



Stazione Zoologica Anton Dohrn, Naples

Vision 2015-2025

Knowledge from the Sea, knowledge for the Sea

Explore the Mediterranean Sea to understand and protect the Global Ocean



TABLE OF CONTENTS

1	Executive summary	4
2	Introduction	5
3	The Stazione Zoologica Anton Dohrn of Naples.....	6
3.1	The origins.....	6
3.2	Historical and present Mission.....	6
3.3	The previous document of Vision SZN: 2010-2020	6
4	Marine research in the international context.....	8
4.1	The international scientific research trends	8
4.2	Priority and emerging scientific issues in global marine research	9
5	Vision for the years 2015-2025.....	10
5.1	Vision and mission	10
5.2	Facing new challenges of Marine Research	10
5.2.1	Research priorities of marine biological of SZN in the years 2015-2025	10
5.2.2	Priorities of marine research in the Mediterranean.....	18
5.3	Improving the contribution to the national research	19
5.3.1	Positioning within the National Research	19
5.3.2	A strategy for marine research in Italy and objectives of SZN in the national scene	19
5.4	Improving at international level	20
5.4.1	European Research Infrastructures.....	20
5.4.2	International initiatives	22
5.4.3	Scientific Journals	23
5.5	Implementing research personnel	23
5.5.1	Role of the researcher and technologist in SZN	23
5.5.2	Role of the technical staff in research	24
5.5.3	Research personnel in the years 2015-2025.....	25
5.5.4	Criteria for future recruitments	25
5.6	Strengthening research.....	26
5.6.1	Evaluation of the results and research performance	26
5.6.2	Technological Transfer.....	27
5.6.3	Promoting the merit.....	28
5.6.4	Facilities and Resources for Research	29
5.7	Contribution of SZN Research to the national cultural and socio-economical framework.....	30



Documento di Vision della SZN per il decennio 2015-2025

5.7.1	Connections with the territory and public institutions	30
5.7.2	Public engagement and additional resources for research	30
5.8	The SZN contribution to high education	32
5.8.1	To contribute to the higher education (Master degrees and PhD)	32
5.8.2	Training of young researchers.....	32
5.8.3	Life-long learning	33



1 Executive summary

The Stazione Zoologica Anton Dohrn of Naples (SZN), founded in 1872, is among the most influential international research organizations in marine biology and ecology. A key aspect of marine biology is biodiversity and this is under-explored. Major contributions are needed to provide significant advancements of knowledge and new tools for sustainable development.

Sustainable development is particularly relevant for Italy, which has 8.500 km of coastline and whose territory is more than 40% “underwater”. This is reflected in the importance of the Blue Growth initiative of the European Union for the development of our country within the scopes of Horizon 2020.

The Mission of the SZN for the years 2015-2025 can be summarized into:

To understand the biological systems of the Mediterranean Sea and the evolution of life to improve the sustainable use of resources in the Global Ocean.

To deliver this, the SZN will enhance multidisciplinary expertise in, and integrates across, current research in: a) Marine Biodiversity; b) Marine model organisms; c) Biological Evolution; d) Marine Ecosystems; e) Global change; f) Conservation; g) Marine Biotechnology. SZN will develop innovative experimental and observatory studies, to understand the biodiversity and functioning of Mediterranean ecosystems as a model of the global ocean.

We will use new opportunities that will arise in the years 2015-2025. These include an increased ability to dissect patterns and processes at different scales of complexity, using infrastructures such as EMBRC (European Marine Biological Resource Centre), EMSO (European Multidisciplinary Seafloor and water column Observatory), LifeWatch. In the next decade, SZN will launch the new International Centre Marine Ecological Data Analysis and Synthesis (MEDAS).

To enhance SZN’s scientific excellence and international leadership, a critical mass of staff is needed. Our current 125 permanent positions must rise to an overall size of 400 (200 permanent, and 200 on fixed term contracts). Our recruitment criteria will be based exclusively on scientific excellence. SZN’s performance will be improved through continuous monitoring and valuation, based on objective criteria, of research outputs.

The SZN will also consolidate its services, to enable the scientific community to easily access to the facilities. The SZN is the Italian reference point in marine biology and will cooperate with other research institutions and private companies to further valorize the products of research.

The Public Aquarium of SZN, which is well-known, will be restored and integrated with the creation of a new Darwin-Dohrn Museum of biological evolution. The new Sea Turtle Research and Rescue Centre in Portici (Naples) will represent the forefront of the Observatory for monitoring the health of the Gulf of Naples.

The SZN also engages in educational activities at Masters and PhD level. These activities will remain a priority for the next decade in order to form a new generation of top marine scientists.

2 Introduction

Marine research is growing exponentially, either because of the discovery of new research areas and for the development of innovative technologies and approaches. The coastal marine ecosystems provide more than 60% of the economic value of goods and ecosystem services offered by Nature and Man, and provide a significant contribution to the national economies, both in advanced countries, and in emerging countries. Italy has more than 40% of its territory “underwater” (territorial waters). The oceans cover more than 70% of the planet and about 50% of this extension are areas beyond national jurisdictions. The use of marine resources represents the new frontier of scientific, industrial, economic and diplomatic interaction amongst countries at international level. Renewable energy sources and non-renewable resources (such as mining), along with the discovery of new molecules and bio-inspired solutions of biomedical or industrial interest, fishing, maritime transportation, tourism, and also the effect of ongoing climate and global change, depend critically on the oceans and on “marine resources”. The potential and prospects for economic growth and employment in this sector does not have any comparison with any other industrial sectors. The European Union has recognized the critical importance of this sector priorities and devoting resources to Blue Growth. In the “Blue” as in many other fields, Life Sciences represent at least two decades the sector with higher perspectives of innovation and the strongest interests for the use of resources. The marine biological research has the advantage of combining in a unique way “Life Sciences” and “Environmental Sciences”, thus becoming a cultural bridge between the development of fundamental knowledge and solutions for sustainable growth of our prosperity. The global context sees a growing population, with increasing needs to find new resources to ensure the welfare, a sustainable development and the environmental quality, which are priority objectives in the Marine strategy Framework Directive of the EU.

The increased critical environmental issues, related either to global change and to the direct human impacts, however, are leading to a loss of marine biodiversity and ecosystem goods and services. Marine research offers real opportunities to respond to the emerging demands of our time, providing new knowledge, new opportunities and allowing the identification of solutions to the complex problems we face. Not least, to identify new ways enabling sustainable economic and social progress and without depriving future generations of the same opportunities. Answering these social, scientific and cultural “challenges” is the pillar activity that the Stazione Zoologica Anton Dohrn in Naples intends to pursue in the years 2015-2025 in national and international contexts.



3 The Stazione Zoologica Anton Dohrn of Naples

3.1 The origins

The Stazione Zoologica Anton Dohrn in Naples (SZN), founded in 1872, is the first research institution created independently from the universities. The Stazione Zoologica Anton Dohrn was recognized as a "Special Scientific Institution" of public interest by Law no. 886 of 20 November 1982 and later became national research institute under the supervision of the Ministry of Education, University and Research (MIUR) in 1991. Its history and location in the Gulf of Naples, one of the regions with the highest marine biodiversity in the world, have given to this institute a key role in the Italian and the international marine research. The SZN has, and always had, an international profile, both its founder, Anton Dohrn, and due to its mission and the international vocation for marine research. Anton Dohrn was one of the earliest and most visionary science managers, tenacious zoologist and convinced promoter of Darwin's theories, he dedicated himself to the proofs in support, and dissemination of Darwinism, both through his scientific and divulgation activities. Dohrn believed that the secrets of evolution could have been revealed by the study of the marine biodiversity, where life originated. The foundation of the Stazione Zoologica in Naples was a choice dictated by the extraordinary biological richness and nature of the region. The decision came in 1870 and the creation of a public aquarium was also decided (one of the first in the world at the time) to help fund research. Dohrn built at his own expenses the first building in 1872 that could accommodate twenty researchers. The aquarium opened to the public on January 26, 1874. In 1885 and in 1906 the building was expanded, tripling the surface. Thanks to the perfect organization of the services and the flexibility to adapt to new challenges and the scientific needs SZN has given important contributions to zoology, botany, ecology, embryology, physiology, biochemistry, oceanography and in research methods. At his death, Dohrn left an institution that was a model of international scientific collaboration, also defined a "permanent congress of scientists", which served as an example for many other institutions. As recognition the Stazione Zoologica from 1982 has the name of its founder "Stazione Zoologica Anton Dohrn".

3.2 Historical and present Mission

The Stazione Zoologica of Naples (SZN) is the first, by date of foundation, Institution of Marine Research in the world free from the university and academies. The SZN is currently among the most influential research organizations in the field of marine biology and ecology at the international level. Initially, the mission of the institute was to provide laboratories and research tools to scientists who obtained a "desk" for their studies by the SZN and that needed marine organisms for their studies. Since decades, the SZN has its own scientific staff and conducts research, supported by visiting researchers.

Today, the mission of the Stazione Zoologica is devoted to basic and applied research on marine organisms and marine ecosystems, their biodiversity, in close connection with the study of their evolution and dynamics of marine ecosystems, and to the fundamental processes of biology and the development of marine biotechnologies. The Stazione Zoologica conducts its research through an integrated and interdisciplinary approach.

3.3 The previous document of Vision SZN: 2010-2020

The "Vision 2010-2020", which is the first document produced by the SZN in its history as Public Research Institute (EPR), was based mainly on the importance and modernity of marine biological research, recognizing its potential development in various areas of application, such



as the protection and conservation of environment, the exploitation and management of fisheries and aquaculture. In addition, it was recognized the indispensable role in the conservation issues, the maintenance and improvement of its resources and to shed light on the role of marine organisms in supporting the balance of the climate of our planet. The document lists the features of the previous Vision SZN as EPR and that the "co-existence of biological and ecological research is essential for an understanding of the marine environments and of the basic mechanisms that govern the ocean functioning". The ability to conduct research at different levels of complexity with expertise in different disciplines such as genetics, cell and developmental biology, physiology, ecology and oceanography, and to explore and develop methodologies and experimental protocols that represent important reference for research transferred to other systems and/or organizations. The document identified the skills "on a broad spectrum of organisms" which allow the study of "marine ecological problems evaluating the contribution of the biological component in all its complexity." Finally, the document emphasized the potential of national and international interactions for SZN, able to "provide access to the use of marine organisms to the international scientific community", as well as providing advanced training. The document reported the role of project coordinator of the preparatory phase of the infrastructure EMBRC (European Marine Biology Resources Centre), a network of research facilities dedicated to Marine Biology, and able to provide, in the future, access to researchers for the use of organisms and marine systems.

The Vision Document 2010-2020 presented the activities of the ten-year projection of as organized in three main research lines: 1. Development of an integrated approach to the study of marine biodiversity; 2. Marine organisms as a source of knowledge; 3. Development of a functional ecology. The element of convergence among the three lines was identified in the understanding of the processes that determine the temporal dynamics of biodiversity. It is promoted the development of an integrated approach to the study of marine biodiversity. The previous Vision document identified possible 'gaps of knowledge' about the "biological mechanisms that underlie: i) the interaction between these organisms and their environment, ii) the interactions and trophic behaviours governing interactions among organisms iii) the adaptive processes that allowed the evolution of life in the sea". It outlines the key role of the programme: diatoms, ascidians (e.g., *Ciona intestinalis*) and echinoderms (especially sea urchins and starfishes), copepods, cephalopods.

The "development of a functional ecology" was indicated as necessary to recover the "delay of knowledge" on the functioning of marine ecosystems with the use of laboratory and *in situ*, analysis and modelling. It was expected a consolidation of the role of the Long-Term Ecological Research sites. SZN was committed with MareChiara (LTER-MC) for the systematic observation of the coastal ecosystem, the *Posidonia oceanica* (LTER Lacco Ameno, Ischia), and the site characterized by natural emissions of CO₂ of volcanic origin (Castello Aragonese, Ischia) that gives access to a 'natural laboratory' of the "effects of acidification on benthic organisms at different hierarchical levels of complexity". Another objective highlighted was the importance of isolation and characterization of marine organisms for identifying new bioactive substances.

The importance of the *Network of Excellence, European Programs*, was finally reiterated and the provision of infrastructure, in addition to the "Global Experimental Marine Biology Laboratories (GEMBIOL)" useful for new partnerships with Marine Biology Stations of the United States and Japan.



4 Marine research in the international context

The research is primarily the advancement of knowledge and understanding of natural phenomena, but also, as increasingly evident in the last decades, a mean of finding solutions to enable the progress of humanity and improving the living conditions of humanity on the planet. Richard E. Smalley, Nobel Prize in Chemistry, in June 2005 identified 10 new challenges for the third millennium, which include among the top 5: Water; Food and Environment;.

Seas and oceans contain more than 98% of water resources of the planet and play a key role in the water cycle. It is estimated that over 50% of energy and mineral resources is still kept in the deep ocean and the oceans can be a key source for renewable energy. The marine environment occupies over 90% of the planet's biosphere, regulates the global biogeochemical cycles, produces about 50% of the oxygen we breathe and sequesters about 50% of the carbon dioxide produced by man. Moreover, the global ocean provides basic food resources, especially in developing countries, and the production of more than 30% of the proteins available for human consumption. In other words, the seas and oceans play a key role in the first four challenges that involve humanity in the next millennium.

4.1 The international scientific research trends

The analysis of the global "Research Trends" of the last 10 years clearly shows the presence of an exponential growth of scientific research (expressed in terms of publications and scientific products) that is unprecedented in the history of Humanity. The impressive ability to generate data is leading to a huge flood of information. It remains limited, as tied to the man and not the scientific instrumentation, the ability to process this information and its transformation into knowledge. These elements allow understanding how great is the potential of data production by technological development, but also that is even more fundamental the training and recruitment of researchers who can exploit these for the "scientific progress".

Among the eight research areas to further development of global knowledge in the last decade, two appear to grow at higher rates than others: 1) Life sciences and 2) Environmental sciences. Marine research conducted at the Stazione Zoologica lies exactly in the middle of these two areas of global research.

The analysis related to marine research in the period 2005-2015, carried out using the Web of Science, indicates a growth rate of 10% per year in terms of both products (publications) and citations. In the last decade, all most advanced countries doubled their annual productivity. France and Germany have taken this step in the same way, Greece and Spain have done even better by increasing the scientific production of 125 and 160% in the last decade. Even the US has seen a steady upward trend in line with the most competitive countries. Only Italy and Japan showed lower growth rates. Italy has in fact grown by 83% showing a decrease in competitiveness in line with the gradual erosion of the number of researchers in the same period (estimated at a reduction of about 15%).

Within this sector, marine research, the most important subject area is that of Marine Biology, with over 42% of products, followed by environmental sciences (that as also a strong ecological component) and finally oceanography and the geo-sciences with less than 20% each. In the Marine Biology area, the sectors that contributed mostly to the scientific production of the last decade were: 1) marine biology and ecology (over 50% of the products of the area); 2) microbiology and biotech (20%) followed by 3) marine biochemistry (about 7%); 4) fishing, 5) evolutionary biology and 6) conservation biology with about 5% each.



The trend of the last decade indicates that even among these scientific areas, the growing sectors are those related to integrative, ecological and multidisciplinary sciences (2500% increase), and conservation (increase of almost 300%), followed by toxicology, fishery biology and microbiology, with increments of 100%.

The results of this decadal analysis at global scale, clearly indicate that the marine biological research, in its various disciplines/areas, is one of the fastest growing research sector with the greatest potential for further development.

4.2 Priority and emerging scientific issues in global marine research

The analysis of scientific trends and the impact of recent publications on the scientific community allow us to identify some emerging areas of growing scientific interest and therefore of socio-economic potential interest:

1. Global dimension of marine ecological research.
2. Exploration of marine biodiversity, including the study of genomes and their evolution.
3. Global impacts on marine ecosystems and multiple stressors.
4. Novel impacts, new contaminants and their effects on marine ecosystems and on humans.
5. Interactions between multidisciplinary research: biological, geological, microbiological, bio-medical research in and for the marine environment.
6. Development of marine biotechnology, including the study of extreme marine environments.



5 Vision for the years 2015-2025

5.1 Vision and mission

The Stazione Zoologica will consolidate its role as an international centre of excellence in the field of marine biology.

The strategy can be summarised in: *Knowledge from the Sea, knowledge for the Sea*

With the aim of: *Innovating research for discovering, valuing and protecting marine life*

We believe that marine biodiversity is the greatest source of knowledge yet unexplored of the planet and that the research that will be carried out in the coming years will provide a major contribution to the advancement of knowledge and new tools for sustainable development.

5.2 Facing new challenges of Marine Research

The development of new technologies that allow us to study the biology of organisms from molecules to global offer unprecedented opportunities for research. These opportunities can be grasped by acquiring the best equipment and facilities for research, accepting the challenge of the complexity characterizing the living and stimulating human resources capable of turning research into data, and data into knowledge. Significant progresses have been made over the past three decades, in terms of integration of the knowledge and multidisciplinary of the approaches, but still much remains to be done to fully exploit the potential offered by the integration of scientific potentials.

The SZN intends to seize this opportunity, on one hand, by further implementing the collaboration with other research sectors (geology, chemistry, physics, economics, engineering), while enhancing its multidisciplinary expertise in the Field of Biology (currently, including marine and fundamental biologists, biologist of reproduction, developmental biologists, zoologists, botanists, ecologists, eco-physiologists, behavioural biologists, evolutionary biologists, geneticists, biochemists, bioinformatics and others).

5.2.1 Research priorities of marine biological of SZN in the years 2015-2025

- a) **Marine Biodiversity:** towards innovative and integrated approaches.
- b) **Marine model organisms:** for studying several key topic from the biology and ecology to the biomedical research
- c) **Marine Genomics:** understanding the structure and function of genes in organisms of the Mediterranean.
- d) **Biological Evolution:** Integrating Epigenetics, genetics, ecology and behaviour.
- e) **Adaptation to extreme marine environments:** new opportunities for knowledge of the limits of life.
- f) **Marine Biotechnology:** for industry, food, medicine and biotech for remediate environmental problems.
- g) **Global changes:** to understand and predict the response of marine ecosystems with a focus on the Mediterranean.
- h) **Conservation:** protect the biological resources and the environment and ensure a sustainable Blue growth.



The content of these main research areas are reported here below:

a) Marine Biodiversity: towards innovative and integrated approaches

Biodiversity, defined as "the richness of life and the different forms in which it manifests itself," includes diversity within species, between species and of ecosystems. Human life is strictly dependent on the services that ecosystems provide through their levels of (bio) diversity. The need to preserve biodiversity has been clearly established by the European Union. The document "Mid-term review of the EU biodiversity Strategy to 2020", published in October 2, 2015, reports that the cost of not achieving by 2020 the objectives on biodiversity set in 2011, it was estimated up to 50 billion euros a year. As an example, one of six jobs in the EU depends to some extent on the nature, without considering the intrinsic values, ethical and emotional, of marine ecosystems.

The Mediterranean, because of its long history of human colonization and the recent deep human alterations (as the opening of the Suez Canal), is also a hotspot for the presence of invasive species. One of the priorities of SZN for the next ten years will be the study of marine biodiversity (including native species and invasive species) at different hierarchical levels of organization, through integrated approaches that include morphology, genetics, genomics (NGS and metagenomics) and modelling. The evolution of biodiversity on the time scale will be studied by exploiting platforms of long-term monitoring and comparing historical data available for specific areas (e.g., Gulf of Naples). In taxonomic analysis life cycles, the physiological differences, the characters ecological, etc. will be considered

An integrated definition of species is important for the interpretation of their distribution in space and time, but will also provide information on their structural and functional differences and therefore the possibility of their exploitation biotechnology.

The challenge for the years 2015-2025:

Identify new species, mapping, protecting and managing biodiversity more efficiently.

b) Marine model organisms

Biological research has been based for a long time on the study of a limited number of "model organisms" (e.g., *Drosophila*, frog, mouse and rat, *Arabidopsis*, the nematode *Caenorhabditis elegans* and very few other species), which have been selected because they can be easily used in laboratory research. However, the use of a few "model" species may hinder the progress in knowledge about many basic biological processes because of poor accessibility to the testing of certain processes in such organization, as well as ethical considerations relating to the use of vertebrates, and mammals in particular. Marine organisms have contributed, since the dawn of experimental biology, to the fundamental discoveries of biological processes. This is testified by the Nobel Prizes awarded for example to Alan Lloyd Hodgkin and Andrew Huxley in 1963 for studies on the axon of the Giant Squid and the one assigned to Martin Chalfie and Roger Y. Tsien in 2008 for the extraction of the Green Fluorescent Protein (GFP) from the jellyfish *Aequorea victoria* that has revolutionized research in many scientific fields. Squids and jellyfish cannot be easily maintained in laboratories, and research on them were made from organisms taken from the marine environment.



The variety of organisms used as "models" in research is currently undergoing a massive expansion, thanks to the reduction in terms of time and costs of genome sequencing and the availability of techniques to selectively alter the patterns of gene expression.

Marine organisms are an important source of new models due to the great variety of species that inhabit the oceans. The SZN aims, on one hand, at enhancing the accessibility of the experimental marine species currently in use, on the other to create a new catalogue, diversified by type of use, with a new generation of species that can extend scientific research in new directions.

The SZN is in a unique position in the national and international context, to offer availability and accessibility to the infrastructure and advanced technologies required for conducting the research. At present SZN maintains several marine models, including the protocordate *Ciona intestinalis*, echinoderms such as sea urchins (*Strongylocentrotus purpuratus* and *Paracentrotus lividus*), and starfish (*Patiria miniata*, *Astropecten araciacus*), the emicordate *Ptychodera flava*, the cephalocordate amphioxus (*Branchiostoma lanceolatum*) and the mollusc *Octopus vulgaris*, just to name a few. Other models such as the hydrozoan *Turritopsis dohrni* (the immortal jellyfish) have also been studied at the SZN.

The use of these "model" organisms will be of fundamental importance for understanding the mechanisms that underlie human diseases. In fact, the high accessibility of these experimental organisms makes them particularly suitable for studying gene regulatory networks underlying cell differentiation, fertilization, stem cell biology, morphogenesis, regeneration and aging, both in physiological and in pathological conditions.

The discovery of biological organism-specific will lead to the enrichment of potential "models" and will encourage the search for alternative methods for reducing the number of living organisms to be tested. The development of cell and organo-typic cultures of marine species will allow the understanding of fundamental biological processes at the cellular and sub-cellular level, to extend the potential of stable cell lines and stem cells and to allow the expansion of research capacity, for example, in biomedical and ecotoxicological fields.

The challenge for 2015-2025: identify novel marine organisms to be tested in pre-clinical studies to replace the traditional species.

c) Marine Genomics: understanding the structure and function of genes in organisms of the Mediterranean

The huge phyletic biodiversity of marine life is reflected by an equally wide variety of metabolic processes, control systems and production of compounds of various nature. These imply the existence, in marine organisms, of an extraordinary genetic potential largely unexplored. The massive sequencing technologies are currently the most popular way for decoding and cataloguing marine genomes and the genes they contain, with transcriptomic, metagenomic and metatranscriptomic experiments undergoing in several sites in the world, and with genome projects completed or initiated for species representing major groups of marine organisms (fish, amphioxus, tunicates, echinoderms, annelids and molluscs, cnidarians, micro- and macro-algae, bacteria). There is no doubt that the next decade will see a huge increase of genomic resources, with the production of new genomes and transcriptomes of marine organisms completely sequenced and functionally annotated. In these large-scale studies there will be the development and promotion of systems and methodologies aimed to study the gene function, similar to the approaches used in the traditional model organisms (banks of mutants, gain and loss of function, methods to study protein-protein and protein-DNA interactions).



In particular, the possibility to study gene functions will be crucial for understanding the role of a fraction of those sequences that show no homology with any known gene, and to define the cellular context in which they act. It will also be possible to select genes with specific functions and study the consequences of their disruption in the cell and in the interactions with other components of the ecosystem of origin, with the real prospect of discovering new mechanisms or new combinations of known strategies. The possibility of carrying out genetic manipulations also results in the possibility to produce transgenic lines for application purposes. Attempts in this direction are, for example, performed on microalgae, promising biofuel production systems and source of various compounds, or ecto-parasites copepods that pose serious threats to aquaculture.

A good basic understanding of the physiology and ecology of marine models selected for functional studies will allow better interpretation of molecular data. Similarly, ecological studies are enhanced by incorporating an extra layer of complexity, the molecular support essential to the understanding of the mechanisms that regulate the functioning of marine ecosystems. The ultimate goal will be the understanding of the complex molecular interactions between organisms and between organisms and the environment, at individual, population and community levels, thanks to metatranscriptomics and metagenomics, which allow the simultaneous analysis of the biodiversity and function of the genes. A future priority will be also connecting the species with their genes and genomes. Currently, in GenBank, the accuracy of the identifications taxonomic is very questionable, with the risk that sequences found in an environment are used to identify species that, because of the errors of identification, may not be present. The future challenge is to address in an integrated way the complex phenotypic and genotypic biodiversity.

The challenge for the years 2015-2025: to complete genomes of 100 species of the Mediterranean in order to discover and value their characteristics and potentials.

d) Biological Evolution: Integrating epigenetics, genetics, ecology and behaviour

The experience consolidated in several years of experimental biology has highlighted that the differences among individuals living in nature are far larger than those detectable from organisms maintained in the laboratory and thus undergoing frequent breeding. The study of marine organisms has confirmed that the diversity of the processes at various levels of biological organization is far larger than that observed on model organisms. This body of evidence makes even more actual the study of the evolution of the genomes in their complexity (either individual, population, behavioural or ecological).

Each body exists in its abiotic context. Biotic and ecological factors interact in this complex and intricate context. This complexity must be investigated, considering, for example, the selective forcing factors operating on the multiple stimuli to which organisms and populations are continuously subjected, in part also due to the increased anthropogenic pressures.

The interactions between environment and organisms (and vice versa) and the factors that in various ways participate and intervene in the 'system' determine the evolution and composition of biological communities. Therefore, it becomes increasingly important to acquire new knowledge for understanding the processes driving the biological evolution.

Various "stressors" affect important biological processes (fertilization, development, physiological and behavioural responses, interactions between species and between organisms and their environment), limiting the ability of species to survive and leading to the reduction of a "wealth" biological biome. The 'stress' can be considered an evolutionary accelerator because it causes the alteration of specific molecular processes resulting in increase of mutations in the



genome. Also transmissibility, through the gametes, of stress responses by epigenetic modifications acquired following the interaction with the environment, in ways independent from the mutations, adds another layer of complexity that appears to contribute significantly to the success of a population.

SZN will study in detail these aspects, taking advantage of the historical context, which sees the "global change" and the increased pressure derived from multiple stresses. In particular the study of fertilization, development, evolvability and behaviour with the most modern approaches to molecular and cell biology, functional genomics and bioinformatics, neuroscience and behavioural biology will open new frontiers of interpretation to the evolutionary process.

The multi-scale and multi-system study enables an integrated approach to the biological and ecosystemic evolution. Basic Technologies and knowledge existing allow to plan, in the next decade, the study of evolution at different levels: i) reproductive capacity, development and differentiation; ii) the variability of genomes and components that enable the evolution of the novelty and complexity, particularly with regard to the non-coding and mobile part of the genome; iii) biological and behavioural plasticity and genetic and epigenetic processes that allow diversification.

The challenge for the years 2015-2025: to identify the genetic mechanisms, and the epigenetic and behavioural factors driving the evolution of marine life.

e) Adjustments to extreme marine environments: new opportunities for knowledge of the limits of life

Extreme environments provide extraordinary opportunities to understand: i) the limits of life; ii) the adaptation to extreme conditions; iii) the mechanisms of symbiosis; iv) the functioning of molecules or biotechnological products of pharmaceutical interest or industrial; v) the effects of environmental forcing in structuring marine communities in the future.

The Mediterranean offers unique opportunities to study extreme environments, from the acidified site of Ischia - Castello Aragonese capable of simulating the pH conditions in year 2100, the deep-anoxic hypersaline basins that host unique life forms that can live in the absence of oxygen. Of particular relevance are the studies of active hydrothermal vents, only recently discovered in the Tyrrhenian Sea, and cold seeps with new communities whose operation is based on the oil spill. Also hypoxic and contaminated areas will be of increasing interest for their effects on marine organisms. The study of these systems, whose operation is typically simpler than the others, would allow the understanding of the mechanisms that structure biological communities in extreme environments.

The challenge for the years 2015-2025: to identify mechanisms biochemical and molecular, cellular, physiological and ecological that allow life in extreme conditions.

f) Marine Biotechnology: for industry, food, medicine and environment

In the context of the global economic crisis, the countries are now facing complex challenges, including the supply of sustainable food and energy, climate change and environmental degradation, human health and the aging population. Marine biotechnologies can give an increasingly important contribution to face these social challenges and support the recovery and economic growth, providing new knowledge, products and services, as also pointed out by the Horizon 2020 Framework Programme of the European Commission about the potential of the "Blue Growth".



Sustainable supply of healthy and high quality products: Biotechnology has contributed significantly to increasing production efficiency and product quality of sea-food, as well as allowed the introduction of new species for intensive cultivation. However, the commercial aquaculture continues to face challenges in understanding and control of reproduction, development, growth, nutrition, and disease state management of animal health and environmental interactions and sustainability.

Improve the welfare and human health: In recent years, the chemistry of natural products derived from marine organisms has received growing interest in the scientific area, with 7 approved pharmaceutical products in clinical use and about 15 marine natural products in various stages of clinical development, especially in the field of oncology. The main challenges of drug discovery from marine biological resources are related to: legal aspects (secure access to marine resources, intellectual property rights); quality of marine resources (identification and variability); costs of drug discovery from marine natural products.

Protecting the marine ecosystems: Marine biotechnologies are playing an increasingly important role in the protection and management of the marine environment (e.g., biosensor technology for high-resolution in situ monitoring of coastal water quality, control of harmful algal blooms, the development of advanced eco-friendly anti-fouling products, the identification of microorganisms enabling the bioremediation of contaminated matrices). The biopolymers of marine origin will have an increasing attention from pharmaceutical industries, bio-medical and biotechnology companies for their numerous applications ranging from biodegradable plastics to food additives, polymers, pharmaceuticals and medical dressings, bio-adhesives, dental biomaterials, tissue regeneration and 3D tissue scaffolds. The marine environment is an unexplored resource for the discovery of new enzymes, biopolymers and biomaterials for industrial applications.

The challenge for the years 2015-2025: to identify new molecules produced by marine organisms of interest in the pharmaceutical, nutraceutical or industrial companies.

g) Global changes: to understand and predict the response of marine ecosystems with a focus on the Mediterranean

The ongoing increase in global temperature of the oceans, accompanied by rising sea level, by changing ocean currents and extreme climate events, the substantial loss of Arctic ice, ocean acidification and deoxygenation are problems universally recognised by the international scientific community. These changes will have direct effects on the physiology and phenology of marine species as well as significantly influencing the spatial distribution and ecological interactions. These changes will also have impacts on habitats and on the structure and functioning of ecosystems, while altering the connectivity between populations. These perturbations can interact among themselves (multiple stressors) and with other anthropogenic effects exasperating the effects and hitting not only the individual species or functional groups, but also the network of interactions in which they live. Specifically, resilience and/or resistance of marine ecosystems to perturbations depend on the degree of acclimatization and adaptation of organisms, on the diversity of ecosystems and on the degree of isolation from contiguous ecosystems.

Understanding marine ecosystems and their dynamics and functions is a long-term priority of marine research. Such systems are subjected to environmental pressures acting individually or together, profoundly changing the interactions between species, the population dynamics and



community structure. The use of an end-to-end approach, the integration of acquired data on space and time scales and the development of innovative methods aimed at an accurate and efficient measurement of the health of ecosystems, will allow to measure, monitor, understand and predict impacts of global change, needed for the sustainable management of oceans and coastal areas.

Given the complexity of marine ecosystems, to which is added the complexity of the climate system as a whole, the commitment of the research in this area should be:

"Look at the local level and understand the structural and functional level, to act at the global level".

The role of marine research is so crucial because there is an absolute necessity to observe and understand biotic and abiotic trends, to study the vulnerability of ecosystems and assess the risks on their health and on their operation, predict and simulate the ecosystem and biogeochemical changes to better protect the environment and / or find answers to change.

The approach to be favoured must therefore be highly integrated, systemic and multidisciplinary, have full coverage to trophic level and functional (i.e., from viruses to mammals) and should investigate the mechanisms going from gene expression (in situ and in the laboratory) to regulatory mechanisms of the structures emerging ecosystem.

The future of research and priorities in this area are:

- 1) developing integrated observatory systems including the biological component to investigate:
 - a) the characterization of the physical and chemical conditions, relevant to the biology (structure and dynamics of the water column, renewal of nutrients and export to deep sea, terrigenous inputs, the role of micro-nutrients, etc.);
 - b) a description of the in situ metabolic state of the organisms (metagenomics and metatranscriptomics) in combination with a detailed description of their diversity, including identification of indicator species at the regional level of the change under way, with emphasis on non-native species;
 - c) the definition of the regulatory mechanisms of intra- and interspecific biotic interactions and the resulting emerging structures, taking into account the seasonal and inter-annual variability and the biological cycles of the species and their associations.
- 2) observations on the functional groups and/or on keystone species with particular emphasis on their ability to adapt to environmental change, through studies under controlled conditions in the laboratory and in situ of the responses of organisms in forcing "multiple stress".
- 3) highlight the relevance of the local processes at the global level through the description and understanding of the inter-annual and decadal changes of ecosystems at local and regional level.
- 4) integrate the knowledge gained into new conceptual models, in order to assess and predict the scope and impact of the changes on the ecosystems and on the society.

In this context, the SZN will strive for greater integration of the different approaches (from observation to simulation through process studies in situ and in the laboratory experiments) in order to create fully integrated and multidisciplinary marine observatories.



The challenge for the years 2015-2025: to develop a global network of observatory integrating biological components to the environmental variables.

h) Conservation: protect the biological resources and the environment and ensure a sustainable blue growth

The biological diversity of the oceans has an essential role for the maintenance of goods and services offered by the planet, but the pressure that human activities have on the sea has grown dramatically in recent decades. The exploitation of biological resources and mining, the human settlement of the coast, maritime transport and climate change undermine the capacity of marine ecosystems to provide essential goods and services to humanity. The gradual depletion of coastal resources has led man to develop technologies for the exploitation of offshore areas previously inaccessible. All the forecast models suggest that the stressors will increase significantly in the near future, and if no measures will be taken, by 2050, commercially exploited fish stocks will collapse. The increasing global fish production from aquaculture will pose risk of pollution. The extraction of gas and oil is already shifting from the continental shelf at depths of between 3000m and 5000m and mining of the deep ocean is rapidly expanding. All these stressors interact in a synergistic or cumulative way, according to dynamics and processes still little known, thereby eroding further the resilience of marine communities. It is now clear the need to improve our understanding of the functioning of marine ecosystems and the comprehension of how they respond to human pressures.

“Biodiversity and the ecosystem services must be protected, valued and duly restored, for their intrinsic value and for their essential contribution to human wellbeing and economic prosperity” (Convention on Biological Diversity, Vision 2050).

Thanks to its tradition and competence, the SZN will take a leading role in documenting and understanding the changes of marine environments considering the synergistic effect of multiple stressors. The main challenge, however, will be to increase the capacity of transferring the knowledge to the public and private sectors through the development of forecasting tools in support of pragmatic choices for the conservation of biodiversity and the dynamic management of marine ecosystems. It will be a crucial contribution to the definition and achievement of good environmental status, as required by the EU Marine Strategy.

The challenge for the years 2015-2025: to develop a network of protection for species and marine habitats able to support the achievements of the objectives of the Marine Strategy.

i) Energy: towards alternative and renewable sources from the sea

The ocean is the largest source of sustainable energy. There are many examples of bioenergy production from marine organisms, but the production of biofuels from microalgae or oils from their products is an option to raise this huge energy potential. The production of energy by means of heat or mechanical, is crucially dependent also upon the biological components, due to their potential impact on offshore facilities. Reducing the impact of organisms on these structures is a further challenge for Marine Research.

The challenge for the years 2015-2025: to develop new approaches to the production of biofuels and providing sustainable solutions for the use of energetic resources exploited from the sea.



5.2.2 Priorities of marine research in the Mediterranean

The Mediterranean Sea is a hotspot of marine biodiversity: although it represents only 0.82% of the oceans surface, it contains more than 7.5% of the global marine biodiversity. The Mediterranean is a semi-closed basin, with reduced exchange of waters with the Atlantic Ocean, with a negative water balance and it is subjected to strong anthropogenic impacts and climate change at different spatial scales.

These factors make the Mediterranean a “miniature ocean”, where the impact of global change is stronger and faster than in all other oceans. Also for this reason it is a natural laboratory for research on the effects of these changes on biodiversity and functioning of marine ecosystems. Numerous environmental emergencies in the Mediterranean need to be addressed, and among them: habitat destruction, overfishing, pollution, introduction of alien species, the progressive acidification and warming of seawater, combined with episodic extreme phenomena and mass mortality events or proliferations of non-indigenous species. These “multiple stressors” act in synergy, with unpredictable effects.

The development of innovative experimental and observatory studies, able to include fully diverse biological components, are a priority to understand the biodiversity and functioning of ecosystems, their health status and their vulnerability. It also requires systemic and holistic approaches that can integrate in different spatial interactions between molecules, organisms, communities and ecosystems; to address multidisciplinary studies that combine molecular biology, biochemistry, genetics, physiology, ecology, oceanography, chemistry and modelling, even with use of remote technologies. For example, the analysis of the function and dynamics of marine ecosystems at the basin scale may benefit from the use of satellites to be integrated with field data and functional observations at different levels of biological organization, from viruses to large mammals. These objectives also require significant international cooperation between SZN, countries of North Africa and the Middle-East who insist the Mediterranean Sea.

The priorities of the research in the Mediterranean in the next decade are:

- **Observatories:** integrated biotic and abiotic, at long term and at different spatial scales.
- **Experimentation** manipulation *in situ*, to understand the ecological, adaptive and regulatory processes, that regulate the functioning of ecosystems.
- **Research** on invasive species and their impact on the balance of Mediterranean ecosystems.
- **Analysis** of fisheries and other biological resources, and their contribution to ecosystem functioning.
- **Evaluation** of the impact and sustainability of new aquaculture systems *in situ* and the breeding of selected species,
- **Conservation** of marine species at risk, and protection of ecosystems and their resources.
- **Understanding** of the impact of multiple “stressors” and extreme phenomena (including episodic events and regime shifts) on biodiversity and functioning of Mediterranean marine ecosystems.
- **Speciation** processes and biological evolution in the context of the Mediterranean Sea.
- **Biotechnology** for exploiting the specific BlueMed potential (Mediterranean Biota)
- **Model organisms of the Mediterranean** to be used in both fundamental and applied research (e.g., *Posidonia oceanica* and other iconic species)
- **Integration** between models and field data for understanding biodiversity and ecosystem functioning.

The priority areas that need the development of marine research actions are:



Tyrrhenian Sea, a key component of the Mediterranean Sea. Volcanoes, seamounts, canyons and deep water close to the coast require a plan of integrated and multidisciplinary research to understand the interaction between biodiversity and functioning, both in terms of mineral resources or energy potentially available.

Gulf of Naples: as an example of areas under multiple stressors

Marine areas at risk: either because of extreme meteorological events (the Tirreno is an ideal site as a workshop for the integrated study of the impact of volcanic, hydrothermal, regime shifts, climate change and others) or other drivers.

Control Marine areas: to be used as a comparison (e.g., Lower Adriatic and Ionian Sea and other ocean areas with appropriate characteristics suitable for comparisons).

5.3 Improving the contribution to the national research

5.3.1 Positioning within the National Research

Based on the analysis conducted on the Web of Science for the period 2004-2014, the SZN contributes 12% to the total marine research carried out by research institutes. However, when the analysis is focused on specific areas of expertise, the Stazione Zoologica is the institution with the greatest scientific impact in the field of marine biology (Area 05, more than any other scientific or academic institution in Italy). The role of leadership in marine biological research must, however, be considerably enhanced in both quantitative (i.e., number of publications in international journals), qualitative terms (i.e., number of citations per article and the relative impact on the international scientific community). Moreover in the future will become even more important the cultural leadership on the scientific products (i.e., position in the Author list as first, corresponding author or chief school in the last position).

The rate of ISI publications per author per year of the scientists at SZN, in the last years, has remained fairly constant (on average about 2 publications by author per year), compared with a significant upward trend at global scale. Over the next five years it is set an average target of 3 publications per author per year, to reach the rate of 4 ISI publications at the end of the decade, in accordance with the best international standards.

The impact on the international scientific community can be even more profitably rated as number of citations per author per year. Also in this case it is possible to indicate targets for improvement in the number of citations in excess of 10% per annum.

The challenge for the years 2015-2025: to produce at least 4 publications in international journals per scientist per year at the end of the decade, and increasing by at least 10% per year the number of publications and citations.

5.3.2 A strategy for marine research in Italy and objectives of SZN in the national scene

Italian marine research still lacks a national strategy. Creating a *Blue Growth Cluster* among research institutions, industries, stakeholders and policy makers will contribute significantly to the definition of an Italian strategy and to the need of a greater integration between the industrial production system and marine research. The “national blue strategy” should tend to offer more opportunities for either the economical development and employment, while



preserving the marine ecosystems. The National Research Plan, seas and oceans, including polar research, are priorities that need appropriate strategies and investments.

The statement of the G7 (Communiqué Meeting of the G7 Ministers of Science Berlin, 8-9 October 2015) indicates a priority for international research on:

- a) diseases linked to poverty
- b) the future of the oceans,

As far as the oceans are concerned, in particular the impact of marine litter and pollutants at sea (including plastics and dumping), and the impact of deep-sea mining.

In this perspective, the Stazione Zoologica can play a role of primary importance at national level and contribute significantly to the Italian leadership in these and other areas of marine research.

This role can become useful in a social perspective in areas such as research devoted to the implementation of the marine monitoring with advanced approaches, including the Marine Strategy applied to deep-sea ecosystems, which in Italy will be assigned to the Research Institutions by the Ministry of Environment (instead of to the Regional Agencies for the Environment, ARPA).

The Stazione Zoologica has also the chance to become a reference point for the identification of marine biological models for biomedical experimentation, suitable for the progressive replacement of traditional models (e.g., mouse, dog, rabbit, guinea pig) and the strengthening of research in the field of marine biotechnology (Blue biotechnologies).

The challenge for the years 2015-2025: To become the reference at national level for the marine research and the forefront of international representation for the Italian marine biological research.

5.4 Improving at international level

5.4.1 European Research Infrastructures

Within the European Research Area (ERA), it is clear that the high-level research, technological development and innovation (RTD & I) depend not only from the scientific capacity of the individuals, but also from the availability of research infrastructures.

Some of these are possible in a transnational framework allowing the development of pan-European research (RIS).

The systems to be set up pointing to:

- 1) internal and external users from Universities and the private sector who need platforms, and data services on a competitive basis;
- 2) internal staff that will have access to cutting-edge infrastructure and share best practices, information, knowledge, and personnel, increasing the standard levels of European research;
- 3) resource sharing on a supranational scale, which enables better planning and management of large systems and their use more efficient and coordinated.

EMBRC (European Marine Biological Resource Centre) is a distributed research infrastructure spread over different countries, including Italy. EMBRC provides access to a wide range of ecosystems and marine organisms, expertise and services needed for both the exploration and



sustainable exploitation of marine biological resources and to be used as models for basic research and applied industrial purposes. Interoperability between EMBRC and its nodes at pan-European level, will make connections between regional seas and latitudes, assess and predict the impact of climate change on marine biodiversity and ecosystem functioning. As a founding member of EMBRC, SZN coordinates and manages the Joint Research Unit in Italy, opening up new opportunities for interdisciplinary collaborations. The Joint Research Unit (JRU) EMBRC-IT, which also includes as partners CNR-IAMC, CNR-ISMAR, OGS and CoNISMa, will coordinate the participation of Italian EMBRC and EMBRC user access to Italian marine resources for research, encouraging research activities and joint training among EMBRC partners, increasing the international visibility of Italian researchers. SZN then must invest in personnel and equipment for the development and management of such infrastructure.

EMSO is another distributed European infrastructure with the aim of monitoring environmental phenomena relevant to the understanding of the complex interactions between the geosphere, hydrosphere and biosphere, with particular reference to the deep environments. The SZN is partner of the Joint Research Unit (JRU EMSO), sharing expertise, databases and resources with other partners to promote the training and joint research and technology transfer in this area of marine science. The years 2015-2025 will be crucial to develop the next generation of marine observers and in particular to work with the new technologies of the Tyrrhenian Sea (the only sea entirely Italian) and the Gulf of Naples.

LifeWatch is a pan-European e-infrastructure deployed for the study of biodiversity and ecosystems. Its goal is to provide researchers with tools and databases useful for the understanding and management of ecosystems. The SZN is Italian partners, operates in the Services Centre of RI, which links state-of-the-art ICT with the needs of biodiversity and ecosystem research and contributes to the Italian JRU of LifeWatch. SZN is the co-coordinator of the Biomolecular Topic Centre (BTC) within the service centre providing access to the tools for analysing genomic, metagenomics, phylogenetic and DNA-barcoding, as well as to existing databases. The research communities associated to SZN will benefit from the infrastructure through the use of tools and services on-line service centre and through the participation of the topic centres and user groups.

ELIXIR is a pan-European and distributed e-Infrastructure to the biological information, which would support research in different fields: medicine, agriculture, bio-industries and society. This RI manages the data that are generated by publicly funded research and provides the necessary services for researchers in the life sciences. It ensures open access to biological datasets rapidly expanding. SZN is not a member of ELIXIR, but collaborates with EMBRC-IT Next Generation Sequencing and aspires to use increasingly in the future the existing datasets for its own scientific purposes.

Euro-Bioimaging is a pan-European and distributed RI for the development of biological imaging technologies. This RI allows the user to access to state-of-the-art biological and molecular imaging and provides image data support and training for users and providers, and updates the new imaging technologies to provide cutting edge services. The cooperation with Euro-Bioimaging and with the Italian node will allow SZN to maintain its microscopy platforms and service provision associated with the forefront of their ability.

SZN intends to initiate a process of synergies between EMBRC, Euro-Bioimaging, LifeWatch, EMSO and ELIXIR, developing joint strategies for the best use of data useful for the development of marine research. Research activities at the SZN produce huge amounts of data, which require adequate arrangements in data store, i.e., the e-infrastructure. Moreover, research at SZN necessitates free access to different sets of data and associated services available in these data stores. SZN must maintain a bridge between EMBRC-IT and EMBRC-ERIC, to promote



interoperability through these RIS with regard to marine biological data, and participate in the development of data standards. These data streams require fast connections, and a staff of specialized personnel to support the scientific community that works with the SZN.

The improved ability to use information and technologies expected in the next decade will work at unprecedented spatial and temporal scales than before, and to increase the capacity of both observation of molecular processes and at different scales of complexity and biological organization with end-to-end approaches. In addition, the development of these infrastructures will develop a new era of research in deep environments and extremes for which activities are needed, and joint efforts at a pan-European level.

The challenge for the years 2015-2025:

- 1) Achieve synergies between international research infrastructure, such EMBRC, Euro-Bioimaging, LifeWatch, EMSO and ELIXIR for better access to infrastructure and the use of data useful for the development of marine research.*
- 2) Increase the capacity of observation of molecular processes at different scales of complexity and biological organization.*
- 3) Start a new era of research in deep-sea and extreme environments.*

5.4.2 International initiatives

The huge amount of information available makes it increasingly necessary to recruit researchers that can transform this information into knowledge. A recent international trend also sees the creation of centres of ecological data analysis and synthesis. In this perspective, the SZN will strengthen the Centre Marine Ecological Data Analysis and Synthesis (MEDAS) in collaboration with the University of Stanford. The goal of these centres is to analyse existing information, by giving answers to the big questions and even economic needs within the Blue Growth. The SZN intends, with this centre, to promote the formation of working groups, summer schools, research activities, visiting scientists and PhDs.

MEDAS will focus on marine systems, the ecosystem-based management, and the definition of new research policies and management of marine resources. SZN intends to improve its expertise in the field of meta-analysis of ecological data and knowledge and technology transfer, thus providing new opportunities of development regionally and nationally.

MARS is a network grouping and organizing European marine research institutions and is a meeting place for the definition of policies and strategies of marine research in the long term, to commit itself with the heads of European research, and to ask for greater attention to the unique role of marine research institutes. SZN is a major partner of this network that allows a wide range of international collaborations.

CoML & TARA: the Census of Marine Life project (CoML 2000-2010), the Tara Oceans expedition (2009-2013, SZN is part of this consortium) and the Ocean Sampling Day (OSD) have brought together international teams of scientists, including those of SZN, to collect data and samples of marine biodiversity. They provided new advanced technologies for measurement, sampling, study of marine organisms, their biodiversity (through the Next Generation Sequencing Meta-barcoding and meta-transcriptomics and high-throughput bio-images) and marked a crucial point for advancement of knowledge on marine biodiversity. These initiatives underscore the importance of promoting and participating in the coming years to scientific initiatives of a global nature that allow to enhance the skills of scientific SZN personnel, providing new opportunities for collaboration. The SZN is firmly oriented to support the process of globalization of scientific research initiatives over the next decade.



SZN intends to align and contribute to the European process of creation of new ERA-NET initiatives such as the Joint Programming Initiatives (JPI), which result in: Healthy and Productive Seas and Oceans, Agriculture, Food Security and Climate Changes, A Healthy Diet for a Healthy Life, More Years - Better Lives, Antimicrobial Resistance. In particular, the research at SZN intends to focus on the major European challenges that include: the fight against loss of biodiversity, the issue of food security, the fight against pandemics and aging.

The future of research in Europe will depend upon the “blue response” to these major challenges, with also social connotations and SZN intends to provide its contribution.

The challenge for the years 2015-2025:

- 1) Launching the International Centre for Marine Ecological Data Analysis and Synthesis.*
- 2) Promoting marine scientific initiatives of a global nature.*
- 3) Contributing to the European ERA-NET on the great challenges the European.*

5.4.3 Scientific Journals

The contribution of the Stazione Zoologica to the international scientific journals panorama is important, either for historical reasons, with the founding of the journal *Marine Ecology: an evolutionary perspective* (previously *Publications of the Stazione Zoologica in Naples* and then *PSZNI: Marine Ecology*), and for the international journal *History and Philosophy of the Life Sciences*. Recently, SZN, in collaboration with the Italian Society of Limnology and Oceanography (AIOL), has supported the development of the open access journal: *Advances in Limnology and Oceanography* (AIOL Journal). In the future the international impact of the SZN scientific journals will be further supported and enhanced with appropriate actions. The SZN researchers are members of the Editorial Board (Chief Editors, Associate Editors, Review Editors, Editorial Board members) of prestigious journals of Web of Science, such as: *European Journal of Phycology*, *Frontiers in Ecology and Evolution*, *Functional Plant Science and Biotechnology*, *Genome Biology and Evolution*, *Harmful Algae*, *Marine Drugs*, *Marine Ecology Progress Series*, *Marine Genomics*, *PLoS ONE*). However, in the future the role of Italian research will depend on the ability to influence more and more on the mechanisms for selecting the products of research and evaluation of the quality of scientific publications. The involvement in the international board from this point of view is essential. The strategy of the years 2015-2025 should focus more and more on the strong involvement of the staff of the Stazione Zoologica in editorial boards of prestigious international journals.

The challenge for the years 2015-2025:

- 1) Increasing the impact of international journals of SZN.*
- 2) Increasing the role of researchers in SZN editorial board of top international journals.*

5.5 Implementing research personnel

5.5.1 Role of the researcher and technologist in SZN

Researchers and technologists in SZN contribute to the development of scientific and technological research and perform specific tasks for research activities of national and international interest. The researchers and technologists whose primary objective is the continuous improvement of their knowledge and scientific production in order to improve their contribution to the competitiveness of the national research in the international arena. The



tasks of the researchers and technologists also includes the activities of field and / or laboratory and / or participation in the testing of new procedures and technologies related to research activities. The tasks of the researchers and technologists include a major effort in the drafting of research projects for national and international competitive calls, aimed at increasing the attraction of external resources. Researchers and technologists have direct access to the funds for scientific research, either at the international level, and nationally and locally. Researchers and technologists perform tasks of scientific research on topics of their choice, in the context of the mission of their Research Institute. Researchers and technologists can freely dispose of the funds allocated, within the terms of the current internal and legislation rules. They can also carry out tasks of industrial research, teaching and mentoring, including internal or external lectures in university courses, specialization or doctorate. They can also attend to examination boards, and can access all the management positions on a competitive basis. The researcher/technologist is also required to ensure its commitment to the various work activities of the organization. The technologists at SZN will be dedicated to the improvement of scientific and technological research for 50% of their time and in implementation activities of services and infrastructures of the SZN for the remaining 50%.

The challenges for the years 2015-2025:

- 1) Doubling the income of external funding.*
- 2) Implementing the services and infrastructures of the Stazione Zoologica.*
- 3) Increase the participation of researchers to the third mission.*

5.5.2 Role of the technical staff in research

The technical staff plays a key role in the research. Highly skilled personnel is essential to the production of quality data, the management of equipment, procurement and maintenance of the materials and consumables necessary for the research. The technicians support the tasks assigned by the staff responsible for research with standardized procedures and measurable goals. As with the research staff, technical staff is obliged to provide continuous cultural and technical training to better use all available resources. In the Vision 2015-2025 these objectives can only be fulfilled if we invest in life-long training of staff already in the SZN. Flexibility and inter-exchangeability of the roles of the technical staff are also indispensable to the proper functioning of the activities of the organization. The core activities of "technical staff dedicated to support the research" are carried out in laboratories, or in the field, because a marine research institution needs work at sea. In the shed of the increasing complexity of research and instrumentation necessary for it, it is necessary to think about a process of lifelong learning and the recruitment of highly qualified figures / specialization and high-level training, while allowing and adequate career opportunity. A similar target must also be programmed for personnel with different abilities that will be enhanced in the future in activities of particular complexity such as those required by the research support.

The challenges for the years 2015-2025

- 1. To provide highly qualified and continuously updated technical personnel for the research.*
- 2. Standardize the procedures of intervention of technical and administrative personnel to make them more qualified and efficient.*
- 3. Improve the quality and efficiency of services provided by the research personnel.*



5.5.3 Research personnel in the years 2015-2025

To meet the objectives of scientific excellence and international leadership requires an appropriate critical mass to compete with the top scientific institutions. The current permanent personnel staff of the SZN is characterized by the presence of researchers in small proportion (about 30%) compared to all other Italian public research institutions. The overall personnel (125 units) appears inadequate to meet the challenge of international competition. Approximately 120 units are hired on fixed term positions or as post-doc or PhD students.

Other research institutions in EU and elsewhere with similar mission have typically higher dimensions in terms of personnel. To give some examples: *Station de Biologie Marine de Roscoff* (France, founded in 1873, which has increased from around 50 to more than 200 units over a decade), Woods Hole Oceanographic Institution (WHOI, USA), Hellenic Centre for Marine Research (HCMR, Greece, with the incorporation of IMBC its foundation in 1989, today has grown to more than 200 units), the NOCS (National Oceanographic Centre, Southampton, UK, founded in 1995, which now has about 540 employees and is the 30th institution in the world in Earth and Marine Sciences, QS Ranking).

The SZN staff makes the Institute agile and competitive in terms of research activities at national and European level, but not enough to take on a leadership role in the management of major projects and infrastructure such as ERIC - ESFRI, the role which could aspire on the basis of the excellent international reputation of the SZN.

In general, the limited number of researchers (either in absolute and in relative terms) makes our country less competitive in the capability to obtain financing from international tenders and EU. Thus, the return to the country's share of contribution to the European research (14%), the portion dedicated to marine research which is consistent, does not exceed 8%. The difference between Italian contribution to EU research and recovery of these funds is a "gift" for other countries: UK, Germany, Holland and France in particular. The goal for the period 2015-2025 is to increase competitiveness of research through expanded staff plan by reaching approximately 200 units. Firstly, the expansion will cover the researchers area, but it is clear that in order to face this expansion it will be necessary to find resources and ways to enhance technical staff.

The challenges for the years 2015-2025: to increase the number of permanent positions to 200 persons and reach an overall size of 400 employees.

5.5.4 Criteria for future recruitments

The remedy for the Italian research is to increase the number of researchers, both in Public Research Institutions and in the Universities. In Italy we have about 4 researchers per 1,000 employees, compared with 7 per thousand in France, 8 per thousand in Germany and 10-11 per thousand in the US and Japan (or Israel). With a halved "army of researchers" compared to that of our competitors, we cannot grow in the ability to collect more EU resources.

The criteria for recruitment in the years 2015-2025 should be guided by the principles of full transparency in procedures, maximum dissemination of information and guarantees of equal access to all candidates, including non-Italians.

The goal for the next decade is to maintain the Stazione Zoologica as an International Research Institution (currently it is the Italian research institution with the highest percentage of international researchers).

The recruitment must always be guided by the principles of merit that are inspired by established international approaches (see the section on the promotion of merit). This will be



conducive to the recruitment of staff demonstrating high records of publication in international journals, leadership in the co-authored publications, use of advanced and innovative technologies, membership of international networks and ability to work in international research teams.

Similar prerogatives are expected by the evaluation committee composed of researchers / professors of recognized international reputation. The priority areas for recruitment are those that have characterized and characterize the research themes of the SZN and are inspired by the Vision 2015-2025, declined annually by the three-year plans of research.

Special attention will be given to the maintenance of skills in the areas of excellence also in respect to the retirement of present research staff and research sectors covered. Priority will also be given in recruitment in areas of strategic interest for which there is a lack of expertise.

An additional initiative for future recruitment will be implemented through temporary association of researchers belonging to other national or foreign institutions. These scientists will be invited to work part-time at SZN on specific projects for up 3-yrs periods in collaboration with SZN researchers, taking advantage of the services and facilities of the SZN. This initiative can stimulate the interaction with other institutions and create the basis for future recruitment.

The challenges for the years 2015-2025:

- 1) Make the Stazione Zoologica the first Italian Research Institution fully open to international researchers.*
- 2) Apply the EU guidelines for the recruitment of researchers aimed at the creation of ERA,*
- 3) Strengthen the strategic areas of of the SZN.*

5.6 Strengthening research

5.6.1 Evaluation of the results and research performance

The SZN conducts yearly monitoring of the scientific performance, based on unbiased criteria, homogeneous scientific area, normalized to the field of research, scientometric criteria, with advanced and integrated approaches to all possible merit indicators. In any case, it is clear that the greatest weight in evaluating the results in the years 2015-2025 will be given to:

- *publications with particular emphasis on top quality papers, defined as publications in top international publications with high rate of citations (eg, publications included in the top 10% of the quotations for the specific area).*
- *international patents.*
- *competitive projects.*
- *activities for third parties.*
- *other activities that allow a better placement of SZN in innovation and competitiveness of international research.*

The challenges for the years 2015-2025:

- 1) To improve assessment of scientific performance of research.*
- 2) Self-assessment of research results through the application of objective criteria.*



5.6.2 Technological Transfer

The technological transfer activities are aimed at the promotion and development of knowledge and its application to environmental protection and the improvement of quality of life. These aims are pursued to develop and promote economic, social and cultural development of the country. For this purpose, the SZN plans a policy of development and promotion of the intangible assets, relaunching evaluation activities, marketing and protecting the intellectual property of the results obtained in research projects and institutional activities funded by public and private companies.

The main activities will be:

- *management and licensing of patents;*
- *valorisation of research results through the participation and / or incubation of spin-off companies;*
- *promotion of industrial partnerships for the development of research skills and the transfer of results of research activities;*
- *intermediary between the scientific and entrepreneurial interests , and those of the institutional system.*

The SZN also defines collaborations with research institutions and private companies with the aim at contributing to the development of knowledge for environmental protection, improving the quality of life, and to develop and promote economic, social and cultural development of the country (Statute Art. 2). In the next decade, the SZN aims to further develop connections with enterprises and all activities of valorisation of research results.

One of the aspects that restrict the competitive potential of our country is the limited industrial investment and more generally of the private sector into the scientific and technological research. While this is understandable on the light of the overwhelming dominance of very small (even individual) and small enterprises (SMEs) that have limited resources to invest in research, this appears difficult to understand for the medium and large enterprises. The public research institutions, however, have the possibility to support the research needed to boost industrial competitiveness and entrepreneurship in general. It becomes important to pursue these objectives in the coming years, identifying the business sectors of interest and growth potential in Cluster Blue growth and provide maximum support. Apart from this, it is necessary to promote more and more the role of reference for the activities for third parties to support the activities of the companies.

In this perspective it is also necessary to implement an Industrial Liaison Office (ILO), which will provide support to qualified researchers in the search for opportunities for collaboration with external parties, in the preparation and management of legal and contractual arrangements, in the patenting procedure, the creation of spin off and monitoring of their activities. This structure, with soft skills make more effective relations between SZN and world production and business. The connection with business in the next decade will be oriented to:

- active management of the portfolio of patents SZN, pursuing a policy of exploitation of the patent as to facilitate as much as possible the use of the patent by the firms concerned;
- continuous "contamination" of the SZN researcher to do business, application and exploitation, so as to encourage and support the creation of spin-off with a good chance of development;



- more opportunities for agreements with other institutions and contracts with companies to do commissioned research, performance and tariff benefits and services account third party thanks to a specific line of activity of the ILO and the availability of equipment and highly techno-scientific qualified expertise;
- active participation in research infrastructure (for example, EMBRC, EMSO, Lifewatch) and intermediary effective and efficient structures (for example, Cluster Blue Growth, incubators, foundations) in order to guarantee access to a network of companies and centres research potentially interested in the services offered by SZN.

The challenges for the years 2015-2025:

- 1) Making active market of the patent portfolio of SZN.*
- 2) Doubling the income from external contracts and agreements.*
- 3) Log on active business networks and research centres involved in research infrastructures.*
- 4) Organize annual entrepreneurship courses*
- 5) Increase the economic and social impact of the SZN researchers*

5.6.3 Promoting the merit

The SZN contributes to the creation of the European Research Area (ERA) and is committed to an increasingly competitive approach and merit-based acquisition of private and public funding it receives. The selection and promotion of best performing researchers are crucial to attract and engage the human capital necessary to achieve the ambitious results that SZN aims at for the next decade. For this purpose, it will be built and used a system of recruitment, career progression and promotion of researchers based on open, transparent and purely meritocratic procedures, applying to the guidelines defined by the Carta of European Researchers of the European Commission. The system will be used for all staff involved in the research. In line with the criteria of evaluation of research defined at national and international level, the merit of the researchers will be evaluated by applying scientometric criteria supported by additional additional indicators on:

- innovation and leadership of research, with analysis of the impact on the international scientific community of reference;
- ability to attract funding and leadership in national and international research projects, selected on competitive calls and under peer review;
- promotion and coordination of international research networks;
- direction or participation in editorial boards of international journals of recognized prestige;
- participation in scientific committees and programming of recognized prestige, both nationally and internationally;
- attribution of teaching positions at universities or official fellowship and research institutions, foreign and international, highly qualified;
- direction or scientific responsibility / coordination of highly qualified national or international bodies or public or private research institutes ;
- prizes and awards for scientific activities;
- ability to improve research results and to carry out outreach activities;
- participation in program committees, and those of national and international policy and strategies.



All procedures will be open and transparent and the incentive system will ensure the enhancement of researchers and technologists who have actually contributed to the objectives of SZN.

The challenges for the years 2015-2025:

- 1) Reward researchers and technologists who have actually contributed to the objectives of SZN.*
- 2) Recruit European citizens who are actually able to contribute to the objectives of SZN.*

5.6.4 Facilities and Resources for Research

The SZN since its foundation has been characterized by the development of facilities and resources for research. The ongoing process of reorganization of the Institute has seen the creation of a Department dedicated to technological research and management of the infrastructures for the marine living resources (RIMAR) designed to:

- **develop** and provide services for the marine biological research;
- **promote** technological development and support the research activities of the SZN;
- **support** international collaborations with particular reference to the Italian contribution to research infrastructures of European ESFRI roadmap;
- **provide** internal and external users a number of services of scientific and technological research
- **contribute** to the realization of the third mission of the organization.

The services are available to universities and to other public and private institutions. The SZN in the next decade will be committed to consolidate its services, to enable its researchers and the scientific national and international community the access easily and at low costs to the different facilities, which include (but are not limited to):

- Marine Biological Resources
- Molecular biology and sequencing
- Bioinformatics
- Taxonomy Marine Organisms
- Electron and Confocal Microscopy
- Bio-imaging
- Sampling at sea
- Collecting marine organisms
- facilities for *in situ* and laboratory research
- Research and experimentation in special marine habitats
- Monitoring the quality of the marine environment
- Research vessels and for training/teaching students

The challenges for the years 2015-2025:

- 1) Increase the space available infrastructure and facilities for research.*
- 2) Strengthen the portfolio of research services for internal and external researchers.*
- 3) Improve the quality of research services.*



5.7 Contribution of SZN Research to the national cultural and socio-economical framework

Marine research should contribute to shape the future of our society, providing opportunities and tools for improving the quality of life, the economy and sustainability of human actions, globally. In this sense, SZN is committed to assess the impact of its research in the socio-economic and cultural regional and national level and to start the process to publish the annual social report of the SZN.

5.7.1 Connections with the territory and public institutions

Research institutions must become more and more in the future a cultural and technical reference for the national public administrations (e.g., Minister of the Environment) and local, to support policy makers and contribute to the protection of the territory and the citizens. In this sense the role of SZN is already evident for the research activities in the field of potentially toxic algae, sources of contamination, and participation to consultations (e.g., marine protected areas etc).

The prospects for a greater regional involvement are however large, both in the local area, in the Campania region (e.g., the new Marine Observatory in Portici, Naples), and outside the regional context. There are important areas or entire regions of the South, such as the region of Calabria, who do not have access to research institutions to support policy makers, for monitoring and for the research at sea. The SZN aspires to become the main reference in marine biology for the public institutions of Southern Italy.

The SZN aims also to coordinate and cooperate with other national research institutions, such as OGS, INGV, CNR, ENEA, INFN and ISPRA part of research activities in the sea, including the establishment of coordination network of marine research. In particular, the priority appears to the establishment of joint structures with Universities. For creating joint research centres that can combine the best human skills and potential instrumental and infrastructural resources, creating new opportunities for synergies and strengthening scientific research.

The challenges for the years 2015-2025:

- 1) Become the benchmark for the Regions of Southern Italy in the field of marine biology and support their strategic and operational activities at sea.*
- 2) Cooperate with other research institutions that operate at sea.*

5.7.2 Public engagement and additional resources for research

Outreach and scientific dissemination

The Stazione Zoologica is internationally renowned for the expertise and the results of research in the marine environment and has always seen the public involvement as crucial. The research conducted at the SZN addresses the most important social challenges involving the sea. The primary objective of the activities SZN in the future will be to raise public awareness with the aim of improving the connection between science and citizens. Researchers will have to make citizens understand what is happening in their laboratories and to keep them informed on the results of research and ongoing projects. With dedicated programs for training, the SZN improves the educational process of children of primary and secondary classes and increases their interest in science and technology, so they can become the researchers of tomorrow, and contribute to a science-literate society.



Museum Archive Library

The SZN intends to analyse the biological diversity of the sea. The Gulf of Naples is in the perfect place for understanding and discovery the biology and conservation of marine species. The Museum, Historical Archives and Library retain traces of this journey that began nearly 150 years ago, for the study of various phenomena, the understanding of the biology, conservation of the environment and the discovery of new resources. Through the reading of the cultural heritage, the scientific collections of marine prepared, the daily diaries of the catch, the maps of the Gulf, the original documentation on file, you can indeed reconstruct marine biodiversity at the time of Dohrn and compare the data with those derived from sampling now in progress.

Virtually reconstruct marine biodiversity existing in the end '800 can serve as support to research and be a starting point for the analysis of changes and diversity of the last 150 years.

At the same time, unearth these wonders and make available the scientific collections, preparations, drawings that often accompanied the field studies and served as a model for publications, can be the key to bring the general public to understand, learn and explore the resource "sea" that both gives life to our planet and from which, unfortunately, continue to steal as much, sometimes indiscriminately.

The task of the Museum-Aquarium-Library in the coming years will be to disseminate and promote research operated in our institute making it available to the public, thanks to future projects requiring significant expansion of facilities currently available.

Aquarium and Marine Turtles Research and Recovery Centre

The Aquarium and The Sea Turtles Research and Rescue Centre are the strategic tools for disseminating the marine science and the scientific knowledge to the general public. Another tool will be the Darwin Museum-Dohrn, which will allow to communicate the concepts of biological evolution, through marine organisms to a large audience. Here is plan also the use of zoological collections of historical marine organisms. Through these facilities the SZN will offer culture, science education and entertainment. The goal for the next decade is to increase tenfold the number of visitors and students, creating a steady stream of visitors from local schools, of tourists and citizens. The objective of the SZN is to be recognized by the general public as a reference point for all the scientific aspects related to the sea.

The challenges for the years 2015-2025

- 1) Disseminate the results of research and projects SZN through all possible media and on the basis of a dissemination annual plan.*
- 2) Educating children and adults to science and awareness of the impact of human activities on the marine environment.*
- 3) Create the Darwin-Dohrn Museum (DaDo Museum) on the evolution of marine life and to explain the importance of the research carried out in the SZN.*
- 4) Create the largest European Centre for Recovery of Marine Turtles.*
- 5) Relaunch the Aquarium of the SZN.*
- 6) Attract 300-500,000 people a year visit the Aquarium, the DaDo Museum and the turtle research centre of the SZN.*
- 7) Make available the Historical Archives of the SZN for further scientific and social studies.*



5.8 The SZN contribution to high education

5.8.1 To contribute to the higher education (Master degrees and PhD)

Research organizations should contribute to the advanced training of future generations of researchers. In the past, the SZN has hosted students for master thesis carried out in its laboratories (mentoring). This role will be enhanced in the next decade. From 2014 the SZN also launched a new Master of Science in International English in “*Biology and Ecology of the marine environment and sustainable use of marine resources*”, in collaboration with the University of Naples Federico II, whose mission is to train highly specialized Marine biologists and to develop skills in the management and conservation of the marine ecosystem. The SZN also offers the possibility of stages designed to provide advanced skills and professional skills in the field of marine scientific research and offering the opportunity to students of a second (Master of Science) and third level (Italian Doctorate and International PhD - Open University) to develop their skills and improve their employment prospects. Thanks to its connotation and international appreciation, the SZN is the only research institution in Italy hosting an international program of doctorate in collaboration with the Open University (UK), active since 1998, as well as several joint educational initiatives with Italian doctorates in collaboration with several universities.

PhD students have the opportunity to develop research of the highest scientific level and improve their personal skills in the laboratories of SZN. The International PhD in Life Sciences of SZN is based on the principles of excellence, internationality, dedicated mentoring and development skills relevant to the scientific career of young researchers. Currently there are doctoral programs in: i) Model organisms for Biomedical Sciences and Veterinary Research, ii) Computational Biology and Bioinformatics, iii) Applied Biology; iv) Veterinary Science; v) Biology; vi) Bio-Engineering.

The SZN intends to further develop the advanced education sector, offering new paths in high-level international cooperation with international networks (e.g., MARS) and European infrastructure (e.g., EMBRC, EMSO, LifeWatch).

Particular attention should be given to the planning and organization of international workshops and advanced courses (including Summer Schools) to be organized annually, together with prestigious seminars with leading scientists from around the world. These activities will require adequate implementation of the structures devoted to these activities.

The challenges for the years 2015-2025

- 1) Launching the new international routes training in collaboration with networks and international infrastructure.*
- 2) Organize top level seminars, workshops and courses recognised with international recognition.*

5.8.2 Training of young researchers

A key component to the success of a research institution is its ability to train and to increase the value of young researchers. Since its foundation, the SZN had an international leadership role in the training of young researchers, activities implemented by giving its support to various national and international initiatives, following the vocation of its founder Anton Dohrn. The next decade will see a special effort in this direction. The SZN aims to attract young researchers from around the world, train them, and eventually select them to strengthen their research



activities. In this perspective, we need to implement investments in research grants, European grant (e.g., Marie Curie) and places to fixed-term researcher (e.g., tenure tracks).

The challenges for the years 2015-2025

- 1) Attract young research talent from around the world.*
- 2) Strengthen the procurement of funding for brain gain.*

5.8.3 Life-long learning

Continuing education is one of the keys to a knowledge society. The SZN intends to contribute to the process of expansion of permanent training offer through some of the initiatives listed above (e.g., highly specialized schools for research staff), and to enhance the SZN staff. Technological and methodological evolution impose the relaunch of training activities for the technical staff, both in the laboratory, and linked to other functional activities of the Institute. The advanced training is also essential for researchers and technologists. In this case, it is implemented through specialized courses, workshops and conferences, but it is a vital objective for the personnel connected to research and technological services.

The challenges for the years 2015-2025: Expand the training for permanent staff and for external personnel