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Mediterranean Marine and Environmental Reseach Center*

The Mediterranean Marine and Environmental Research Center – *Centre Mediterrani d'Investigacions Marines i Ambientals* (CMIMA) – is located on Barcelona's marine drive, the Centre belongs to the Scientific Research Council – *Consejo Superior de Investigaciones Científicas* (CSIC) – . The CMIMA, officially opened in Autumn 2001, is composed by the Institute of Marine Sciences – *Institut de Ciències del Mar de Barcelona* (ICM) – and the Marine Technology Unit – *Unitat de Tecnologia Marina* (UTM) –. The goal of the CMIMA consists on furthering and expanding our scientific understanding of the seas and oceans and discovering their role in the context of our planet. As a governmental research centre, it also has the task of reporting and disseminating the knowledge generated by its activities.

The *Institut de Ciències del Mar de Barcelona* (ICM), one of the components of the CMIMA, was established in 1951 as the Fisheries Research Institute – *Instituto de Investigaciones Pesqueras* –, and located on the Sant Sebastià beach in Barcelona's Barceloneta District since 1959. Through its more than 50 years of existence, the ICM has never ceased to expand and advance. At the same time it has undergone a series of changes, such as the inclusion of a Marine Geology Section and the name change to ICM in 1986 and the recent transfer to its new headquarters building as part of the CMIMA. Today's ICM is engaged in the integrated, multidisciplinary study of the marine environment and the organisms that inhabit it. The Institute's protracted experience and its human resources, with a staff of more than 150 members, which covers most of the fields of oceanographic research (physical and chemical oceanography, geology, and biology) give it a global vision of marine ecosystems and the ability to assess the impact of man on the environment and seek appropriate solutions.

The *Unitat de Tecnologia Marina* (UTM) was created by the CSIC in 2000 to take charge of R&D, logistical and technical support for oceanographic technical research. The UTM is responsible for the technical management of some of our country's major oceanographic facilities, such as the Oceanographic Research Vessel Hespérides and Spain's "Juan Carlos I" Antarctic Base.

The association of the ICM and the UTM makes the CMIMA one of the leading marine research centres in Spain and in the Mediterranean region. CMIMA researchers take part in international oceanographic projects and surveys in nearly all the world's seas and oceans. In recent years it has had an annual operating budget of ten million euro, of which over one-third comes from external sources such as the National Research Plans, European Union programmes, contract work for Catalonia's Autonomous Government (Generalitat), and commissions from public and private companies.

Facilities for the scientific community

The CMIMA makes available a number of different services to the oceanographic research community: a public library

Figure 1. CMIMA headquarters.

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This paper has been collectively prepared by the CMIMA scientists.

containing around 7,000 specialised volumes and 1,400 periodicals dealing with the marine sciences, one of the largest collections in its field in the Mediterranean; an experimental aquarium and chamber facility (ZAE) that is one of the best of its kind in Spain and in the Mediterranean; an experimentation and calibration tank for oceanographic instruments; an ARGUS video imaging coastal observation laboratory; and a satellite data receiving station. The ICM also keeps valuable reference collections.

These include a biological reference collection containing fish and crustaceans from all over the world and from the Mediterranean in particular; a marine sediment core collection housing over 1,000 cores; and a collection of seismic reflection profiles from the Mediterranean Sea, Atlantic Ocean, and the Antarctic compiled over more than 20 years. In addition, during the course of its operations, the ICM has collected a large body of varied oceanographic data, stored in an oceanographic database. A new marine station to encompass these services is being set up, and the CMIMA plans to become a venue for meetings, congresses, and courses and a pole of attraction where researchers from all over the world will come to work and study. A focus on co-operation with other public and private institutions and entities aims at promoting interdisciplinary research, and access to the Centre's marine research facilities is open to researchers from other centres.

The Centre maintains co-operative programmes with most of the world's marine science and technology centres, with particular focus on the Mediterranean. At the present time it has a sizeable population of guest students from different countries, many of whom are working on their doctoral dissertations under the guidance of the centre's scientific staff members.

In short, the CMIMA is one of the key centres for scientific study and advice for the management of marine ecosystems, especially in the Mediterranean. The following pages describe in some detail the main areas covered by the research programmes that are under way as well as the facilities and services the centre offers to the scientific community.

ICM – research areas

Ocean structure and dynamics on different scales

The ocean is a dynamic system, which has consequences for the structure of the water masses and marine biogeochemical processes. Ocean structure and dynamics can be analysed on different scales. For instance, general circulation and processes governing the formation and distribution of water masses are studied on a global scale, along with the ocean's role in climate change. The CMIMA's main focus is on the Mediterranean, a sea which, from the standpoint of dynamics and despite its small size, can be regarded as a small model of the ocean. This comparison is borne out by the predominant thermohaline pattern of circulation and certain other processes involved in the dynamics of the Mediterranean Sea. Deepwater formation is a good example of this, involving the same process as in some oceans, but on a much smaller scale which is thus much more operationally accessible.

Mesoscale dynamics covers processes that take place on a spatial scale of from a few score to a few hundred kilometres over a time frame of from days to months. Seasonal thermoclines, density fronts, wind-driven circulation, eddies, instabilities in the circulation pattern caused by bottom topography, continental run-off, or wind, and the like, are all examples of processes that take place on this scale. Advection and diffusion, along with the distribution of dissolved matter (pollutants, nutrients, etc.) or suspended matter (seston, plankton), are dependent on mesoscale dynamics. The role of mesoscale dynamics is particularly significant in coastal zones, on the shelf and on the continental margin, because of interactions between the sea bed and the coast. Mesoscale dynamics play a major role in the distribution, structure, and function of planktonic and benthic ecosystems, seston dynamics, and sedimentation. The requisite observations for mesoscale studies are ordinarily obtainable by means of regional, and sometimes local, oceanographic surveys. This information can be supplemented by time series data from observations made at fixed points (moorings) and the compilation of synoptic data collected by remote sensing (satellites). Additionally, combining models of circulation and mesoscale structures or associated processes with observational data makes it possible to run simulations of possible responses to perturbations in marine mesoscale dynamics.

Microscale structures have a duration of less than one day and take place on a spatial scale of only a few metres. These include double diffusion processes, capillary waves, and turbulence. At present microscale studies at the CMIMA are carried out experimentally in the laboratory or by means of numerical modelling. Laboratory experiments (using microcosms and mesocosms) to study the effects of turbulence on planktonic communities are one example of this type of approximation.

The CMIMA's research programmes in this area have been a part of various international research projects that entail the marshalling of observational resources (*in situ* and remote) to set up a permanent ocean observation network (GOOS) or to study ocean circulation and climate (WOCE, CLIVAR). Additionally, combined observational, experimental, and numeric modelling work on the coupling of ocean and atmospheric dynamics (JGOFS) or littoral zone dynamics (LOICZ) is also in progress.

Marine sediment record and development of the continental margins and basins

The sediments that have accumulated on the continental margins and ocean basins offer a unique and continuous record of the geological, climate, and environmental changes and evolution taking place on our planet in both recent times and in the remote geological past. An understanding of sediment stratigraphy and architecture as well

as of sedimentation processes and of the nature and physicochemical and biological components of present-day and recent deposits on the continental margins and ocean basin is therefore essential to an understanding of our planet's past and to an ability to predict possible changes and their future effects.

The main transfer of matter and energy from the continents to the ocean basins takes place on the continental margins. Large volumes of sediments accumulate in the basins, which are also storehouses for a large proportion of geological non-renewable natural resources of indisputable socioeconomic interest. The continental shelf is interesting and important not only because of the resources located there but also because of the many inputs from river run-off it receives. These influxes include anthropogenic discharges, which may be transported to the oceanic zone via submarine canyons and valleys dug out of the continental slopes. The continental shelf is also the principal recording medium for the effects of changes in climate and for the consequences of these changes in the rise and fall of sea level, hence it is highly sensitive to processes involved in global change. The deep environments comprise active sedimentary systems partly regulated by global ocean dynamics, giving rise to environments where complex ecosystems are home to organisms able to tolerate extreme conditions.

Finally, the Earth's geodynamics result in periodically violent events that continuously change the morphology, structure, and nature of the sea bed. Earthquakes, volcanic eruptions, and major sediment landslides have a particularly active role in certain areas of the continental margins and ocean basins. The study and understanding of these natural geological events and quantification of the factors and processes acting on them are basic to our ability to predict and avoid future disasters or damage to a wide range of human activities. All these aspects are among the top international scientific priorities, as evidenced by the continued existence of such long-standing international programmes as the *Integrated Ocean Drilling Program* (IODP) and the vigour of such other projects such as MARGINS, PAGES, STRATAFORM or ANTOSTRAT.

Matter and energy fluxes in the oceans

The interactions between oceanic circulation and physical, chemical, biological, and sedimentary processes regulate the exchanges of matter and energy and shape the oceans' biogeochemical cycles. Many of these interactions take place in the water column between the coastal zone and the deep sea, where the ocean/atmosphere, ocean/sediment, and ocean/continent interfaces are fundamental in determining the biogeochemical operation of the oceans.

Marine life depends on an ongoing transfer of substances, mainly driven by light and mechanical energy inputs. The biomass of the different living components of a marine ecosystem and the matter and energy flows among them are dependent upon a variety of factors, including physical forcing (light, temperature, water circulation, turbulence); allochthonous, particulate and dissolved, matter fluxes; and the availability of elements essential to primary production (N, P, Si, and Fe and other metals) and light. The photosynthetic organisms in the plankton and the benthos located in the oceans' euphotic zones use the Sun's energy to produce organic matter, which is then transferred through a web of trophic interactions to the top levels of consumers.

The marine environment receives particulate matter by the effects of the wind and through river discharges. The nature of these influxes, which may contain organic and biological material, will affect the distribution of marine organisms and the biodiversity of planktonic and benthic communities. At the same time, organisms interact with the particulate matter to form aggregates and affecting, together with hydrodinamic processes, the fluxes of sediment and the resuspension of particles. These interactions are ultimately responsible for the rate of sediment accumulation on the seabed and for the oceans' biogeochemical budgets.

The oceans exchange a wide range of substances with the atmosphere, and many of these affect climate. The role of the marine environment as a source or sink for climatically active atmospheric compounds is regulated by a series of physical, chemical, and biological processes which in turn depend upon the interactions between the ocean and the atmosphere and, in the end, by climate. This is a two-way process that shapes the oceans' important role in regulating climate on Earth. Such major international programmes as JGOFS, SOLAS, and PAGES all have as their underlying goal achieving an understanding of the oceans' role in global biogeochemical cycles and their responses to global climate change.

Studying the oceans' biogeochemical cycles calls for an interdisciplinary vision encompassing aspects ranging from energy inputs into the system to the ecosystem features responsible for the reactivity and mobility of the various elements and compounds. Special attention needs to be focused on the different processes involved in all these cycles and on the interfaces between the different compartments (water-particle, water-organism, water-air, water-sediment), where a large proportion of matter and energy fluxes occur, but without losing sight of integration into an overall global framework.

Biodiversity and dynamics of marine ecosystems

Elucidation of biodiversity, defined as the set of elements (genetic sequences, species, communities, ecosystems) potentially present in a given habitat, is one of the most important objectives of the study of marine environments. Biodiversity is maintained by structural and functional variability within the biosphere as a whole.

The study of biological diversity, i.e., the fraction of potential biodiversity manifested in each individual case, is a prerequisite for understanding the dynamics of natural communities and is of fundamental importance in being able to assess natural resources and to manage those resources in a sustainable manner, especially in the framework of the challenges posed by global change. Among

other aspects, the natural complexity of ecosystems is important because it acts to cushion the effects of natural hazards and the threats ensuing from mankind's activities. The growing pace of loss of biodiversity (of species and their genetic heritage, of communities, and of ecosystems) in many parts of the ocean is well documented. Still, there are large gaps in our understanding of the mechanisms that cause biodiversity and diversity to increase, decrease, or stay the same at different levels of organization. Methods based on molecular biology have come into use in the study of ecology in recent years and have yielded extremely important and valuable information on the genetic structure of species and populations of numerous marine organisms, specially, microorganisms, which do not exhibit much morphological diversity.

Lately, there has been an alarming drop in the numbers of "traditional taxonomists", specialists trained in collecting, identifying, and inventorying marine organisms on the basis of morphological features. We know that many natural phenomena (climate change, floods, etc.) and the effects of human activity adversely impact biodiversity. However, we are often unable to explain the mechanisms underlying such impacts and in most cases are even incapable of assessing lost biodiversity, because we lack the taxonomic specialists to quantify biodiversity. In addition, we have little knowledge of the original biodiversity under pristine conditions. Many marine organisms offer interesting potential as sources of biomolecules with applications in the pharmaceutical industry. However the rate of species extinction is so fast now and the rate of exploration for pharmaceutically active biomolecules is so slow that we risk losing many potential medical and economic benefits of the ocean's biota.

The structure and dynamics of marine communities are closely linked to the nature and variability of the physical characteristics of the habitat. Marine primary production is to a large extent based on the use of the Sun's energy through the photosynthesic activity. However, other forms of energy exist and may also interact with organisms. For instance, water movement, from large-scale circulation to small-scale turbulence, exerts a basic influence on selection of the dominant forms of phytoplankton as well as on the routes of energy flow through the food web. Thus, improved methods of determining biomass and activity levels and of approaching the quantitative aspects of population dynamics, along with the development of suitable models, are essential to a better understanding of how marine ecosystems operate.

International awareness of the scientific challenges facing this area of research has spawned such action programmes as GLOBEC, under the sponsorship of SCOR, IOC, and IGBP, and "Diversitas", under the auspices of IUBS, SCOPE, UNESCO, and other bodies.

Biology of marine species and populations

One of the basic research objectives of marine biology is an understanding of the structure and physiology of marine organisms, from single-celled organisms to vertebrates, as they relate to the medium in which they dwell. For that reason, we carry out studies that focus on different aspects of the biology of these organisms at different levels of organization, from the subcellular level through the individual and population level, while also contemplating the spatiotemporal changes that take place.

The environment selects from within the genetic variability present and thereby conditions the attributes of the organisms inhabiting it. The responses of living beings to biotic and abiotic variations in environmental factors is expressed as the adaptations that have taken place over the course of evolution. Because many fundamental processes are shared among all living species, these evolutionary adaptations can be used to illustrate how the challenges to life posed by differing environments has resulted in the selection of functional specializations, thereby allowing colonization of all the many varied marine habitats. The upshot of all this is the broad diversity of morphological structures and physiological processes that gain expression in different and precise ways during an organism's life cycle. Gene pools shape the populations that harbour them, and the populations, in turn, condition the structure and operation of the ecosystems in which they dwell. Accordingly, studies at the subcellular level identify fundamental mechanisms, common patterns, and conserved processes. Studies at the individual level elucidate the full range of possible adaptations in all their richness. And finally, studies at the population level reveal how the structural and functional responses of species to environmental conditions culminate in specific strategies.

Current research into the biology of marine species is carried out both *in situ* on board oceanographic research vessels or by means of direct sampling as well as under controlled laboratory conditions reproducing the micro–, meso– or macrocosm. The approximation used will depend both on the level of organization or the size of the organisms being studied and on the spatiotemporal scales governing the biological processes under consideration. Laboratory experimentation is intended not only to complement research carried out at sea but also to provide specific information on the biological processes concerned in order to be able to improve the accuracy of the predictive models used in biological oceanography. As a result, *in situ* and laboratory studies on basal metabolism, feeding, growth, and reproduction in the context of environmental factors are both essential aspects of marine research.

Integrated coastal system research

The coastal system is the region where the closest interaction between human activity and the marine ecosystem takes place. It is the primary zone for interchanges between the continents and the oceans. Coastal ecosystems, under the influence of continental inputs and high-energy physical processes (waves, winds, tides, and currents), exhibit high levels of biological productivity, very active sediment dynamics, and extremely intense and dynamic chemical processes.

Interactions between land, sea, and atmosphere in the coastal zone are quite pronounced. Influxes of all kinds, of differing natures and compositions, alter the circulation patterns and structure of the zone, not to mention water quality. The coastal system is the marine region that is most affected by the direct action of man: alterations to the coastline and circulation caused by the construction of new structures (harbours, jetties, etc.); alterations to the sea bed caused by dredging operations; alterations to beach deposits caused by changes in sand dynamics caused in their turn by jetties, dams, nourishment, etc.; setting up of aquaculture facilities; sewage discharges, etc. Furthermore, the impacts of pollution and eutrophication are most direct and most intense in the coastal zone. These impacts reach the systems located in the open sea and in the deep sea via the coastal zone as a result of the ongoing circulation and interchange of water masses.

Coastal systems display high spatiotemporal heterogeneity because of high hydrodynamic, sedimentary, and morphological variability, resulting in an exceptional diversity of habitats. Furthermore, the pelagic ecosystem and benthic ecosystem are quite close to each other in the coastal zone, which means that many species spend part of their life cycles in one system and part in the other. The complexity of coastal systems calls for multidisciplinary studies to enable synopticity, integration of the different observations made, resolution of spatiotemporal variability on various scales, compilation of lengthy time series of data, and collection of observations through intense field work during short-term perturbations.

The proximity of the coastal zone to the continent heightens the zone's vulnerability but at the same time makes it more accessible to new, sophisticated technologies which in turn make it possible to study the marine environment on the basis of a more global approach. This accessibility makes the coastal zone ideal for *in situ* observation of organisms and ecosystems in their natural context and hence means that the coastal zone will be an important point of reference for oceanographic research.

Not only is research on the coastal zone and on coastal processes fascinating in its own right from a scientific standpoint, it is also a basic priority to ensure proper management thanks to the growing social demand in coastal areas the world over. This interest in the integrated study of the coastal zone has gained expression in such international programmes as LOICZ, ELOISE, and LMER. Furthermore, there are a series of international networks, e.g., Netcoast, in which specialists in a number of different disciplines all take part in unison.

Sustainability of marine resources

Fishing is a human activity that has had a distinctly important impact on marine ecosystems since antiquity. This activity has deep cultural roots and hence is of great social significance. Ongoing technical advances in fishing gear along with socioeconomic components, have combined to bring about a tendency to overexploit fishing grounds, threatening the viability of resources. Sustainable exploitation of a renewable resource entails removing an amount of biomass equal to the amount that is added through growth or recruitment, which means that there is a need for responsible fishing to maintain the equilibrium.

Fishing is generally a non-selective activity that has repercussions for a large segment of the ecosystem in which it takes place. Many species that are not targets of fishing activity are affected, not only as a result of by-catches but also through trophic interactions among species. Accordingly, catches of a given species will have an effect upon the whole, leading to important, sometimes irreversible, changes in the structure of the entire ecosystem. The impact of certain gears on the sea bed is an additional problem, in that it leads to deterioration of the habitats of marine communities, both by physical erosion of the sediment and by its action as a perturbation disturbing benthic organisms.

Even so, many events that have been observed in catch trends (collapses, replacement, fluctuations, etc.) cannot be explained solely in terms of fishing but must instead be viewed in a global ecological context. Environmental fluctuations are thus one of the main sources of uncertainty in resource management, having either a positive or a negative impact on the resource. One of the current challenges in fisheries biology is to find ways of addressing this uncertainty using multispecies models that include interspecies interactions, oceanographic factors, as well as socioeconomic aspects.

Marine reserves, where no fishing activity is allowed, are a concept that is daily growing in significance as an alternative fisheries management measure as opposed to fishing effort control and fleet reduction, always so controversial. Besides decreasing fishing mortality, reserves offer the advantage of preserving biodiversity and protecting system integrity. Comprehensive information on the habitats, abundance levels, and demographic structures of the species considered, as well as on their dispersal capabilities at different stages in their life cycles, is needed in order to be able to plan out the basic features of a reserve.

In addition, the growth undergone by marine aquaculture in recent years and forecasts for the future growth of fish farming pose a challenge with a view to environmentally friendly exploitation. Sustainable aquaculture requires thoroughgoing knowledge of the biology of the species being farmed and of how ecosystems should best be conserved along with improvements in culture technologies and diversification with regard to suitable species, in terms of both the local environment and socioeconomics, in order to be able to minimize the impacts caused by effluents and other waste products.

Clearly, then, truly sustainable management of marine resources will require responsible, interdisciplinary action on the part of scientists, society, and the administration and a commitment to provide the necessary equipment and means to be able to expand our overall understanding of exploited systems.

UTM – Unitat de Tecnologia Marina

The UTM is an Institute operating under the auspices of the CSIC performing R&D and providing logistical and technical support for oceanographic research. The UTM is committed to deeper involvement in technical development and hence is intended to serve as the cornerstone of Spain's oceanographic research. The UTM was set up as a maintenance and support service for the oceanographic research vessels (ORV) *Hespérides* and *García del Cid*, in order to be able to meet the growing technical and logistical demands of Spain's marine and polar research programmes. Logistical and technical support for Spain's "Juan Carlos I" Antarctic Base have since also been added to its duties.

The UTM's technical and logistical support has been a vital contribution to the scientific results achieved by Spain's oceanographic research in recent years.

The oceanographic research vessels *Hespérides* and *García del Cid* are interdisciplinary laboratories that are intended to be operational 24 hours a day more than 300 days a year. In its turn, the "Juan Carlos I" Antarctic Base is a laboratory facility given over exclusively to science, and the UTM not only is responsible for providing technical and logistical support for scientific projects but also has to ensure the proper operation of all services after the nine-month winter shut-down.

The principal objective of the UTM is to supply the Ministry of Science with the necessary logistical and technical support for marine and polar research in keeping with the National Plan for R&D&I, providing coordination and back-up for activities by publicly owned and operated major scientific platforms.

Its main function is to furnish the basic appropriate equipment for research projects. For this reason, it performs the following essential duties:

- Maintenance of scientific installations on vessels and at Antarctic bases
- Maintenance, calibration, and operation of scientific instruments
- Equipment design, upkeep, and management
- Technical assistance for oceanographic surveys
- Real-time acquisition of oceanographic data
- Technical development

Oceanographic vessels

The ORV *Hespérides* was built in Spain (at Cartagena) by the Empresa Nacional Bazán shipyards, today IZAR Construcciones Navales S.A. The vessel was publicly funded by the CSIC. The ship is operated by the CSIC and engages in oceanographic research, carrying out projects selected on the basis of scientific merit.

Since it was launched in March 1990 and delivered to the Spanish Navy in 1991, the vessel has conducted more than 80 oceanographic surveys in the Antarctic, Atlantic, and Eastern Pacific oceans and in the Mediterranean Sea. The *Hespérides* travels to Antarctica every year for a two-fold purpose, on the one hand to furnish supplies and logistical support for Spain's "Juan Carlos I" and "Gabriel de Castilla" Antarctic Bases and on the other to carry out scientific cruises.

The ship has been divided into different levels or decks numbered in descending and ascending order from the main deck, or Level 1. Decks 2, 3, etc. are located below the main deck, while decks 01, 02, 03, etc. are located above the main deck. The work deck, with a surface area of 280 m^2, was designed with the multidisciplinary nature of oceanographic surveys in mind and also taking into account the need to carry out numerous surveys in remote locations.

The vessel has eleven wet and dry laboratories with a total

Figure 2. The ORV *Hespérides* in the Gerlache Strait (Antarctic Peninsula).

surface area of 345 m^2 located on the main and lower decks in an area where buffeting from wave and ocean action is least. The laboratories are equipped for research in hydrochemistry, ecology, oceanography, meteorology, and marine geoscience.

The oceanographic research vessel *García del Cid* was built in Tarragona, Spain in 1977 and is owned and operated by the CSIC. This ship was specially designed for marine scientific research and is available to national and international scientific organizations conducting oceanographic research. It is based in Barcelona harbour and is managed by the CSIC's Unitat de Tecnologia Marina.

In its more than twenty years of service, the ship has carried out more than 280 oceanographic surveys in the Mediterranean Sea and Eastern Atlantic Ocean, amassing some 3,037 days of steaming in the service of oceanographic research.

The ORV *García del Cid* was originally designed to work in oceanography, fisheries in particular. The vessel is fully equipped to work with trawl gears, including bottom trawls, midwater trawls, and semipelagic trawls. The vessel was refitted in the 1980s: a trawl gantry that can be raised and lowered was installed, the laboratory was enlarged, and the two fishing winches were replaced by a single-winch system. Ongoing refurbishment of the vessel's plant and facilities in recent years has ensured that it is in optimal condition for research cruises.

Antarctic bases

Spain's "Juan Carlos I" Antarctic Base is located on the Hurd Peninsula on Livingston Island (South Shetland Islands).

The base has been renovated and expanded since it was first opened in 1988 and at the present time consists of four separate areas, each for a different purpose.

Living quarters, comprising nine prefabricated modular units, all joined together, a storeroom, and a radio room, plus a porch built on site. In addition, there are two *Satellite Cabin* igloos to provide extra multipurpose space.

Science section, comprising five interconnected modules plus an enclosed area used as a storeroom for equipment and supplies. The weather, geology, and biology laboratories, the last dedicated to Dr. Antoni Ballester (CSIC Research Professor and founder of the base) are suitably outfitted modules measuring 15 m^2 each.

Service area, consisting of six ISO 20' insulated containers with a total surface area of 90 m^2, housing a workshop and several storage areas. There are three additional storerooms built during the 2000 and 2001 seasons.

Mountain station, located at the foot of the Hurd glacier at an elevation of 140 m about a 30-minute walk from the base. Its purpose is to facilitate the tasks of the scientific research groups, providing a protected site near the glacier and a place for storing materials and equipment.

Protection of the surrounding environment has been a special concern from the very outset of operations at Spain's "Juan Carlos I" Antarctic Base, and accordingly procedures to ensure compliance with the Madrid Protocol have been put in place. Pursuant to Spanish regulations, which in turn fully comply with the recommendations of the Antarctic Treaty, environmental impact assessments must be submitted in advance for all of the base's activities as well as for all research projects performed there.

Practically from the very start, the "Juan Carlos I" Antarctic Base has endeavoured to diversify on-site energy production using alternative energy sources. To that end, the base has three experimental wind-driven generators that produce 1,000, 2,000, and 2,500 W, as well as a solar panel array generating 1,000 W. These installations are intended to allow a series of sensors to remain operational during the nine-month Antarctic winter.

Figure 3. *Juan Carlos I* Antarctic Base on Livingston Island.

Research support services

The CMIMA provides different technical services in support of research activities, intended to facilitate scientific work both by the centre's own staff as well as by the scientific community as a whole.

- Basic chemical analysis. The service performs a number of determinations that are standard for chemical oceanography and water quality control.

- Library. Open to the public, the library is one of a network of CSIC libraries. It holds the largest oceanography and marine science collections in Spain, with book holdings totalling nearly 7,000 volumes and 1,400 journal titles, 500 of which are current subscriptions or exchanges.

- Biological Reference Collections. These collections hold more than 1,000 fish, crustaceans and cephalopod species from all over the world. They are widely used in taxonomic and faunistic studies. Inquiries relating to all inventoried species can be made on site or via the Internet.

- Seismic Reflection Profile Collection. The profiles have been compiled in the course of over twenty years using a variety of systems (sediment profilers, sparkers, boomers, air cannons, and sidescan sonar). They cover the entire continental margin of the area off Catalonia and the Balearic Islands, with profiles from the regions of the Alboran Sea, Gulf of Cadiz, the Canary Islands, the Equatorial Atlantic, the Caribbean, and the Antarctic also being available.

- Marine Sediment Core Collection. Cores are available from the continental margins and basins around the Iberian Peninsula and islands of Spain. The more than 1,000 cores stored combine to make up a sediment column measuring several thousand metres in total length.

- Satellite imaging station. The station has a real-time HRPT satellite image receiving system. Its purpose is to provide colour and temperature images of locations of oceanographic interest for the CMIMA's scientific studies.

- Coastal video monitoring system (ARGUS). These systems consist of five video cameras automatically recording images every hour, thereby providing continuous monitoring of the coastal zone.

- Informatics (Computer Service Center). The center is equipped with a communications network that operates internally at 100 MBPS and is branched to the optical fiber network of the Catalonian Scientific Ring through an access point at 34 MBPS. The Informatic Service (SI) provides the necessary maintenance for the communications network (about 300 nodes) and furnishes advice and technical support for institutional and basic personal computing resources. The service is also involved in several software development projects to manage and process scientific databases.

- Instrumentation. The service advises the centre's working groups on the purchase and installation of scientific instruments and on the design or construction of instruments needed to carry out their work. It also performs maintenance on the existing equipment and plant and oversees calibration of measuring instruments in a tank holding over 70,000 Litres of sea water.

- Electron Microscopy. The Centre has two scanning electron microscopes, one conventional apparatus (SEM) and a variable pressure apparatus (VPSEM). The former is equipped with backscattered and secondary electron detectors. The VPSEM is equipped with secondary and backscattered electron detectors, and a secondary electron detector for observation at variable pressure. It also has an energy dispersive spectrometer (EDS) for x-ray microanalysis at a resolution of 129 eV capable of detecting elements from boron up. The laboratory also has suitable equipment for use in sample preparation and furnishes advice to users on both sample preparation and equipment usage.

- *Scientia Marina*. This international journal of marine sciences (formerly *Investigación Pesquera*) has been published by ICM-CSIC since 1955. At present it is the only journal in the field of marine science and natural resources published in Spain that is listed in the SCI (Science Citation Index). The journal publishes original papers in marine research and a range of monographs in the fields of biology and ecology, physical and chemical oceanography, geology, fisheries and coastal zone management.

- Experimental Aquarium and Chamber Facility (ZAE). Is a modern infrastructure in the Mediterranean region, designed to hold different types of aquatic organisms. Its purpose is to facilitate research into different aspects of the biology of such organisms, including interspecific relationships, community structure and dynamics, life cycles, biochemistry and physiology, behaviour, reproduction, feeding, ecology, and aquaculture. Occupying a surface area of 650 m^2, the facility consists of a machine room, three aquarium rooms, eleven temperature-controlled walk-in chambers, a wet laboratory, and a dry laboratory. Water is supplied via a submarine inlet located at a depth of 10 m 300 m offshore. The facility is also equipped with a storage tank to hold seawater obtained elsewhere for specific research needs. The machine room has a water treatment system that includes pumps, sand, charcoal, membrane, biological, and UV filters, along with heat exchangers. Many of the components have back-ups to ensure the safety and survival of the organisms. The facility is computer-controlled and monitored 24 hours a day by a system of probes connected to alarms. In all, nine different water regimes can be sup-

plied to a total of 150 aquaria ranging from 15 to 5,000 liters in capacity. Controlled environmental variables include light intensity and photoperiod, water temperature and salinity, dissolved oxygen and nutrients. This all makes it possible to simulate a broad spectrum of aquatic habitats, from the subpolar to the tropical. The ZAE is used by ICM scientists, but it is available to other scientists, organizations, and companies. It is able to furnish aquaria and chambers, research space tailored to individual needs, and husbandry services.