General Description

Aquaculture is the fastest growing food-producing sector, and it already produces 50% of all the fish consumed worldwide.

Over 567 species are currently being farmed, which means there is a considerable genetic diversity both within and across species.

Aquaculture is practised by both poor farmers and large multinational corporations.

Eating seafood is part of the cultural milieu of many human societies. Fish is also a healthy option, with high nutritional value. Seafood is a good source of protein, fat, vitamins, minerals and essential micronutrients.

Aquatic plants, such as algae, are also an important aquacultural resource. They are highly nutritious, can be used as food and also have important industrial functions.

80% of current aquacultural production concerns animal species which are near the bottom of the food chain, such as omnivorous and herbivorous fish and molluscs.

Given the sector’s dynamic behaviour over the last 30 years and the progressive decline of capture-fishing, it seems likely that future growth of the fishing sector will rely largely on aquaculture (source: FAO).
Fish nutrition

In order to survive, fish need to consume organic matter such as plants, other animals or prepared foods that contain animal and vegetal matter. It is, therefore, very important that fish farms have the right foodstuffs both in terms of quality and quantity. CEI·MAR is currently exploring the following avenues of research:

- The development and application of in vitro digestion systems for monogastric animals.
- The biochemistry of fish digestion.
- The assessment of the formulation and production of commercial fish fodder.
- The nutritional and metabolic evaluation of fish fodder.
- The kinetic study of alimentary photosynthetic microalgae production and the development of open-air microalgae crops for the production of commercial formulae.
- The production and applications of marine microalgae; the design and use of phototrophic systems for large-scale open-air microalgae production; the creation of protocols for the processing and conservation of microalgae biomass; the characterisation of qualitative nutritional and functional aspects of sea microalgae.
- The productive, physiological and biochemical aspects of sea microalgae and their trophic value for aquaculture.
- The analysis of cultivation, the accumulation of commercially valuable intracellular products and the potential applications of microalgae, from biochemical, physiological, molecular and analytical perspectives.
- The valorisation of alternative protein sources, other than fish flour, and sustainable aquacultural fodder.
- The survey of alternative marine raw materials, other than fish, for their use as aquacultural fodder.
- The aquaculture of marine species; the nutrition of farmable species; the development of breeding techniques for species with farming potential.
- The development of farming techniques for new species of molluscs and fish with farming potential.
- The development of know-how of pilot plants for the production of experimental foodstuffs.
- The study of insects as potential animal fodder.
Physiological analysis of marine species

This research profiles revolves around studying how known marine species interact with their environment by developing characteristic functions and, therefore, also the effect that the environment has on these species. Specifically, **CEI-MAR** is currently exploring the following avenues of research:

- The application of functional genomics to nutrition, immunity and the development of marine species; the use of techniques based on gene expression when investigating nutrition, immunity and development control-related processes in relation to marine species.
- The modification of genes in microalgae in order to increase the production of oils.
- The vehiculation of nutrients and bioactive substances in order to improve the development of farmed species; the microencapsulation and nanoencapsulation of biomolecules in the shape of stable particles, which will facilitate the analysis of their effect on farmed species.
- The innovations in and optimisation of farming systems, stressing those species with farming potential; the analysis of patterns which reduce physiological stress and promote immunostimulation; the reduction of stress through the use of food supplements; the parameters related to the measurement of stress and animal welfare in fish farms; the effect of farming conditions; welfare in fish-production systems; the optimisation of fish- and mollusc-farming techniques through the analysis of metabolic indicators of chronic stress.
- The influence of different biotic and abiotic conditions on the oxidative and welfare parameters of farmed fish.
- The reproductive physiology of species with farming potential; the physiology of fish development; fish biorhythms.
- The analysis of physiological aspects related to farming-relevant processes (growth, reproduction, stress, metabolism, osmoregulation, etc.) in species with a high commercial value such as bream, sole and sea bass; the service which will carry out these analyses will prepare and analyse samples, and will also deal with the statistical processing of results.
- The pathological study of marine species.
- The detection and diagnosis of viral illnesses in fish.
- The pathological study of fish and molluscs; the characterisation and prognosis of illness in bivalve molluscs and fish; the development of molecular diagnosis methods; distribution and prevalence analysis.
- The beneficial and toxic effects of inorganic and organic species in marine organisms.
- The presence of radionuclides and trace elements in biota.
- The applications of molecular genetics and cytogenetics in the study of marine organisms; genetics and biotechnology, as applied to aquaculture.
Pollution and pollutants and remediation of aquatic systems

This area of research revolves around the presence in water of elements which may, directly or indirectly, have a negative effect on its quality, later uses and environmental function. This area also deals with those technologies which aim to remediate or minimise the effects of this pollution. Specifically, CEI-MAR is currently exploring the following avenues of research:

- The biofiltration of effluents from aquacultural plants by means of algae.
- The study of bioindicators of metallic pollution in aquatic systems, including the analysis of commercially valuable fish species.
- The analysis of micro-toxins, traces, pesticides and other polluting agents in food, including veterinary residue.
- The analysis of effluents in indoor aquaculture.
- The development of analytical methodologies for the detection of micropollutants in marine samples.
- The speciation of organometallic compounds in marine organisms (algae, bivalves and fish).
- The biotransformation of inorganic species into marine organisms.
- The beneficial and toxicological effects of inorganic and organic species on marine organisms.

Entrepreneurship and innovation in aquaculture

This research profile aims to present services that facilitate the decision-making processes for private sector actors. In order to develop these services, the associated research groups use tools such as regression, correlation, linear programming, choice theory and game theory, as well as assessment based on entrepreneurial decision-making processes. Specifically, CEI-MAR is currently exploring the following avenues of research:

- The assessment of environmental impact in marine aquaculture.
- The management and exploitation of natural populations of molluscs, based on the ecosystem-carrying capacity.
- The economy and viability of aquaculture.
- Agroalimentary marketing.
- Work-risk prevention in aquaculture.
- The valorisation of fish by-products for their use in the alimentary industry; the design of functional alimentary products from marine species; the generation of bioactive compositions
from fish residue and discards, such as biomolecules and other parts with nutritional and functional value (e.g. omega-3- and fatty acid-rich fish oils), as well as the development of new products based on the transformation of these components.

- Legal studies.
- The quality assessment of aquacultural products.
- Innovation in sustainable fish farming through the application of recirculation systems (RAS) and the use of solar energy for the calefaction and refrigeration of fish-farm water.
- Innovation in and optimisation of aquacultural systems; the development of new species: a) sperm management and larvae breeding in valuable species (sole, sea bass, snapper, sea bream, mullet, grouper); b) methods for mollusc- and cephalopod (octopus) egg harvesting in captivity and pre-fattening of the egg of bivalve molluscs (clam).
- The use of (bio)parameters for the assessment of food quality; the examination of traces of metals for the characterisation of provenance and alimentary safety through the application of atomic spectroscopic techniques and chemometrics.
- Applying molecular markers to control traceability in aquaculture; the genetic improvement of farmed species; the use of techniques based on the identification of specific DNA fragments, which leads to detailed monitoring of aquacultural processes, the taxonomic identification of fished and farmed species and the elaboration of programmes of genetic selection; the identification of marine species using miscellaneous samples (fresh, frozen and processed) and molecular markers.
- Digital-image processing of fish otoliths and calcified structures for the estimation of the age and growing dynamics.
- The production of juvenile stages in species with commercial potential.
- The scientific and technological assessment of the alimentary industry.
- Farming techniques of new species and applied engineering.
- Applied engineering in aquaculture; the optimisation of energy use and the development of water-distribution systems.
- Increasing the production levels in intensive systems.
- The impact of farming conditions on the structural characteristics and the post-mortem evolution of fish; lengthening of use-life and market potential.
Researchers and research groups in CEI-MAR

- Metallomic and environmental analysis (UHU)
- Analysis and planning of the natural environment (UHU)
- Marine biology and aquaculture (ICMAN-CSIC)
- Algae biotechnology (UHU)
- Biotechnology of natural products (UAL)
- CCMAR - Centre of Marine Sciences (UAlg)
- Science and public law in the 21st century (UAL)
- Marine farming and fishing resources (IFAPA)
- Diversification and biotechnology in aquaculture (IFAPA)
- Aquatic ecology and aquaculture (UAL)
- Radiation physics and the environment (Fryma) (UHU)
- Physiology and pathology in aquaculture (UCA)
- Photobiology and biotechnology of aquatic organisms (UMA)
- Marine geochemistry (UCA)
- Globalisation and territorial dynamics (UCA)
- Marine and fishing biology research group (UCA)
- Natural resources research group (UMA)
- Engineering of complex fluids (UHU)
- Food engineering and technology (UCA)
- Social innovation in marketing (UCA)
- Instrumentation and environmental sciences (UCA)
- Applied microbiology and molecular genetics (UCA)
- Animal nutrition (UAL)
- Fish nutrition (UGR)
- Pathology, genetics and biotechnology of farmed fish species (UMA)
- Job risk prevention (UCA)
- Pelagic trophic networks (UGR)
- Cellular response and adaptation to environmental stress (UHU)
- Animal breeding technology (UHU)
- Environmental technologies (UCA)
- Digital processing of radiological images (UMA)
CEI·MAR has undertaken a strategic avenue of research in nautical and underwater archaeology, in order to reinforce the teaching and research of underwater archaeology, which to date have been poorly developed in Spanish universities, in contrast with the efficient management and dissemination programmes launched by the central and regional governments.

In addition, maritime history is a key subject for Spain and its neighbouring countries, all of which have a long maritime history stretching from antiquity up to the present day. This history includes historical events of significance such as the Phoenician and Roman presence in the Strait of Gibraltar and colonial contact with America in the Modern period.

The diachronic analysis of coastal heritage studies has global implications, and involves varied topics such as modern and contemporary poliorcetics (coastal fortifications and military vigilance systems), the examination of evidence for Roman and medieval fishing practices, the exploitation of marine resources and coastal geoarchaeological studies, and the analysis of cultural landscapes.
Potential for Transference

✓ Valorisation of Cultural Heritage

UNESCO defines cultural heritage (of a country, region or city) as the monuments, architectural complexes and other locations possessed by said country, region or city. Historical heritage is understood as the features, material or immaterial, accumulated by a given society over time. These features can be artistic, historical, palaeontological, archaeological, documental, bibliographic, scientific and technical. Specifically, CEI·MAR is currently exploring the following avenues of research:

- Cultural and natural heritage.
- Industrial-mining heritage.
- Ethnological heritage.
- Fishing-related cultural and historical heritage.
- The cultural and historical heritage of marshlands and saltpans.
- The cultural and historical heritage of the naval industry.
- Scientific-cultural consulting on historical heritage-related issues.
- Cultural heritage in mathematics.
- Immaterial cultural heritage: the culture of water.
- The cataloguing of heritage items; the digitisation of heritage objects, including the cataloguing, ordering and classification of archives, documents, photographs, maps, etc.; creating, using this material, online collections and libraries.
- Georeferenced mapping of heritage items, involving in house-developed software and GIS methodologies for the elaboration of maps with historical interest, thus providing accurate resources which combine historical veracity and the most accurate spatial-analysis tools.
- The use of design and infographic tools for the management of historical heritage items: using ITCTs allows for the production of 3-D models of historical and cultural heritage objects, as well as high-resolution photographs (gigaphotography) or special-format images which can be used to reproduce heritage-rich contexts (immersive photography) – all of these methods are used to provide a rigorous and accurate reproduction of the historical item.
- The investigation, recovery and valorisation of medieval and modern harbours.
- The analysis of samples taken from altarpieces.
- The mineralogical and petrological determination of monumental heritage items.
- The conservation of historical (from a geological perspective) and historical-natural heritage.
- The conservation of Andalusia’s geological heritage.
- The valorisation of fisheries, canning companies, fishermen’s brotherhoods, associations etc.;
recovering their historical and documental heritage.

- The analysis and assessment of the social impact of environment-changing projects; impact and social planning, from an applied and strategic approach focused on influencing decision making in affected communities and stakeholders in general (private firms, public agencies, the general population, and civil society).

✓ **COASTAL, NAUTICAL AND SUBAQUATIC ARCHAEOLOGY**

Underwater archaeology has been given many names over time: hydro-archaeology, marine archaeology and subaquatic archaeology. CEI·MAR has begun research in underwater and nautical archaeology with the aim of becoming a national and international reference in the field, in both training and research. Specifically, CEI·MAR is currently exploring the following avenues of research:

- Maritime and underwater archaeology; industrial archaeology.
- Legislation concerning underwater cultural heritage.
- Archaeological consulting; archaeological and heritage-related assessment; watching briefs, survey, excavation and post-ex analysis.
- The investigation, recovery and valorisation of Roman fisheries.
- The analysis of stone tools.
- The analysis of archaeological ceramics.
- The granulometric and mineralogical analysis of archaeological soils.
- The characterisation and provenance of ancient stonework.
- Sea-related heritage studies: archaeological items found in the sea; marine archaeology; the sea trade in the ancient world (this will also involve the musealisation and dissemination of archaeological heritage).

✓ **SEA-RELATED CULTURAL AND HISTORICAL STUDIES**

Historically, the sea has played a crucial role in the interaction between different cultures, contributing greatly to the growth and development of civilisation over time. Sometimes, the sea has been regarded as a dividing chasm, but just as often the sea has been viewed as a bridge that joins different communities. For this reason, the humanities, the arts and cultural studies must underline the cultural value of the sea in the construction
of identities at international, national, regional and even individual levels. Research on the effects of this extraordinary feature involves the discovery of old and new ways of thought, different approaches to what the sea means for society, especially concerning its positive effects. CEI·MAR is currently exploring these and other related topics, such as intercontinental migrations, exile, cultural transference across the sea (circulation of ideas, practices and technology), the emergence and development of sea-related economic activities (fishing and the production of preserves), historical and documental heritage related to sea-based economic activities, international relations and conflict. Related topics are as follows:

- The sea as a cultural value.
- The approximation of the role of the sea in the formation of gender and cultural identities.
- The analysis of the relationship of the sea and migratory trends and diasporas.
- The diagnosis of identitary causes and the consequences of physical, psychological and cultural transitions.
- The analysis of different cultural itineraries of migrant communities.
- Specialised consulting: the assessment of specific topics such as international relations, contemporary migratory trends and cultural heritage.
- The comparison of responses to mobility and their representation in different cultural manifestations.
- Healing processes after traumatic transit experiences.
- The analysis and valorisation of the transatlantic cultural heritage: interaction zones.
- Research and consultancy on migration-related topics and cultural and social integration.
- Cultural translation: translation in the cultural sector, including museums, art galleries and exhibition halls (catalogues, leaflets, communication with foreign organisms, etc.); cultural events.
- Historical research from a current affairs perspective, involving the development of historical research skills in relation to the present time, and from a perspective that underlines a contemporary approach to the analysis of society (demographics, environment, economics, politics and culture) and proposes innovative interpretations and proposals.
- The elaboration of historiographical research cooperation projects, involving the assessment of the planning, management and implementation of research and cooperative projects with different bodies, private firms and institutions.
- Cultural management, involving cooperation with different private firms, NGOs and public bodies at local, regional, national and international levels, and the dynamisation of the work carried out by different social collectives.
Development and implementation of new techniques for the conservation of historical materials and related subjects

CEI·MAR is working on the development of new techniques which may be used to stabilise and conserve historical materials, as well as other related subjects, such as palaeo-diets. Similarly, our research teams are exploring electrolytic treatments, and analysing consolidating substances and the development of analytical protocols for the treatment of items found underwater. Our research involves the following:

- The assessment of the development and application of new techniques which can be used to stabilise and conserve historical materials.
- The development of in situ corrosion studies in underwater archaeological sites; the assessment of the state of preservation of sites and the implementation of mitigation measures.
- The use of new nanomaterials in the conservation of the monumental heritage.
- The characterisation of historical metal objects.
- Biogeochemistry of stable isotopes in archaeology; the study of palaeo-diets.
- The mineralogical, petrological and geochemical analysis of lithic, ceramic and other inorganic materials.
- The analysis of pigments in wall paintings.
- The analysis of mortars and plasterwork.
- The analysis of media and pigments in works of art.
Sea-related linguistic and literary studies

The universities that make up CEI·MAR play host to a large number of scholars whose research focuses on the philological analysis of Greek, Latin and Arabic texts from ancient, medieval and modern times. This research has led to the production of numerous editions, translations and philological-literary commentaries. Many of the texts so examined are related to the sea and other associated subjects (trade, sailing, etc.).

For their part, linguists interested in living languages, especially English, French and Arabic, are often also interested in the evolution of these languages and of their literature and associated literary critique. Such studies have a direct impact on teaching and research.

Literary and linguistic studies, as well as a literary education in sea-related topics, have enormous potential for society, opening up a wide interdisciplinary field of study which may involve the following:

- Reading cartographies for the promotion of reading in sea-related spaces: spas, etc.
- The recovery of myths and legends associated with specific geographical locations.
- Cultural tourism: literary routes.
- Environmental education through literature.
Researchers and research groups in CEI-MAR

- Biogeochemistry of stable isotopes (EEZ-CSIC)
- Corrosion and protection (UCA)
- Written, oral and media culture (UAL)
- Law, economics and society (UHU)
- Learning democracy (UHU)
- The region of the Strait of Gibraltar: archaeological and archaeometric approaches to society between Prehistory and Late Antiquity (UCA)
- The legacy of antiquity (UAL)
- ESEIS-Studies of Social Intervention (UHU)
- Current affairs history group (UCA)
- Literature-Image-Translation (UCA)
- Magnetism and applied optics (UCA)
- Ideology, society and environment in Andalusia and Latin America (UHU)
- Mineralogy and chemistry of sedimentary and metamorphic environments (UGR)
- Observatory of culture and heritage (UHU)
- The historical heritage of antiquity in Andalusia (UCA)
- PHOENIX Mediterranean: Protohistory in Western Andalusia (UCA)
- Preservation of geological heritage in Andalusia: inventory and scientific assessment of endogenous rock outcrops in the Baetican mountain ranges (UGR)
- Molecular sieves and other nanomaterials (UCA)
- Approximation theory and orthogonal polynomials (UAL)
- Cultural theory and studies (UHU)
- Urbanitas (UHU)
General description

Marine organisms are an important source of natural products: they have unique characteristics and enormous potential for use in the biomedical, agrochemical and cosmetic industry. Over the course of the last twenty years, the sea has become the most important source of bioactive molecules. This is unsurprising, considering that the sea covers 70% of the earth’s surface, and that it hosts 95% of the planet’s biological diversity. Another interesting fact is that 1.8% of marine extracts have in vitro reactions (against 0.4% of land-based extracts). Although the biological diversity of oceans is much greater than that of the land, this field remains largely unexplored as far as the search for new chemical compounds is concerned. Currently, ‘barely’ 15,000 sea-based natural products are known. The number of known land-based products is ten times greater.
Potential for Transference

Research in this area involves, amongst other things, the discovery and development of new medicines and bioproducts, functional foods, algae and microalgae, invertebrates and microorganisms as sources of bioproducts, and sponges as sources of lipidic compounds. Specifically, CEI-MAR is currently exploring the following avenues of research:

- The analysis of marine food resources and new products.
- The vehiculation of bioactive compounds and the improved development of farmed marine species through the application of micro- and nanoencapsulation technologies.
- Microalgae as a platform for the extraction of industrial polymers.
- The breeding of species which can be used for the production of bioproducts on the basis of autochthonous strains.
- The biotechnology of lipids in microalgae; the increase of lipid production through genetic modification.
- Applied uses of marine microalgae and macroalgae.
- Studies on the cultivation and accumulation of commercially viable intracellular products and potential applications of microalgae through the implementation of biochemical, physiological, molecular and analytical tools.
- Photosynthetic efficiency assessment (using a modulated amplitude fluorometer); the quantification of algae respiration using an optode fluorometer; the isolation and cultivation of algae species; experimental aquaria systems.
- The design, construction and operation of plants used for the production of microalgae and the recovery and purification of algae metabolites.
- The investigation of plant-based natural products or semisynthetic products, such as psychiatric medicines or painkillers.
- The use of marine by-products.
- The synthesis of biologically active natural products; the isolation of natural products.
- The isolation, structural elucidation and chemical transformation of natural sea products.
- Supercritical extraction processes used for the collection of plant-based industrial compounds; the extraction of natural antioxidants, sweeteners, aromas and colourants through supercritical extraction of plants.
- The extraction of bioactive compounds from residues and discards of the fishing sector, including biomolecules and nutritional and functional compounds such as omega-3-, fatty acid- and protein-rich fish oils, as well as the development of the products elaborated on the basis of these components; the synthesis of natural products and sea-based bioproducts.
• The investigation of plant-based natural products or semisynthetic products, such as psychiatric medicines or painkillers.
• The quantification of the structure (density, biomass, elemental composition C, N, P) and activities (primary and secondary production, excretion and consumption of organic carbon, etc.) of microbian communities in aquatic ecosystems, using epifluorescence microscopy techniques, image processing, radiotracers, CARD-FISH, and the preparation of samples for cytometry/sorting and elemental analysis.
• The cultivation of filamentous fungi for the extraction of secondary metabolites.
• The production of c13 and n15 stable isotope-marked products.
• The production of enzymatic technology-structured lipids.
• External services: gas chromatography, flux cytometry, molecular distillation and HPLC.
• Isolation, structural characterisation and synthesis of natural products (UCA)
• Environmental analysis and bioanalysis (UHU)
• Analysis and design of processes with supercritical fluids (UCA)
• Algae biotechnology (UHU)
• Sea microalgae biotechnology (UAL)
• Biotechnology of natural products (UAL)
• Diversification and biotechnology in aquaculture (IFAPA)
• Functional ecology (UGR)
• Granada University Herbarium as a centre for taxonomic and diversity studies (UGR)
• Structure and dynamics of aquatic ecosystems (UCA)
• Research group in neuropsychopharmacology and psychobiology (UCA)
• Engineering of complex fluids (UHU)
• Food engineering and technology (UCA)
• Laboratory of organic synthesis and photochemistry (UHU)
• Marine natural products (UCA)
**General Description**

Harbours are essential exchange hubs for supply chains and are thus key players in international trade. Next-generation ports aspire to become logistic platforms that facilitate the interaction of different modes of transport and provide added-value services. Their general target is to contribute to transport systems that are smart, sustainable and fully integrated in efficient, competitive, safe and affordable transport chains, thus assisting balanced economic growth and increased competitiveness. This research will ultimately contribute to more territorial cohesion and accessibility, and to greater integration through the application of an intermodal approach.

Through the promotion and application of innovative methodologies and developments, we can improve the efficiency and sustainability of harbour nodes and transport chains, as well as implement technological solutions and smart transport systems in order to improve the efficiency of logistics through an intermodal approach. It is also necessary to improve the efficiency of administrative processes in order to eliminate obstacles and develop the fluid exchange of goods.
POTENTIAL FOR TRANSFERENCE

✓ OPTIMISATION OF RESOURCES IN HARBOUR LOGISTICS

The optimisation of resources is a lateral discipline which involves a large number of research fields, including environmental- and energy-focused fields. The optimisation of production processes leads to greater efficiency in meeting targets: that is, greater efficiency in achieving the same target but using fewer resources. Specifically, CEI-MAR is currently exploring the following avenues of research:

- The management of logistic distribution systems.
- Harbour logistics.
- Coastal landscape resources, coastal and harbour parklands.
- Harbour law and administration (harbours, merchant fleets and navigation).
- Environmental management.

✓ POLLUTION AND POLLUTANTS AND REMEDIATION OF AQUATIC SYSTEMS

This area of research revolves around the presence in the water of elements which may, directly or indirectly, have a negative effect on its quality, later uses and environmental functions. This area also deals with those technologies which aim to remediate or minimise the effects of this pollution. Specifically, CEI-MAR is currently exploring the following avenues of research:

- The study and analysis of emissions in harbours and marine transport.
- The diagnostic and technological development of applications for polluted marine sediments in coastal and civil engineering contexts.

✓ ENTREPRENEURSHIP

This research profile aims to provide services that facilitate decision-making processes for private sector actors. In order to develop these services, the associated research groups use tools such as regression, correlation, linear programming, choice theory and game theory, as well as assessment based on entrepreneurial decision-making processes. Specifically, CEI-MAR is currently exploring the following avenues of research:
• Naval energy-use assessments for shipyards and shipping companies.
• The economic and social impact of harbour activities; integrated impact analysis – economic, social, and environmental – of economic activities.
• The analysis of economic and business environment.
• The cost-benefit analysis of economic activities.
• The integrated strategic planning and evaluation of territorial projects.
• Infrastructures (harbours, trains, roads, airports).
• The economics of logistics.
• Methodologies for the evaluation of infrastructures.
• Nautical tourism (leisure ports).
• The development of observatories and territorial intelligence systems in public agencies.
• The analysis and assessment of the social impact of environment-changing projects. Impact and social planning, from an applied and strategic approach focused on influencing decision making in affected communities and stakeholders in general (private firms, public agencies, the general population, and civil society).
Researchers and research groups in CEI-MAR

- Administrative law (UCA)
- Ecology and environment (UHU)
- Economics of innovation and transport (UCA)
- ESEIS- Studies of Social Intervention (UHU)
- Radiation physics and environment (Fryma) (UHU)
- Innovation and development in the touristic sector (UHU)
- Institute of local development (UHU)
- Orel-Optimization of resources, statistics, transports and logistics (UCA)
- Research techniques and economic development (UHU)
- Environmental technologies (UCA)
**General Description**

Marshlands are defined as being contained within a depression (generally caused by a river) near the sea. This setting results in low and swampy terrain, which is prone to flooding from both the sea and the river. This azonal climatic landscape can coexist with deltas and estuaries. Marshlands are wetlands, and they often become rich ecosystems that are inhabited by a wide range of life forms — from diminutive planktonic algae to numerous plant and animal species, especially birds. Marshlands are among the most fertile agricultural landscapes in the world, owing to the rich sediments deposited by the tide.

Saltpans are areas where salt water is left to evaporate, leaving the salt behind, which can then be collected and commercialised. There are two kinds of salt pans: those located on the coast, which have seawater, and those located inland, which have spring water that runs through underground salt deposits before coming to the surface. Saltpans have been in use since before the Roman period, but it was the Romans who generalised the use of salted products and created great salting factories, which led to the intensive exploitation of all available salt resources. This context means that salt had a strategic value, and salt pans became valuable property, a cause of conflict and a source of wealth. In the 20th century, with the emergence of alternative systems for preserving food, the use and production of salt decreased dramatically.
Potential for transference

✓ Exploitation of natural resources

Humankind uses natural forces and products as sources of wealth and economic growth. Minerals, the soil, animals and plants are all natural resources that can be used and exploited directly. For this reason, CEI-MAR’s researchers are currently studying issues related to the exploitation of natural resources, always from an ecological perspective that means total respect for the environment is the first priority. Specifically, CEI-MAR is currently exploring the following avenues of research:

- The use of sea minerals (commercial magnesium-rich salts).
- The development of new types of alimentary sea salt (salt flowers, salt flakes, salt substitutes).
- Technical consultancy for the improvement of the quality and the productive characteristics of salt (this also involves training).
- The cultural and historical heritage of marshlands and saltpans.

✓ Territorial management

This area of research was created because integrated public management strategies are necessary for the coastline, and it is also important to identify and remedy problems faced by coastal areas, and to prevent the deterioration of their environmental, socioeconomic and cultural resources. Specifically, CEI-MAR is currently exploring the following avenues of research:

- Taxonomic studies of marine species belonging to all fauna groups.
- The presence of radionuclides and trace elements in biota.
- Ecology: descriptive studies of processes concerning coastal ecosystems.
- The evaluation of the ecological state in transitional systems, including the ecology of saltpans.
- The characterisation of the biodiversity of ecosystems.
- Ideology, society and the environment in relation to the marshlands.
- The hydrogeology of wetlands.
- The management and regeneration of coastal wetlands.
- The planning and management of marshy wetlands.
- The structure and operation of wetlands and coastal ecosystems.
- Biological monitoring in coastal wetlands; biological and fauna-conservation studies.
- Vegetation studies; biological and flora-conservation studies.
• Environmental impact assessment of a certain area, based on the population of phytoplankton and micro/macrophytobenthos.
• Legal studies.
• The implementation of remote-sensing techniques, GIS and other next-generation techniques for monitoring and characterising ecosystems.
• The production, processing and analysis of high-precision georeferenced data.
• The identification and characterisation of biological indicators, based on biodiversity and ecological processes, for environmental monitoring.
• The management and conservation of natural resources; the recovery of coastal landscapes.
• The effects of pollution on ecosystems.
• The assessment of coastal trophic resources.
• The analysis in coastal ecosystems of trophic relations between species with fishing and farming potential; the prospection of resources that can be used for new sea-based food sources.
Researchers and Research Groups in CEI·MAR

- Science and public law in the 21st century (UAL)
- Conservation of coastal wetlands (UCA)
- Aquatic ecology and aquaculture (UAL)
- Ecology and environment (UHU)
- Ecozonar (ecology of arid zones) (UAL)
- Granada University Herbarium as centre for taxonomic and diversity studies (UGR)
- Radiation physics and environment (Fryma) (UHU)
- Integrated territorial management and spatial information technologies (UAL)
- Fishing and sea biology group (UCA and IEO)
- Hydrogeology group from the University of Malaga (Ghuma) (UMA)
- Marshlands and beaches (UHU)
- Ideology, society and environment in Andalusia and Latin America in the Modern period (UHU)
- Coastal planning and management (UCA)
- Hydric resources and environmental geology (UAL)
- Pelagic trophic networks (UGR)
- Technology for biomass (UHU)
**GENERAL DESCRIPTION**

The European naval sector is made up of shipyards that build new ships and those that repair shipyards. According to the European Commission, there are around 300 shipyards in the EU, approximately 80% of which are small facilities with the capacity to build ships between 60 and 150 Tm. The associated auxiliary industries comprise approximately 7,500 companies, nearly all of which are labelled SMEs.

LeaderSHIP 2020 (the Initiative by European Maritime Technology) makes short- and mid-term recommendations (2014-2020), the aim of which is for the sector to develop a sustainable model based on the cooperation of the private and the public sectors, as this will lead to the generation of added value employment and new research approaches in the field of maritime technology. The initiative also aims to provide the sector with financial tools (with the participation of the European Investment Bank), and develop smart strategies within the framework of regional development policies in the fields of innovation, environmental management, new technologies and the exploration of emerging markets, such as sea-based renewable energy.
Ship construction and repair involve the construction, transformation and repair of ships and offshore facilities, as well as the increasingly important auxiliary industry. Activity in this industry revolves around the production of construction shipyards. Specifically, **CEI-MAR** is currently exploring the following avenues of research:

- The analysis of materials for the naval sector.
- The thermal treatment of steel.
- The use of synthetic diamonds for engineering materials.
- Photovoltaic material engineering for the naval sector.
- Reinforced polymers for aeronautics.
- Additive manufacturing, materials and nanotechnology in the naval sector:
  - The characterisation of materials on the microscale and the nanoscale; the characterisation of the structure and composition of materials; the determination of the structural properties of materials on the microscale and nanoscale, as well as the correlation of these with other interesting functional properties, may lead to drastically improved materials.
  - The nanofabrication of materials; irradiation with focalised ion beams (FIB) can be used to locally alter the surface of materials in a controlled way, resulting in the formation of nanostructures which improve the properties of the materials.
  - Innovation in materials and products using nanotechnology: the introduction of nanoparticles and the formation of nanostructures in the materials leads to greatly improved materials which can, in turn, result in new materials and products.
  - The analysis of nanostructures in composite semiconductors.
- The study of nanomaterials through advanced electronic microscopy, with special emphasis on nanoparticle-based materials; the main focus of this research is the textural, chemical, nanoanalytical and nanostructural characterisation of materials based on particulated materials:
  - The preparation of samples for electronic microscopy.
  - Ultramicrotomic sample preparation techniques.
  - Anaerobic transference sample trays after sample preparation is undertaken in controlled conditions.
  - Morphological and compositional characterisation using SEM and microanalysis techniques.
  - Nanoanalysis using EDS and EELS.
  - Structural characterisation of the nanometric scale using high resolution electronic microscopy
  - Structural characterisation by electron diffraction techniques.
  - 3-D characterisation of nanostructures using electronic tomography (acquisition and processing of tomographic series).
  - The analysis of chemical composition on the nanometric scale using EELS spectrum imaging and the acquisition of EFTEM.
- The preparation of TEM samples in controlled conditions (redactors, oxidants and reaction mixtures), with the potential for subsequent transference to the microscope under controlled conditions.
- The complementary analysis of processes and the simulation of electronic microscopy images; the modelling and simulation of nanostructured systems.
- The development of new ways to synthesise metallic nanoparticles; the development of new electrode materials; the characterisation of (nano)materials for the manufacture of electrochemical sensors, as well as of the devices thus developed.
- The development and industrial application of composite materials.
- The chemical characterisation, structural characterisation and mechanical characterisation of metallic materials.

- The analysis, using instrumental and computational techniques, of the chemical and physical characteristics of materials: metals, semiconductors, ceramics, paints, etc.
- The characterisation of materials and their responses to damage and impact using physical, chemical and microscopic tests. This will involve studying structural protection against shock and the description and numerical simulation of thermomechanical phenomena: e.g. the deformation of steel owing to industrial thermal processes.
- The description of the heating of steel by conduction-induction: the introduction of intervening physical variables, phase transition, temperature, etc.
- The optimisation and control of the thermal treatment of steel.
- The analysis of the magnetic properties of materials.
- The evaluation of the resilience of aluminium plates against fatigue.
- The determination of the hardness of metal rods.

- Structure and foundation dynamics.
- Concrete structures.
- Vibration analysis and industrial maintenance.
- Non-destructive tests on the effects of mechanical vibrations and acoustic emissions in machinery, and preventive maintenance:
  - Consulting services, which can be used in the designing of systems and equipment used to monitor mechanical vibrations and acoustic emissions: choice of sensors, data acquisition cards and data transmission methods.
  - System simulation: parametrisation of the system and computer modelling, used for the interpretation of the system’s dynamics.
  - The designing of test and measurement software: incorporation of AI options, in an open system which allows tailor-made functions to be involved.
  - Vibro-acoustic characterisation.
  - Marine and submarine communications.
  - Mobile radio communications.
- The advanced simulation and control of naval systems and marine vehicles.
- The design of operational checks to test the soundness of systems under different operational conditions, as well as the analysis of behaviour in cases of malfunction and failure.
- The simulation and optimal-robust control of industrial processes; this will involve the designing of control advanced systems for naval and aeronautic industrial systems, using well-tested methodologies (such as PID controllers and programmable automata) for more complex systems such as multivariable or multiple entry and also multiple output systems (MIMO).
- Geotechnical reports.
- The synthesis, characterisation and application of new nanomaterials and coatings such as sol-gel in order to provide protection against corrosion and wear.
- The analysis of Timken coatings for gears and engine parts, and the assessment of wear by identifying traces of metals in lubricant oils.
- The examination of naval systems and devices by means of infrared light.
- The numerical simulation of turbulent currents in compressible and non-compressible fluids.
- Offshore wind farming.
- The analysis of the cultural and historical heritage of the naval industry.

**Researchers and research groups in CEI•MAR**

- ACETI – Malaga (UMA)
- Theoretical and numerical analysis of experimental science models (UCA)
- Automatics, signal processing and system engineering (UCA)
- Science and engineering of materials (UCA)
- Corrosion and protection (UCA)
- Structure and chemistry of nanomaterials (UCA)
- Computational and electronic industrial instrumentation (ICEI) (UCA)
- Instrumentation and environmental sciences (UCA)
- L.A.V. (Laboratory of Acoustic engineering)
- Applied magnetism and optics (UCA)
- Composite materials (UCA)
- Materials and nanotechnology for innovation (UCA)
- Ideology, society and environment in Andalusia and Latin America (UHU)
- Naval signals, systems and communications (UCA)
- Simulation, characterisation and evolution of materials (UCA)
- Environmental technologies (UCA)
- Underwater technology team (UMA)
 Operational oceanography

**General Description**

Operational oceanography includes all activities which involve measurement and sampling in the oceans, the sea and the atmosphere, as well as the dissemination of results and their interpretation. Operational oceanography responds to the increasingly widespread need – in the industrial sector, various services, the administrative and legal sectors and, naturally, the scientific community – to create observation systems with which to routinely monitor the state of the oceans in a way that is reminiscent of the now-common meteorological services.

The purpose of this area of research is to provide users and decision-makers with reliable, validated data concerning the status of the marine environment. This data will make offshore activities safer, and contribute to the management and monitoring of the quality of the sea and the sustainable use of marine resources *(source: Real Academia de Ingeniería)*.
Oceanography is the science that studies all physical, chemical and biological processes that take place in the sea and oceans. Oceanography is, therefore, a multidisciplinary science, focused on the oceans, the phenomena that occur in them and their interaction with the continental landmasses and the atmosphere. Within this discipline, the design of instruments and their use for environmental monitoring are key areas of development. Specifically, **CEI·MAR** is currently exploring the following avenues of research:

- The design of scientific instruments.
- Environmental monitoring and instrumental computation.
- AI and monitoring equipment.
- The optimisation of data-monitoring techniques for the discrimination of signals.
- The design of oceanographic research campaigns across several disciplines (geology, physical oceanography, chemistry and biology; the evaluation of pelagic and demersal resources, and the marking and recapture of commercially viable species).
- The design and implementation of measurement systems and data processing using virtual instruments; the design and application of electronic equipment and specific tasks, which can be used for the acquisition and processing of data and control:
  - Virtual instruments: we plan to design and implement the use of virtual equipment for processing and control applications.
  - Electronic equipment: we plan to design and implement complete, digital-based (or other), solutions for signal acquisition problems, treatment, processing and control.
  - System connection: we plan to connect physical systems and the computer environment through micro-controlled electronic interfaces.

**Numerical modelling**

Numerical models are a tool that can be used for the evaluation and interpretation of the dynamics of natural environments. Physical conditions are simulated, and preventive and corrective alternatives can be evaluated for technical, scientific and environmental purposes, with the ultimate aim of improving and protecting the natural conditions of marine ecosystems. Numerical models are very useful for analysing oceanic dynamics and assessing the environmental impact of high seas projects (submarine emissions, dredging, etc.) in marine ecosystems.
The numerical modelling of geophysical fluids, which will involve simulating the spatial and temporal distribution of dynamic variables (speed and other associated variables) and the biophysical characteristics of the water column (temperature, salinity, biomass, concentration of pollutants, etc.) in a high resolution 3-D model. The implementation of such a model is complex and requires a thorough knowledge of the underlying physical laws and great computational power – which can only be achieved by the best research institutes and universities. Specifically, CEI·MAR is currently exploring the following avenues of research:

- The ocean primitive equation; modelling turbulence and Navier-Stokes equation.
- Regional physical oceanography; numerical simulation.
- Numerical simulation of fluids with turns.
- Biological oceanography; ecological modelling of aquatic ecosystems.
- System modelling.
- The prediction of marine currents.
- The coupling of physical and biological processes:
  - Several zones and ecosystems.
  - The generation of simulated data and operational 72-h forecast of oceanographic variables in the region of the Strait of Gibraltar.

Marine dynamics

Water masses are not static, but are in perpetual motion. The main factor in the dynamics of the sea is the wind, but other factors have a decisive effect on the movement of water masses between different places, such as cosmic influence and the water’s physical and chemical characteristics. The analysis of sea dynamics involves several disciplines and has a wide variety of applications. Specifically, CEI·MAR is currently exploring the following avenues of research:

- Marine dynamics and meteorology; hydrodynamics.
- The dynamics and morphodynamics of bays and estuaries; coastal protection; the characterisation of oceanographic dynamics.
- The use of natural radionuclides as indicators of processes that affect coastal water processes.
Remote detection involves the collection of information from a specific item or an area using various devices and methods, such as land survey and meteorological satellites, marine and atmospheric beacons, magnetic resonance images, positron emission tomography, x rays and spatial probes. GIS are the result of applying ICTs to the management of georeferenced geographical information. A global navigation satellite system (GNSS) is a constellation of satellites which transmits beams of signals that can be used to localise any given point on the earth’s surface, be it on land or in the sea. They are used for navigation, transport, geodesics, hydrography and other associated activities. Currently, CEI-MAR is exploring the following avenues of research:

- The remote detection and processing of satellite very-high-resolution imaging.
- Remote oceanographic studies and relationship with the environment.
- The study and development of materials for radiometric sensors.
- The design, development, maintenance and quality control of permanent GNSS geodesic networks.
- The design and development of GIS and GIS in automatic environments.
- The georeferencing of cartographic products.
- Marine and submarine sensor networks and protocols and systems of submarine communication.

✅STUDIES OF MARINE ACOUSTICS AND DIGITAL-IMAGE PROCESSING

Maritime acoustics is concerned with the propagation of sounds in the sea. This field of study has a wide variety of applications, such as the identification of fishing resources, the determination of climatic issues, the location of submarine items, and the determination of sea depth. Specifically, CEI·MAR is currently exploring the following avenues of research:

- Environmental acoustics.
- The processing of sea-related sounds and images; the digital processing of images.
- Submarine acoustics (propagation of waves, channel models, arrays of hydrophones, processing of signals).
Researchers and research groups in CEI-MAR

- Theoretical and numerical analysis of experimental science models (UCA)
- CINTAL - Centro de Investigação Tecnológica do Algarve (UAlg)
- Structure and dynamics of aquatic ecosystems (UCA)
- Radiation physics and environment (Fryma) (UHU)
- Geodesics and geophysics Cádiz (UCA)
- Integrated territorial management and spatial information technologies (UAL)
- Marine and fishing biology group (UCA and IEO)
- Coastal and marine geology and geophysics group (UCA and IEO)
- Applied computer science group (UAL)
- Physical oceanography group, University of Malaga (GOFIMA) (UMA)
- Computational and electronic industrial instrumentation (ICEI) (UCA)
- L.A.V. (Laboratory of Acoustic engineering) (UCA)
- Fluid mechanics (UMA)
- Physical oceanography: dynamics (UCA)
- Oceanography and remote detection (UCA)
- Simulation, characterisation and evolution of materials (UCA)
- Intelligent computation systems (UCA)
- Digital processing of radiological images (UMA)
- Underwater technology team (UMA)
GENERAL DESCRIPTION

Fishing consists of the capture of aquatic organisms in maritime, coastal and interior regions. As well as being used for aquaculture, the sea and continental fishing also provide food and employment to around 820 million worldwide, and the capture, processing, commercialisation and distribution of fish are all involved. Fishing also plays an important role in the identity of many human groups.

One of the biggest threats for the sustainability of fishing resources worldwide is uncontrolled fishing.

Fishing and aquaculture have the potential – if adequately supported and developed according to environmentally friendly criteria – to significantly contribute to improving the lives of the poorest communities in underdeveloped countries, and to achieve several of the Millennium Development Goals, especially in relation to reducing poverty, increasing alimentary safety and defending the environment and biodiversity (source: FAO).
**Potential for Transference**

**Nutrition and Feeding of Fish**

In order to survive, fish need to consume organic matter such as plants, other animals or prepared foods that contain animal and vegetal matter. It is, therefore, very important that fish farms have the right foodstuffs, both in terms of quality and quantity. **CEI-MAR** is currently exploring the following avenues of research:

- The survey of marine raw materials other than fish, for their use as aquacultural fodder.
- The analysis of coastal ecosystems and the trophic relations of species with fishing and farming potential; the prospection of resources that may be used as new sea-based food sources.

**Pollution and Pollutants and Remediation of Aquatic Systems**

This area of research revolves around the presence in the water of elements which may, directly or indirectly, have a negative effect on its quality, later uses and its environmental function. This area of research also deals with those technologies which aim to remediate or minimise the effects of this pollution. Specifically, **CEI-MAR** is currently exploring the following avenues of research:

- The analysis of micro-toxins, traces, pesticides and other polluting agents in food.
- The presence of radionuclides and trace elements in biota.
- The analysis in coastal ecosystems of trophic relations between species with fishing and farming potential; the prospection of resources that can be used as new sea-based food sources; the survey of alternative marine raw materials to fish, for their use as aquacultural fodder.
- The valorisation of fish by-products for their use in the alimentary industry; the design of functional alimentary products from marine species; the generation of bioactive compositions from fish residue and discards, such as biomolecules and other products with nutritional and functional value, such as omega-3- and fatty acid-rich fish oil, as well as the development of new products based on the transformation of these components.

**Study and Assessment of Fishing Resources**

This includes the application of new molecular and biogeochemical techniques for the analysis of fishing. Specifically, **CEI-MAR** is currently exploring the following avenues of research:
• The analysis of the habitats and ecology of species which are potentially interesting in terms of their future incorporation into ecosystem-based management systems and the spatial integration of marine and coastal environments.
• The study of pelagic trophic networks, involving the functional evaluation of exploited coastal ecosystems.
• Biological studies of small pelagic and demersal species.
• The study of communities of ichthyoplankton and larvae ecology.
• The biogeochemistry of stable isotopes in food, involving the study of trophic chains and food traceability.
• Applying molecular markers to control traceability in aquaculture; the genetic improvement of farmed species; the use of techniques based on the identification of specific DNA fragments, which may lead to the in-depth monitoring of aquacultural processes, the taxonomic identification of fished and farmed species, and the elaboration of programmes of genetic selection; the identification of marine species on the basis of miscellaneous samples (fresh, frozen and processed) using molecular markers.
• Marine community dynamics; the dynamic of fish populations.
• The evaluation of fishing resources:
  - The evaluation of fishing resources (different trophic levels).
  - The evaluation of fishing resources (invertebrates).
• Biodiversity (including molecular system studies) and the conservation of marine ecosystems.
• The determination and enforcement of fishing prohibitions (invertebrates, cycles).
• Fishing tackle-selection studies.
• The study of the discards of trawling fleets.
• The analysis of long-term trends and changes on the continental shores of the Sea of Alborán.
• Digital-image processing of fish otoliths and calcified structures for the estimation of the age and growing dynamics of fish.
• Synoptic cartography of the trends in abundance and biomass in small- and medium neritic pelagic species through the application of vertical eco-probing/eco-integration, and of demersal and bentonic species through sampling by trawling and non-invasive sampling methods.
• The development of computer applications for the estimation, prediction and control of variables related to fisheries.
Physiological analysis of marine species

This research profile revolves around how known marine species interact with their environment by developing characteristic functions and, therefore, the effect that the environment has on these species. Specifically, CEI-MAR is currently exploring the following avenues of research:

- The growth and reproduction of molluscs and decapod crustaceans.
- The determination of the condition of the larva and its relationship with the recruitment of species that have fishing potential.

Entrepreneurship

This research profile aims to provide services which will facilitate decision-making processes for private sector actors. In order to develop these services, the associated research groups use tools such as regression, correlation, linear programming, choice theory and game theory, as well as assessment based on entrepreneurial decision-making processes. Specifically, CEI-MAR is currently exploring the following avenues of research:

- The economy and viability of fishing; the bioeconomic modelling of fisheries.
- Fishery-creation policies.
- Agroalimentary marketing.
• Health and safety policies in the fishing industry.
• Legal studies.
• Scientific consultancy for institutions, fishing- and environment-related public bodies and private firms, concerning the sea resources being exploited and their sustainability, on the basis of the assessment of demersal and pelagic fishing resources, via direct and indirect methods, including species that inhabit deep waters; the determination of parameters of reproductive and growth biology; the application of biological monitoring and commercially viable fisheries; the study of population dynamics.
• On-demand consultancy oriented towards seine fishing, trawling and traditional fishing practices, for the public (Commission of the European Union, central government, regional governments) and private sectors.
• The use of (bio)parameters for the assessment of food quality; the study of traces of metals for the characterisation of provenance and alimentary safety through the application of atomic spectroscopic techniques and chemometrics.
• Scientific and technological consultancy for the food industry.
• The study of the cultural and historical heritage of fishing.
• The analysis and assessment of the social impact of environment-changing projects; impact and social planning, from an applied and strategic approach that is focused on influencing decision making in affected communities and stakeholders in general.
Researchers and research groups in Cei-MAR

- Analysis and planning of the natural environment (UHU)
- Biogeochemistry of stable isotopes (EEZ-CSIC)
- CCMAR - Centre of Marine Sciences (UAld)
- Science and public law in the 21st century (UAL)
- Marine farming and fishing resources (IFAPA)
- Dynamics of fish population (UCA)
- Diversification and biotechnology in aquaculture (IFAPA)
- Marine ecosystems in Alborán: temporal trends and climate change (IEO)
- ESEIS-Studies of Social Intervention (UHU)
- Radiation physics and environment (Fryma) (UHU)
- Globalisation and territorial dynamics (UCA)
- Marine and fishing biology group (UCA and IEO)
- Research into natural resources (UMA)
- Engineering of complex fluids (UHU)
- Engineering and food technology (UCA)
- Social innovation in marketing (UCA)
- Instrumentation and environmental sciences (UCA)
- MEMPES-AEA: Econometric modelling and mathematic of fisheries (UHU)
- Ideology, society and environment in Andalusia and Latin America (UHU)
- Applied microbiology and molecular genetics (UCA)
- Maritime policy (UHU)
- Posidonia Sur (UMA)
- Analytical chemistry of pollutants (UAL)
- Pelagic trophic networks (UGR)
- Digital processing of radiological images (UMA)
General description

Mineral resources are natural concentrations of metallic, non-metallic and mineral elements, as well as the rocks that form the earth’s crust. It is possible to extract these resources in an economically viable way, given the current state of our scientific and technical knowledge. Oceans, which cover two-thirds of the earth’s surface, contain, largely untouched, the greatest mineral reserves on our planet, both in terms of quality and concentration. Current research is, therefore, turning the sea into a new frontier of mineral-resource extraction.

Water resources also include coastal water resources, and methods of turning sea water into fresh water by techniques (such as reverse osmosis) are of the utmost importance.
**Potential for Transference**

Humankind can use natural elements and forces as sources of wealth. Mineral and water resources, among others, are non-living resources that can be directly exploited. For this reason, CEI-MAR’s researchers are currently working on issues related to the exploitation of non-living natural resources, always from an ecological perspective that makes total respect for the environment the first priority. Specifically, CEI-MAR is currently exploring the following avenues of research:

- Water resources; hydrogeology and hydrological research in coastal water sources.
- Seismic prospection.
- Structural and tectonic geology.
- Reverse osmosis; energy optimisation and water desalination by reverse osmosis.
- The risk analysis of membrane spoiling in sea-water treatment plants, and the development of more efficient plants:
  - Membrane autopsy: analytically evaluating the degree of soiling of membranes used for filtering sea water.
  - The determination of the degree of polarisation: analysing the level of salt concentration on the surface or in reverse osmosis membranes.
  - Water-quality analysis: assessing the quality of sea water before and after desalination, as part of the control processes, protocol design; assessing water quality; risk assessment.
  - The analysis of the need for the chemical cleaning of inverse osmosis membranes: assessing the degree of spoiling of membranes and the analysis of the most adequate chemical cleaning processes.
  - The assessment of the risk of membrane spoiling by micro-organisms in desalination plants; surface analysis for the evaluation of the degree of development of biofilms, and the assessment of the efficacy of the means of control implemented.
- The design of passive treatments (sustainable) of heavy metal-rich acid drainages. This system, which involves very low maintenance costs, effectively removes heavy metals from acid drainages of industrial or mining origin.
- The physical and chemical characterisation of the surface of solid materials – materials are interpreted as any conglomerate of matter that can be transformed and merged (in nature, materials form rocks, soils, mineral agglomerations, for example of petroleum, asphalt, natural gas, etc.)
Researchers and research groups in CEI-MAR

- Structural and tectonic geology (UGR)
- Hydrogeology group from University of Malaga (Ghuma) (UMA)
- Research group in water resources (UGR)
- Solids chemistry and catalysis (UCA)
- Water resources and environmental geology (UAL)
- Environmental technologies (UCA)
- Water management and processing technologies (UGR)
- Tectonics and marine geology (GR)
- Tharsis: Laboratory of mineralogy and environmental geochemistry
Renewable energy is energy which is obtained from virtually inexhaustible natural sources – these are said to be virtually inexhaustible because of the immense energy these sources provide or because they regenerate naturally. Renewable energy includes hydroelectric, wind-generated, solar, geothermic, tidal, and biomass- and biofuel-generated energy.

Oceans have enormous potential as sources of energy. By means of different technologies, this energy may be transformed into electricity and contribute to meeting current energy demands.

Within this field, there are specific technologies designed to exploit sea-based energy. The harvesting of tidal energy, sea-current power, ocean thermal energy conversion, wave power and osmotic power should all be mentioned in this context (source: Instituto para la Diversificación y el Ahorro de Energía).
**Potential for transference**

### Power generation: biomass

Biomass is a renewable source of energy which depends on the ability of plants to fix the energy provided by the sun through photosynthesis. This energy is liberated by breaking the bonds between the organic compounds via combustion, which results in carbon dioxide and water. For this reason, biomass products used as sources of energy are known as biofuels. Solid biofuels are largely used for the extraction of thermal and electric energy, whereas the liquid ones are used in locomotion. Specifically, CEI-MAR is currently exploring the following avenues of research:

- Integrated biorefinery with microalgae: the extraction of biogas from microalgae generated during anaerobic digestion processes.
- The extraction of oils used as sources of energy: different techniques are used for the isolation of lipids, which can be later used as sources of energy; the production of biodiesel from different raw materials (plant oils, microalgae) by means of high-pressure techniques.
- Solid catalysers for the transformation of plant oils to high-energy, environmentally friendly fuels (biodiesel).
- The production of biofuels.
- The production of biodiesel and bioethanol.
- The biotechnological improvement of microalgae for the production of biodiesel.

### Power generation: wind energy

Sea wind power involves the construction, operation and maintenance of wind farms in the sea. The only difference between these wind farms and those located inland is that these wind farms are built in the sea. In general, sea wind farms are found in shallow waters, far away from commercial routes, military facilities and areas of special environmental value. Specifically, CEI-MAR is currently exploring the following avenues of research:

- Offshore wind farms.
- The assessment of the potential of wind power: this will involve the selection of appropriate locations, production estimates and regional analysis.
- Consultancy in the designing of wind farms: e.g. the selection of wind turbines and of ideal locations (using WASP and in-house designed software).
• Wind data: supplying wind-related data, generating virtual stations, short-term wind forecasting, detecting and correcting failures and anomalies.
• The design of wind turbines: modelling with CFD methodology; the design of blades and estimation of curves, power, thrust and associated coefficients; the design and optimisation of wind turbine control and advanced control.
• The monitoring and detection of failures in the electrical signal of wind turbines.

✅ **Power generation: solar energy**

Solar energy is a renewable energy source. The sunlight is transformed by means of photovoltaic cells or solar panels. Specifically, **CEI·MAR** is currently exploring the following avenues of research:

- Nanomaterials for photoelectric solar cells.
- The analysis of photovoltaic materials.
- Microstructural and textural analysis using electronic microscopy (scan and transmission), nanoscale structural analysis and composition analysis.
- The assessment of deformation in materials.
- Structural, compositional and deformation parameters, from the nanoscale to the atomic column level.
- Reports on demand: a) results, b) overview of the state of development of photovoltaic and other electronic and optoelectronic materials, c) advice on the improved production of photovoltaic and other optoelectronic materials.
- The optimisation of photovoltaic plants connected to the grid.
- Systems and materials for solar energy; photovoltaic efficiency.
- Macroscopic determinations of photovoltaic efficiency; the characterisation of photovoltaic cells, and the determination of IV curves, recombination kinetics, etc.
- Surface mapping of photovoltaic efficiency on several wavelengths, with micrometric resolution; the characterisation of microdamage, local efficiency in polycrystalline systems, etc.
- The textural characterisation of photoactive surfaces and the determination of reflectances.
- The characterisation of cells based on nanostructured semiconductors; the determination of BandGap in nanostructured semiconductors.
- Quantic simulation of colorants and of photovoltaic elements.
- The determination of temperature coefficients and the study of the relationship between thermal parameters and efficiency.
- The characterisation of specular elements in concentration systems; the determination of specular reflectance on mirrors and the characterisation of micro-fissures.
- The simulation of spoiling/cleaning of photoactive surfaces and the analysis of accelerated ageing of panels, cells and mirrors.
• The preparation of samples, involving grinding and cutting with diamond discs, metallographic polishing, mounting in polyurethane resin, etc.
• Micrographic reports of samples, including 10x to 500x optic magnification and high-resolution electronic microscopy.

✔️ **Power generation: marine current power**

This involves making use of kinetic energy provided by sea currents, by means of devices which are similar to wind turbines but which have been adapted to underwater conditions. Specifically, CEI·MAR is currently exploring the following avenues of research:

• The extraction of energy from sea currents; studies on the potential of sea energy.
• The extraction of renewable energy from sea currents is one of the less explored sources of clean energy, despite its enormous potential. The main problem with this system is finding the right location for the efficient implementation of the technology available. The Strait of Gibraltar is, in this regard, unique. Sea currents are not only strong and constant, but markedly unidirectional. However, choosing the right spot for this sort of facility is a complex task, which demands a thorough knowledge of the environment and significant research resources. Researchers at CEI·MAR have developed a high-resolution hydrodynamic model of the Strait of Gibraltar, capable of accurately simulating the current regimes, in order to survey and propose locations for the plant. This research team also possesses in situ measuring instruments which validate the data used in the simulator and allow for objective observations.
• The characterisation of the current regime in the proposed location of a plant, by means of high-resolution numerical models.
• Searching for the optimal location for plants.
• The generation of field data for the validation of models and the characterisation of the current regime in the proposed location.

✔️ **Legislation, monitoring, evaluation and management in relation to renewable energy**

Specifically, CEI·MAR is currently exploring the following avenues of research:

• The legal regulation of sea-based renewable energy.
• Sustainable energy development; the environmental impact in relation to electrical equipment and facilities.
• The evaluation and forecast of potential renewable energy sources.
• Environmental law and renewable energy.
• Measuring instruments, remote monitoring and sensors that can be used for sustainable energy engineering and have an environmental application.
• Proposals for the optimisation of energy consumption.
• The analysis and assessment of the social impact of environment-changing projects; impact and social planning, from an applied and strategic approach focuses on influencing decision-making in affected communities and stakeholders in general.
Researchers and research groups in CEI·MAR

- ACETI – Malaga (UMA)
- Analysis and design of processes with supercritical fluids (UCA)
- Algae biotechnology (UHU)
- Biotechnology of natural products (UAL)
- Administrative law (UCA)
- Science and engineering of materials (UCA)
- ESEIS-Studies of Social Intervention (UHU)
- Management, efficient use and diversification of energy sources (UCA)
- Physical oceanography research group, University of Malaga (GOFIMA) (UMA)
- Computational and electronic industrial instrumentation (ICEI) (UCA)
- Environmental microbiology (UGR)
- Solids chemistry and catalysis (UCA)
- Simulation, characterisation and evolution of materials (UCA)
- Knowledge society (UHU)
- Environmental technologies (UCA)
- Tensioactivity and renewable and alternative energy sources (UCA)
**General Description**

Marine risk management is a topic of interest worldwide. It concerns every risk and development that affects coastal zones and open waters. This topic includes those events caused by nature and by man, such as geological events, physical, chemical, bacteriological and radiological pollution, the effects of these on the ecosystem, the destruction of habitats, benthic and vertical fluxes, the implementation of European directives for the protection of the environment and the implementation of emergency, contention and prevention plans, among other matters.

This field of study involves the hydrodynamic and physical modelling of coastal areas and open waters, coastal geology, the modelling of sedimentation in coastal systems, environmental analysis and assessment, the study of matter and energy fluxes across borders (including nutrient flows and physical-biological interaction within ecosystems), the study of biodiversity and ecology, pollution and environmental impact, the diagnosis and response of ecosystems to climate change, coastal defences, the recovery of sea regions and the organisation of public crisis-response policies.
POTENTIAL FOR TRANSFERENCE

✓ POLLUTION OF AQUATIC SYSTEMS

This area of research revolves around the presence in water of elements which may, directly or indirectly, have a negative effect on its quality, later uses and environmental function. It is important to point out that industrial development means greater consumption of water and the generation of more waste, a good deal of which ends up in aquatic systems. Also, sea and river transport often leaves pollutants in the water, sediments and biota, as well as the atmosphere. Specifically, CEI-MAR is currently exploring the following avenues of research:

- Field sampling and experimentation using lab-based simulation for the determination of sea pollution.
- Environmental inorganic, synthetic and emerging contaminant pollution studies, involving the identification, quantification and analysis of processes involved in pollutants’ distribution, transport, toxicity and resilience in the environment, including degradation processes.
- Bio-indicators of metallic pollution in aquatic systems: the analysis of commercially viable fish species and early warning biomarkers.
- Environmental quality in aquatic systems; bio-indicators of environmental quality in ecosystems.
- Environmental impact assessment of a certain area, based on the population of phytoplankton and micro/macrophytobenthos.
- The development of new methods of preconcentration and speciation of metallic ultratrace in biological and environmental samples; the analysis of organic micropollutants (pesticides, PCBs, PAHs, dioxins, emerging contaminants, etc.)
- The simplification, miniaturisation and automation of analytical methodologies used in the determination of micropollutants in marine samples.
- Environmental metal pollution, accessibility, etc.
- Phosphogypsum and its impact on estuarine systems; ecotoxicology in environments contaminated by acid drainage of mines.
- The evaluation of the environmental quality of dredging material; the selection and preparation of biological tests for the characterisation of dredging material.
- The diagnostic and technological development of applications for marine sediments contaminated during coastal engineering works.
- Pollution related to mining spills.
- The elimination of heavy metals and/or hydrocarbons from contaminated soils and silts; the comprehensive management of heavy metal and hydrocarbon found in industrial waste using...
bioremediation techniques (degradation and immobilisation) in order to minimise the polluting effects of these residues (the procedures and strategies used for the application of some or a combination of these bioremediation techniques in polluted areas are already in place).

- The speciation and biotransformation of pollutants in sea organisms.
- Ecophysiology and ecotoxicology in aquatic systems.
- The evaluation of the impact on and environmental quality of coastal and marine ecosystems.
- The study of water quality in beaches.
- Quality control and the treatment of industrial waste.
- Studies on the thermal impact of the spill of refrigeration water.
- Modelling the dispersion of pollutants in coastal and estuarine waters.
- Residue treatment by oxidation (OASC) and gasification (GASC).

✅ **Noise pollution**

Noise pollution is defined as an excess of noise which alters normal environmental conditions in a given area. Although noise does not accumulate, travel or remain over time, like other forms of pollution, it can have grave effects on the quality of life if it is not kept under control. **CEI·MAR** is studying this issue with the aim of mitigating the effects of excessive noise as much as possible. Specifically, **CEI·MAR** is currently exploring the following avenues of research:

- Noise maps and action plans; legislation and noise regulations; submarine acoustics.
- Environmental monitoring and instrumental computation.
- The evaluation of levels of noise pollution; the environmental diagnosis of aquatic systems.
- The analysis and proposal of changes in regulations against noise pollution.

✅ **Air pollution**

Air pollution is detrimental to human health and the environment. In Europe, the emission of many pollutants has decreased over the last few decades, and air quality has subsequently improved. However, the concentration of pollutants is still very high, and air-quality problems persist. Specifically, **CEI·MAR** is currently exploring the following avenues of research:

- The analysis of particulated atmospheric matter in relation to air quality and metal content.
- Chemical speciation in environmental samples, including samples from the air.
**Analysis of Marine Microorganisms**

This research profile focuses on the study and analysis of microscopic living beings in marine environments. In most cases, these are single-cell organisms, although in some cases they may be coenocyte organisms composed of multinucleate cells, or even multicellular organisms. Microorganisms are of the greatest importance for sea life because, in addition to being an essential part of the trophic link, they are crucial for the production of organic matter. They can be found at all depths, including the deepest regions (over 5,000 m below the surface) although they are more abundant closest to the surface.

**Nuclear Energy and Radioactivity**

Nuclear or atomic energy is liberated naturally or artificially after a nuclear reaction. Radioactivity is a chemical phenomenon by which some bodies or chemical elements, which are known as radioactive, emit radiation that has the ability to leave impressions on radiographic plaques, ionise gases, produce fluorescence and go through bodies which are opaque to ordinary light, among other things. In summary, it is a phenomenon that takes place in the nucleus of certain unstable elements which are capable of transforming or decaying spontaneously, and in the atomic nucleus of more stable elements. Specifically, CEI·MAR is currently exploring the following avenues of research:

- The stochastic evaluation of the risk of storing nuclear waste.
- The presence of radionuclides and trace elements in sea water (dissolution and particulation), sediments and biota.
- The distribution of radionuclides in coastal sediments; the dating of sedimentary columns; the migration of radionuclides in sedimentary columns; the study of sedimentary processes by radionuclides.
- The sea-scavenging model and its application in the evaluation of the extraction rate of reactive species; the estimation of carbon flows and reactive species based on scavenging models with radionuclides (234Th-234U, 210Po-210Pb, etc.)
- Hydrology-oriented isotopic studies in zones where salt and fresh water mix, and the analysis of marine intrusions.
Environmental management consists of the management of all the factors that affect the evolution of the environment, and includes the concept of sustainable development. In other words, environmental management is the strategy by which anthropic actions that have an effect on the environment are organised, in order to ensure a good quality of life and prevent or mitigate damage to the environment. Specifically, CEI·MAR is currently exploring the following avenues of research:

- Cycles of nutrients, carbon and greenhouse gases.
- The characterisation and simulation of chemical processes in estuaries.
- The conservation and restoration of ecosystems; the restoration of the environment; the removal of exotic invasive species; the characterisation of biodiversity of ecosystems; the identification of marine invertebrates.
- The study of ecological indicators of the marine ecosystem (pelagic, demersal and suprabenthic).
- The study of the accumulative impact of global stress on biodiversity; the operation of ecosystems; the mitigation of stressing agents such as global warming, ultraviolet radiation and CFCs.
- Environmental impact assessment and monitoring.
- The analysis, modelling and conservation of Mediterranean ecosystems.
- The implementation of European framework directives, such as the Water Framework Directive and the Marine Strategy Framework Directive; legal implications of the environment, environmental standards and environmental regulations.
- Administrative law and protection of marine environments.
- Protected marine spaces; the management of natural protected areas.
- Environmental management and waste management.
- Specialised scientific consulting for the storage of carbon dioxide in submarine geological formations.
- The analysis and assessment of the social impact of environment-changing projects; impact and social planning, from an applied and strategic approach that is focused on influencing decision making in affected communities and stakeholders in general.
- Mathematical modelling of the coastline.

Coastal dynamics involve the coastal processes associated with marine climatic agents and their effects. The main factors in this equation are the acting agents, the environment in which they act and the transportation of matter between locations. The main marine climatic agents are the surf, the wind, the changes in sea level and the currents. Coastal erosion takes place in coastlines that are exposed to long-distance waves or energy-
rich sea winds. These coasts are dominated by cliffs, the bases of which are platforms eroded by waves. Coastal erosion is caused by water pressure (posed by the waves that break at the feet of the cliff) and the impact of waterborne sediments against the rock. Geological studies involve analysing the composition and internal structure of the earth, the nature of its component elements, the formation, change and alteration processes that they have undergone over time, and their present position. Specifically, CEI·MAR is currently exploring the following avenues of research:

- Dynamics and morphodynamics in bays and estuaries; coastal protection.
- Natural risk analysis in coastal areas.
- The study and characterisation of coastal hydrodynamic processes; human alteration of coastal dynamics.
- Geological risk; the study of the geotechnics of materials in coastal areas; coastal tectonic problems; coastal geomorphology; the geophysical characterisation of continental shores; orogen and basin dynamics.
- The design and development of geodesic networks for volcanic monitoring.
- Coastal erosion processes.
- The analysis of palaeolevels (in the Mediterranean in the Quaternary period).
- The production, processing and analysis of high-precision georeferenced data.
Researchers and research groups in CEI·MAR

- Inorganic analysis (UMA)
- Environmental analysis and bioanalysis (UHU)
- Metallomic and environmental analysis (UHU)
- Theoretical and numerical analysis of experimental science models (UCA)
- Analysis and design of processes with supercritical fluids (UCA)
- Biodiversity, conservation and plant resources (UMA)
- Biology of epicontinental waters (UHU)
- CCMAR - Centre of Marine Sciences (UAlg)
- CIMA - Marine and Environmental Research Centre (UAlg)
- Pollution of aquatic systems (UCA)
- Dynamics of environmental fluids, marine section (UGR)
- Orogen and basin dynamics (UHU)
- Functional ecology (UGR)
- Ecology and environment (UHU)
- Ecotoxicology and ecophysiology of marine systems (ICMANCSIC)
- Ecozonar (Ecology of arid zones) (UAL)
- Granada University Herbarium as centre for taxonomic and diversity studies (UGR)
- ESEIS-Studies of Social Intervention (UHU)
- Structure and dynamics of aquatic ecosystems (UCA)
- Radiation physics and environment (Fryma) (UHU)
- Geodesics and geophysics Cádiz (UCA)
- Coastal and marine geology and geophysics (UCA and IEO)
- Geology and environmental geochemistry I (UHU)
- Environmental geomorphology and water resources (UHU)
- Marine geochemistry (UCA)
- Integrated territorial management and spatial information technologies (UAL)
- Marine and fishing biology group (UCA e IEO)
- Engineering and environmental management group (UMA)
- Applied computer science research group (UAL)
- Legal implications of the environment, environmental
standards and environmental regulations (UMA)
• Civil engineering and environmental quality (UHU)
• Computational and electronic industrial instrumentation (ICEI) (UCA)
• Laboratory of acoustics and vibrations (LAV) (UCA)
• Physical oceanography (UCA)
• Oceanography and contamination of the coastline (UCA)
• Oceanography and remote detection (UCA)
• Solids chemistry and catalysis (UCA)
• Radioactivity and environment (UCA)
• Biological and enzymatic reactors (UCA)
• Water resources and environmental geology (UAL)
• Cellular response and adaptation to environmental stress (UHU)
• Sulphur (UMA)
• Environmental technologies (UCA)
• Approximation theory and orthogonal polynomials (UAL)
• Tharsis: Laboratory of mineralogy and environmental geochemistry (UHU)
• Analytical and environmental toxicology (UCA)
Territorial management is a topic of worldwide interest. This topic was developed in response to the need for integrated public territorial-management protocols. It outlines and proposes measures with which to remedy some of the problems suffered by coastal areas and the deterioration of environmental, socioeconomic and cultural resources. Territorial management includes all aspects of coastal planning: the economic and legal evaluation of coastal ecosystems and environmental assessment, spatial coastal planning, coastal economic activities, the evaluation of sustainability and the governance of marine activities, the integration of land and sea territorial policies, social responsibility and marine reserves.

This involves the analysis of ecosystems and of the environmental, economic and social impact of the comprehensive planning of coastal systems on local, regional, national and trans-border scales, through the use/application of developmental instruments such as urban planning, sustainability, carrying capacity, the delimitation of national and international waters, different methodologies (GIS, remote detection), legal aspects (public policies and strategies, planning instruments, fiscal instruments), as well as the analysis of marine reserves from economic, management, conservation, modelling and characterisation perspectives.
Coastal planning consists of the management and sustainable planning of the coastline and the territory at large. Specifically, CEI-MAR is currently exploring the following avenues of research:

- The planning and management of coastal areas; the integrated management of coastal areas; knowledge of the structure and function of coastal ecosystems.
- The management of water reservoirs, wetlands and lakes.

Environmental evaluation and assessment includes, among other aspects, assessments that identify, prevent and interpret the environmental impact of a given project, as well as environmental diagnoses and the conservation and recovery of ecosystems. Specifically, CEI-MAR is currently exploring the following avenues of research:

- Environmental impact assessment in the marine environment.
- Marine areas: characterisation, evaluation, management and knowledge.
- The conservation and recovery of ecosystems.
- Landscape management, coastal cities, coastal landscape resources, tourism, parklands.

Maritime legislation and territorial planning

Territorial planning is a multifaceted discipline (it involves applied science, politics and law, among other subjects) which analyses, develops and manages the planning and development of given geographical units. The main aim of this discipline is to coordinate the use of space for different human activities, such as transportation, telecommunications and energy. The philosophy behind this discipline is the consolidation of rational uses that combine the need for sustainability, cohesion and competitiveness. Specifically, CEI-MAR is currently exploring the following avenues of research:

- International law and politics: international protection of the sea.
- Integrated maritime policies.
• Maritime security policies.
• Coastal law; urban and territorial planning.
• Protected marine areas.
• The history of maritime law.
• Natural spaces, the public domain, infrastructures, public works, territorial planning.
• Population, the environment and urban development.
• The articulation of the responsibilities of the public regional and interregional public agencies.
• Demography and urban planning; new migrations and private sector demographics.
• Rural areas and endogenous development; the spatial articulation of activities.
• Integrated strategies for the economic, social and environmental sustainability in coastal areas.
• Territorial and urban planning; the legal status of public services, civil servants and public agencies.
• Emerging technologies in the production of 2-D and 3-D digital cartography; the fusion of multisource geospatial data.
• The analysis and assessment of the social impact of environment-changing projects, and this impact and social planning, from a strategic approach focused on influencing decision making in affected communities and stakeholders in general.
Researchers and research groups in CEI-MAR

- Administrative law (UCA)
- Science and public law in the 21st century (UAL)
- CIMA - Marine and Environmental Research Centre (UAIg)
- International trade law: electronic contracting (UCA)
- Law, economy and society (UHU)
- Maritime ecology and limnology (UMA)
- Ecology and the environment (UHU)
- Ecozonar (Ecology of arid zones) (UAL)
- ESEIS-Studies of Social Intervention (UHU)
- Structure and dynamics of aquatic ecosystems (UCA)
- Integrated territorial management and spatial information technologies (UAL)
- Globalisation and territorial dynamics (UCA)
- Current affairs history group (UCA)
- Legal implications of the environment, environmental standards and environmental regulations (UMA)
- Coastal planning and management (UCA)
- Maritime policy (UCA)
- International law and policies (UHU)
- Posidonia Sur (UMA)
- Research techniques and economic development (UHU)
Maritime transport consists of the carrying of passengers or freight (solids, liquids or gases) between two points across the sea. It is the most widely used means of transport throughout history, and it remains the most widely used, as far as international trade is concerned, despite the technological advances which have made possible other forms of transport, such as air and land transport. Sea transport, therefore, hauls more cargo than any other system, both in terms of containers and bulk. Maritime transport has several characteristics that make it the ideal means of transporting large cargos, large pieces of machinery, cars, etc. In addition, some vessels are specially designed for the transportation of a specific product: for example, oil tankers.

Technological innovation in maritime transport is reflected in the increasing tendency to transport all cargos in containers and the increase in the size of vessels. In harbours, innovation takes the shape of increasingly modern equipment, the provision of added-value services and the use of next-generation computer and communication systems. Another crucial innovation is concerned with health and safety.
POTENTIAL FOR TRANSFERENCE

✓ STUDY AND DEVELOPMENT OF NEW DEVICES

This profile encompasses very different areas of study, brought together by their aim to create devices that can be used to measure different parameters. Specifically, CEI·MAR is currently exploring the following avenues of research:

- The development of electronic documents for international maritime transport.
- The regulation and control of naval systems.
- Modelling, simulation and system control.
- Technical projects, and the supervision of execution and certification concerning common communication infrastructures.
- The study of electromagnetic compatibility prior to the installation of antennae.
- The development of air beacons.
- Experience of multiple wireless standards and technologies: e.g. RFID, WiFi, WiMAX, GSM/GPRS, UMTS, WSN, Wireless Sensor Networks, SDR, Software-Defined Radio.

✓ NAVIGATION

This is the ability to steer a vessel, knowing at all times the position, direction and distance of said vessel and its destination. Depending on the orientation method, we can distinguish between three types: dead reckoning, coastal navigation and astronomic navigation. Specifically, CEI·MAR is currently exploring the following avenues of research:

- Systems for the regulation of traffic, navigation, circulation and conduction.
- The control instruments used in sea travel.
- The design of GIS for automatic environments.
- Maritime and submarine communications.
- Mobile radio communication.
- The analysis and development of control and combat systems.
- The simulation and advanced control of naval systems and maritime vehicles.
- The optimisation of logistic networks in maritime lines; navigation support systems.
- Studies of maritime navigation in sea wind farms.
- The analysis, design and implementation of radio-communication systems and signal processing subsystems by platforms of Software-Defined Radio (SDR) and FPGAs; the characterisation of radio-electrical channels: radio-electric propagation measures, electromagnetic compatibility, frequency spectrum use, electromagnetic radiation, quality of service.
Traffic and maritime safety

The main characteristics of maritime traffic include: its international character, since it is virtually the only way to transport large cargos between distant points at a reasonable cost; capacity, since ships can carry a lot more cargo than any other transport system; flexibility, resulting from the possibility of using different-sized ships; competitiveness, since, despite the protectionist measures imposed on some countries, most international traffic is carried out under conditions of free competition and under similar market conditions; versatility, because generally the ships can carry all sorts of cargo. On the other hand, maritime safety involves all actions conducive to saving human life and ensuring the security of the ships. If necessary, safety also involves taking the necessary measures to save endangered human lives and fighting against the contamination of the sea. Other equally important aspects are traffic control, the registration of civil ships, administrative traffic regulations, emergency actions, trailing, finds and maritime extractions. Specifically, CEI-MAR is currently exploring the following avenues of research:

- Multimodal maritime transport.
- International maritime insurance.
- Transport infrastructures and networks.
- Safety in maritime transport.
- The expert assessment of maritime accidents.
- The reduction of the environmental impact of maritime transport.
- The design, development, maintenance and quality control of permanent GNSS geodesic networks.
- The study and analysis of emissions in harbours and marine transport.
- Antifouling treatments.
- Training for nautical licenses.
- Specialised maritime training (Guardia Civil del Mar, Sociedades de Estiba).

Entrepreneurship

This research profile aims to provide services oriented to facilitate decision-making processes for private sector actors. In order to develop these services, the associated research groups use tools such as regression, correlation, linear programming, choice theory and game theory, as well as assessment based on entrepreneurial decision-making processes. Specifically, CEI-MAR is currently exploring the following avenues of research:

- Maritime trade.
- Migration and transatlantic commerce; travellers and transoceanic experiences.
- The economics of maritime transport; the logistics of maritime transport.
- Administrative maritime law (harbours, merchant fleet and navigation).
• Legal studies.
• Assessment and support in telecommunications: telecommunication projects (projection, direction and certification), field tests in maritime and naval environments, the theoretical planning of telecommunication networks and adjustment of simulations using experimental measures.
• Viability assessments for the establishment of telecommunication networks.
• The analysis and assessment of the social impact of environment-changing projects; impact and social planning, from an applied and strategic approach focused on influencing decision making in affected communities and stakeholders in general.

**Researchers and research groups in CEI-MAR**

• Automatics, signal processing and system engineering (UCA)
• Administrative law (UCA)
• Science and public law in the 21st century (UAL)
• International trade law: electronic contracting (UCA)
• Economics of innovation and transport (UCA)
• Learning democracy in Andalusia (UHU)
• ESEIS-Studies of Social Intervention (UHU)
• Geodesics and geophysics (UCA)
• Research group for the development of the maritime sector (UCA)
• Transdisciplinary group in knowledge engineering and control systems (UCA)
• Institute of local development (UHU)
• Orel-optimisation of resources, statistics, transport and logistics (UCA)
• Maritime politics (UCA)
• RNM-205 Physical oceanography: dynamics (UCA)
• Naval signals, systems and communications (UCA)
• Environmental technologies (UCA)
• Transport and tourism (UMA)
• Underwater technology team (UMA)
**General Description**

Tourism is a key economic sector in many coastal areas because of beaches, leisure and cultural programmes and the presence of important historical heritage monuments. Certain specialisations may also be highlighted.

**Tourism and healthcare:** this combines tourism with close attention to a healthy lifestyle.

**Subaquatic cultural tourism:** this is concerned especially with diving around ancient shipwrecks.

**Sea-based active tourism:** this involves amateur or professional sporting activities at holiday destinations, both in the sea (naval sports, rowing, canoeing, surf, diving, water-skiing) or on the coast (this is a rapidly-growing sector).

**Cruise tourism:** the demand for cruises is growing rapidly, and this demand is being met by increasingly large ships.

**Sustainable tourism/ecotourism:** a recent trend in alternative tourism, which differs from traditional tourism. The focus of these activities is on sustainability, preservation and the appreciation of the environment (both natural and cultural), which raises awareness among travellers. Although different approaches exist, in general ecotourism is promoted as an ‘ethical’ form of tourism which also takes into consideration the well-being of host populations. Generally, this philosophy is reflected in the structure and operations of the firms that specialise in this sort of service.
Potential for Transference

Sea-based Tourism

Among the key factors for this form of tourism we may highlight coasts and beaches, and cruises and sea sports. Specifically, CEI-MAR is currently exploring the following avenues of research:

- Coastal tourism.
- Nautical tourism (leisure ports).
- Sailing tourism.
- Social tourism.
- Tourism and fishing heritage.
- Industrial tourism (visits to private companies, for example).

Entrepreneurship

This research profile aims to provide services which facilitate decision-making processes for private sector actors. In order to develop these services, the associated research groups use tools such as regression, correlation, linear programming, choice theory and game theory, as well as assessment based on entrepreneurial decision-making processes. Specifically, CEI-MAR is currently exploring the following avenues of research:

- Social and socio-environmental marketing; marketing and a healthy lifestyle; marketing and ICTs.
- The analysis of specific forms of maritime tourism.
- The elaboration of teaching material in the field of touristic economics.
- Landscape management, coastal cities, coastal landscape resources, tourism and parklands.
- The management of environmental knowledge.
- Corporate social responsibility.
- The assessment of touristic resources and activities, which is necessary for the adequate planning and territorial management of touristic activities:
  - The valorisation of touristic resources
  - Good-practice guides
  - Touristic plans
  - The analysis of touristic activities
  - Designing touristic cartography
  - Constructing touristic information systems
• The analysis and assessment of the social impact of environment-changing projects; this involves studying the impact and social planning, from an applied and strategic approach focused on influencing decision making in affected communities and stakeholders in general.
Researchers and research groups in CEI·MAR

- Written, oral and media culture (UAL)
- Ecology and environment (UHU)
- ESEIS-Studies of Social Intervention (UHU)
- Research group on natural resources (UMA)
- Social innovation in marketing (UCA)
- Innovation and development in the touristic sector (UHU)
- Institute of local development (UHU)
- Culture and heritage observatory (UHU)
- Coastal planning and management (UCA)