theodoridi Antonia	Competitive behavior, ethological patterns and the role of glucocorticosteroid receptors	PhD cand	PhD ongoing	Tsigenopoulos, C.	PhD Co-supervisor	Department of Biology University of Crete	Greece
MSc	Goulia Andromachi	Bioenergetics in Fish Nutrition	MSc	2018	Nengas, I.	Thesis co-supervisor	University of Patra	Greece
	Kakaridi Eleni	The effect of aeration on the digestive system of Gilthead sea bream (*Sparus aurata*) and sea bass (*Dicentrarchus labrax*)	MSc	2018	Papadakis, I.	Thesis co-supervisor	Department of Biology University of Patras	Greece
	Keet Thomas	The development of a larval feeding regimen for dusky Kob, *Argyrosomus japonicus*, with a specific focus on the effect of weaning period on larval development and survival	MSc	2018	Papadakis, I.	Thesis external evaluator	Rhodes university	South Africa

	Kotari Ioanna	Study of the evolution and expression of paralogous genes with roles during the pigmentation in early developmental stages of the three-spined stickleback (*Gasterosteus aculeatus*).	MSc Thesis	2018	Sarropoulou E.	Thesis supervisor	Department of Biology University of Crete	Greece
	Pouli Marina	Histological and molecular aspects of gender differentiation in the greater amberjack (*Seriola dumerili*).	MSc Thesis	2018	Sarropoulou E.	Thesis co-supervisor	University of Crete, Department of Biology	Greece
	Badogiannis Nikos	Real-Time Embedded System for Hole Detection in Fish Cage Nets	MSc	2019	Papandroulakis, N.	Thesis co-supervisor	TUC, School of Electrical and Computer Engineering	
	Paspalakis Stavros	Real time video processing for recognition and localization of problems in aquaculture nets	MSc	2020	Papandroulakis, N.	Thesis co-supervisor	TUC, School of Electrical and Computer Engineering	
	Shina Chara	The ontogeny of Gilthead Sea bream (*Sparus aurata*) eye	MSc	2020	Papadakis, I.	Thesis co-supervisor	Department of Biology University of Patras	Greece
	Chakkalakkal George Joseph	Identification and Characterization of piRNAs in Teleosts	MSc Thesis	2021	Sarropoulou E.	Thesis supervisor	ERASMUS+/ACES	Greece
	Garpousis Konstantinos	Integrated MultiTrophic Aquaculture_Exploration of co-culture bivalves and finfish	MSc	2021	Cotou E.	Thesis co-supervisor & Committe Evaluator	Agricultural University of Athens	Greece
	Mallick Sreeradha	Effect of temperature on the immunity and microRNAs in the European seabass (*Dicentrarchus labrax*)	MSc Thesis	2021	Sarropoulou E.	Thesis supervisor	ERASMUS+/ACES	Greece
	Papachristou Elektra	Planktonic microbial community daily cycle in aquaculture	MSc Thesis	2021 ongoing	Pafilis E., Zafeiropoulos H.	Thesis co-supervision & Committe Evaluator (Pafilis E.)	University of Crete, Department of Biology	Greece
BSc	Maravelia Aggeliki	WNT Signaling patterns in fish tissue	BSc	2019	Pavloudi, C.	Thesis supervisor	Department of Marine Sciences, University of the Aegean	Greece
	Liapi Aspasia	Chemical composition of mussels & oysters co-cultured in finfish and shellfish parks	BSc	2021	Cotou E.	Thesis co-supervisor	Agricultural Univeristy of Athens	Greece

5.3 Innovation and Intellectual Property

Provide information about the following:

a. New IP, patents generated during the period:

Provide information including Names of Inventors, Title of IP, Date filed.

Fish Texture Evaluation Tool (FTET)

The Fish Texture Evaluation Tool (FTET, **Photo 1**) is a rapid non-destructive methodology for assessing texture of fish. Texture is evaluated by application non-destructive on fish surface / flesh. Texture is a quality attribute that can be related either to freshness or to dietary history or aquaculture management of the product and this is done by the means of stochastic modeling. An initial IP (protected by national patent since 2016, Patent nr: OBI 1009084) is owned by the two developers of the methodology (**Dr. K. Grigorakis from IMBBC** and Dr. Dimitrios Dimogianopoulos, University of West Attika). The continuation of the on-going project (bound to different research projects) has led to an industrial prototype (see **Photo** below) that has finished lab-scale testing and is being tested under an industrial environment. This prototype is also going to be IP protected by a patent that is going to be filed in the near future. The aspiration is to further exploit this technology, probably by selling the IP to a commercial partner or make a new start-up.

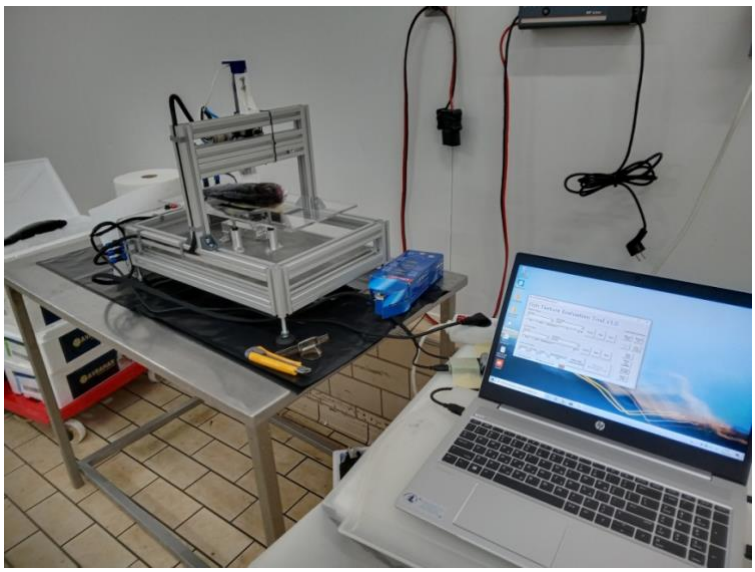


Photo 1. The FTET under operation during industrial trial. The laptop with the FTET-software interface (in front) are visible during European sea bass freshness evaluation in a packaging and processing plant of a large commercial aquaculture operation.

b. Creation of new spin-off and start-up companies during the period:

Provide information including Company Name, Institute Members role, short (one paragraph) description about the scope of the Company.

Three new spin-off companies – the first ever in the HCMR- have been established during the reporting period. A brief description follows.

Spin-off 1 - Aquatic Biologicals

https://www.aquatic-biologicals.com/

Aquatic Biologicals SA is a newly founded marine biotechnology company, spin-off of the Hellenic Centre for Marine Research.

Aquaculture has become the leading export power of the Agri-Food sector in Greece. The Greek but also the whole Mediterranean industry is being expanded both in volume and in diversity as more novel fish species are currently being introduced in the production process. From the marketing and sales viewpoint this has very positive prospects, however it comes along with a significant risk, the risk of diseases. The fragmentation of the market is the biggest impediment for the Pharma industry to invest and develop new tools that will be needed to support this expansion. This is because licensing is time-consuming, and extremely costly.

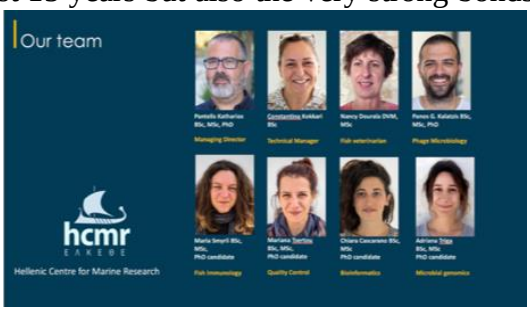
This is the gap that Aquatic Biologicals aspires to fill in. For the past 15 years**, Dr. P. Katharios** and the research team of Aquaculture Microbiology lab of IMBBC, has been specializing in the management of diseases in the Mediterranean aquaculture developing innovative tools that are eco-friendly and can be used as preventive and therapeutic tools.

Aquatic Biologicals, develops autogenous vaccines which are custom-made vaccines that can be used without a license in cases where registered vaccines for the specific disease are not commercially available. The limitation is that autogenous vaccines can be prepared only using the pathogen isolated from the affected farm and can be used and sold only in that specific farm. In Greece the registered vaccines are only for 2 diseases, therefore all other diseases can be prevented only with autogenous products.

Apart from vaccines, Aquatic Biological develops phage therapy products. Bacteriophages or phages are viruses that infect and kill bacteria. They are nature's oldest and most efficient bacterial "predators". They are highly host-specific, meaning that not only they infect bacteria alone, they target specific strains and species. Phage therapy can be used both prophylactically and therapeutically against bacterial diseases. It is a highly efficient alternative to antibiotics. The most attractive characteristic of phage therapy is that it is highly targeted. With phages you can eliminate bacterial pathogens without harming beneficial bacteria of the environment or the gut of the host.

Finally, Aquatic Biologicals provides advanced diagnostic services to the aquaculture companies. This service is complementary to the previously described activities. Novel -omics technologies are employed for identifying and study pathogens and diseases. Pathogenic strains of bacteria are being kept in biobank with cryopreservation. Aquatic Biologicals works closely with the aquaculture companies providing customized solutions for the sustainability of their businesses.

Aquatic Biologicals capitalizes on the research results obtained by the Aquaculture Microbiology lab in IMBBC-HCMR over the past 15 years but also the very strong bonds developed with the aquaculture industry. Right after its establishment (May 2019), Aquatic Biologicals submitted a proposal in the General Secretariat of Research and Technology program (Research-Innovate-Create, Activity III, Valorization of Research Results), which after the evaluation was ranked 1st with a mark of 4.75/5.00. Through this proposal AB secured state funds of € 835.605 which represents 45% of the total budget needed to invest in a production plant for its products. Since both phages and vaccines are pharmaceuticals, they should be produced in a GMP (Good Manufacturing Practice) compliant facility. This requires a significant investment for facilities, equipment, personnel and quality systems. In December 2020, Aquatic Biologicals and IRIDA SA, a Greek fish feed manufacturer came into agreement and IRIDA became the main investor of the company. Aquatic Biologicals has been transformed to a Limited Liability Company and currently is in the process of building a state-of-the-art GMP-compliant facility for aquaculture vaccine production.



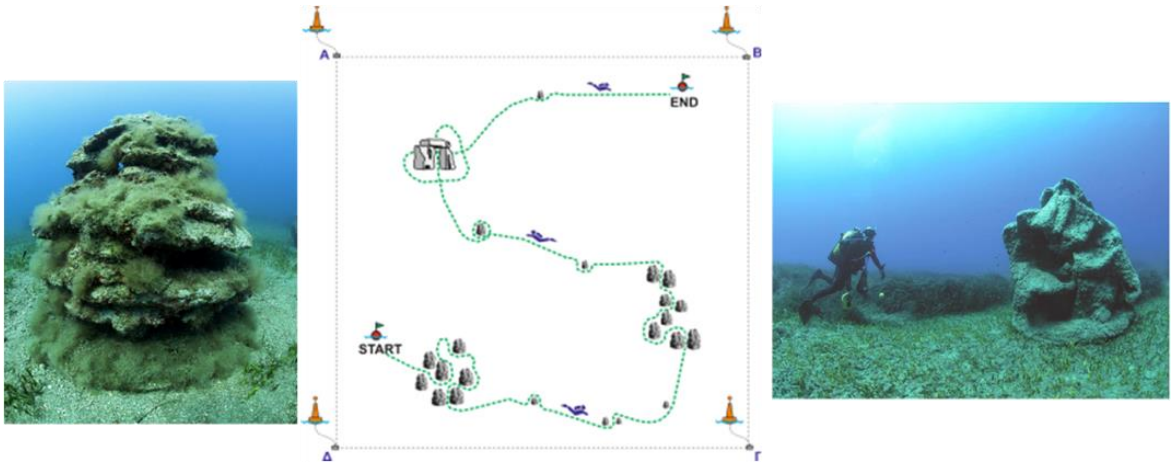
Spin-off 2 - Artificial Reef Innovative Applications *(ARIA*)

The recent degradation of many recreational diving destinations all over the world due to impacts from massive tourism necessitated the adoption of new management measures. The HCMR has developed an innovative technology for the creation of **artificial underwater ecotourism attractions (oases)** using specially constructed **artificial reefs** in an attempt to simulate the functional and morphological characteristics, and the aesthetics of the natural rocky reefs. This new technology has been tested, validated and demonstrated successfully in the **Underwater Biotechnological Park of HCMR in Crete**. Furthermore, HCMR industrial property rights have been already protected by a European patent granted centrally by EPO (designated countries Greece, Spain, France, Italy, Malta, Cyprus, Turkey and Croatia) while a patent application to USPTO is expected to be granted within 2022.

In this context, HCMR has developed and demonstrated two innovative concepts: "HCMR-Recreational Diving Oasis™" and "HCMR-Artificial Reef for Recreational Diving™". These products are currently promoted in the market by a new spinoff private company named "**ARTIFICIAL REEF INNOVATIVE APPLICATIONS (ARIA)".** The company is co-founded by HCMR and **Dr. C. Dounas** (IMBBC Research Director and inventor) together with a team of high level scientists and engineers in the fields of Marine Biology and Ecology, artificial habitat technology, technical project

management and scientific diving with the aim to exploit technological knowledge and further develop new products and services. Up today, the spinoff participates in six projects aiming at constructing "Recreational Diving Oases with HCMR artificial Reefs" in the Region of Crete (Apokoronas, Agios Nikolaos, Gournes, Stalida, Mononaftis and Ierapetra). It is estimated that for the period 2022-23 a network of more than ten (10) recreational Diving Parks will be constructed only within the Crete Region with a total budget of more than € 2,5 M.

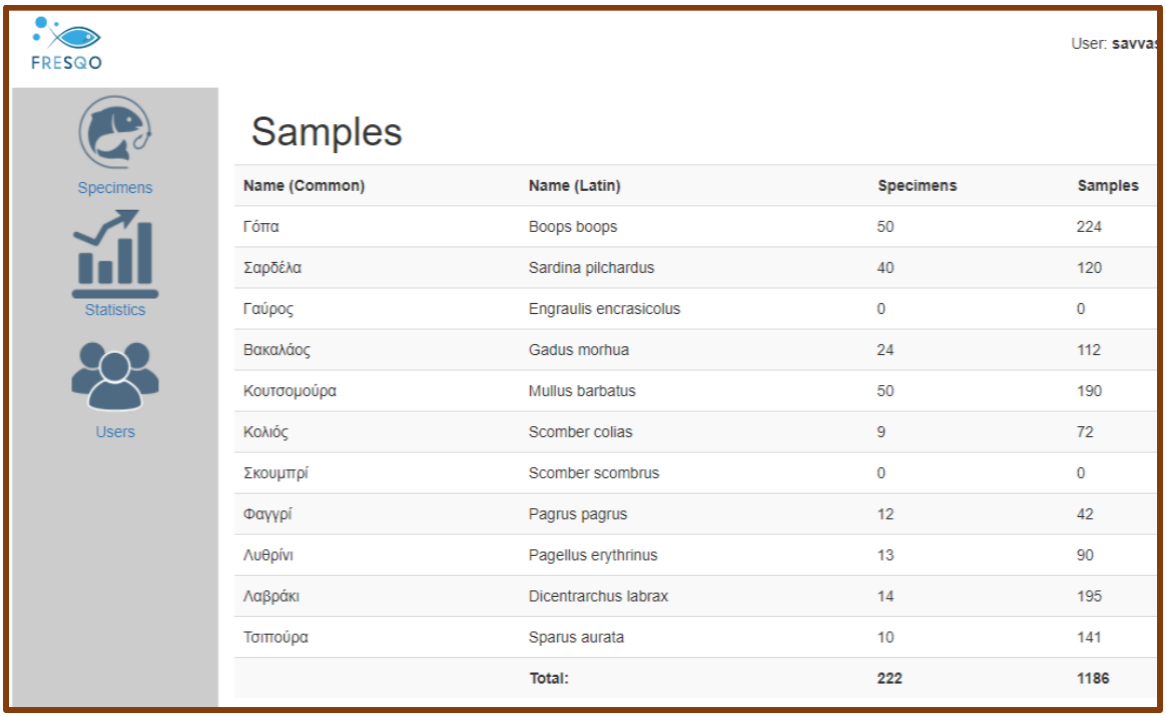
ARIA is aiming at collaborating with public authorities and private firms located in other maritime Regions of Greece which are interested in applying HCMR innovative technologies. It is foreseen that in the next 5 years more than 50 Recreational Diving Parks and Open Diving Attractions will be constructed along the Greek coasts with an estimated total budget of € 12-15 M. Furthermore, **ARIA** will exploit exclusive rights and know-how deriving from the HCMR patented invention and its up-today technical experience in Mediterranean countries and abroad having an additional target of € 0.5 M as annual revenue. Finally, **ARIA** is expected to participate as a partner in national and EU R&D consortia for the development, testing and demonstration of novel technologies relevant with the creation, function and maintenance of recreational diving parks, special fisheries management areas, extensive aquaculture and many other blue growth-related topics.



Spin-off 3 – FresQo

FresQo is a start-up company that is under establishment at this moment, which will be based in Athens. It is owned and founded by Athena RC, HCMR, FORTH, and University of Patras. The business plan has been completed and is being edited by the partners. The aspiration is to be an active company the first half of 2022. FresQo is the outcome of a project under the same name. The development of a rapid non-destructive methodology for assessing seafood freshness has led to a functional tool that is the product to be exploited by the company. This tool uses a hyper-phasmatic camera that takes photos of a fish or other seafood and based on artificial intelligence and a real-time comparison with a database of photos (depository created by the project) can read changes in appearance related to freshness alteration and conclude on the current freshness of the seafood. At this moment

a depository for 12 different species has been created and is being continuously enlarged (see **Table 1** below). **Dr. K. Grigorakis** is the IMBBC researcher that is a member of the company, as the expert on fish and seafood freshness. The scope of the company is to provide services for key players in the seafood industry and retailers (B2B) and later on for consumers (B2C).



Name (Common)	Name (Latin)	Specimens	Samples
Γόπα	Boops boops	50	224
Σαρδέλα	Sardina pilchardus	40	120
Γαύρος	Engraulis encrasicolus	0	0
Βακαλάος	Gadus morhua	24	112
Κουτσομούρα	Mullus barbatus	50	190
Κολιός	Scomber colias	9	72
Σκουμπρί	Scomber scombrus	0	0
Φαγγρί	Pagrus pagrus	12	42
Λυθρίνι	Pagellus erythrinus	13	90
Λαβράκι	Dicentrarchus labrax	14	195
Τσιπούρα	Sparus aurata	10	141
	Total:	**222**	**1186**

Table 1. User interface of the depository as it appears in the **FresQo** database (including common and scientific names of species and numbers of samples undergone review for their freshness).

c. Participation in Greek or foreign companies

Dr. **C. Arvanitidis** is the Chief Executive Officer of LifeWatch ERIC, with the headquarters in Seville, Spain.

Dr. **T. Dailianis** and **Dr. P. (Yolanta) Koulouri** participate in the HCMR spin-off ARIA (Artificial Reef Innovative Applications) P.C., founded by Dr. C. Dounas. The company's main focus is the design and implementation of recreational diving parks.

Dr. **T. Dailianis** participates in the Greek company Cleopatra's Sponges P.C. The company's main focus is the sustainable exploitation of Aegean sponges and Dr. T. Dailianis serves as an expert advisor.

Dr. **C. Dounas** is the founder of the HCMR spin-off ARIA (Artificial Reef Innovative Applications) P.C. The company's main focus is the design and implementation of recreational diving parks.

Dr. **P. Katharios** is the founder of Aquatic Biologicals SA, spin-off company of HCMR. He is currently the CEO of the company and the Vice President of the Board of Directors.

Aquatic Biologicals develops and produces autogenous vaccines for aquaculture companies and provides health services including advanced diagnostics.

d. Income from Royalties or exploitation of IP during the period

No income from royalties was obtained during the period.

e. Description of TTO office and practices to promote generation and exploitation of new IP.

Unfortunately, the HCMR does not have a TTO office so far. The state is currently encouraging the creation of such offices in all research centers, institutes and universities in Greece, and we are in communication with the UoC in order to examine the feasibility of creating a joint office that will support not only our respective organization, but perhaps other research organizations in Crete.

Nevertheless, IMBBC has historically had very close ties with the Aquaculture industry. In the 1990s, the predecessor of IMBBC – the Institute of Marine Biology of Crete, IMBC-provided practical courses for aquaculture personnel and managers, and provided eggs and juveniles for the young, but rapidly growing industry in Greece. As a result of this close relationship, new methods, technologies and products resulting for the research activities of IMBBC find their way to the Greek aquaculture industry quite rapidly, through direct interaction with the relevant researchers. Also, for many years, IMBBC researchers provide consulting services to the major Greek aquaculture companies in aspects of Broodstock management, Fish health and vaccinations, Feed formulation and feeding, etc., and through these relations they can easily and rapidly transfer any new technologies to the industry.

f. Other commercial activities

A number of Permanent Researchers are involved in "commercial activities" relevant to their expertise, in the form of provision of biological material (eggs, juveniles, edible fish), analyses and consulting. **Money obtained from these consulting activities goes into a special account for each researcher**, after deduction of a 20-25% overhead charge by the HCMR and more recently a 2% by IMBBC. **These monies are managed by each researcher** and may cover the salaries of students and contracted personnel, purchase/service of office and laboratory equipment, maintenance of the facilities, participation and travel to conferences, purchase of consumables for preliminary studies, etc.

The Broodstock management facility (AQUA, Dr. C.C. Mylonas) produces eggs of a number of Mediterranean marine fishes, including gilthead seabream, European seabass, meagre and greater amberjack, which are sold to commercial hatcheries in Greece and Europe. These eggs are sold to hatcheries that either do not have broodstocks of these species in their facilities, or they need the eggs to satisfy some emergency requirements due to increases in production or problems with their production at a certain time. The eggs are produced by the various broodstocks we maintain at IMBBC, as part of research projects or as production stocks for our own hatchery needs.

Dr. **S. Chatzifotis** (AQUA) offers testing and evaluating feed additives for commercial companies.

Dr. T**. Dailianis** (MB&B) has served as expert advisor to assess the suitability and value of underwater areas in the Ionian Sea for the establishment of diving parks for the company AMBIO Consultants S.A.

Dr. **E. Fountoulaki and Dr. I. Nengas** (AQUA) were involved in eight individual contracts for the period 2018-2020 providing analyses of aquafeeds and feed ingredients, evaluation of nutritional products *in vivo* and *in vitro* for fish producers and nutritional solution providers, as well as aquaculture companies such as TETHIS AQUACULTURE Ltd, ALLTECH Ltd, FRAMELCO BV., La PRAIRIE Aqua Tech, PHILOSOFISH and Galaxidi Marine Farms.

Dr. **P. Katharios** (AQUA) conducts fish disease diagnostic services for the Greek Aquaculture companies.

Mrs **N. Keklikoglou** (MB&A) offers micro-CT scans and 3D analysis of a variety of samples for different companies and research centers.

Dr. **I. Kotzamanis** and Dr. **G. Triantaffylidis** (AQUA) cooperate with Private Greek and foreign commercial companies and organizations (*e.g.* the American Soybean Association-USSEC), offering service in the field of fish nutrition and aquaculture.

Dr. **P. (Yolanda) Koulouri** (MB&B) has provided ecosystem management services regarding monitoring studies in the marine areas of wastewater treatment plants of different cities of Crete Island (*e.g.* Heraklion, Chania, Platanias, Rethymnon) as well as measures for the conservation and management of marine biological resources of Elounda Bay (Crete).

Dr. **C.C. Mylonas** (AQUA) has signed various contracts for consultation to various commercial operations in Greece, Europe and the World (a total of >20 so far), in the area of Broodstock Management and Control of Reproduction in Aquaculture fish. Some of the companies include IRIDA S.A., Galaxidi Marine Farms, Argosaronikos Fishfarming, Selonda, Kefalonia Fisheries, Philosofish, (Greece); Kilic Aquaculture (Turkey); Aquabridge, Dubai, U.A.E. This consulting work has been carried out since the early 2000, and has many benefits for Dr. Mylonas and his laboratory, but also IMBBC. Due in part to this consulting activities carried out by Dr. Mylonas -but also other IMBBC researchers- IMBBC has gained a very good reputation with the Mediterranean aquaculture industry, and many companies express an interest to collaborate with us in solving production problems they may face.

Dr. **I. Papadakis** (AQUA) offers as service the evaluation of Snapper larval rearing protocols for the New Zealand Institute for Plant and Food Research.

Dr. Dr. **N. Papandroulakis** (AQUA) offers consulting on larval rearing and grow-out methodologies. In addition, the Pilot scale hatchery sells fish juveniles to private companies of a number of Mediterranean marine fishes, including European seabass, meagre and greater amberjack. These juveniles are sold to companies that either do not have their own hatchery, or do not have breeders of these species in their facilities. In addition, the Pilot netpen aquaculture farm of IMBBC sells harvest size fish for human consumption.

Dr. **G. Rigos** (AQUA) offers experimental & challenge trials to the companies Skretting AS, Nutriad International NV, BioMar Hellenic ABEEI, Allteck Ltd, Seloda SA and the university Ecole Polytechnique Fédérale de Lausanne. Further, he offers scientific reports

regarding fish antimicrobials to the company Vethellas AEBE. He also conducts toxicological reports for the companies S&B Industrial Minerals S.A, Vethellas AEBE and the Hellenic Aquaculture Producers Organization (HAPO). Finally, he offers the evaluation of quality and safety of aquatic products for the company AB Vasilopoulos SA.

Dr. **D. Tsaparis** (MB&B) offers as a service the genetic analysis of samples for the NGO "Agriogido".

Dr. **C. Tsigenopoulos** (MB&B) conducts annual service contracts to Universities, Research Centers and aquaculture companies of approximately 40.000€ for sequencing, microsatellite genotyping and breeding services.

5.4 Awards and Distinctions

Dr. A. (Cilia) Antoniou

-Member of Organizing and Scientific Committee 2018: EMBO Practical Course: Computational Molecular Evolution, 6 - 17 May 2018, IMBBC, HCMR, Heraklion, Greece.

-Member of Organizing and Scientific Committee 2019: Wellcome Trust-EMBL-EBI advanced course on Computational Molecular Evolution. 13 - 24 May 2019, Wellcome Trust Genome Campus, Hinxton, Cambridge, UK.

Dr. C. Arvanitidis

-2018: Awarded with the Frontiers Community Support Fund as a recognition for the work carried out as an Associate Editor for Frontiers in Marine Science, by the College of Chief Editors.

Dr. E. Chatzinikolaou

-Scientific responsible on 1st Call for Research Projects ELIDEK (HFRI, Hellenic Foundation for Research and Innovation) for the support of Post-doctoral Researchers, 2018-2021. "Effects of climate change and ocean acidification on marine gastropods (ECCO) (project ID: 343)". Scientific research area: H. Environment and Energy - Funded by: General Secretariat of Research and Technology, Budget: 140,000 €.

-Postdoc Scholarship for the call «Support of researchers with emphasis on new researchers" ΕΔΒΜ34, 2018-2019. «Estimation of volume and density of thrombotic material with the use of micro-CT in patients with ST elevation acute myocardial infarction (STEMI) following primary percutaneous coronary intervention (PCI) and thromboaspiration. Correlation with angiographic and clinical outcome" (MIS 5004707) - Funded by ESPA/NSRF.

Dr. Thanos Dailianis

-Member of the scientific and organizing committee for the international conference CMBR Web Conference - Blue Growth in the Eastern Mediterranean: challenges and opportunities. May 12-13, 2021, organized by IMBBC.

-Associate Editor for the journal Frontiers in Marine Science (2020 IF=4.912), section Marine Biology.

Dr. V. Gerovasileiou

-Greek National Expert on marine and coastal biodiversity, 2021. Greek Ministry of Environment and Energy & UNEP/MAP-RAC/SPA in the frame of the “Post-2020 Strategic Action Programme for the conservation of Biological Diversity in the Mediterranean Region”.

-Scientific Committee member, 2021. 4th International Congress on Applied Ichthyology, Oceanography & Aquatic Environment (HydroMediT 2021), 4-6/11/2021, Mytilene, Greece.

-Scientific Committee member, 2019. RAC-SPA/UNEP-MAP Symposia on marine key habitats and Non-Indigenous Species in the Mediterranean, 14-18/01/2019, Antalya, Turkey.

-Scientific Committee member, 2018. 4th International Symposium on “Anchialine Ecosystems”, 10/2018, Lanzarote, Spain.

-Scientific Committee member, 2018. 12th Panhellenic Symposium of Oceanography & Fisheries, 31/05-03/06/2018, Corfu, Greece.

Dr. N. Gioti

-Member of the Hellenic Bioinformatics (H. Bioinfo) Board of Directors (through elections), 2019-2021.

-Scientific Committee member of the Hellenic Bioinformatics (H. Bioinfo) Conference, HBio 12, FORTH, Heraklion, 11-13 October 2019.

Dr. T. Manousaki

-European Reference Genome Atlas (ERGA) council member, 2021. Elected by the Greek members of the ERGA initiative as a council member representing the country.

-Organizing member of the Data Analysis Committee and Bylaws Committee of ERGA, 2021.

-Marine Evolution conference (Strömstad, Sweden), 2018. Session "2. Evolutionary Biology of Marine Invasions" co-organizer.

Mrs D. Mavraki

-RDA Europe Expert grants, 2019. Grant winner as an expert European Researcher & Scientist working with data to attend the 14th RDA Plenary meeting, in Helsinki, Finland 23-25 October 2019, under the theme “Data Makes the Difference” https://grants.rd-alliance.org/OpenCalls/call-experts-rda-14th-plenary.

Dr. C.C. Mylonas

-Organizer – 12th International Symposium of Fish Reproductive Physiology, May 2023, Hersonissos, Crete.

-President of the Scientific Committee for Agrotechnology and Nutrition, of the Greek Republic – 2020-2022. Consulting body for the National Committee for Research, Technology and Innovation, of the Republic of Greece (Ministry of Development and Investment).

-Board of Directors of the European Aquaculture Society, member (elected for two terms, 2018- present).

Dr. C. Pavloudi

-5th OBPS Community Workshop, 2021. Track organizer on "Enhancing the value of marine omics/eDNA practices across the ocean community".

-5th OBPS Community Workshop, 2021. Panelist on session "Coordinating genomic sampling across a European Infrastructure".

-JGI Annual Meeting, 2021. Poster judging team.

-Workshop on "Biomonitoring of aquatic ecosystems using genetic methods", 2021. Lecturer, Member of the organizing committee.

-1st DNAQUA International Conference, 2021. Member of the Scientific Committee.

-Seminar on "HPC analyses and DNA metabarcoding", 2020. Lecturer, Member of the organizing committee.

-Costas Drainas Scholarship for Early Researchers from the Hellenic Society Mikrobiokosmos, 2018. 1 month visit to the Microbial Ecophysiology group of the University of Bremen.

-FEMS Meeting Grant, 2018. Participation in the 5th International Symposium on Microbial Sulfur Metabolism, Vienna (Austria).

-Murray Foundation (MF) Grant, 2018. Participation in the 8th European Coastal Lagoons Symposium (EuroLag), Athens (Greece).

Dr. G. Rigos

-Session Chair at the European Aquaculture Society, Aquaculture Europe 2019, Our Future -GROWING from WATER, Berlin, Germany, October 07-10 2019.

-Session Chair at the 19th International Conference on Diseases of Fish and Shellfish – European Association of Fish Pathologists-EAFP 2019, Porto, September 09-12 2019.

5.5 Societal Impact

The IMBBC has a significant role in the society, through its many activities related to the most important economic resource of Greece -the marine environment, which are governed by (a) scientific excellence, (b) strategic collaborations with research, academic and industrial partners in Greece, Europe and the world, and (c) employment of modern technologies in parallel to conventional knowledge. Based on the above principles and the extensive involvement of IMBBC research staff in EU and national research projects, the activities of the institute are relevant both locally and globally, and have impacted society significantly in the areas of marine aquaculture and tourism (via the study and conservation of the coastal marine environment). Through its research, education, dissemination, outreach and business activities, IMBBC has succeeded in bringing the issues of marine biodiversity (*e.g.* sustainable exploitation of marine biological resources) and sustainable development of aquaculture at the highest priority at the regional and national level. The institute greatly supports the development and expansion of the aquaculture industry in Greece, which is the 3rd largest export industry of agricultural products.

a. Dissemination and outreach activities to the public

IMBBC has (co-)organized conferences, workshops, schools and seminars in order to disseminate and outreach scientific knowledge during the evaluation period (see section 5.2 Training & Educational activities). We participate in the networking for the Mediterranean Science Commission (CIESM) consisting of several thousand marine researchers, applying the latest scientific tools to better understand, monitor and protect a fast-changing, highly impacted Mediterranean Sea. More specifically, IMBBC represents one of the focal points of the CIESM program "watching for jellyfish blooms" and in collaboration with the Port Authorities monitors jellyfish blooms along Cretan coasts for the safety of the citizens and tourists (2014 to date).

Dr. P. (Yolanda) Koulouri is a member of the international non-profit organization European Marine Science Educators Association (EMSEA) committed to boost Ocean Literacy in Europe and worldwide. In addition, the EMSEA-Mediterranean Working Group (of which Dr. Y. Koulouri is a founding member) provides basic fundamental knowledge about the Mediterranean Sea to educators, teachers, scientists, NGOs, the blue business sector and policymakers. In this way, it helps to achieve awareness at all levels of society and, therefore, a blue and sustainable Mediterranean region. In this context, personnel of IMBBC along with other institutes of HCMR has actively participated during the evaluation period in events such as Researcher's Night, European Maritime Day, Mediterranean Coast Day, World Ocean Day in order to promote ocean/marine citizenship.

Dr. Y. Koulouri is also a member and was elected recently as the co-chair of the Ocean Literacy Working Group of the European Global Ocean Observing System (EuroGOOS) which, among other activities (*e.g.* policy documents and campaigns), has launched a long-term UN Ocean Science Decade Action Programme to bring considerable added value to empowering citizens to use their acquired knowledge of the ocean and awareness of ocean-related issues to communicate about the ocean in a meaningful way and make informed decisions for their lives that will impact on their future wellbeing. IMBBC is also a founding member of EU4Ocean Coalition, which connects diverse organizations, projects and people that contribute to ocean literacy and the sustainable management of the ocean. Supported by the European Commission, this bottom-up inclusive initiative aims at uniting the voices of Europeans to make the ocean a concern of everyone. The coalition is made up of three

components: a platform for organizations and individuals engaged in Ocean Literacy initiatives, a European Youth Forum for the Ocean and a Network of European Blue Schools.

Also, the institute participates in the activities of the Cretaquarium (which is part of HCMR), not only in the realization of its construction and operation, but also in different events organized for the local population and the visitors. The **Director of IMBBC (Dr. C.C. Mylonas) has been the Director of the Cretaquarium** between March 2021 and March 2022, and its chief aquariologist (Dr. A. Sterioti) is a researcher of IMBBC. As such, the research activities of IMBBC (and HCMR as a whole) are highly visible in the visitors of the aquarium, and have contributed greatly in strengthening the interest of the local society, but also beyond, in the area of marine life, conservation, biodiversity and aquaculture, since Crete is a popular destination for domestic and international tourism. Since 2021, we have organized a permanent exhibition at the Cretaquarium, with the purpose to disseminate and promote the key messages and objectives of the UN Decade of Ocean Science for Sustainable Development, by producing audiovisual and educational material and using modern scientific instruments and educational tools in order to improve the interaction of students and citizens with the results of current marine research.

Finally, in the last two years, a significant effort has been undertaken to bring the research done by IMBBC researchers closer to the public, and bring awareness about the importance of the marine environment and the health of our Oceans and Seas in the maintenance of the Climate, the stability of the ecosystems, the provision of healthy food, the discovery of important pharmaceuticals and industrial compounds, and wellbeing of coastal communities. A series of interviews of all of our researchers and post-docs is published in local or national newspapers every 1-2 months, while news releases are sent to all media when a new research programs starts its implementation. We believe this has increased the awareness of the public regarding IMBBC and the HCMR, and helps in educating our fellow citizens of important environmental, biodiversity and aquaculture issues. In 2020, a total of 30 publications were produced in different media (newspapers, websites, magazines and TV programs) and in 2021 a total of 74 publications were made, including also press releases regarding new projects. **In the following pages, we provide some examples of these interviews-articles that have been published so far.**

ΡΕΠΟΡΤΑΖ 9

Ο Μ. ΜΑΝΔΑΛΑΚΗΣ ΣΤΗΝ "Π"

«Οι λαγοκέφαλοι ήρθαν για να μείνουν στην Κρήτη»

Η αξιοποίηση των σπόγγων

Interview of Dr. E. Mandalakis, presenting his research on using the rabbit fish to extract valuable compounds.

ΔΙΑΤΡΟΦΗ

Η ταυτότητα του ΙΘΑΒΒΥΚ

Το Ινστιτούτο Θαλάσσιας Βιολογίας, Βιοτεχνολογίας & Υδατοκαλλιεργειών (ΙΘΑΒΒΥΚ) είναι ένα από τα τρία ινστιτούτα του Ελληνικού Κέντρου Θαλασσίων Ερευνών (ΕΛΚΕΘΕ) με έδρα το Ηράκλειο Κρήτης και εγκαταστάσεις σε Ανάβυσσο Αττικής και Σούδα Χανίων. Με προσωπικό 120 ατόμων και 27 τακτικούς ερευνητές, δραστηριοποιείται στη θαλάσσια βιοποικιλότητα, γενετική και γενωμική, και στις υδατοκαλλιέργειες.


Ο Κρίτων Γρηγοράκης


Ο Κωνσταντίνος Μυλωνάς

ΤΩΝ
ΚΩΝΣΤΑΝΤΙΝΟΥ ΜΥΛΩΝΑ, ΚΡΙΤΩΝΟΣ ΓΡΗΓΟΡΑΚΗ

ΨΑΡΙ ΠΕΛΑΓΙΣΙΟ Ή ΙΧΘΥΟΚΑΛΛΙΕΡΓΕΙΑΣ;


Μαγιάτικο, το νέο είδος εκτροφής της ελληνικής ιχθυοκαλλιέργειας, αποτέλεσμα ερευνητικών προγραμμάτων του ΕΛΚΕΘΕ

Το **ερώτημα** που **όλοι θέτουμε** στον εαυτό μας, **απαντημένο από τους ειδήμονες** οι οποίοι γνωρίζουν καλά την **ποιότητα** των **ψαριών** που **παράγονται στην Ελλάδα**

Ακούμε συχνά ότι τα άγρια ψάρια είναι καλύτερα από τα εκτρεφόμενα στις υδατοκαλλιέργειες και ότι οι καταναλωτές γενικά προτιμούν τα άγρια. Αυτό συμβαίνει γιατί μέχρι μόλις τα μέσα του 20ού αιώνα, περισσότερο από το 95% των «ιχθυηρών» (ψάρια, όστρακα, μαλάκια, καρκινοειδή, φύκια, κ.τ.λ.) που καταναλώναμε παγκοσμίως ήταν προϊόν ερασιτεχνικής και επαγγελματικής αλιείας. Ο καταναλωτής δεν έχει συνηθίσει ακόμα στην ιδέα της «ιχθυοκαλλιέργειας». Πολύ λίγοι από εμάς έχουν δει φάρμες με ψάρια, ενώ όλοι έχουμε δει στα χωριά μας κτηνοτρόφους να μεγαλώνουν οικόσιτα ζώα. Ετσι, κανείς δεν αμφισβητεί ότι τα κοτόπουλα, πρόβατα, γουρούνια και μοσχάρια προέρχονται από φάρμες, και δεν υπάρχει συζήτηση εάν τα «άγρια» είναι καλύτερα από τα εκτροφής. Αντίθετα, υπάρχει συζήτηση και προτίμηση για την προέλευση του ζώου (ντόπιο κατσίκι, μοσχάρι Αργεντινής) ή τη ράτσα του (Angus ή Charolais μοσχάρια). Για κάποια πολύ γνωστά ήδη ψαριών, όμως, όπως ο σολομός και η πέστροφα, σχεδόν κανείς δεν αναρωτιέται εάν είναι άγρια ή όχι, διότι εξυπακούεται ότι είναι προϊόντα υδατοκαλλιέργειας.

Αρωμα, γεύση, ποιότητα

Είναι όμως γεγονός ότι τα ψάρια από την αλιεία υπερτερούν σε άρωμα και γεύση. Οπως έχουν δείξει «τυφλά τεστ» με καταναλωτές, μια όντως άγρια τσιπούρα χαρακτηρίζεται από αρώματα «φρέσκων καρκινοειδών/γαρίδας» και «φρέσκων φυκιών/θάλασσας» πολύ εντονότερα από αντίστοιχη εκτροφής. Αυτό είναι φυσικό! Σε όλα τα ζώα που αποτελούν τροφή του ανθρώπου, αυτά που μεγαλώνουν στη φύση έχουν καλύτερη γεύση και άρωμα, λόγω της μεγαλύτερης ποικιλίας στην τροφή τους. Ωστόσο ο καταναλωτής ας λάβει υπόψη και άλλα, πιο σημαντικά κριτήρια επιλογής στα οποία τα εκτρεφόμενα ψάρια υπερτερούν ξεκάθαρα των αντίστοιχων αλιευμένων του ιδίου είδους:

α) Τιμή. Τα ψάρια εκτροφής έχουν τιμές που είναι κατά πολύ χαμηλότερες από τα αντίστοιχα αλιευμένα. Επίσης, οι τιμές των αλιευμένων τείνουν να έχουν σταθερά αυξητικές τάσεις, κάτι που δεν συμβαίνει με τα ψάρια εκτροφής.

β) Ασφάλεια του τροφίμου. Στην ιχθυοκαλλιέργεια ελέγχουμε απόλυτα πού εκτρέφονται και με τι τρέφονται τα ψάρια, και οι τροφές τους είναι ελεγμένες για τοξίνες και βαρέα μέταλλα. Αντίθετα, τα άγρια ψάρια μπορούν να εκτίθενται σε διάφορες πηγές ρύπανσης και αυτό είναι πολύ δύσκολο να ελεγχθεί στην αγορά.

γ) Σταθερότητα στην ποιότητα. Ανάλογα με την εποχή, μπορεί να αλλάζει η διατροφική αξία των άγριων ψαριών ανάλογα με τη διαθεσιμότητα τροφής, αλλά και τη φάση της αναπαραγωγής τους. Στην ιχθυοκαλλιέργεια τα ψάρια τρώνε σταθερά και καθημερινά ανάλογα με την όρεξή τους, έτσι η διατροφική τους αξία είναι πιο σταθερή.

δ) Ευζωία του εκτρεφόμενου ψαριού. Τα ψάρια της ιχθυοκαλλιέργειας θανατώνονται άμεσα με όσο δυνατότερο ανώδυνους τρόπους, χωρίς να παλεύουν σε αγκίστρια και να τραυματίζονται σε δίχτυα. Αυτό έχει θετικές επιπτώσεις και στην ποιότητα της σάρκας τους.

ε) Φρεσκότητα. Τα εκτρεφόμενα ψάρια αμέσως μετά την εξαλίευση διατηρούνται πάντα σε θερμοκρασία κάτω των 4ºC μέχρι να φτάσουν στο καλάθι του καταναλωτή. Ετσι η φρεσκάδα τους διατηρείται για περισσότερο χρονικό διάστημα. Επίσης, εξαλιεύονται μόνο όσα ζητά η αγορά και δεν «μένουν στο ράφι» για μεγάλο χρονικό διάστημα.

Συμπερασματικά, κάτω από τις σωστές προδιαγραφές ιχθυοκαλλιέργειας, η ποιότητα των εκτρεφόμενων ψαριών είναι άριστη, εξίσου ή και ανώτερη από κάποια άγρια, αλιευμένα είδη. Ετσι, πιστεύουμε ότι όσο θα ωριμάζουν οι συνθήκες, όσο ο καταναλωτής θα εξοικειώνεται με την ιδέα του εκτρεφόμενου ψαριού και θα πληροφορείται σωστά, θα τείνει να το προτιμά περισσότερο.

Χωρίς αντιβιοτικά!

Υπάρχουν όμως και προκαταλήψεις για τα ψάρια ιχθυοκαλλιέργειας που οφείλονται εν μέρει σε αρνητικά (και αναληθή) δημοσιεύματα. Γίνεται συχνά αναφορά για χρήση αντιβιοτικών, ενώ για το ψάρι υδατοκαλλιέργειας υπάρχει ελάχιστη έως καθόλου χρήση αντιβιοτικών, χωρίς κατάλοιπα στο τρόφιμο. Η ειρωνεία είναι ότι δεν υπάρχουν αντίστοιχης συχνότητας ή επιθετικότητας δημοσιεύματα για μορφές εκτροφής χερσαίων ζώων, όπου αντίθετα γίνεται ευρεία χρήση αντιβιοτικών.

Για την προκατάληψη εναντίον της ιχθυοκαλλιέργειας ευθύνονται εν μέρει και οι ιχθυέμποροι, οι οποίοι έχουν περισσότερο κέρδος από τα άγρια ψάρια και τα προωθούν περισσότερο. Επίσης, τις μεγάλες τσιπούρες, λαβράκια και κρανιούς (ή μυλοκόπια) που προέρχονται από την ιχθυοκαλλιέργεια (3-4 χρόνων, περίπου 1 κιλό σε βάρος) τα πουλάνε σαν «πελαγίσια» ή «αλανιάρικα» και σε τιμές παρόμοιες με τα άγρια ψάρια, δημιουργώντας έτσι την εντύπωση στον καταναλωτή ότι τα άγρια είναι γενικά ανώτερα από αυτά της ιχθυοκαλλιέργειας. Αυτά τα ψάρια όμως δεν διαφέρουν σε τίποτα (εκτός από την ηλικία και το μέγεθός τους) από τα μικρότερα ψάρια ιχθυοκαλλιέργειας, και έχουν την ίδια διατροφική αξία αφού προέρχονται από ακριβώς τις ίδιες μονάδες ιχθυοκαλλιέργειας και τρέφονται ακριβώς με τις ίδιες τροφές!

Ο δρ Κωνσταντίνος Μυλωνάς είναι διευθυντής ερευνών και διευθυντής του Ινστιτούτου Θαλάσσιας Βιολογίας, Βιοτεχνολογίας & Υδατοκαλλιεργειών (ΙΘΑΒΒΥΚ) και ο δρ Κρίτων Γρηγοράκης είναι διευθυντής ερευνών του ΙΘΑΒΒΥΚ.

ΕΥΚΟΛΑ ΣΤΟ ΠΙΑΤΟ ΕΝΑ ΥΨΗΛΗΣ ΠΟΙΟΤΗΤΑΣ ΤΡΟΦΙΜΟ

Μέχρι μόλις πριν από 70 χρόνια, σχεδόν 100% των «ιχθυηρών» ήταν προϊόν ερασιτεχνικής και επαγγελματικής αλιείας. Μετά από ραγδαία ανάπτυξη δεκαετιών, σήμερα το 52% των ιχθυηρών που καταναλώνονται παγκοσμίως προέρχεται από την υδατοκαλλιέργεια (Παγκόσμιος Οργανισμός Τροφίμων των Ηνωμένων Εθνών, www.fao.org)! Αφού οι ωκεανοί, τα ποτάμια και οι λίμνες μας υπεραλιεύονται για δεκαετίες τώρα και δεν μπορούν να παραγάγουν περισσότερα αλιεύματα, είναι σίγουρο ότι αυτό το ποσοστό θα αυξηθεί ακόμα περισσότερο. Η κατανάλωση ιχθυηρών επίσης αυξάνεται συνεχώς, λόγω της άριστης διατροφικής τους αξίας και των ευεργετικών για την υγεία μας ιδιοτήτων τους. Ειδικά τα θαλασσινά ψάρια είναι πολύ σημαντικά για την ανάπτυξη και υγεία του εγκεφάλου και του καρδιαγγειακού συστήματος, λόγω της περιεκτικότητάς τους σε ω-3 λιπαρά οξέα και ιχνοστοιχεία.

Στην Ελλάδα, το 62% των ιχθυηρών παράγονται από την υδατοκαλλιέργεια, η οποία αποτελεί τον πρώτο εξαγωγικό κλάδο ζωικής παραγωγής, συμβάλλοντας θετικά στο εμπορικό ισοζύγιο της χώρας. Επίσης, ο τομέας εργοδοτεί περίπου 12.000 εργαζόμενους κυρίως σε απομακρυσμένες και νησιωτικές περιοχές της ελληνικής επικράτειας, γεγονός που συμβάλλει σημαντικά στην οικονομική ανάπτυξη των τοπικών κοινωνιών. Η ιχθυοκαλλιέργεια έδωσε τη δυνατότητα στον καταναλωτή να βάλει στη καθημερινή του διατροφή αυτό το υψηλής ποιότητας τρόφιμο σε πολύ ανταγωνιστική τιμή.

Interview of Drs. K. Grigorakis and C.C. Mylonas (**AQUA**), on the value of farmed Mediterranean fish and the Greek aquaculture industry.

Η ΔΡ. ΠΑΝ. ΚΟΥΛΟΥΡΗ ΣΤΗΝ "Π"

Ο άνθρωπος ίσως αποδειχθεί αυτοκαταστροφικός για τον πλανήτη

Της Κατερίνας Μυλωνά

Η εντατική εκμετάλλευση των θαλάσσιων πόρων, η ρύπανση, η παράκτια αστικοποίηση και η κλιματική αλλαγή έχουν οδηγήσει σε μια ραγδαία υποβάθμιση ή και καταστροφή πολλών θαλάσσιων οικοσυστημάτων με αποτέλεσμα την υποβάθμιση της υγείας τόσο του ωκεανού όσο και των ανθρώπων.

Το παραπάνω τονίζει, σε συνέντευξή της στην «Π», η Δρ. Παναγιώτα (Γιολάντα) Κουλούρη, κύρια ερευνήτρια στο Ινστιτούτο Θαλάσσιας Βιολογίας, Βιοτεχνολογίας & Υδατοκαλλιεργειών στο Ελληνικό Κέντρο Θαλάσσιων Ερευνών.

Η ίδια μιλά για το «Θαλάσσιο Γραμματισμό», το πρόγραμμα «Μπλε Σχολεία» και την ανάγκη ενημέρωσης των παιδιών για αυτά τα θέματα.

Η συνέντευξη έχει ως εξής:

Τι εννοούμε όταν λέμε «Θαλάσσιος Γραμματισμός» και ποιο είναι το αντικείμενο της δικής σας έρευνας;

«Ο όρος «Θαλάσσιος Γραμματισμός» αποδίδει στη γλώσσα μας τον αγγλικό όρο "Ocean Literacy". Η καταχρηστική απόδοση του όρου «ocean» στην ελληνική γλώσσα ως «θάλασσα – θαλάσσιος» γίνεται γιατί, ως κάτοικοι της Μεσογείου, είμαστε περισσότερο εξοικειωμένοι με την έννοια της θάλασσας παρά με εκείνη του ωκεανού. Ο γραμματισμός, γενικά, εκφράζει την ικανότητα των ανθρώπων να κατανοούν, να αναλύουν και να χρησιμοποιούν τις γνώσεις που αποκτούν κατά τη διάρκεια της ζωής τους στην καθημερινότητά τους. Αντίστοιχα λοιπόν, ο «Θαλάσσιος Γραμματισμός» δεν έχει να κάνει μόνο με τη γνώση και την κατανόηση του θαλάσσιου περιβάλλοντος αλλά και με την ικανότητα να συζητάμε για σχετικά θέματα, να διαμορφώνουμε αντιλήψεις και να συμμετέχουμε ως πολίτες στη λήψη εμπεριστατωμένων και υπεύθυνων αποφάσεων τόσο για τα παγκόσμια περιβαλλοντικά ζητήματα, όπως η κλιματική αλλαγή, όσο και για απλούστερα καθημερινά, όπως ο περιορισμός των πλαστικών μιας χρήσης.

Η άρρηκτη σχέση της θάλασσας με την επιβίωση του ανθρώπου, καθώς και η άμεση ανάγκη προστασίας της μέσα από την κατανόηση αυτής της σχέσης, αποτελούν βασικούς στόχους του κινήματος του «Θαλάσσιου Γραμματισμού» που ξεκίνησε από τις ΗΠΑ το 2004. Προκειμένου να κατανοήσουμε αυτή την ιδιαίτερη σχέση μας με το θαλάσσιο περιβάλλον, οφείλουμε να γνωρίζουμε ορισμένες βασικές αρχές και θεμελιώδεις έννοιες που καθορίστηκαν στο πλαίσιο μιας μακράς διαδικασίας διαβούλευσης στην οποία συμμετείχαν κορυφαία επιστημονικά ιδρύματα, διεθνείς οργανισμοί για την προστασία του θαλάσσιου περιβάλλοντος και οι εκπαιδευτικοί. Καθορίστηκε δηλαδή το πλαίσιο των γνώσεων που θα πρέπει να αποκτήσει από το σχολείο ένας εγγράμματος ως προς τον ωκεανό άνθρωπος, ενώ παράλληλα δόθηκαν οδηγίες για τον τρόπο διδασκαλίας τους, σε κάθε εκπαιδευτική βαθμίδα. Οι αρχές και έννοιες του «Θαλάσσιου Γραμματισμού» είναι πλέον αποδεκτές από την επιστημονική κοινότητα σε παγκόσμιο επίπεδο και προωθούνται στο ευρύτερο κοινό.

«Η άγνοια, η αδιαφορία και τα συμφέροντα αποτελούν την αιτία των περισσότερων περιβαλλοντικών προβλημάτων που αντιμετωπίζει σήμερα η παγκόσμια κοινότητα», αναφέρει

Το αντικείμενο της έρευνάς μου είναι η θαλάσσια βιολογία/οικολογία. Μελετώ τη βιοποικιλότητα του θαλάσσιου πυθμένα, τη δομή και δυναμική των παράκτιων οικοσυστημάτων, καθώς και τις ανθρωπογενείς επιδράσεις στο θαλάσσιο περιβάλλον. Ωστόσο, τα τελευταία δέκα χρόνια και στο πλαίσιο διαπαιδαγώγησης των παιδιών μου - έχω δυο κόρες 14 και 4 χρονών- αισθάνθηκα την ανάγκη, ασυνείδητα στην αρχή και περισσότερο συνειδητά στη συνέχεια, να τους μεταλαμπαδεύσω τις γνώσεις μου, το ενδιαφέρον μου και την αγάπη μου για τη θάλασσα. Μέσα από αυτή τη διαδικασία, και παράλληλα με τις ερευνητικές μου δραστηριότητες, άρχισα να οργανώνω εκπαιδευτικές δραστηριότητες και να συνεργάζομαι δημιουργικά με εκπαιδευτικούς της πρωτοβάθμιας και δευτεροβάθμιας εκπαίδευσης. Ενδεικτικά, να σας αναφέρω το αποτέλεσμα μιας τέτοιας συνεργασίας που ήταν η συμμετοχή μαθητών/τριών του Δημοτικού Σχολείου Γουρνών Πεδιάδος στο 4ο Εκπαιδευτικό Συμπόσιο Φυκολογίας που πραγματοποιήθηκε στο Ενυδρείο Κρήτης το 2015. Η συμμετοχή των παιδιών με ένα διαδραστικό παραμύθι και με θέμα την εισαγωγή ξενικών ειδών στη Μεσόγειο πήρε το 1ο βραβείο για την επιστημονική και παιδαγωγική του προσέγγιση».

Οι ωκεανοί

Τι θα μας προσφέρει η κατανόηση των ωκεανών και η επίδρασή τους στον άνθρωπο;

«Ο παγκόσμιος Ωκεανός καλύπτει το 71% της επιφάνειας της Γης, παράγοντας περισσότερο από το 50% του οξυγόνου της ατμόσφαιρας, υποστηρίζοντας μια τεράστια ποικιλία ζωής και παρέχοντας τροφή σε ένα μεγάλο τμήμα του παγκόσμιου πληθυσμού. Ως αναπόσπαστο κομμάτι της βιόσφαιρας, ο ωκεανός βρίσκεται σε συνεχή αλληλεπίδραση με την ατμόσφαιρα και την ξηρά επηρεάζοντας το παγκόσμιο κλίμα και επομένως τη ζωή και την καθημερινότητα όλων των ανθρώπων. Ωστόσο, η εντατική εκμετάλλευση των θαλάσσιων πόρων, η ρύπανση, η παράκτια αστικοποίηση και η κλιματική αλλαγή έχουν οδηγήσει σε μια ραγδαία υποβάθμιση ή και καταστροφή πολλών θαλάσσιων οικοσυστημάτων με αποτέλεσμα την υποβάθμιση της υγείας τόσο του ωκεανού όσο και των ανθρώπων. Για να διασφαλιστεί η βιώσιμη χρήση των πόρων του, υπάρχει σήμερα όσο ποτέ η ανάγκη για αυστηρότερους κανονισμούς και στρατηγικές διαχείρισης και κυρίως για υπεύθυνη ατομική συμπεριφορά πολιτών με υψηλό επίπεδο γνώσης, κατανόηση του τρόπου με τον οποίο οι νοοτροπίες και οι αξίες τους συνδέονται άμεσα με την καλή κατάσταση του ωκεανού και έχουν τη θέληση να αναλάβουν δράση για τα θέματα αυτά. Προς αυτή την κατεύθυνση, τα Ηνωμένα Έθνη έχουν ανακηρύξει τη δεκαετία 2021-2030 ως Δεκαετία των Επιστημών του Ωκεανού για την Αειφόρο Ανάπτυξη. Στις αποφάσεις της διεθνούς διάσκεψης των Ηνωμένων Εθνών για τον «Ωκεανό», που πραγματοποιήθηκε στη Νέα Υόρκη το 2017, το άρθρο 13α αναφέρεται ειδικότερα στην ανάγκη στήριξης και προώθησης της εκπαίδευσης στο πλαίσιο των αναλυτικών προγραμμάτων σπουδών με στόχο την ανάπτυξη του θαλάσσιου γραμματισμού και μιας παγκόσμιας κουλτούρας διατήρησης, αποκατάστασης και βιώσιμης χρήσης του ωκεανού. Αναγνωρίζεται το γεγονός ότι τα παιδιά μας εκπροσωπούν τους αυριανούς πολίτες, οι οποίοι θα αναπτύξουν προσωπικές στάσεις και θα λάβουν κρίσιμες αποφάσεις που αναπόφευκτα θα επηρεάσουν τόσο το περιβάλλον όσο και το ίδιο το μέλλον τους».

Ο μεγάλος εχθρός

Ειδικά, η άγνοια είναι ο μεγαλύτερος εχθρός των περιβαλλοντικών εγκλημάτων, μεγάλων ή μικρών;

«Πράγματι, η άγνοια, η αδιαφορία και τα συμφέροντα αποτελούν την αιτία των περισσότερων περιβαλλοντικών προβλημάτων που αντιμετωπίζει σήμερα η παγκόσμια κοινότητα. Στο πλαίσιο μιας διεθνούς έρευνας που βρίσκεται σε εξέλιξη, σε συνεργασία με το Δημοκρίτειο Πανεπιστήμιο Θράκης και την Ευρωπαϊκή Ένωση Θαλάσσιων Εκπαιδευτών, σε διάφορες βαθμίδες της εκπαίδευσης, οι μαθητές/τριες δείχνουν να κατανοούν σε έναν μέτριο βαθμό θέματα των επιστημών της θάλασσας, έχοντας αρκετές παρανοήσεις σχετικά με τα φυσικοχημικά χαρακτηριστικά και τον κύκλο του νερού, τις επιπτώσεις των ανθρώπινων παρεμβάσεων κ.ά. Πολλές από αυτές τις παρανοήσεις δε σχετίζονται αυστηρά με άγνοια, αλλά με μια υποκειμενική αντίληψη του στενού περιβάλλοντος στο οποίο διαβιούν και όχι σε μια ουσιαστική κατανόηση του μεγέθους και της κρισιμότητας των παγκόσμιων περιβαλλοντικών προβλημάτων.

Η Δρ. Γιολάντα Κουλούρη μιλά στην «Π» για το «Θαλάσσιο Γραμματισμό» και τα «Μπλε Σχολεία»

Η προώθηση του «Θαλάσσιου Γραμματισμού» είναι εξαιρετικά σημαντική σε όλες τις βαθμίδες της εκπαίδευσης αλλά και στο πλαίσιο της δια βίου μάθησης. Τα παιδιά είναι φορείς κοινωνικής αλλαγής που με τη γνώση, τη στάση και τη συμπεριφορά τους θα επηρεάσουν αντίστοιχα τις γνώσεις, τις στάσεις και τις συμπεριφορές των οικογενειών τους, των φίλων και της ευρύτερης κοινωνίας. Τα παιδιά διατηρούν μια έμφυτη περιέργεια για τον φυσικό κόσμο, οπότε είναι εξαιρετικά σημαντικό οι εκπαιδευτικοί, με την υποστήριξη των επιστημόνων, να στρέψουν την προσοχή τους σε θέματα σχετικά με τον ωκεανό και την προστασία του, δίνοντας ανάλογες προοπτικές και κατευθύνσεις στα αναλυτικά προγράμματα σπουδών».

Τα Μπλε Σχολεία

Το δίκτυο των «Μπλε σχολείων» πού αποσκοπεί;

«Οι περιορισμένες γνώσεις των μαθητών/τριών σχετικά με τον ωκεανό θα μπορούσαν να αποδοθούν στο γεγονός ότι τέτοια θέματα δεν αποτελούν βασικό τμήμα των αναλυτικών προγραμμάτων σπουδών. Στα εγχειρίδια των σχολείων της πρωτοβάθμιας και δευτεροβάθμιας εκπαίδευσης υπάρχουν αναφορές στα θαλάσσια οικοσυστήματα και τις ανθρωπογενείς επιδράσεις, ωστόσο η προσέγγιση των θεμάτων αυτών παραμένει επιφανειακή και κατακερματισμένη.

Επιπλέον, οι πρωτοβουλίες πολλών εκπαιδευτικών με έντονο ενθουσιασμό για τη διεξαγωγή προγραμμάτων περιβαλλοντικής εκπαίδευσης δεν μπορούν να ανταποκριθούν στις ανάγκες για μια ουσιαστική εκπαίδευση σε θέματα που αφορούν τον ωκεανό. Αρκετές διεθνείς αλλά και δικές μας έρευνες, δείχνουν ότι η συμμετοχή των μαθητών/τριών σε περιβαλλοντικά προγράμματα, οι επισκέψεις σε ενυδρεία και η συνεργασία των σχολείων με επιστημονικούς φορείς συμβάλλει σημαντικά στο υψηλότερο επίπεδο γνώσεων τους για τα ζητήματα αυτά.

Προς την κατεύθυνση αυτή, έχει αναπτυχθεί τελευταία και με την υποστήριξη της Ευρωπαϊκής Ένωσης το Δίκτυο των "Μπλε Σχολείων" που αποτελεί παγκοσμίως έναν από τους κύριους στόχους της επόμενης δεκαετίας. Το ΕΛΚΕΘΕ συμμετέχει σε ένα ανταγωνιστικό ευρωπαϊκό πρόγραμμα, μαζί με επιστημονικούς φορείς και σχολεία από 4 τέσσερις μεσογειακές χώρες (Γαλλία, Ιταλία, Ελλάδα και Μάλτα). Στόχος του προγράμματος είναι η επιστημονική υποστήριξη εκπαιδευτικών της πρωτοβάθμιας και δευτεροβάθμιας εκπαίδευσης στο πλαίσιο των αναλυτικών προγραμμάτων σπουδών και σχολικών δραστηριοτήτων ώστε να διερευνήσουν μαζί με τους μαθητές/τριές τους, θέματα σχετικά με το θαλάσσιο περιβάλλον και να επικοινωνήσουν τα ευρήματά τους στο ευρύτερο κοινό. Στο πλαίσιο του συγκεκριμένου προγράμματος τέσσερα σχολεία της Ελλάδας (ένα στην Κρήτη) θα γίνουν τα πρώτα "Μπλε Σχολεία" στη χώρα μας με αξιολόγηση από το αντίστοιχο Ευρωπαϊκό Δίκτυο.

Γενικότερα, οι επιστήμονες του ΕΛΚΕΘΕ εδώ και πολλά χρόνια οργανώνουν σε εθελοντική βάση εκπαιδευτικές δραστηριότητες συμβάλλοντας στη διαδικασία μεταφοράς της γνώσης και εξειδίκευσης πάνω σε θέματα που αφορούν το θαλάσσιο περιβάλλον. Το Ενυδρείο της Κρήτης και ο Υδροβιολογικός Σταθμός της Ρόδου του ΕΛΚΕΘΕ αποτελούν επίσης σημαντικά κέντρα διάχυσης της γνώσης για τη θαλάσσια έρευνα. Επιπλέον, οι επιστήμονες του ΕΛΚΕΘΕ συντονίζουν και συμμετέχουν σε δράσεις προγραμμάτων που προϋποθέτουν τη συμμετοχή των πολιτών και έχουν στόχο την ενημέρωση και ευαισθητοποίηση του ευρύτερου κοινού για την προστασία και διατήρηση του θαλάσσιου περιβάλλοντος».

"Διαταράξαμε την ισορροπία"

Αν η κατάσταση συνεχίσει ως έχει, ποιο πιστεύετε πως θα είναι το μέλλον των θαλασσών μας;

«Πιστεύω πως αν τα σύγχρονα περιβαλλοντικά προβλήματα όπως η ρύπανση, η κλιματική αλλαγή, η υπεραλίευση, καθώς και η συστηματική υποβάθμιση των περισσότερων θαλάσσιων οικοσυστημάτων συνεχίσουν με την ίδια ένταση και έκταση, τότε το πιθανότερο σενάριο, που δυστυχώς πολλοί/ές εξακολουθούν να θεωρούν ως επιστημονική φαντασία, είναι η προοδευτική εξαφάνιση της ζωής από τον πλανήτη μας. Βλέπετε, το είδος μας «κατόρθωσε» τα τελευταία χρόνια να διαταράξει την οικολογική ισορροπία σε κάθε γωνιά της Γης και αναπόφευκτα έρχεται η ώρα να εισπράξει τα αποτελέσματα της καταστροφικής επιρροής του. Ποια θα είναι η συνέχεια; Πιθανότατα ό,τι συνέβη και με την εξαφάνιση των δεινοσαύρων. Η ζωή στον πλανήτη Γη θα εξακολουθήσει ενδεχομένως να υπάρχει με άλλες κυρίαρχες μορφές ζωής. Η διαφορά μας από είδη τα οποία έχουν ήδη εξαφανιστεί ή απειλούνται με εξαφάνιση είναι ότι είμαστε το μοναδικό είδος στην εξελικτική πορεία της ζωής που δρώντας τόσο βιοκεντρικά (π.χ. αξίες, ιδανικά) όσο και ανθρωποκεντρικά (π.χ. ένστικτα) επηρεάζουμε σε τέτοιο βαθμό το περιβάλλον μας ώστε να έχουμε τη δυνατότητα είτε να το προστατεύσουμε ή να το καταστρέψουμε με τη δική μας θέληση.

Ωστόσο, κοιτώντας στα μάτια τα παιδιά μας, τη «Γενιά του Ωκεανού», όπως κάποιοι/ες λίγοι/ες προς το παρόν θέλουμε να τα ονομάζουμε, αισιοδοξώ ότι θα καταφέρουν τελικά να «βουτήξουν και να κολυμπήσουν» σε έναν καλύτερο κόσμο και προς ένα ασφαλέστερο μέλλον».

Τραγικό ρεκόρ με περισσότερες από 700 νεκρές χελώνες

Περισσότερες από 700 νεκρές χελώνες καταγράφηκαν φέτος στη χώρα μας, αναφέρει ο «ΑΡΧΕΛΩΝ», καλώντας όλους σε εγρήγορση εν όψει της θερινής περιόδου. Η Οργάνωση κάνει λόγω για ένα τραγικό ρεκόρ, καθώς πρόκειται για τις περισσότερες από κάθε άλλη χρονιά από την έναρξη λειτουργίας του Δικτύου Διάσωσης το 1992. Τυχαίες συλλήψεις σε αλιευτικά εργαλεία και πλαστικά απορρίμματα αποτελούν τις κύριες απειλές στη θάλασσα.

Όπως κάνει γνωστό η Οργάνωση, κάθε χρόνο φτάνουν στο Κέντρο Διάσωσης Θαλάσσιων Χελωνών του «ΑΡΧΕΛΩΝ» στη Γλυφάδα όλα τα «Δελτία Εκθαλάσσωσης» που αφορούν θαλάσσιες χελώνες από τις κατά τόπους λιμενικές Αρχές όλης της χώρας, μαζί με φωτογραφίες και άλλα σχετικά στοιχεία.

«Για πρώτη χρονιά από το 1992, που ιδρύθηκε από τον «ΑΡΧΕΛΩΝ» το Εθνικό Δίκτυο Διάσωσης θαλάσσιων χελωνών, οι αναφορές των εκβρασμών νεκρών χελωνών ξεπέρασαν τις 700. Τα προηγούμενα χρόνια οι αναφορές κυμαίνονταν από 500-600 ανά έτος. Οι ερευνητές/εθελοντές που υποστηρίζουν το Δίκτυο Διάσωσης, εξετάζουν συστηματικά κάθε περίπτωση εκβρασμού, με σκοπό την καλύτερη οργάνωση του Δικτύου και την αξιολόγηση των απειλών που αντιμετωπίζουν οι θαλάσσιες χελώνες ανά περιοχή», υπογραμμίζει.

Όπως αναφέρει ο «ΑΡΧΕΛΩΝ», οι αιτίες θανάτου των χελωνών σχετίζονται κυρίως με τις τυχαίες συλλήψεις χελωνών σε αλιευτικά εργαλεία, την κατάποση πλαστικών, την παγίδευση σε πλαστικά απορρίμματα στη θάλασσα και την σύγκρουση με ταχύπλοα σκάφη αναψυχής.

Όμως, σύμφωνα πάντα με τον «ΑΡΧΕΛΩΝ», συχνά δεν είναι δυνατόν να διαπιστωθεί το αίτιο θανάτου, ειδικά αν έχει επέλθει σήψη. Επίσης, δεν είναι δυνατόν να εντοπιστεί η ακριβής περιοχή που υπήρξε συγκεκριμένο πρόβλημα,

καθώς τα ρεύματα και τα κύματα μπορεί να παρασύρουν τα νεκρά ζώα σε μακρινές αποστάσεις.

Στις περιπτώσεις που τα εκβρασμένα ζώα φέρουν εμφανή τραύματα στο κεφάλι ή στο καβούκι, είναι δυνατόν αυτά να έχουν προέλθει από σύγκρουση με σκάφος ή σκόπιμο τραυματισμό από ανθρώπους. Επίσης, η αλληλεπίδραση με αλιευτικά εργαλεία (δίχτυα, παραγάδια) είναι δυνατόν κάποιες φορές να αφήσει εξωτερικά σημάδια που καθορίζουν την αιτία θανάτου. Πολλές φορές όμως δεν υπάρχουν εμφανή τραύματα ή σημάδια στα νεκρά ζώα, οπότε τα συμβάντα παραπέμπουν σε πνιγμό μετά από τυχαία σύλληψη σε αλιευτικά εργαλεία ή σε κατάποση πλαστικών που οδηγεί σε αργό θάνατο, καθώς το γαστρεντερικό τους σύστημα δεν μπορεί να επεξεργαστεί το πλαστικό.

Σύμφωνα πάντα με την Οργάνωση, είναι χαρακτηριστικά τα περιστατικά ομαδικών εκβρασμών νεκρών χελωνών σε εκτεταμένα αλιευτικά πεδία, όπως πολύ πρόσφατα στον Κυλλήνιο κόλπο στη Δυτική Ελλάδα, αλλά και στις ακτές του Θρακικού πελάγους πριν μερικά χρόνια. Τέτοιες περιπτώσεις είναι πιθανό να οφείλονται στις «καλάδες» από μηχανότρατες, που λόγω του ομαλού βυθού διαρκούν πολύ χρόνο και δεν επιτρέπουν στις παγιδευμένες χελώνες να αναδυθούν για να αναπνεύσουν. Όταν οι νεκρές χελώνες εκβραστούν στην ακτή, είναι συνήθως πολύ αργά για να αποδοθούν ευθύνες σε συγκεκριμένα σκάφη.

Τι να κάνεις σε περίπτωση εκβρασμού νεκρής θαλάσσιας χελώνας

Ενημερώνεις την πλησιέστερη Λιμενική Αρχή, έτσι ώστε να γίνει η καταγραφή του συμβάντος με τη συμπλήρωση ειδικού εντύπου (Δελτίο Εκθαλάσσωσης). Αν είναι δυνατόν, καλείται και ο νομοκτηνίατρος για να διαπιστωθεί ο θάνατος και η αιτία που τον προκάλεσε. Η λιμενική Αρχή είναι αρμόδια να καλέσει την Υπηρεσία του Δήμου για την υγειονομική ταφή.

Παρακολουθήστε σε αυτό το ΒΙΝΤΕΟ (https://www.youtube.com/watch?v=ZT_i_0RwIKM)σχετικές οδηγίες από τον ΑΡΧΕΛΩΝ σε περίπτωση που βρείτε τραυματισμένη ή άρρωστη θαλάσσια χελώνα.

Interview of Dr. Y. Koulouri (**MB&B**), on marine ecosystems and Ocean Literacy actions.

ΩΚΕΑΝΟΓΡΑΦΙΑ

ΓΝΩΜΗ

Η ΚΛΙΜΑΤΙΚΗ ΑΛΛΑΓΗ ΣΤΟ ΘΑΛΑΣΣΙΟ ΠΕΡΙΒΑΛΛΟΝ

ΤΗΣ ΕΥΑΓΓΕΛΙΑΣ ΧΑΤΖΗΝΙΚΟΛΑΟΥ

Οι ωκεανοί καλύπτουν το 71% του πλανήτη μας. Γιατί όμως είναι τόσο σημαντικό για τον άνθρωπο το θαλάσσιο περιβάλλον; Οι ωκεανοί παρέχουν το 50% του οξυγόνου στον πλανήτη, παρέχουν τροφή εξαιρετικής ποιότητας που αντιστοιχεί στο 16% της ζωικής πρωτεΐνης που καταναλώνεται παγκοσμίως, φιλοξενούν ένα τεράστιο αριθμό ειδών συμβάλλοντας στην αύξηση της βιοποικιλότητας και επιπλέον προσφέρουν πεδίο εργασίας σε πάνω από 40 εκατομμύρια ανθρώπους παγκοσμίως.

Μια ακόμα σημαντική λειτουργία του θαλάσσιου περιβάλλοντος είναι η συμβολή του στη ρύθμιση του κλίματος. Οι ωκεανοί απορροφούν τεράστιες ποσότητες θερμότητας από την ατμόσφαιρα και συμβάλλουν έτσι κατά 90% στη ρύθμιση της θερμοκρασίας του πλανήτη. Μικρές διακυμάνσεις στη θερμοκρασία έχουν παρατηρηθεί και στο παρελθόν, όμως στην παρούσα φάση η αυξητική τάση είναι υψηλότερη και ταχύτερη. Τα τελευταία 30 χρόνια αποτέλεσαν τη θερμότερη περίοδο των τελευταίων 1.400 χρόνων και η θερμοκρασία αυξάνεται περίπου κατά 0,85 βαθμούς Κελσίου ετησίως. Η αύξηση της θερμοκρασίας στην επιφάνεια του πλανήτη περιγράφεται με τον όρο «κλιματική αλλαγή» και οφείλεται στο φαινόμενο του θερμοκηπίου. Η αυξημένη ποσότητα ρυπογόνων αερίων που παράγονται από ανθρωπογενείς δραστηριότητες εγκλωβίζονται στην ατμόσφαιρα και απορροφούν την ηλιακή ενέργεια που αντανακλάται από την επιφάνεια της Γης, προκαλώντας έτσι μεγαλύτερη αύξηση της θερμοκρασίας. Ενδεικτικά αναφέρεται ότι το διοξείδιο του άνθρακα στην ατμόσφαιρα έχει αυξηθεί κατά 40% από τον 18ο αιώνα μέχρι σήμερα.

Ξινό νερό!

Μια λιγότερο γνωστή επίπτωση της κλιματικής αλλαγής είναι η λεγόμενη οξίνιση των ωκεανών. Το επιπλέον διοξείδιο του άνθρακα που καταλήγει στην ατμόσφαιρα από τις ανθρωπογενείς εκπομπές απορροφάται από την επιφάνεια της θάλασσας, με αποτέλεσμα να διαταράσσεται η χημική ισορροπία των ανθρακικών ιόντων και των ιόντων υδρογόνου. Όταν τα ιόντα υδρογόνου αυξάνονται, τότε η θάλασσα γίνεται περισσότερο όξινη. Ακόμα και αν αυτές οι μεταβολές μάς φαίνονται αμελητέες (π.χ. της τάξης των 0,1 μονάδων στην κλίμακα του pH), στην πραγματικότητα δεν είναι. Σύμφωνα με τη Διακυβερνητική Ομάδα για την Κλιματική Αλλαγή (IPCC), μέχρι το τέλος του αιώνα αναμένεται επιπλέον αύξηση της οξύτητας στους ωκεανούς κατά 0,3-0,5 μονάδες αν δεν υπάρξει καμία πτωτική τάση στις ανθρωπογενείς εκπομπές. Οι επιστήμονες έχουν διαπιστώσει πόσο δραματικές συνέπειες μπορεί να έχει η μικρή αυτή αύξηση της οξύτητας για τους θαλάσσιους οργανισμούς και ιδιαίτερα για αυτούς που κατασκευάζουν το κέλυφος ή τον σκελετό τους από ανθρακικό ασβέστιο (π.χ. θαλάσσια σαλιγκάρια, δίθυρα όστρακα, κοράλλια). Η χαμηλή συγκέντρωση ανθρακικών ιόντων έχει ως αποτέλεσμα τη μειωμένη σύνθεση νέου κελύφους ή την αυξημένη διάβρωση του υπάρχοντος. Έτσι οι οργανισμοί αυτοί έχουν λιγότερο ανθεκτικά όστρακα με αποτέλεσμα να είναι πιο επιρρεπείς στους θηρευτές και οι πληθυσμοί τους να μειώνονται. Τόσο ο οικολογικός ρόλος όσο και η οικονομική αξία των οργανισμών αυτών είναι ιδιαίτερα σημαντικά. Επηρεάζουν τη δομή και τις λειτουργίες του οικοσυστήματος, αποτελούν βασικό κρίκο της τροφικής αλυσίδας και είναι οι «καθαριστές» του θαλάσσιου περιβάλλοντος. Πολλά είδη είναι βρώσιμα και έχουν σημαντικό οικονομικό ενδιαφέρον καθώς αποτελούν το 75,5% της παγκόσμιας παραγωγής της θαλάσσιας υδατοκαλλιέργειας (13,9 εκατομμύρια τόνοι για το 2012, FAO).

> *Η οξίνιση των ωκεανών, αποτέλεσμα της αύξησης του διοξειδίου του άνθρακα στην ατμόσφαιρα, αλλάζει μεταξύ άλλων και τις ισορροπίες στην τροφική αλυσίδα καθιστώντας ευάλωτους τους οργανισμούς που φέρουν κέλυφος*

Πειραματική απόδειξη

Τα τελευταία χρόνια στο Ινστιτούτο Θαλάσσιας Βιολογίας, Βιοτεχνολογίας και Υδατοκαλλιεργειών (ΙΘΑΒΒΥΚ) του Ελληνικού Κέντρου Θαλασσίων Ερευνών (ΕΛΚΕΘΕ) πραγματοποιούνται πειράματα σε ελεγχόμενες συνθήκες στο εργαστήριο. Τα πειράματα αυτά έχουν σκοπό να διερευνήσουν την επίδραση της κλιματικής αλλαγής και της οξίνισης των ωκεανών στους θαλάσσιους οργανισμούς και πιο συγκεκριμένα στην ανάπτυξή τους, στην αναπαραγωγική τους δραστηριότητα και στη συμπεριφορά τους κατά την εύρεση τροφής ή την αποφυγή των θηρευτών τους. Οι διεργασίες αυτές είναι ζωτικής σημασίας για την επιβίωση των ειδών και τη διατήρηση της βιοποικιλότητας των κοινωνιών τους. Η συγκεκριμένη έρευνα επί του παρόντος χρηματοδοτείται από το έργο ECCO στο πλαίσιο του ΕΛΙΔΕΚ για την ενίσχυση των μεταδιδακτορικών ερευνητών.

Στις εγκαταστάσεις του ΙΘΑΒΒΥΚ στο Ηράκλειο της Κρήτης φιλοξενείται ένας αξονικός μικροτομογράφος μεγάλης διακριτικής ικανότητας που μας δίνει τη δυνατότητα να δημιουργήσουμε τρισδιάστατες εικόνες από τα κελύφη των οργανισμών και να διαπιστώσουμε τυχόν διαφοροποιήσεις τους. Με τη χρήση του εξοπλισμού αυτού μπορούμε να μελετήσουμε την εξωτερική μορφολογία και ιχνη του κελύφους, την πυκνότητά του, καθώς ακόμα και τυχόν διαφοροποιήσεις στο σχήμα του.

Έτσι, για παράδειγμα, το θαλάσσιο σαλιγκάρι που φαίνεται στη δεξιά πλευρά της εικόνας έχει αναπτυχθεί σε συνθήκες υψηλότερης οξύτητας και θερμοκρασίας για ένα περιορισμένο χρονικό διάστημα τριών μηνών. Παρ' όλα αυτά, όμως, οι διαφοροποιήσεις στο κέλυφός του είναι εμφανείς σε σχέση με τον οργανισμό του ίδιου είδους αριστερά που έχει αναπτυχθεί σε φυσιολογικές συνθήκες. Στη δεξιά εικόνα, η κορυφή του οστράκου είναι κατεστραμμένη, τα χαρακτηριστικά αυλάκια στην επιφάνειά του έχουν λειανθεί και διακρίνονται περιοχές που είναι πολύ λεπτές, σχεδόν διαφανείς.

Η δρ Ευαγγελία Χατζηνικολάου είναι συνεργαζόμενη ερευνήτρια στο Ινστιτούτο Θαλάσσιας Βιολογίας, Βιοτεχνολογίας & Υδατοκαλλιεργειών (ΙΘΑΒΒΥΚ) του Ελληνικού Κέντρου Θαλασσίων Ερευνών (ΕΛΚΕΘΕ).

Το μέλλον μας εξαρτάται από τους ωκεανούς

Οι ωκεανοί προσφέρουν πολύτιμες υπηρεσίες, όπως η ρύθμιση του κλίματος, η απορρόφηση των ατμοσφαιρικών ρύπων, η παροχή τροφής, οξυγόνου και ανανεώσιμων πηγών ενέργειας, καθώς και οφέλη που αφορούν την ευζωία, τον τουρισμό, το εμπόριο και τις μετακινήσεις. Σύμφωνα με την Περίληψη για τους Φορείς Χάραξης Πολιτικής που εκδόθηκε από το IPCC το 2019, οι ωκεανοί έχουν ήδη απορροφήσει το 90% της περίσσειας θερμότητας του κλιματικού συστήματος από το 1970, ενώ ο ρυθμός αύξησης της θερμοκρασίας και η συχνότητα των κυμάτων καύσωνα έχουν διπλασιαστεί τα τελευταία 30-40 χρόνια. Η πρόβλεψη μέχρι το τέλος του 21ου αιώνα αναφέρει περαιτέρω αύξηση της θερμοκρασίας και της οξύτητας και μείωσης του οξυγόνου στους ωκεανούς καθώς και αύξηση των ακραίων καιρικών φαινομένων. Η πρόκληση για την αντιμετώπιση των αρνητικών συνεπειών είναι σημαντική σε παγκόσμιο επίπεδο. Η υιοθέτηση των Στόχων για τη Βιώσιμη Ανάπτυξη των Ηνωμένων Εθνών αποτελεί μονόδρομο για την αποτελεσματική διαχείριση και εξομάλυνση των αρνητικών συνεπειών στα φυσικά οικοσυστήματα και κατ' επέκταση στον άνθρωπο με βασικό στόχο τη μείωση των εκπομπών διοξειδίου του άνθρακα.

Interview of Dr. E. Chatzinikolaou (**MB&B**), on the effects of Climate Change on marine ecosystems.

ΠΑΤΡΙΣ ΤΕΤΑΡΤΗ 26 ΜΑΪΟΥ 2021
ΣΥΝΕΝΤΕΥΞΗ 9

Ο Δρ. ΠΑΝΑΓΙΩΤΗΣ ΚΑΣΑΠΙΔΗΣ ΣΤΗΝ "Π"

Πόσο δραματικές είναι οι αλλαγές στις θάλασσές μας

Ο Δρ. Παναγιώτης Κασαπίδης

Συνέντευξη στην **Κατερίνα Μυλωνά**

Μία σταγόνα νερό μπορεί να μας δώσει εκατομμύρια πληροφορίες! Ο Δρ. Παναγιώτης Κασαπίδης, κύριος ερευνητής στο Ινστιτούτο Θαλάσσιας Βιολογίας, Βιοτεχνολογίας και Υδατοκαλλιεργειών του ΕΛΚΕΘΕ, αναφέρει, σε συνέντευξή του στην «Π»: «Μπορούμε φιλτράροντας λίγα λίτρα θαλασσινού νερού να συλλέξουμε περιβαλλοντικό DNA και να διαπιστώσουμε ποια είδη ψαριών ή άλλων οργανισμών ζουν στην περιοχή που μελετάμε».
Η συνέντευξη έχει ως εξής:

Ανάλυση περιβαλλοντικών δειγμάτων σε γενετικό αναλυτή υψηλής απόδοσης στο ΕΛΚΕΘΕ

Τι πληροφορίες θα μπορούσε να μας δώσει ένα λίτρο νερό για τα είδη που ζουν στις θάλασσές μας;

«Τα τελευταία χρόνια, η ραγδαία ανάπτυξη νέων τεχνολογιών αλληλούχισης ("ανάγνωσης") του DNA μάς έχει δώσει τη δυνατότητα, μεταξύ άλλων, να μπορούμε να προσδιορίσουμε τα είδη των οργανισμών που ζουν σε μια περιοχή απλώς συλλέγοντας και αναλύοντας το DNA τους που βρίσκεται διάσπαρτο στο περιβάλλον. Το DNA αυτό, που το ονομάζουμε "περιβαλλοντικό DNA", απελευθερώνεται με τις απεκκρίσεις των οργανισμών, από νεκρά κύτταρα που αποβάλλονται αλλά και από τους οργανισμούς όταν πεθαίνουν. Έτσι, για παράδειγμα, μπορούμε φιλτράροντας λίγα λίτρα θαλασσινού νερού, να συλλέξουμε περιβαλλοντικό DNA και να διαπιστώσουμε ποια είδη ψαριών ή άλλων οργανισμών ζουν στην περιοχή που μελετάμε. Φυσικά η διαδικασία είναι κάπως πιο σύνθετη: πρέπει να πολλαπλασιάσουμε με τη μέθοδο PCR τμήμα ενός γονιδίου του περιβαλλοντικού DNA από μια ομάδα οργανισμών που μας ενδιαφέρει, όπως τα ψάρια, να "διαβάσουμε" μαζικά αυτά τα κομμάτια DNA με σύγχρονα μηχανήματα αλληλούχισης, να κάνουμε βιοπληροφορική ανάλυση του μεγάλου όγκου δεδομένων που παράγονται και, τέλος να ταυτοποιήσουμε τους οργανισμούς από τους οποίους προέρχονται με το να συγκρίνουμε τα τμήματα DNA με βάσεις δεδομένων DNA.

Για να μπορέσουμε όμως να ταυτοποιήσουμε τα είδη του δείγματός μας με ασφάλεια, θα πρέπει ιδανικά να έχουν χαρακτηριστεί γενετικά όλα τα είδη των οργανισμών ώστε να έχουμε πλήρεις βάσεις δεδομένων, κάτι που ακόμα δεν ισχύει, ειδικά για τους μικρότερους ασπόνδυλους οργανισμούς.

Σε μια εποχή μεγάλων οικολογικών προκλήσεων, τέτοιες μέθοδοι μπορούν να έχουν εφαρμογές στην παρακολούθηση των αλλαγών στην βιοποικιλότητα, που προκαλούνται από παράγοντες όπως η υποβάθμιση των οικοσυστημάτων και η κλιματική αλλαγή, στην έγκαιρη ανίχνευση ξενικών/εισβολικών ειδών και στον εντοπισμό σπάνιων και απειλούμενων ειδών.

Τα τελευταία χρόνια δοκιμάζουμε και αναπτύσσουμε τέτοιες μεθόδους στο ΕΛΚΕΘΕ για διάφορες ομάδες οργανισμών. Πρόσφατα δοκιμάσαμε, νομίζω για πρώτη φορά στην Ελλάδα, αυτή τη μεθοδολογία, για θαλάσσια είδη ψαριών. Χρησιμοποιήσαμε δείγματα νερού που συλλέξαμε από δεξαμενές του Cretaquarium όπου ξέραμε τι είδη ψαριών υπάρχουν και σε τι αφθονία (για να ελέγξουμε το πόσο καλά δουλεύει η μέθοδος), καθώς και από μια παραλία στην Αγία Πελαγία και είχαμε πολύ καλά αποτελέσματα. Στην Αγ. Πελαγία εντοπίσαμε 69 είδη ψαριών, αρκετά από αυτά ξενικά, και κάποια που είναι δύσκολο να εντοπιστούν με κλασικές μεθόδους όπως η αλιεία ή η οπτική παρατήρηση. Σύντομα θα μπορούμε να εφαρμόσουμε αυτή την τεχνική ως ρουτίνα για να παρακολουθούμε συστηματικά τη θαλάσσια βιοποικιλότητα με τρόπο μη παρεμβατικό, γρήγορο, τυποποιημένο και με σχετικά χαμηλό κόστος σε σχέση με συμβατικές μεθόδους».

Τα ξενικά είδη

Όταν μιλάμε για ξενικά είδη, είναι αναπόφευκτα - για να το πούμε απλά - κάτι κακό; Έρχονται οφέλη και ευκαιρίες μέσα από την εισβολή ή έχουμε μονάχα αρνητικές συνέπειες;

«Δεν προκαλούν όλα τα ξενικά είδη βλάβες στο οικοσύστημα. Κάποια όμως από αυτά, που τα ονομάζουμε εισβλητικά ή χωροκατακτητικά, μπορούν να εξαπλωθούν πολύ γρήγορα και να αυξήσουν τους πληθυσμούς τους, να ανταγωνιστούν αυτόχθονα είδη και να τα οδηγήσουν σε εξαφάνιση, αλλά και να προκαλέσουν ευρύτερη οικολογική αλλά και οικονομική βλάβη.

Έχουμε για παράδειγμα εισβλητικά φύκη του γένους Caulerpa, που εξαπλώνονται και "πνίγουν" τα λιβάδια της Ποσειδωνίας, το φυτοφάγο ψάρι "γερμανός" που εισήλθε στη Μεσόγειο πριν αρκετές δεκαετίες, αλλά πρόσφατα έχουν αυξηθεί οι πληθυσμοί του και απογυμνώνει τον βραχώδη βυθό από φύκη, τον λαγόκεφαλο που είναι τοξικό είδος αλλά και δεινός θηρευτής και πολλά άλλα είδη.

Από την άλλη, μπορούν να υπάρξουν και οφέλη: κάποια από τα ξενικά είδη μπορούν να έχουν εμπορική αξία και να προσφέρουν εισόδημα στους αλιείς. Είδη όπως ο γερμανός και το λεοντόψαρο, αν και φέρουν δηλητηριώδεις άκανθες και θέλουν κάποια προσοχή κατά την αλίευση, είναι νόστιμα ψάρια. Το ΕΛΚΕΘΕ έχει αναλάβει δράσεις για να ενημερώσει αλιείς και καταναλωτές για την εμπορική αξία αυτών των ψαριών. Το όφελος είναι διπλό, οικονομικό και οικολογικό, αφού η εμπορική αλίευση αυτών των ειδών θα ελέγξει τους πληθυσμούς τους και θα περιορίσει τις αρνητικές τους επιπτώσεις στο οικοσύστημα.

Μπορεί να υπάρξουν και άλλα οφέλη μεσο-μακροπρόθεσμα. Η συνεχής είσοδος νέων ειδών από την Ερυθρά Θάλασσα στην Ανατολική Μεσόγειο μέσω της διώρυγας του Σουέζ, η επονομαζόμενη λεσεψιανή μετανάστευση, αναμένεται να αντισταθμίσει την απώλεια πιο ψυχρόφιλων ειδών που πιθανώς θα εξαφανιστούν από τη Μεσόγειο λόγω της κλιματικής αλλαγής και της σταδιακής αύξησης της θερμοκρασίας. Βλέπουμε λοιπόν δύο ανθρωπογενείς δράσεις, τη λεσεψιανή μετανάστευση και την κλιματική αλλαγή, που προκαλούν οικολογικές διαταράξεις σε τοπικό και παγκόσμιο επίπεδο, αντίστοιχα, να αντισταθμίζει η πρώτη κάποιες από τις αρνητικές επιδράσεις της δεύτερης.

Κατά τη διαδικασία αυτή θα δούμε και άλλα "ανεπιθύμητα" είδη να εισέρχονται και να προκαλούνται δραματικές αλλαγές στη βιοποικιλότητα και το οικοσύστημα. Γι' αυτό είναι σημαντικό να παρακολουθούμε συστηματικά αυτές τις μεταβολές και οι γενετικές μέθοδοι βιοπαρακολούθησης που σας προανέφερα μπορούν να βοηθήσουν σημαντικά σε αυτό».

Το μέλλον των θαλασσών

Μπορούμε να προβλέψουμε πώς θα είναι οι θάλασσές μας τα επόμενα 10 χρόνια; Οι όποιες αλλαγές θα έρθουν πιο γρήγορα, θα είναι ορατές στον καθένα μας;

«Όπως και στη μετεωρολογία, για να μπορέσουμε να κάνουμε ακριβείς προβλέψεις, πρέπει να έχουμε πολλά και καλής ποιότητας δεδομένα που να συλλέγονται συστηματικά, σε βάθος χρόνου και που θα τροφοδοτούν μοντέλα πρόβλεψης. Αφενός δεν διαθέτουμε ακόμα αρκετά δεδομένα, αφετέρου τα οικοσυστήματα είναι ιδιαίτερα πολύπλοκα συστήματα για να μπορούμε να τα μοντελοποιήσουμε πλήρως και να κάνουμε ακριβείς προβλέψεις.

Παρόλα ταύτα, όσον αφορά την κλιματική αλλαγή και τις επιπτώσεις της στα οικοσυστήματα, υπάρχουν μοντέλα που προβλέπουν, βάσει σεναρίων, το πόσο γρήγορα θα αυξηθεί η θερμοκρασία, πώς θα επηρεάσει την γεωγραφική κατανομή των ειδών και την παραγωγικότητα των οικοσυστημάτων, πόσο θα ανέβει η στάθμη των θαλασσών.

Πιθανώς μέσα στην επόμενη δεκαετία να μην δούμε ακόμα δραματικές αλλαγές στις θάλασσες και τις ακτές της περιοχής μας λόγω της κλιματικής αλλαγής, αλλά από το 2030 και μετά οι αλλαγές μπορεί να είναι ραγδαίες και οι υπέροχες παραλίες της Κρήτης να αρχίσουν σταδιακά να εξαφανίζονται με την άνοδο της στάθμης της θάλασσας.

Από την άλλη, λόγω της λεσεψιανής μετανάστευσης που έχει ενταθεί τα τελευταία χρόνια, κυρίως λόγω της διαπλάτυνσης και εκβάθυνσης της διώρυγας του Σουέζ, θα βλέπουμε συνεχώς νέα είδη. Σκεφτείτε ότι πριν 15 χρόνια δεν υπήρχαν λαγοκέφαλοι στην Κρήτη και πριν 5 χρόνια δεν βλέπαμε λεοντόψαρα, ενώ τώρα οι ψαράδες τα αλιεύουν συστηματικά και με μια απλή κατάδυση μπορεί ο καθένας να δει αρκετά είδη που δεν υπήρχαν στην περιοχή μας πριν λίγα χρόνια.

Επιπλέον, τα επόμενα χρόνια, ίσως και μέσα στα επόμενα 10 χρόνια, αναμένεται να αναπτυχθούν και να ενταθούν οικονομικές δραστηριότητες στο θαλάσσιο περιβάλλον και της περιοχής μας, όπως οι υποθαλάσσιες εξορύξεις και η ανάπτυξη υπεράκτιων ανεμογεννητριών και υδατοκαλλιεργειών που θα αλλάξουν το θαλάσσιο τοπίο. Ειδικά οι υποθαλάσσιες εξορύξεις, και δεν αναφέρομαι μόνο στην άντληση πετρελαίου και φυσικού αερίου, αλλά και στην εξόρυξη μεταλλευμάτων από τον πυθμένα, πιθανώς θα έχουν καταστροφικές συνέπειες για τη θαλάσσια βιοποικιλότητα σε περιοχές που είχαν μείνει ανέγγιχτες από τον άνθρωπο».

Οι αλλαγές στις θάλασσες

Μπορούμε να συνοψίσουμε τις αλλαγές που έχουν συντελεστεί τα τελευταία χρόνια στις θάλασσές μας; Κυρίως στην Κρήτη;

«Ίσως η σημαντικότερη και πιο εμφανής αλλαγή, όπως προανέφερα, είναι η συνεχής άφιξη νέων ξενικών ειδών όπως ο λαγοκέφαλος, το λεοντόψαρο και άλλα, που πλέον έχουν μεγάλους πληθυσμούς και έχουν γίνει μέρος της θαλάσσιας βιοκοινότητας.

Άλλες αλλαγές, που παρατηρούνται και σε παγκόσμιο επίπεδο, είναι η ρύπανση, ειδικά από πλαστικά που έχει αυξηθεί κατά πολύ, ειδικά από τα μικροπλαστικά, δηλαδή μικροσκοπικά σωματίδια πλαστικών που προέρχονται από διάσπαση των πλαστικών αλλά και από τα συνθετικά ρούχα όταν πλένονται. Μέχρι πρόσφατα πιστεύαμε ότι οι τεράστιες ποσότητες πλαστικών που κατέληγαν στις θάλασσες εξαφανίζονταν με έναν μαγικό τρόπο στα απέραντα βάθη των ωκεανών· πλέον διαπιστώνουμε ότι έχουμε γεμίσει τον πλανήτη πλαστικά.

Η σταδιακή αύξηση της θερμοκρασίας είναι μια άλλη αλλαγή που ήδη παρατηρείται και που μεταξύ άλλων προκαλεί αλλαγές στη γεωγραφική κατανομή των ειδών, που είναι πιο εμφανείς σε μεγαλύτερα γεωγραφικά πλάτη. Είδη όπως ο γαύρος και η σαρδέλα εξαπλώνονται προς τη Βόρεια Θάλασσα, αλλά αρχίζουμε και βλέπουμε και αλλαγές στη Μεσόγειο με ψυχρόφιλα είδη να μετακινούνται προς τις βόρειες ακτές της και πιθανώς να εξαφανιστούν ενώ αρχίζουν να κυριαρχούν πιο θερμόφιλα είδη».

Ο ερευνητής

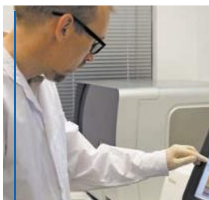
Ο Δρ. Παναγιώτης Κασαπίδης είναι κύριος ερευνητής στο Ινστιτούτο Θαλάσσιας Βιολογίας, Βιοτεχνολογίας και Υδατοκαλλιεργειών του ΕΛΚΕΘΕ. Ασχολείται με τη μελέτη θαλάσσιων οργανισμών σε γενετικό επίπεδο, με σκοπό την κατανόηση της εξελικτικής τους ιστορίας και του τρόπου που ανταποκρίνονται σε περιβαλλοντικές αλλαγές, καθώς και με τη μελέτη της βιοποικιλότητάς τους μέσω σύγχρονων γενετικών μεθόδων, όπως η ανάλυση του περιβαλλοντικού DNA.

Τα όπλα των επιστημόνων

Ποιο είναι σήμερα το πιο ισχυρό όπλο των επιστημόνων απέναντι στην κλιματική αλλαγή;

«Το πιο ισχυρό όπλο των επιστημόνων, όχι μόνο απέναντι στην κλιματική αλλαγή, θα έλεγα ότι είναι η γνώση και η δυνατότητα πλέον να αποκτάται αυτή η γνώση γρήγορα και σε βάθος και να δίνει απτά αποτελέσματα. Δείτε για παράδειγμα την περίπτωση του κοροναϊού: μόλις εντοπίστηκε, οι επιστήμονες ανέλυσαν αμέσως το γονιδίωμά του και μέσα σε λιγότερο από ένα χρόνο κατασκεύασαν τόσα πετυχημένα εμβόλια. Αυτό είναι ένας άθλος που δεν θα ήταν δυνατόν να επιτευχθεί πριν από 15-20 χρόνια.

Για να αντιμετωπιστεί μια μεγάλη κρίση, όπως είναι η κλιματική αλλαγή, χρειάζεται η συμβολή πολλών επιστημονικών κλάδων. Όσον αφορά τη συμβολή της Βιολογίας, σε πρώτο επίπεδο προσπαθούμε να κατανοήσουμε σε βάθος τη λειτουργία των οικοσυστημάτων από το επίπεδο των γονιδίων, όπως για παράδειγμα το πώς προσαρμόζονται γενετικά οι οργανισμοί στις αλλαγές τους περιβάλλοντος, μέχρι το επίπεδο του πώς λειτουργούν και αλλάζουν τα οικοσυστήματα και η βιοποικιλότητα στον χρόνο, για να μπορούμε να προβλέψουμε τις αλλαγές που θα συμβούν και να εισηγηθούμε κατάλληλα μέτρα. Γι' αυτό, μεταξύ άλλων, είναι σημαντική η συστηματική παρακολούθηση των οικοσυστημάτων, στο οποίο υστερούμε ακόμα ως χώρα.



Έλεγχος γενετικών αναλύσεων

Με ρωτήσατε προηγουμένως για το πόσο έχουν αλλάξει οι θάλασσές μας τα τελευταία χρόνια. Δεν το γνωρίζουμε με ακρίβεια γιατί δεν έχουμε πολύ καλή εικόνα του πώς ήταν τα θαλάσσια οικοσυστήματα πριν 20-30 χρόνια και πώς έχουν αλλάξει στο χρόνο.

Τα τελευταία χρόνια, με τη θέσπιση ευρωπαϊκών οδηγιών όπως οι Οδηγίες-Πλαίσιο για τα ύδατα και τη θαλάσσια στρατηγική, έχει αρχίσει η πιο συστηματική παρακολούθηση των θαλάσσιων οικοσυστημάτων, για να μπορέσουμε να διατηρήσουμε τη βιοποικιλότητα και τις λειτουργίες τους.

Φυσικά υπάρχει και μεγάλη πρόοδος στην ανάπτυξη νέων τεχνολογιών, π.χ. για την παραγωγή ενέργειας, την ενεργειακή βελτίωση, την κυκλική οικονομία, που μπορεί να αποτελέσουν ισχυρά όπλα απέναντι στην κλιματική αλλαγή».

Οι ιθύνοντες έχουν συνειδητοποιήσει την κρισιμότητα της κατάστασης; Λαμβάνουν μέτρα; Υπολογίζουν τους επιστήμονες;

«Στα λόγια τουλάχιστον οι περισσότεροι ιθύνοντες πλέον μιλάνε για κλιματική αλλαγή, οικολογική κρίση, πράσινη ανάπτυξη. Στην πράξη όμως δεν είμαι σίγουρος ότι έχουν συνειδητοποιήσει την κρισιμότητα της κατάστασης. Σε ευρωπαϊκό και παγκόσμιο επίπεδο λαμβάνονται πλέον πρωτοβουλίες για την αντιμετώπιση της κλιματικής αλλαγής αλλά τα μέτρα είναι ακόμα άτολμα και ανεπαρκή και υπάρχουν και σοβαρά πισωγυρίσματα, όπως με την περίπτωση ηγετών τύπου Τραμπ και Μπολσονάρου.

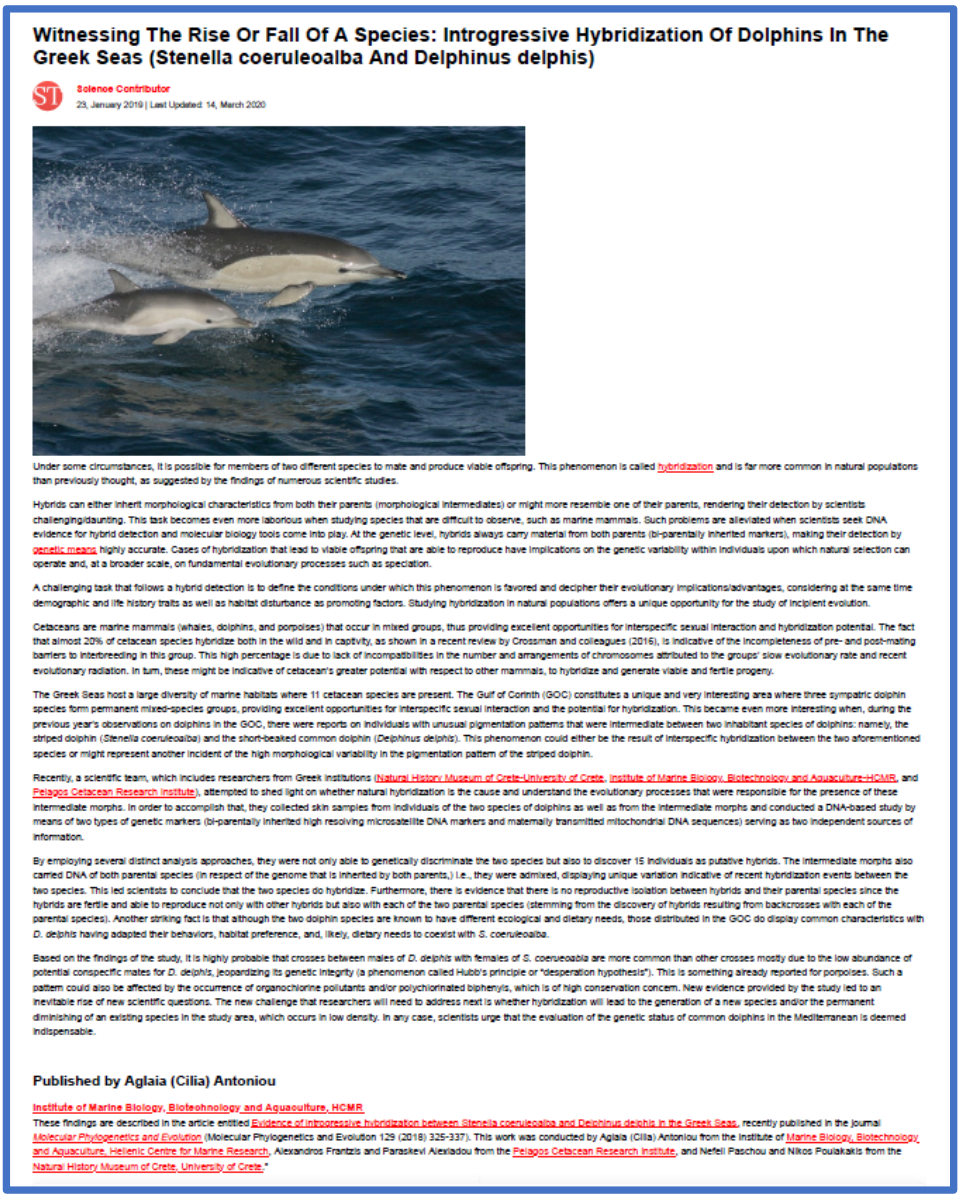
Όσον αφορά την Ελλάδα, αυτή τη στιγμή η ελληνική επιστημονική κοινότητα, παρότι υψηλού επιπέδου, αντιμετωπίζει διάφορα προβλήματα, που δεν επιτρέπουν την πλήρη αξιοποίηση του δυναμικού της. Τα πιο σοβαρά προβλήματα είναι η έλλειψη σταθερής χρηματοδότησης, η απίστευτη γραφειοκρατία στη διαχείριση των ερευνητικών κονδυλίων, που αναγκάζει τους Έλληνες επιστήμονες να ασχολούνται πιο πολύ με το πώς θα προμηθευτούν υλικά για την έρευνά τους, παρά με την ίδια την έρευνα, και οι μακροχρόνιες ελαστικές σχέσεις εργασίας πολλών νέων επιστημόνων. Το τελευταίο σε συνδυασμό με την έλλειψη σταθερής χρηματοδότησης, συχνά οδηγεί στο να αγωνιζόμαστε να κρατήσουμε ταλαντούχους επιστήμονες, που τελικά φεύγουν στο εξωτερικό ή προς τον ιδιωτικό τομέα.

Τελειώνοντας, θα ήθελα να αναφέρω κάτι που διάβασα, πως οι άνθρωποι, παρότι είμαστε νοήμονα όντα και με τα μέσα και τη γνώση που διαθέτουμε μπορούμε να κάνουμε προβλέψεις και να λαμβάνουμε αποφάσεις για να αποτρέψουμε δυσάρεστες εξελίξεις, όπως η κλιματική αλλαγή, εντούτοις τείνουμε ως κοινωνίες να δρούμε κοντόφθαλμα.

Όταν όμως βρεθούμε αντιμέτωποι με μια καταστροφή, τότε κινητοποιούμαστε άμεσα και ξεπερνάμε τον εαυτό μας. Ίσως και με την κλιματική αλλαγή να πρέπει να φτάσουμε ένα βήμα πριν την καταστροφή για να κινητοποιηθούμε αποτελεσματικά, αλλά ίσως τότε να είναι αργά».

Δειγματοληψία νερού σε λιβάδι Ποσειδωνίας στην Αγία Πελαγία με τη βοήθεια δυτών

Interview of Dr. P. Kasapidis (**MB&B**), on marine biodiversity, invasive species and modern methods to monitor their presence.



Witnessing The Rise Or Fall Of A Species: Introgressive Hybridization Of Dolphins In The Greek Seas (Stenella coeruleoalba And Delphinus delphis)

Science Contributor
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Under some circumstances, it is possible for members of two different species to mate and produce viable offspring. This phenomenon is called hybridization and is far more common in natural populations than previously thought, as suggested by the findings of numerous scientific studies.

Hybrids can either inherit morphological characteristics from both their parents (morphological intermediates) or might more resemble one of their parents, rendering their detection by scientists challenging/daunting. This task becomes even more laborious when studying species that are difficult to observe, such as marine mammals. Such problems are alleviated when scientists seek DNA evidence for hybrid detection and molecular biology tools come into play. At the genetic level, hybrids always carry material from both parents (bi-parentally inherited markers), making their detection by genetic means highly accurate. Cases of hybridization that lead to viable offspring that are able to reproduce have implications on the genetic variability within individuals upon which natural selection can operate and, at a broader scale, on fundamental evolutionary processes such as speciation.

A challenging task that follows a hybrid detection is to define the conditions under which this phenomenon is favored and decipher their evolutionary implications/advantages, considering at the same time demographic and life history traits as well as habitat disturbance as promoting factors. Studying hybridization in natural populations offers a unique opportunity for the study of incipient evolution.

Cetaceans are marine mammals (whales, dolphins, and porpoises) that occur in mixed groups, thus providing excellent opportunities for interspecific sexual interaction and hybridization potential. The fact that almost 20% of cetacean species hybridize both in the wild and in captivity, as shown in a recent review by Crossman and colleagues (2016), is indicative of the incompleteness of pre- and post-mating barriers to interbreeding in this group. This high percentage is due to lack of incompatibilities in the number and arrangements of chromosomes attributed to the groups' slow evolutionary rate and recent evolutionary radiation. In turn, these might be indicative of cetacean's greater potential with respect to other mammals, to hybridize and generate viable and fertile progeny.

The Greek Seas host a large diversity of marine habitats where 11 cetacean species are present. The Gulf of Corinth (GOC) constitutes a unique and very interesting area where three sympatric dolphin species form permanent mixed-species groups, providing excellent opportunities for interspecific sexual interaction and the potential for hybridization. This became even more interesting when, during the previous year's observations on dolphins in the GOC, there were reports on individuals with unusual pigmentation patterns that were intermediate between two inhabitant species of dolphins: namely, the striped dolphin (*Stenella coeruleoalba*) and the short-beaked common dolphin (*Delphinus delphis*). This phenomenon could either be the result of interspecific hybridization between the two aforementioned species or might represent another incident of the high morphological variability in the pigmentation pattern of the striped dolphin.

Recently, a scientific team, which includes researchers from Greek institutions (Natural History Museum of Crete-University of Crete, Institute of Marine Biology, Biotechnology and Aquaculture-HCMR, and Pelagos Cetacean Research Institute), attempted to shed light on whether natural hybridization is the cause and understand the evolutionary processes that were responsible for the presence of these intermediate morphs. In order to accomplish that, they collected skin samples from individuals of the two species of dolphins as well as from the intermediate morphs and conducted a DNA-based study by means of two types of genetic markers (bi-parentally inherited high resolving microsatellite DNA markers and maternally transmitted mitochondrial DNA sequences) serving as two independent sources of information.

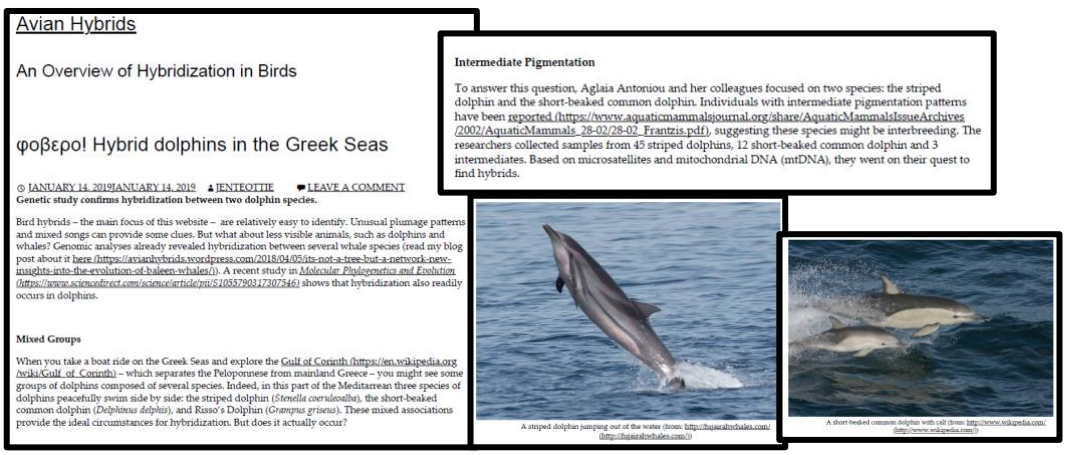
By employing several distinct analysis approaches, they were not only able to genetically discriminate the two species but also to discover 15 individuals as putative hybrids. The intermediate morphs also carried DNA of both parental species (in respect of the genome that is inherited by both parents,) i.e., they were admixed, displaying unique variation indicative of recent hybridization events between the two species. This led scientists to conclude that the two species do hybridize. Furthermore, there is evidence that there is no reproductive isolation between hybrids and their parental species since the hybrids are fertile and able to reproduce not only with other hybrids but also with each of the two parental species (stemming from the discovery of hybrids resulting from backcrosses with each of the parental species). Another striking fact is that although the two dolphin species are known to have different ecological and dietary needs, those distributed in the GOC do display common characteristics with *D. delphis* having adapted their behaviors, habitat preference, and, likely, dietary needs to coexist with *S. coeruleoalba*.

Based on the findings of the study, it is highly probable that crosses between males of *D. delphis* with females of *S. coeruleoalba* are more common than other crosses mostly due to the low abundance of potential conspecific mates for *D. delphis*, jeopardizing its genetic integrity (a phenomenon called Hubb's principle or "desperation hypothesis"). This is something already reported for porpoises. Such a pattern could also be affected by the occurrence of organochlorine pollutants and/or polychlorinated biphenyls, which is of high conservation concern. New evidence provided by the study led to an inevitable rise of new scientific questions. The new challenge that researchers will need to address next is whether hybridization will lead to the generation of a new species and/or the permanent diminishing of an existing species in the study area, which occurs in low density. In any case, scientists urge that the evaluation of the genetic status of common dolphins in the Mediterranean is deemed indispensable.

Published by Aglaia (Cilia) Antoniou

Institute of Marine Biology, Biotechnology and Aquaculture, HCMR

These findings are described in the article entitled Evidence of introgressive hybridization between Stenella coeruleoalba and Delphinus delphis in the Greek Seas, recently published in the journal Molecular Phylogenetics and Evolution (Molecular Phylogenetics and Evolution 129 (2018) 325-337). This work was conducted by Aglaia (Cilia) Antoniou from the Institute of Marine Biology, Biotechnology and Aquaculture, Hellenic Centre for Marine Research, Alexandros Frantzis and Paraskevi Alexiadou from the Pelagos Cetacean Research Institute, and Nefeli Paschou and Nikos Poulakakis from the Natural History Museum of Crete, University of Crete."



Avian Hybrids

An Overview of Hybridization in Birds

φοβερο! Hybrid dolphins in the Greek Seas

JANUARY 14, 2019JANUARY 14, 2019 JENTEOTTIE LEAVE A COMMENT

Genetic study confirms hybridization between two dolphin species.

Bird hybrids – the main focus of this website – are relatively easy to identify. Unusual plumage patterns and mixed songs can provide some clues. But what about less visible animals, such as dolphins and whales? Genomic analyses already revealed hybridization between several whale species (read my blog post about it here (https://avianhybrids.wordpress.com/2018/04/05/its-not-a-tree-but-a-network-new-insights-into-the-evolution-of-baleen-whales/)). A recent study in *Molecular Phylogenetics and Evolution* (https://www.sciencedirect.com/science/article/pii/S1055790317307546) shows that hybridization also readily occurs in dolphins.

Mixed Groups

When you take a boat ride on the Greek Seas and explore the Gulf of Corinth (https://en.wikipedia.org/wiki/Gulf_of_Corinth) – which separates the Peloponnese from mainland Greece – you might see some groups of dolphins composed of several species. Indeed, in this part of the Mediterranean three species of dolphins peacefully swim side by side: the striped dolphin (*Stenella coeruleoalba*), the short-beaked common dolphin (*Delphinus delphis*), and Risso's Dolphin (*Grampus griseus*). These mixed associations provide the ideal circumstances for hybridization. But does it actually occur?

Intermediate Pigmentation

To answer this question, Aglaia Antoniou and her colleagues focused on two species: the striped dolphin and the short-beaked common dolphin. Individuals with intermediate pigmentation patterns have been reported (https://www.aquaticmammalsjournal.org/share/AquaticMammalsIssueArchives/2002/AquaticMammals_28-02/28-02_Frantzis.pdf), suggesting these species might be interbreeding. The researchers collected samples from 45 striped dolphins, 12 short-beaked common dolphin and 3 intermediates. Based on microsatellites and mitochondrial DNA (mtDNA), they went on their quest to find hybrids.

A striped dolphin jumping out of the water (from: http://hujairahwhales.com/)

A short-beaked common dolphin with calf (from: http://www.wikipedia.com/)

Rising public awareness and communicating research findings on dolphin hybrids found in the Greek Seas by Dr. Aglaia (Cilia) Antoniou (**MB&B**).

b. Services and Applications for public health

Although this is no longer one of the main objectives of the Environmental Microbiology Laboratory, we provide a service to local municipality as well as private companies, running analyses for water for human consumption, (*i.e.* packaged water, spring water or wells) or from surface waters (lakes, rivers, coastal and bathing waters) and marine waters from various depths. The laboratory also participates in the HCMR educational team activities, with various presentations given to primary, secondary and tertiary education on issues related to microbiology and infections from contaminated waters, as well as on the rules of protection and safety for humans.

c. Training and educational activities targeted for the public

We are actively involved with public training and education, through our memberships in the European Marine Science Educators Association, the Expert Working Group on Ocean Literacy of EuroGOOS and EU4Ocean Platform. These programs also benefit teachers, influence school curricula and support the Network of European Blue Schools. Several important Ocean Literacy dimensions (knowledge, attitudes, behavior of school students towards ocean sciences issues within the frameworks of Ocean Literacy and Mediterranean Sea Literacy) are already under investigation by EMSEA-Mediterranean Working Group in different Mediterranean countries such as Croatia, Italy, Greece, Malta, Turkey, Spain, Egypt, Cyprus, France. By being one of the principle investigators of an EU Horizon 2020 ERASMUS+ project, we support the development of socially-inclusive blue challenges in schools in the Mediterranean Sea basin. The project aims at developing, testing and evaluating innovative approaches to integrate marine issues in the curriculum and educational activities of schools in different Mediterranean countries. Being partners and members of the User Advisory Board of the EU funded project entitled "Inclusive open schooling through engaging and future-oriented science (CONNECT)", we scientifically support teachers and educators of elementary and secondary schools for designing and developing educational scenarios concerning marine environmental issues. IMBBC is also a partner of the EU-funded project entitled "NAUTILOS: New Approach to Underwater Technologies for Innovative, Low-cost Ocean obServation", and scientifically responsible for synergies aiming at dissemination and communication activities of the project to the public.

d. Other activities with socio-economic impact

The institute keeps increasing its visibility at the local and national levels of public administration, scientific fora and public media. In the area of policies and the formulation of research and innovation priorities, IMBBC has pursued an active presence in decision-making and policy-making bodies at the local, regional and national level. The institute maintains a close cooperation with the Region of Crete, which is the administrative body of developing policies and decision making, by participating in advisory committees on a number of economic development issues, such as primary production, environment, blue growth, alternative tourism, etc.

IMBBC co-organized with the Region of Crete (2018), a special meeting with the participation of the Regions of Europe having blue growth as priority area, inviting

successful examples of industrial applications in blue growth. The aim was to transfer good practices for innovation to the Region of Crete and support technology transfer.

During the last few years, various researchers of IMBBC have been selected by the State to participate in the Thematic Scientific Council (TES) in Agrotechnology and Nutrition. Since November 2020, **the director of IMBBC (Dr. C.C. Mylonas) and Dr. E. Fountoulaki have been appointed as President and Deputy President of the current Thematic Scientific Council in Agrotechnology and Nutrition**. The function of the TES is to provide advice to the National Council of Research and Innovation (ΕΣΕΤΕΚ) on research priorities, initiative to foster collaborations between research centers and industry, and methods to implement new technology and innovations in the area of their expertise. Through this role, IMBBC can play a significant role in influencing the State strategy in supporting research in this area, which has a very significant socio-economic impact through its role in food security, sustainable seafood production and environmental and biodiversity protection.

Drs C.C. Mylonas and G. Rigos (**AQUA**) have been appointed (since 2012) as members in the **Committee on Introduced and Exotic Species**, of the Department of Fisheries, Ministry of Rural Development and Food. This committee convenes to evaluate applications from aquaculture companies to import non-native species (freshwater or marine).

The **Underwater Biotechnological Park of Crete** facilitates a multidisciplinary approach clustering a cost-effective combination of services to target users originating from the public and private sector, international research programs and networks, academia and government. Emphasis is given to the: a) demonstration of the patented innovative concept "HCMR Recreational Diving Oasis" based on the construction and deployment of special artificial reefs made of concrete that mimic the shape and function of natural rocky reef habitats for the development of recreational diving parks; b) biological designation of candidate native marine seaweeds and macrobenthic invertebrate species of biotechnological interest (e.g. sponges, bryozoans, mollusks, polychaetes) and testing of their cultivation ability and commercial usability (mass production); c) the collaboration with HCMR spin-off company for its exploitation by the local private sector. In addition, the UBPC will collaborate with the Cretaquarium (also part of the HCMR) for broadcasting in real time underwater television images presenting the infrastructure and functioning of the park to the audience of both HCMR aquaria, as well as to end users worldwide. In this context, UBPC can be used as a tool for supporting various experimental and educational activities including the implementation of a broad spectrum of Citizen Science projects.

6 Additional Information – Director's CV

In this section you may provide any additional information not included in the above sections (optional completion, maximum 2 pages).

Researcher's Name: Constantinos C. Mylonas
Current Position: Researcher A, Director of IMBBC
Research Group: AQUA
Field of Research: Fish reproduction

Scientific impact

Publication record (23/3/2022)		**Research Projects**		**Student supervision**	
h-index (**Scopus**)	43	Coordinator (Co)	7	PhD	18
Articles (ISI-index)	143	Principal investigator (PI)	17	MSc	27
Citations (total)	5,540	Project member	6	BSc	54
Citations (non-self)	4,559	Funding (Co + PI)	5,421,000 €		

Personal summary: My research field may be summarized in (a) the study of fish reproductive biology and endocrinology, (b) the identification of the dysfunctions exhibited by female and male broodstocks in captive conditions, and (c) the development of pharmacological methods for the control of reproduction, induction of spawning and improvement of sperm production in fish of interest for the aquaculture industry. In this framework, I have been involved in research aiming at the optimization of broodstock management methods, focusing on marine fishes. My research gave me the opportunity to be in close contact with the aquaculture industry, and to study more than twenty different cultured fish species, including large benthic and pelagic fishes such as the wreckfish (*Polyprion americanus*), greater amberjack (*Seriola dumerili*) and the Atlantic bluefin tuna (*Thunnus thynnus*), species which we succeeded in controlling their reproduction in captivity.

Education

Doctor of Philosophy in Marine-Estuarine and Environmental Sciences (1996), Center of Marine Biotechnology, **University of Maryland**, College Station, Maryland, USA

Master of Science in Zoology (1991), **North Carolina State University**, Raleigh, North Carolina, USA

Bachelor of Science (1988) with Summa Cum Laude Honors in Wildlife and Fisheries Sciences, Aquaculture option, **Texas A&M University**, College Station, Texas, USA.

Notable achievements

I have **coordinated** 7 projects, of which 1 from the EU (FP7), and 3 national and 3 bi-national. In addition, I have participated as the **Principle Investigator** from HCMR in 7 EU projects (FP 5, FP7 and H2020). I have acquired **a total funding of 5,42€ million**, of which 3,8€ million from EU funded projects, 976,000€ from national projects, and 533,000€ from Private contracts with companies and research organizations. I have provided consulting services for companies in Greece, Europe, Asia and the Americas. I have **published** 1 edited book (in English), 6 book chapters (five in English, one in Greek) and **143 articles** in ISI-Indexed Scientific Journals. I have presented **23 invited speeches** in Conferences, Workshops and Meetings and **24 invited lectures** in University courses for undergraduate or graduate students, and in Educational organizations for professionals. I have been the **president of the Scientific Committee for Agrotechnology and Nutrition, of the Greek Republic** in 2020-2021. I have been the **Director of IMBBC since 2020** and the **Head of the Cretaquarium** in 2021-2022. I have been a **member of the Scientific Programme Committee** of 3 international Conferences (EUROPEAN AQUACULTURE 2011, 2017 and AQUAGAMETE 2015) and have been given the organization of one international conference in 2022 (12th International Symposium on Reproductive Physiology of Fish). I have been elected member of the **Board of Directors of the European Aquaculture Society** since 2018 (2 terms).

Professional activities and societies

Deputy director of Cretaquarium, Crete – 2021-2022. Responsible of all operations.

President of the National Scientific Committee for Agrotechnology and Nutrition, of the Greek Republic – 2020-2022. Consulting body for the State.

Advisory Committee on "The Use of Exotic and non-Native Species in Aquaculture" Department of Agriculture and Agricultural Development, Republic of Greece. 2010- to date

Expert Contributor – European Food Safety Organization (EFSA). Working group on Stunning and Killing of Tuna. 2008-2009, Parma, Italy.

European Aquaculture Society, member (Board of Directors, 2018- present)

Proposal-project evaluator

2020, 2011, 2008, 2006. The United States - Israel Binational Agriculture Research and Development Fund (BARD), Israel.

2014. United States of America Department of Agriculture (USDA), External reviewer of Small Business Innovation Research (SBIR) Proposals.

2011. European Commission, DG RESEARC). External reviewer of 7th Framework Program (KBBE), midterm and final evaluation.

2003. The Biotechnology and Biological Sciences Research Council (BBSRC), United Kingdom

Recent or selected funded projects

(May 2020-2023) BESTBROOD: Identification of broodstock performance indicators to boost the aquaculture of emerging fish species. **Horizon 2020 (ERA-NET BLUEBIO 2020)**, €1,921,854 (Total), €174,650 for HCMR (Partner Principle Investigator and WP 4 leader)

(January 2020-2024) NEWTECHAQUA: New Technologies, Tools and Strategies for a Sustainable, Resilient and Innovative European Aquaculture, under the Call: Sustainable European aquaculture 4.0: nutrition and breeding, **Horizon 2020 (DT-BG-04-2018-2019)**, €6,999,996 (Total), €254,500 for HCMR (Partner Principle Investigator and WP 4 leader)

(May 2017-2021) MedAID: Mediterranean Aquaculture Integrated Development, **Horizon 2020 (SFS-23-2016-2)**, €6,999,996 (Total), €531,000 for HCMR (Principle Investigator HCMR)

(December 2013-2018) DIVERSIFY: Enhancing the European aquaculture production by removing production bottlenecks of emerging species, producing new products and accessing new markets, **EU 7th FP,** European Commission (KBBE2013.1.2.09, €11,838,080 (Total), €1,758,012 for HCMR (Project Coordinator, Principle Investigator HCMR)

Recent or selected top five publications

Corriero, A., Wylie, M.J., Nyuji, M., Zupa, P., **Mylonas, C.C.**, 2021. Reproduction of greater amberjack (*Seriola dumerili*) and other members of the family Carangidae. **Rev. Aquacult.**, 2021, 1-35.

Chatzifotis, S., Gutierrez, A.G., Papadaki, M., Caruso, F., Sigelaki, I., **Mylonas, C.C.**, 2021. Lack of negative effects of fasting of gilthead seabream (*Sparus aurata*) breeders during the spawning period on maternal and egg nutrient composition, fertilization success, and early embryo/larval development. **Fish Physiol. Biochem.** 47, 1257-1270.

Superio, J., Fakriadis, I., Tsigenopoulos, C.S., Lancerotto, S.A., Rodriguez, A.V., Vervelakis, E., **Mylonas, C.C.**, 2021. Spawning kinetics and parentage contribution of European sea bass (*Dicentrarchus labrax*) broodstocks, and influence of GnRHa-induced spawning. **Aquacult. Rep.** 21

Chatzifotis, S., Gutierrez, A.G., Papadaki, M., Caruso, F., Sigelaki, I., **Mylonas, C.C.**, 2021. Lack of negative effects of fasting of gilthead seabream (*Sparus aurata*) breeders during the spawning period on maternal and egg nutrient composition, fertilization success, and early embryo/larval development. **Fish Physiol. Biochem.** 47, 1257-1270.

Papadaki, M., Mandalakis, M., Anastasiou, T.I., Pouli, M., Asderis, M., Katharios, P., Papandroulakis, N., **Mylonas, C.C.**, 2021. Histological evaluation of sex differentiation and early sex identification in hatchery-produced greater amberjack (*Seriola dumerili*) reared in sea cages. Fish Physiol Biochem. 47(6), 1777-1792. doi:10.1007/s10695-021-01007-7

7 Annex I – IMBBC Bibliography (MB&B and AQUA)

Journal articles

2018

Alexi, N., Byrne, D.V., Nanou, E., Grigorakis, K., 2018a. Investigation of sensory profiles and hedonic drivers of emerging aquaculture fish species. Journal of the Science of Food and Agriculture 98, 1179–1187. https://doi.org/10.1002/jsfa.8571

Alexi, N., Nanou, E., Lazo, O., Guerrero, L., Grigorakis, K., Byrne, D.V., 2018b. Check-All-That-Apply (CATA) with semi-trained assessors: Sensory profiles closer to descriptive analysis or consumer elicited data? Food Quality and Preference 64, 11–20. https://doi.org/10.1016/j.foodqual.2017.10.009

Antoniou, A., Frantzis, A., Alexiadou, P., Paschou, N., Poulakakis, N., 2018. Evidence of introgressive hybridization between *Stenella coeruleoalba* and *Delphinus delphis* in the Greek Seas. Molecular Phylogenetics and Evolution 129, 325–337. https://doi.org/10.1016/j.ympev.2018.09.007

Bounas, Anastasios, Catsadorakis, G., Logotheti, A., Voslamber, B., Magoulas, A., Tsaparis, D., 2018. Conservation genetics of a resident population of Greylag Goose (*Anser anser*) at the southernmost limit of the species' distribution in Europe. Avian Res 9, 47. https://doi.org/10.1186/s40657-018-0139-0

Bounas, A., Tsaparis, D., Efrat, R., Gradev, G., Gustin, M., Mikulic, K., Rodríguez, A., Sarà, M., Kotoulas, G., Sotiropoulos, K., 2018a. Genetic structure of a patchily distributed philopatric migrant: Implications for management and conservation. Biological Journal of the Linnean Society 124, 633–644. https://doi.org/10.1093/biolinnean/bly073

Bounas, A., Tsaparis, D., Gustin, M., Mikulic, K., Sarà, M., Kotoulas, G., Sotiropoulos, K., 2018b. Using genetic markers to unravel the origin of birds converging towards pre-migratory sites. Scientific Reports 8. https://doi.org/10.1038/s41598-018-26669-x

Bulleri, F., Eriksson, B.K., Queirós, A., Airoldi, L., Arenas, F., Arvanitidis, C., Bouma, T.J., Crowe, T.P., Davoult, D., Guizien, K., Iveša, L., Jenkins, S.R., Michalet, R., Olabarria, C., Procaccini, G., Serrão, E.A., Wahl, M., Benedetti-Cecchi, L., 2018. Harnessing positive species interactions as a tool against climate-driven loss of coastal biodiversity. PLoS Biology 16. https://doi.org/10.1371/journal.pbio.2006852

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Chatzinikolaou, E., Mandalakis, M., Damianidis, P., Dailianis, T., Gambineri, S., Rossano, C., Scapini, F., Carucci, A., Arvanitidis, C., 2018. Spatio-temporal benthic biodiversity patterns and pollution pressure in three Mediterranean touristic ports. Science of the Total Environment 624, 648–660. https://doi.org/10.1016/j.scitotenv.2017.12.111

Christakis, C.A., Polymenakou, P.N., Mandalakis, M., Nomikou, P., Kristoffersen, J.B., Lampridou, D., Kotoulas, G., Magoulas, A., 2018. Microbial community differentiation between active and inactive sulfide chimneys of the Kolumbo

submarine volcano, Hellenic Volcanic Arc. Extremophiles 22, 13–27. https://doi.org/10.1007/s00792-017-0971-x

Dailianis, T., Smith, C.J., Papadopoulou, N., Gerovasileiou, V., Sevastou, K., Bekkby, T., Bilan, M., Billett, D., Boström, C., Carreiro-Silva, M., Danovaro, R., Fraschetti, S., Gagnon, K., Gambi, C., Grehan, A., Kipson, S., Kotta, J., McOwen, C.J., Morato, T., Ojaveer, H., Pham, C.K., Scrimgeour, R., 2018. Human activities and resultant pressures on key European marine habitats: An analysis of mapped resources. Marine Policy 98, 1–10. https://doi.org/10.1016/j.marpol.2018.08.038

Dimarchopoulou, D., Gerovasileiou, V., Voultsiadou, E., 2018. Spatial variability of sessile benthos in a semi-submerged marine cave of a remote Aegean Island (eastern Mediterranean Sea). Regional Studies in Marine Science 17, 102–111. https://doi.org/10.1016/j.rsma.2017.11.015

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Duncan, N.J., Mylonas, C.C., Milton Sullon, E., Karamanlidis, D., França Nogueira, M.C., Ibarra-Zatarain, Z., Chiumento, M., Aviles Carrillo, R.O., 2018. Paired spawning with male rotation of meagre *Argyrosomus regius* using GnRHa injections, as a method for producing multiple families for breeding selection programs. Aquaculture 495, 506–512. https://doi.org/10.1016/j.aquaculture.2018.06.017

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Forner-Piquer, I., Mylonas, C.C., Calduch-Giner, J., Maradonna, F., Gioacchini, G., Allarà, M., Piscitelli, F., Di Marzo, V., Pérez-Sánchez, J., Carnevali, O., 2018. Endocrine disruptors in the diet of male *Sparus aurata*: Modulation of the endocannabinoid system at the hepatic and central level by Di-isononyl phthalate and Bisphenol A. Environment International 119, 54–65. https://doi.org/10.1016/j.envint.2018.06.011

Gerovasileiou, V., Dailianis, T., Sini, M., Otero, M.D.M., Numa, C., Katsanevakis, S., Voultsiadou, E., 2018. Assessing the regional conservation status of sponges (Porifera): the case of the Aegean ecoregion. Medit. Mar. Sci. https://doi.org/10.12681/mms.14461

Guy-Haim, T., Lyons, D.A., Kotta, J., Ojaveer, H., Queirós, A.M., Chatzinikolaou, E., Arvanitidis, C., Como, S., Magni, P., Blight, A.J., Orav-Kotta, H., Somerfield, P.J., Crowe, T.P., Rilov, G., 2018. Diverse effects of invasive ecosystem engineers on marine biodiversity and ecosystem functions: A global review and meta-analysis. Glob Change Biol 24, 906–924. https://doi.org/10.1111/gcb.14007

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Saura M., A. Fernández, J. Fernández, R. Peiro-Pastor, C. Peñaloza, L. Bargelloni, C. S Tsigenopoulos, B. Villanueva Population structure and genetic variability based on genomic information in gilthead seabream and European seabass populations, Aquaculture Europe 2021, October 4-7, Madeira, Portugal

Saura M., A. Fernández, J. Fernández, R. Peiro-Pastor, C. Peñaloza2 L. Bargelloni, T. Manousaki, CS Tsigenopoulos and B. Villanueva An application of the MedFish SNP array: Determining population structure and genetic variability of gilthead seabream (Sparus aurata) and European seabass (Dicentrarchus labrax) (oral), 38th International Society for Animal Genetics Virtual Conference 2021., July 26-30 2021

Siaperas R, Topakas E, Kotoulas G, Gioti A. 2021. Genomic features of a marine-derived fungus. Hellenic Bioinformatic HBio Bridge Event, June 2-5, 2021. (selected for oral talk by R. Siaperas)

Smith C, Morato T, Bilan M, Carreiro-Silva M, Papadopoulou N, Sweetman A, Jones D, Matabos M, Gambi C, Colaço A, Gori A, Linares C, Sarrazin J, Billett D, Ramirez-Llodra E, Cuvelier D, Sevastou K, Grehan A, Martins I, Carugati L, Montseny M, Amaro T, Dailianis T, Gerovasileiou V, Danovaro R 2021. Principles and key concepts for ecological restoration in the deep-sea. Book of Abstracts of the 16th Deep Sea Biology Symposium, p. 11.

Stavrakidis-Zachou, O., K. Lika, M. Pavlidis, M. H. Assad and N. Papandroulakis, 2021. Thermal tolerance and biological performance of European seabass *Dicentrarchus labrax* reared under high temperatures EAS 2020 Pp 551-552

Stavrakidis-Zachou, O., N. Papandroulakis, M. Pavlidis, K. Lika, 2021. Preliminary Dynamic Energy Budget models for studying the thermal tolerance of E. seabass and meagre. EAS 2021 Pp 1244-1245

Superio J., I. Fakriadis, C. S. Tsigenopoulos, S. A. Lancerotto, A. Villena Rodriguez, E. Vervelakis, C. C. Mylonas 2021 Spawning kinetics and parentage contribution of European sea bass (*Dicentrarchus labrax*) broodstocks and influence of GnRHa-induced spawning. (poster), Aquaculture Europe 2020, April 12-15 2021 (Virtual) – Session Chair

Tampou, A., S. Andreopoulou, I., Nengas, A. Vasilaki, I.T. Karapanagiotidis, E. Mente, 2021.GROWTH Performance of gilthead seabream (sparus aurata) fed low fishmeal organic diets. Aquaculture Europe 2021, European Aquaculture Society. Madeira, Portugal, October 4-8, 2021.

Theologi, O. et al., A chemical Named Entity Recognition and Association Rule Mining approach to facilitate the study of metabolic processes in hyperthermophilic microorganisms. 2021, Mikrobiokosmos2021

Tsigenopoulos C., R. Cannas, L. Zane, I. Marino, A. Cariani, F. Maroso, T. Manousaki, D. Tsaparis, R. Franch, S. Iori, L. Bargelloni, R. Melis, L. Carugati, R. Corti, A. Ferrari, F. Piattoni, E. Piazza, F. Tinti, V. Terzoglou, K. Ekonomaki, A. Tsakogiannis, & M. T. Spedicato Population Genetics and Phylogeographic Studies for the Identification of Biological Units for two fish and four crustacean species in the Mediterranean Sea: the MED_UNITs project (oral), The 6th International Marine Connectivity Conference (iMarCo), December 6-8 2021, Paris, France

Tsigenopoulos C., V. Papadogiannis, T. Manousaki, J. Kristoffersen, A. Tsakogiannis, O. Nousias, C. C. Mylonas, D. Chatziplis, C. Batargias. The first complete genome assembly for the meagre Argyrosomus regius, Aquaculture Europe 2021, October 4-7, Madeira, Portugal

Tsopanakis, V., Oikonomou, M.V., Polymenakou, P., Magoulas, A. and I.V. Pavlidis. 2021. Identification of novel polysaccharide-degrading enzymes from metagenomic libraries of extreme environments. BioTrans, Graz, Austria Online, 19-22 July.

Vasilaki, A., G. Rigos, C. Nikoloudaki, G. Pyrenis, S. Adamidou, I. Nengas. 2021. EVALUATION OF SEMI-Moist feed in growth performance and feed utilization of juvenile greater amberjack, Seriola dumerilli (Risso,1810). Validation in large scale experiment. Aquaculture Europe 2021, European Aquaculture Society. Madeira, Portugal, October 4-8, 2021.

Vasilaki, A., G. Rigos, C. Nikoloudaki, G. Pyrenis, D. Kogiannou, S. Adamidou, I. Nengas 2021. Evaluation of semi-moist feed in growth performance and feed utilization of juvenile greater amberjack, Seriola dumerili (Risso,1810). validation in large scale experiment European Aquaculture Society, 4-7 October 2021 Funchal, Madeira

Vasileiadou K., Loukovitis D., Litsi Mizan V., Apostolaki E., Protopapas D., Pavloudi C. Population structuring of Posidonia oceanica from Eastern Mediterranean, (WCMB2020), December 2020, Auckland, New Zealand, Poster

Vernadou E, Gerovasileiou V, Glampedakis I, Mandalakis E, Voultsiadou E, Dailianis T, 2021. Contrasting sponge assemblages between distinct coastal locations in Crete Island, Aegean Sea. 6th European Conference on Scientific Diving, 21-22 April 2021, Bergakademie Freiberg, Germany.

Zacheilas T., N. Papandroulakis, K. Moirogiorgou, M. Zervakis, E. Sotiriades, A. Dollas, 2021. An FPGA-Based System for Video Processing to Detect Holes in Aquaculture Nets, BIBE 2021: 1-6

Zafeiropoulos, H. et al., Mining literature and -omics (meta)data to associate microorganisms, biological processes, and environment types, 2020, FEMS Online Conference on Microbiology

Zafeiropoulos, H. et al., Bacteria are everywhere, even in your COI marker gene data! 2021, First DNAQUA International Conference
Zafeiropoulos, H. et al., PEMA v2: addressing metabarcoding bioinformatics analysis challenges, 2021, First DNAQUA International Conference

Other Conferences

2018

Arvanitidis A, Bourtzis T, Chatzigianni E, Boyes SJ, Elliott M, Chatzinikolaou E 2018. The European and Greek existing framework for marine environmental protection and the challenges in its application. NATURA 2000 areas: Protection and sustainable development. Chania, Greece. 10-12 May 2018.

Arvanitidis C, Chatzinikolaou E, Gerovasileiou V, Panteri E, Bailly N, Minadakis N, Hardisty A, Los W, Aravanopoulos F, Antaloudaki E, Avramidou E, Bekiari C, Bourtzis T, Damianidis P, Dimitrakopoulos P, Dimitriou P, Doerr M, Evangelopoulos T, Fanini L, Faulwetter S, Filiopoulou I, Galanidis A, Georgiadis C, Giannoulis T, Gougousis A, Karakassis I, Keklikoglou K, Kevrekidis T, Kotoulas G, Koutsoubas D, Lagnel J, Legaki A, Legakis A, Lyberakis P, Lykidis D, Magoulas A, Mamouris Z, Mavraki D, Michalakis N, Mylona Z, Nikolaidou A, Nikolopoulou M, Oulas A, Ouzounis C, Pafilis E, Papastefanou G, Paranou-Lioliou G, Patkos T, Pattakos N, Pavloudi C, Perantinos G, Potiris M, Reizopoulou S, Skouras Z, Stoumpoudi M, Tsaltas G, Tsiamis G, Tsikopoulou E, Tsompanou M, Valavanis V, Varsos C, Vasileiadou K 2018 LIFEWATCHGREECE Research Infrastructure. Key note Speech in the 12th Panhellenic Symposium of Oceanography & Fisheries.

Arvanitidis C, Warwick R M, Somerfield P J, Pavloudi C, Pafilis E, Oulas A, Chatzigeorgiou G, Gerovasileiou V, Patkos T, Bailly N, Hernandez F, Vanhoorne B, Vandepitte L, Appeltans W, Keklikoglou K, Chatzinikolaou E, Michalakis N, Filiopoulou I, Panteri E, Gougousis A. 2018. Research Infrastructures and their collaborative potential to address scientific questions at global scale. 9th Panhellenic Ecology Conference (HELECOS-9), Heraklion, Crete, Greece. 4-7 October 2018 (presentation).

Arvanitidis C, Warwick RM, Somerfield P, Pavloudi C, Pafilis E, Oulas A, Chatzigeorgiou G, Gerovasileiou V, Patkos T, Bailly N, Hernandez F, Vanhoorne B, Vandepitte L, Appeltans W, Keklikoglou K, Chatzinikolaou E, Michalakis N, Filiopoulou I, Panteri E, Gougousis A, Bravakos P, Christakis C, Kasapidis P, Kotoulas G, Magoulas A 2018 Research Infrastructures and their collaborative potential in addressing challenging scientific questions at global scale. Book of Abstracts of the Hellenic Bioinformatics Conference 2018 “H. Bioinfo 11”, p. 62.

Chatzinikolaou E, Damianidis P, Dailianis T, Gambineri S, Rossano C, Scapini F, Carucci A, Arvanitidis C, 2018. Benthic biodiversity in Mediterranean touristic ports. Proceedings of the 12th Panhellenic Symposium of Oceanography and Fisheries – “Blue Growth for the Adriatic-Ionian Macroregion and the Eastern Mediterranean”, 31 May to 3 June 2018, Corfu, Greece: 51.

Chatzinikolaou E, Grigoriou P, Martini E, Sterioti A. 2018. Impact of ocean acidification and warming on the feeding behavior of Hexaplex trunculus. 12th Panhellenic Symposium of Oceanography & Fisheries, Corfu, Greece. 30 May - 3 June 2018 (poster).

Chatzinikolaou E. 2018. Climathon - Heraklion is facing the challenges of climate change. Invited speaker as expert-mentor. Heraklion, Crete. 26th October 2018.

Chatzinikolaou E. 2018. WP4: Enriching management toolbox with ecosystem connectivity-based instruments. 1st Interim Meeting RECONNECT Project, Larnaca Cyprus. 12-14 June 2018 (presentation).

Christina Pavloudi, Georgia Sarafidou, Eugenia T Apostolaki, Georgios Chatzigeorgiou, Evangelia Chatzinikolaou, Kleoniki Keklikoglou, Christos Arvanitidis 2018 Population connectivity of key-species in the Marine Protected Area (MPA) of Karpathos (Greece). 4th International Marine Connectivity (iMarCo) Conference, Heraklion (Greece)

Christina Pavloudi, Katerina Vasileiadou, Mercedes González-Wangüemert, Christos Arvanitidis, Evangelia Chatzinikolaou 2018 Comparison of sediment microbial communities between Western (Ria Formosa, Portugal) and Eastern European lagoons (Amvrakikos Gulf, Greece). 8th European Coastal Lagoons (EuroLag) Symposium, Athens (Greece)

Dimitriou P, Chatzinikolaou E, Polimerakis D, Damianidis P, Arvanitidis C. 2018. The ecological status of the Mediterranean Ports: Are they as impacted as expected? 12th Panhellenic Symposium of Oceanography & Fisheries, Corfu, Greece. 30 May - 3 June 2018 (presentation).

Fanini L., Tsouchnika A., Taiti S., Chatzaki M., Mazza G., Koulouri P., Lowry J., 2018. Substrate-related communities: a study on discriminating scale and traits of resident fauna. International Sandy Beaches Symposium, 25-29 May 2018, Crete, Greece.

Faulwetter S., Papageorgiou N., Koulouri P., Fanini L., Chatzinikolaou E., Markantonatou V., Pavloudi C., Chatzigeorgiou G., Keklikoglou K., Vasileiadou K., Basset A., Pinna M., Rosati I., Reizopoulou S., Nicolaidou A., Arvanitidis C., 2018. Response of community and trait patterns to simulated species loss in coastal lagoons. 8th European Coastal Lagoons Symposium, 20-23 Mar. 2018, Athens, Greece.

Florido M, Świacka K, Sedano F, Rallis I, Plaitis W, Dailianis T, Dounas C, Gerovasileiou V, Chatzigeorgiou G, 2018. Macrofaunal assemblages on artificial reefs deployed in the Underwater Biotechnological Park of Crete: preliminary results. Proceedings of the 12th Panhellenic Symposium of Oceanography and Fisheries – "Blue Growth for the Adriatic-Ionian Macroregion and the Eastern Mediterranean", 31 May to 3 June 2018, Corfu, Greece: 170.

Fountoulaki E, Cotou E, Henry M, Grigorakis K, Kogiannou D, Kotsiri M, Vassilaki A, Nikoloudaki Ch, Pyrenis G, Sweetman J, Nengas I. 2018. Benefits of organic minerals vs inorganic on growth, health and product quality of the European sea bass Dicentrarchus labrax (Linnaeus, 1758). 12th Panhellenic Symposium of Oceanography & Fisheries, Ionian University, Corfu, May 30- June 3, 2018 «Blue Growth for the Adriatic-Ionian Macroregion and the Eastern Mediterranean».

Gerovasileiou V, Stamouli C, Kiparissis S, Jimenez C, Mytilineou Ch, Lefkaditou E, Thasitis I, Kavadas S, Smith CJ, M Otero 2018 Vulnerable deep-sea megabenthos in the Eastern Mediterranean Sea: benefits of photographic documentation in experimental fishing surveys. Proceedings of the 12th Panhellenic Symposium of Oceanography & Fisheries, p. 47.

Giulia Realdon G., Cheimonopoulou M., Koulouri P., Mokos M., Mogias A., Boubonari T., Kevrekidis T., Previati M., Santoro F., Gazo M., 2018. EMSEA Med: birth and development of an initiative aimed at fostering Mediterranean Sea Literacy. European Geosciences Union General Assembly 2018, 8-13 April 2018, Vienna, Austria.

Kakakiou RV, Konstantinou D, Gerovasileiou V, Voultsiadou E, Gkelis S 2018 Polyphasic characterization of eukaryotic microalgae isolated from marine sponges. Book of Abstracts of the 12th Panhellenic Symposium of Oceanography & Fisheries, p. 169.

Karakasi D., Antoniou A., Psonis N., Giokas S., Vardinoyannis K., Mylonas M., Poulakakis N. Phylogenetic relationships of the pulmonate snail Albinaria. 9th

Panhellenic Conference on Ecology HELECOS-9, UoC 4-7 October 2018, Herakleion, Crete, Greece (p.47)

Katharios P. 2018. Invited speaker at the COLUMBUS PROJECT (EU-Horizon 2020) Industry training Event Organized by Aquark and the Federation of Greek Mariculture. Presentation title: Phage applications is seabass and seabream nurseries. Crowne Plaza Hotel, Athens

Katharios P. 2018. Invited speaker in Europe-MENA USSEC Conference "Updates on Nutritional Value, Quality Control and Application of Second Generation High-Protein and High-Energy Spy Ingredients. EU Demand Poultry & Livestock - Promoting U.S. SBM, Advantages to Feed Mills. Activity:3: Feed Ingredients Seminar Fermented Soy, USSEC. January 24-25th, 2018, Athens, Greece.

Katharios P. 2018. Invited speaker at the meeting for Piscirickettssia salmonis organized by the Programa Para La Gestion Sanitaria en La Acuicultura, Sernapesca. Presentation title: Phage therapy in Aquaculture. Prospects and drawbacks, Puerto Montt, Chile

Kogiannou D, Nikoloudaki Ch, Pyrenis G, Rigos G. "An HPLC-UV method for florfenicol bioavailability assessment after oral administration in european sea bass (*Dicentrarchus labrax*)". 12th Panhellenic Symposium on Oceanography & Fisheries Blue Growth for the Adriatic-Ionian Macroregion and the Eastern Mediterranean" Corfu, Corfu Island, Greece, 30 May - 3 June 2018 Ionian University, Corfu

Konstantinou D, Gerovasileiou V, Voultsiadou E, Gkelis S 2018 Diversity of sponges-cyanobacteria associations: Global overview and new data from the Eastern Mediterranean. Proceedings of the 12th Panhellenic Symposium of Oceanography & Fisheries, p. 52.

Koulouri P, Chatzinikolaou E, Maidanou M, Kober N, Giannoulaki M, Machias A, Dounas C. 2018. Feeding habits of the red mullet in an oligotrophic fishing ground impacted by an invasive seaweed in the Eastern Mediterranean Sea (Crete, S. Aegean Sea). 12th Panhellenic Symposium of Oceanography & Fisheries, Corfu, Greece. 30 May - 3 June 2018 (poster).

Kristoffersen JB, Viet QH, Lagnel J, Borutta F, Bridges C, Sarropoulou E 2018. Atlantic Bluefin tuna de novo genome assembly with Illumina and Nanopore sequences. Advances in Industrial Aquaculture Genetics, North meets South. EMBRIC WORK PACKAGE 8 Workshop 3rd – 4th May 2018 Bergen, Norway.

Melanthia Stavroulaki. EUROMARINE "APPRISE" Workshop: Anticipating Potential Pathways and Routes for Innovation towards desirable Socio-Economic impacts (focus on macro algae) - "How do we build a competitive, sustainable and responsible European macro algae industry", Station Biologique Roscoff, Brittany, France, 6–7/09/ 2018

Mylonas, C.C., Fakriadis, I., Papandroulakis, N., Papadaki, M. and I. Sigelaki. 2018. Broodstock management and spawning induction of greater amberjack *Seriola dumerili* reared in sea cages in Greece. 11th International Symposium on Reproductive Physiology of Fish, 3-8 June, Manaus, Brazil.

Panagiotou K, Konstantinou D, Galani A, Gerovasileiou V, Voultsiadou E, Gkelis S 2018 Sponge-associated cyanobacteria in the North Aegean Sea: specialist and generalist communities. Book of Abstracts of the 12th Panhellenic Symposium of Oceanography & Fisheries, p. 171.

Panagiotou K, Koutsouveli V, Galani A, Oikonomaki K, Terzoglou V, Voultsiadou E, Gerovasileiou V, Dailianis T, 2018. Molecular taxonomy of sponges from marine caves of Greece. Proceedings of the 12th Panhellenic Symposium of Oceanography

and Fisheries – "Blue Growth for the Adriatic-Ionian Macroregion and the Eastern Mediterranean", 31 May to 3 June 2018, Corfu, Greece: 178.

Pavloudi C, Apostolaki E, Argyrou M, Beqiraj S, Berov D, Chatzigeorgiou G, Chatzinikolaou E, Christodoulaki S, Daskalov G, Diplaros P, Filiopoulou I et al. 2018 Balkan-Med Project: Regional Cooperation for the Transnational Ecosystem Sustainable development (RECONNECT). 12th Panhellenic Symposium of Oceanography & Fisheries, Corfu, Greece. 30 May - 3 June 2018 (presentation).

Previati M., Cheimonopoulou M., Koulouri P., Realdon G., Mokos M., Mogias A., Boubonari T., Kevrekidis T., 2018. EMSEA Med: a vibrant network for the diffusion of Ocean Literacy in the Mediterranean region. 6th European Marine Science Educators Association Conference 2018, 2-5 Oct. 2018, Newcastle, UK.

Rallis I, Sedano F, Florido M, Chatzigeorgiou G, Dailianis T, Tsiamis K, Dounas C, Gkelis S, Gerovasileiou V. 2018. Baseline survey of sessile benthos on artificial reefs deployed in the Underwater Biotechnological Park of Crete: preliminary results. Proceedings of the 12th Panhellenic Symposium of Oceanography and Fisheries – "Blue Growth for the Adriatic-Ionian Macroregion and the Eastern Mediterranean", 31 May to 3 June 2018, Corfu, Greece: 168.

Ramos, S., Gonzalez, W., Karamanlidis, D., França Nogueira, M.C., Milton, E., Mylonas, C.C. and N. Duncan. 2018. Reproductive control of meagre (*Argyrosomus regius*) to obtain families for genetic breeding programs. 11th International Symposium on Reproductive Physiology of Fish, 3-8 June, Manaus, Brazil.

Realdon G., Fabris S., Candussio G., Rossi M.M.P., Cheimonopoulou M., Koulouri P., Previati M., 2018. Ocean Literacy and Blue Growth: an innovative project linking science education and marine economy. 6th European Marine Science Educators Association Conference 2018, 2-5 Oct. 2018, Newcastle, UK.

Sedano F, Florido M, Rallis I, Espinosa F, Gerovasileiou V 2018 Comparing sessile benthos on shallow artificial versus natural hard substrates in Crete Island, Greece (Eastern Mediterranean Sea). Book of Abstracts of the 12th Panhellenic Symposium of Oceanography & Fisheries, p. 167.

Sevastou K, Papadopoulou N, Smith CJ, Fraschetti S, Guarnieri G, Gerovasileiou V, Dailianis T, 2018. A literature review on the economic cost and benefits of marine restoration. Proceedings of the 12th Panhellenic Symposium of Oceanography and Fisheries – "Blue Growth for the Adriatic-Ionian Macroregion and the Eastern Mediterranean", 31 May to 3 June 2018, Corfu, Greece: 144.

Smith CJ, Papadopoulou K-N, Dailianis T, Gerovasileiou V, Sevastou K, and the MERCES Consortium, 2018. H2020 Project MERCES: Marine Ecosystem Restoration in Changing European Seas. Proceedings of the 12th Panhellenic Symposium of Oceanography and Fisheries – "Blue Growth for the Adriatic-Ionian Macroregion and the Eastern Mediterranean", 31 May to 3 June 2018, Corfu, Greece: 120.

Sofoulaki K., Kalantzi I., Machias A., Zeri C., Mastoraki M., Chatzifotis S., Mylona K., Pergantis S.A., Tsapakis M. 2018. Marine metal pollution monitoring using anchovy and sardine: bioindicators, health risks and benefits, proximate composition. 12th Panhellenic Symposium of Oceanography & Fisheries. Ionian University, Corfu, 30 May – 3 June 2018.

Vasilaki, A., Rigos, G., Nikoloudaki, C., and I. Nengas. 2018. Benefits of organic minerals vs inorganic on growth, health and product quality of the European sea bass Dicentrarchus labrax (Linnaeus, 1758). 12th Panhellenic Symposium of Oceanography & Fisheries, Ionian University, Corfu, May 30- June 3, 2018.

2019

Katharios P. 2019. Invited speaker at the Conference of the Hellenic Society for Biological Sciences, Katerini, Greece. Presentation title: Biotechnological application in the prevention and diagnosis of diseases in aquaculture.

Katharios P. 2019. Invited speaker in "Advances in Value Added Soy Protein Ingredients and Feed Extrusion Technology for Sustainable and Profitable Aqua and Animal Production", USSEC' Technical Conference, September 24 and 25 2019, Intercontinental Hotel, Athens, Greece.

Bolgan, M., Pereira, B., Crucianelli, A., Vieira, M., Pousão-Ferreira, P., Mylonas, C.C., Parmentier, E., Fonseca, P.J. and Amorim, M.C.P. 2019. Soud variability in a fish species of high commercial value: geographical variation of calls in a passive acoustic monitoring perspective. XI Congress of the Portuguese Ethological Society, 9-10 October, Vairão, Portugal.

Cheimonopoulou M., Mogias A., Realdon G., Mokos M., Koulouri P., Previati M., Boubonari T., 2019. Mediterranean middle school students' knowledge, attitudes, and behaviors towards ocean-related topics: An EMSEA-Med pilot study. 7th European Marine Science Educators Association Conference 2019, 16-20 Sept. 2019, São Miguel, Azores.

Cheimonopoulou M., Realdon G., Mogias A., Koulouri P., Mokos M., Previati M., Boubonari T., 2019. Ocean literacy intervention activities: case study from a European Maritime Day (EMD) event in mainland Greece. 7th European Marine Science Educators Association Conference 2019, 16-20 Sept. 2019, São Miguel, Azores.

Christina Pavloudi, Saar Y Sztejrenszus, Jon B Kristoffersen, Niko Lahajnar, Marleen De Troch, Christos Arvanitidis, Michael W Friedrich 2019 Identification of microbial communities by RNA stable isotope probing and 16S rRNA sequencing from the Benguela coastal upwelling system. 8th Conference of the Hellenic Scientific Society of Mikrobiokosmos, Patras (Greece)

Christos Arvanitidis, Richard Warwick, Paul J Somerfield, Christina Pavloudi et al 2019 The Collaborative Potential of Research Infrastructures in Addressing Global Scientific Questions. Biodiversity Information Science and Standards (TDWG), doi: 10.3897/biss.3.37289

de Mello, P., Fakriadis, I. Lanceroto, S., Tsoukali, P., Calloni, L., Kopper, S., Sarracino, R., and Mylonas, C.C. 2019. Influence of thermal manipulations during gametogenesis on reproductive maturation of meagre (*Argyrosomus regius*), spawning success, gamete and egg quality. 17th Panhellenic Conference of Ichthyologists, 31/10 – 3/11, 2019, Heraklion, Crete. pp 297-300.

de Mello, Paulo H., Fakriadis, I., Tsoukali, P., Lancerotto, S., Calloni, L., Köpper S., Sarracino, R. and Mylonas, C.C. 2019. Influence of thermal manipulations during gametogenesis on reproductive maturation of meagre (*Argyrosomus regius*), spawning success, and gamete and egg quality. 7th International Workshop on the Biology of Fish Gametes, 2-6 September 2019, Rennes, France.

Fakriadis, I., Karapanagiotis, S., Tsele, N and C.C. Mylonas .2019. Timing of GnRHa treatment application in greater amberjack *Seriola dumerili*, 17th Panhellenic Conference of Icthyologists, 31/10-3/11, 2019, Herakleion, Crete, pp 277-280

Fakriadis, I., Zanatta, E.M. and C.C. Mylonas. 2019. Enhancement of spermiation in meagre *Argyrosomus regius* using GnRHa implants and evaluation of sperm quality using Computer Assisted Sperm Analysis (CASA), 17th Panhellenic Conference of Icthyologists, 31/10-3/11, 2019, Herakleion, Crete, pp 281-284.

Gioti A, Pafilis E, Christakis C, Bravakos P, Keklikoglou K, Polymenakou P, Arvanitidis C, Kotoulas G 2019 The Elixir-GR Marine -omics pilot action and the LifeWatch-GR microCT vLab. Hellenic Bioinformatics 12, Heraklion, Greece. 11-13 October, 2019, Poster.

K. Lika, O. Stavrakidis-Zachou, N. Papandroulakis, 2019. Impacts of climate-related drivers on finfish aquaculture. Sixth International Symposium on Dynamic Energy Budget theory for metabolic organization, Brest, Pp 105-105

Karagannidis E, Konstantinidis N, Sofidis G, Chatzinikolaou E, Daskalaki P, Meletidou M, Sianos G. 2019. Quantitative estimation of volume and density of thrombotic material with the use of micro-computed tomography in patients with acute myocardial infarction (STEMI) with ST segment elevation who are subjected to primary percutaneous coronary intervention (PCI) and thromboaspiration. 18th Panhellenic Congress of Cardiology - Northern Greece Society of Cardiology, Thessaloniki, Greece. 16-18 May 2019. Awarded with the 2nd prize for best presentation.

Karagiannidis E., Konstantinidis, N., Sofidis, G., Chatzinikolaou E., Sianos, G. 2019. Analysis of thrombotic material with the use of micro-CT: an innovative method for the quantitative and qualitative evaluation of aspirated intracoronary thrombus. 40th Panhellenic Congress of Cardiology - Hellenic Society of Cardiology, Ioannina, Greece. 17-19 October 2019.

Keklikoglou K, Faulwetter S, Chatzinikolaou E, Panteri E, Filiopoulou I, & Arvanitidis C 2019 Micro-CT at HCMR: applications and examples. BIOIMAGING-GR workshop, Heraklion, Greece, 29 October 2019, Oral Presentation

Melanthia Stavroulaki 2019. European Commission Workshop: "Marine genetic resources in areas beyond national jurisdiction: bridging policy, law, science and research and development", Martin's Hotel, Brussels, Belgium, 21-22/05/2019

Mylonas, C.C., Conidis, A., Sarropoulou, E., Papadaki, M., Papadakis, I., Kotzamanis, I., Chatzifotis, S. and A. Krystallis. 2019. MedAID: Integrated Aquaculture Development (Horizon 2020). 17th Panhellenic Conference of Ichthyologists, 31/10 – 3/11, 2019, Heraklion, Crete.

Mylonas, C.C., Papandroulakis, N., Katharios, P., Tsigenopoulos, C., Grigorakis, K., Chatzifotis, S. and I. Papadakis 2019. The DIVERSIFY project- Assessing the biological and socioeconomic potential of new/emerging fishes for the expansion of the EU aquaculture. 17th Panhellenic Conference of Ichthyologists, 31/10 – 3/11, 2019, Heraklion, Crete.

Skarvelis, K., Tsaparis, D., and P. Peristeraki, 2019. First record of the lessepsian fish *Parupeneus forsskali* (Fourmanoir & Guézé,1976) in the seas around Crete. 17th Panhellenic Congress of Ichthyologists, Heraklion, Greece, 31 October-3 November.

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