destruction of coral reefs, and of their repercussions. What the exhibition sets out to stress is the need to protect the global marine environment to maintain biodiversity for future generations also.

The second theme, closely linked to the one described above, is global change, in other words, the impact of human activity on the fundamental processes that regulate the biosphere, a consequence of the growth of the world's population combined with increase in the per capita exploitation of resources. The objective here is to make society conscious of the challenges this problem currently poses: the ocean is receiving major impacts with important consequences for biodiversity, for the way the biosphere functions and for the benefits that society reaps from the waters of the oceans. Moreover, global change is a potential source of social conflict, of ill health and of decreased capacity to guarantee security, both in the present and in the future. It is a matter of devising different lines of action by which to meet this challenge through a combination of research and political action in close, necessary international cooperation. Of great importance in this context is the act of conveying the message that, independently of scientific or political action, all citizens can and must contribute to this process, since they are in a position to question and change their habits towards a more responsible use of the natural environment.

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These three sections of the exhibition are intrinsically linked to each other and constitute a thematic whole with its own chronological order. The information is presented as a set of core themes, which focus on the development of knowledge, of work techniques and scientific instruments, of cartography, of the construction and equipping of ships, of changes through the ages as regards the scientific results obtained during the expeditions and as regards the crews' life on board ship. Having established this contrast between eras in the context of the exhibition, and in particular between Malaspina's historical expedition and the present one, the aim is to inform visitors of the problem of global change and of the challenges the problem poses to present-day society, both the scientific community and civil society, since it constitutes the great scientific challenge to be addressed in the twenty-first century.

The exhibition also sets out to inform society of the expertise of the Spanish scientific community in the field of the marine sciences, a community that figures today among the world's most productive and highly developed. Furthermore, the exhibition contains elements that establish a rapprochement between professional scientific activity and visitors, with which the intention is to foster both scientific vocations and the desire to contribute to the furtherance of scientific knowledge, in this case the ambitious challenge of exploring life on our planet and seeking ways to prevent its deterioration.

In short, the exhibition is of a markedly divulgative nature and uses audio-visual and sensorial resources of several kinds. Exhibits include objects, maps, portraits, calibration instruments, engravings, books, texts, a whole gamut of audio-visual material, measuring instruments, scale models of different ships, plates from the historical Malaspina Expedition, graphics, photographs, publications, slide projections, interactive elements and the recreation of several deep-water ecosystems.

With all this, apart from arousing awareness of the extent of global change and its impact on the ocean, we set out to bring visitors closer to the experience of oceanographic expeditions through the ages, convey the passion that has led people over the past five hundred years to explore the planet's remote regions and seas, and finally to instil a spirit of involvement in one of the most important expeditions in the history of Spanish marine sciences: Malaspina 2010 circumnavigation expedition.

The Malaspina Expedition 2010 and the Training of a New Generation of Oceanographers in Spain

Fidel Echevarría, Sara Bertrand, José Luis Acuña, Carlos M. Duarte, Jesús Forja, May Gómez, Rafael Mañanes, Mónica Salomone and Montserrat Vidal

The *Expedición de circunnavegación Malaspina 2010: Cambio global y exploración de la biodiversidad del Océano* research project constitutes a landmark in the recent history of Spanish oceanography. It is a highly ambitious project that marks a change of scale in relation to the more usual projects in the Science and Marine Technology section of the *Plan Nacional de I+D+i* (National R+D+i Plan). Indeed, it is the only oceanographic project funded by the *Consolider-Ingenio 2010* programme, launched in 2006 with the aim of stimulating the critical mass and research excellence by gathering experts of international renown around projects with an interdisciplinary component whose objectives stand at the frontier of knowledge. By virtue of the greater ambition of the Consolider programme projects, when we compare the Malaspina 2010 project with other marine projects of the *Plan Nacional*, many characteristic variables present values of a greater order of magnitude. This occurs, for example, in the duration of the campaign, the number of miles covered, the participating scientific personnel, the institutions involved, the global budget and the number of students linked to the project.

This latter aspect, the training of young researchers, is one of the most distinctive objectives of the Malaspina Project 2010. The training of a new generation of scientists with an interdisciplinary outlook on the marine sciences is the objective of block 10, one of the project's four horizontal blocks (together with those of: coordination, block 1; communication, block 9; and integration, block 11). These horizontal blocks have a transversal effect on the entire structure of the project, while the remaining blocks are thematic and focus on specific research aspects.

In 2006 the Spanish National Research Council (Consejo Superior de Investigaciones Científicas [CSIC]) published in its *Informes* (Reports) collection a study conducted by a sizeable team of researchers coordinated by Professor Carlos M. Duarte, entitled *Las ciencias y tecnologías marinas en España* (Duarte *et al.*, 2006). The study is an extensive, meticulous analysis of this field of knowledge, in which a section is devoted to aspects related to training in the marine sciences in Spain. One of the conclusions drawn is that deficiencies existed in the training of researchers due to a drop in the number of scientific vocations in general and in marine sciences and technologies in particular. In the last chapter of this book, recommendations are put forward to remedy some of the weaknesses detected, and in the specific case of training, it is suggested that 'competitive training capacities be generated through coordination of doctorate programmes in the Marine Sciences' (Duarte *et al.*, 2006).

The Malaspina Expedition 2010 constitutes a clear opportunity to reverse the downward trend in terms of marine sciences research thanks to a quality training proposal addressed to young people taking their first steps in this fascinating discipline. In the first place, because the project pursues very ambitious objectives related to global change and biodiversity; secondly, because it offers the lure of a circumnavigation campaign on two of Spanish oceanography's best ships (the BIO *Hespérides* and the BO *Sarmiento de Gamboa*); thirdly, because some of the country's best marine sciences researchers are involved; and lastly, because the project in itself offers significant training opportunities.

Indeed, as from the very genesis of the Malaspina Expedition 2010 it was decided to devise a block of tasks aimed at channelling all aspects related to training, with the ultimate objective of contributing to reversing the downward trend in marine science vocations. An oceanographic campaign certainly constitutes a magnificent programme of apprenticeship. Students live together 24 hours

a day in a milieu that foments scientific curiosity, surrounded in a reduced space by people more expert than them, devoted exclusively to obtaining, interpreting and analysing data and samples. In this case, by virtue of some of its specific characteristics, the project is a highly attractive one to young researchers: (1) given its interdisciplinary nature, it is a project in which physicists, chemists, biologists and experts in taxonomy, genetics, biogeochemistry, history and so on are involved; (2) it also has an inter-institutional component, since over thirty research centres belonging to 17 Spanish institutions and 13 universities are involved; (3) it is an inter-territorial project, in which centres and researchers from practically all Spain's coastal regions participate; and (4) it has a definitely international character, given that the objective is to travel round the world making stopovers in at least six countries, with the participation of foreign researchers – and students – and with a significant number of associated institutions from outside this country (for example NASA, NIOZ and universities such as those of Hawaii, Aveiro and Vienna).

▶The genesis of the training block

When work began on the preparation of this project, it was decided to lay special emphasis on training by assigning to it a complete block of activities. The training block would be addressed to post-graduates, that is, students who already had a degree or other qualification related to marine research (the marine sciences, biology, environmental sciences, chemistry, physics, etc.). Initially the possibility was suggested of organising an inter-university master's degree in oceanography, specific to the Malaspina Project. Indeed, definition began of this degree with discussions on possible subjects, the total number of credits and the share-out between theoretical credits and those assigned to the practical training module.

However, when we made our initial contacts with different universities, a number of obstacles emerged that hindered execution of the proposal. This was in 2007, when Spanish universities were setting their new post-graduate programmes in accordance with the requirements stipulated in the Bologna Plan. Royal Decree 1393/2007, published in the *Boletín Oficial del Estado* (Official State Bulletin, BOE) on October 29 2007, established the new regulations for official university education and a new structure in accordance with the general guidelines issuing from the European Higher Education Space (EHES). The University of Las Palmas de Gran Canaria, for example, had just introduced a master's degree course in oceanography which was first imparted during the 2006-2007 academic session. The universities of Cadiz and Barcelona began their new master's degree courses in 2007-2008, while those of Oviedo and Menéndez Pelayo set them in motion in 2008-2009 (Table 1). In short, the proposal for an inter-university master's course linked to the Malaspina 2010 project would have generated rivalry for students. On the other hand, the proposal was articulated around the main campaign of the project and was therefore restricted to one or two academic sessions at most.

Eventually it was decided that the most feasible solution was to maintain the identity of the master's courses offered by each of the universities associated with the project, with the idea that students would follow one of these. The linking element was the opportunity to participate in one of the stages of the circumnavigation campaign and submit a research study (the master's dissertation), directed by one of the project's researchers, within the framework of the Malaspina Expedition.

▶The connection between five universities: the Malaspina master's dissertations

Inviting master-degree students to carry out research on board for their dissertations during different phases of the campaign is one of the basic elements of the Malaspina Project training programme. This training programme is fruit of an agreement with five universities at which master degree courses are imparted related to oceanography or global change, namely the universities of Cadiz (UCA), Las Palmas de Gran Canaria (ULPGC), Barcelona (UB), Oviedo (UOvi) and the Universidad Internacional Menéndez Pelayo (UIMP), this latter with its premises on Mallorca and which imparts a master's course in global change. Geographically, these five universities are quite evenly distributed, with one on each archipelago (ULPGC and UIMP), one on the Cantabrian Sea (UOvi), one on the Mediterranean (UB) and one in the south, near the Straits of Gibraltar (UCA).

In order to form part of this training programme, the universities in question had to meet three prerequisites: (1) they had to offer a master's degree course in a subject related to the contents of the project; (2) this course must have been granted a quality mention on the part of the Spanish Education Ministry; and (3) in order to guarantee correct coordination between teaching and research, it was requested that at least five of the lecturers involved in each master's degree course should also be Malaspina Project researchers.

Table 1 shows the titles of these master degree courses together with other information of inter-

TABLE 1. **Characteristics of the master's degrees of the five universities involved in the Malaspina Project 2010 training programme**

	Universidad de Cádiz	Universidad de Las Palmas de Gran Canaria	Universidad de Oviedo	Universidad Internacional Menéndez Pelayo	Universidad de Barcelona
Master's degree title	Oceanography	Oceanography	Marine biodiversity and conservation	Master's degree in global change	Marine sciences: oceanography and marine environment management
Universities	U. Cádiz	U. Las Palmas, ICM (CSIC)	U. Oviedo	UIMP	U. Barcelona and UPC
Itineraries	Research	Research	Research and professional	Research	Research and professional
Contents	Physical oceanography, processes and marine ecosystems, physical-biological interaction, marine biogeochemistry, interface processes and GC	Physical, chemical, biological and geological oceanography	Marine biology, oceanography, conservation	Motors of the biosphere, components of GC, impacts of GC, GC and society	Physical, chemical and biological oceanography, ecology and coastal system management, conservation, geology and engineering
Teaching staff	Professors from the UCA, CSIC, IEO, AZTI, UMA, IGME + guest professors	Professors from the ULPGC + CMIMA + 10 guest professors	Professors from the UOvi, CSIC, IEO, UNICAN, University of Massachusetts	Professors from the CSIC, UIB, UC3M	Professors from the UB, UPC and CSIC + guest professors
Total credits (master's dissertation)	60 (20) 1 course	90 (30) 2 courses	60 (30) 1 course	66 (6) 1 course	60 (20) 1 course
Initial course	2007-2008	2006-2007	2008-2009	2008-2009	2007-2008
Places available	28	30	7	50	50
Further information	http://posgrado.uca.es/	http://www.fcm.ulpgc.es	http://www.unioviedo.es/mbmc	http://www.uimp.es/posgrado/	http://www.ub.edu/masteroficial/cienciesdelmar

est. Here we clearly appreciate the heterogeneity of these training programmes, with their different subject matter and study structures. The course imparted at the ULPGC stands out conspicuously over the others by virtue of its 90 ECTS credits and the fact that it lasts for two years. The element that unifies the five master's degree courses is the research component, which means that in order to obtain their degree, students must submits an original piece of research work, the master's dissertation.

In the case of those students who participate in the Malaspina Project, this research study entails their involvement in one or other of the campaign stages during the practical stage of preparing the dissertation. On average, three master's-degree students from each of the five universities participate in one of the stages of the main campaign aboard the BIO *Hespérides*, or in the transatlantic campaign aboard the BO *Sarmiento de Gamboa*.

Of all the researchers on board, these master's-degree students were the ones with least experience. During the two years prior to the main campaign, at plenary preparation sessions and in conversation and correspondence with different researchers, it was often felt that these students' level of training was too low for them to respond effectively to the demands of a project of this nature. Some researchers preferred to have more highly trained personnel at their disposal, PhD students with a research grant and more time ahead of them in which to develop their work in the form of a doctoral thesis. The project organisers suggested that a duality be established between trainee and assistant. Master's-degree students would be trainees, to whom more time should be devoted and who should not be assigned too much responsibility or placed in charge of any aspect crucial to the development of the project. On the other hand, PhD students would be granted greater independence and allowed to assume greater responsibility; consequently, their role would more closely resemble that of assistant researchers.

This point was a source of disagreement during much of the time prior to the beginning of the campaign. Eventually, a tacit compromise was established by which some of the places on board were set aside for students at the initial stages of their training, that is, for master's-degree students. The project and the campaign should grant a number of places to this group of people who were taking their first steps in the world of oceanographic research, thereby making room for these new talents, even if this meant sacrificing places that might be occupied by people with greater experience. It was felt that this group of students might embody part of the future of oceanographic research and that, consequently, extra effort devoted to their training would be worthwhile. The Malaspina Project campaigns were therefore opened up to fifteen master's-degree students from these five universities.

▸The 2011 Oceanography Training Ship

The main campaign of the Malaspina Expedition 2010 was the voyage of circumnavigation aboard the *Hespérides*. However, as in Alejandro Malaspina's original campaign on the corvettes *Descubierta* and *Atrevida*, a second ship was involved in this project, namely the *Sarmiento de Gamboa*, Spain's most modern oceanographic vessel. This ship was entrusted with the task of carrying out a transatlantic campaign following parallel 24.5° latitude north, with the main mission of studying heat exchange between low and high latitudes, thereby repeating a transect that had been previously studied on several occasions, with a prominent role played by Spanish researchers. The voyage across the Atlantic took researchers to the port of Santo Domingo, capital of the Dominican Republic, where the campaign ended.

To complete the formative aspects of the Malaspina Expedition, those in charge of the five master's-degree courses requested that the Spanish Ministry of Science and Innovation (MICINN) set in motion a complementary programme to take advantage of the return voyage of the *Sarmiento de Gamboa* from Santo Domingo to Vigo, where it is based. The proposal consisted of applying for five extra days on the ship, which added to the anticipated 14 days' transit gave a total of 19 and the opportunity to conduct sampling on this return route. Fifteen master's-degree students, three from each of the universities involved in the project, would join the ship. The complementary programme having been approved, funding was obtained from the MICINN (reference CTM2009-08399-E/MAR) and additional financial backup was secured from the University of Cadiz as part of a teaching innovation project (reference DIB06).

The leading researcher in this complementary programme was Jesús Forja, professor at Cadiz University and expert in chemical oceanography. The other people who signed the request were those in charge of the master's degree courses linked to the project: Magdalena Santana (ULPGC), Carlos M. Duarte (UIMP), Montserrat Vidal (UB) and Jose Luis Acuña (UOvi). Professor Forja acted as head scientist aboard the ship during the campaign and was accompanied by other professors from the remainder of the participating universities: Ricardo Anadón (UOvi), Joan Doménech Ros (UB), Aurore Regadie (UIMP), Abelardo Gómez (UCA) and Rafael Mañanes (UCA, occupying the place initially assigned to a physicist from the ULPGC). A total of six professors and fourteen students embarked on this training ship, with all the equipment and instruments that had been deployed on the outward voyage, and over a period of 19 days registered the properties of the water mass and collected samples of dissolved elements, particles and organisms using the most advanced techniques and instruments available to oceanographic research. The ship stopped at a station at the same time each morning to begin sampling operations, devoting between 5 and 6 hours to each one before setting off again. At the end of the 19 days assigned, they reached Vigo early in March after what had been an unforgettable experience for all.

The *Sarmiento de Gamboa* campaign completed the basic training programme of the Malaspina Expedition 2010. The training ship provided all the students with the opportunity to obtain the samples needed for their master's dissertation. Furthermore, students were in an academic environment in which the professors on board imparted classes on the different aspects of present-day oceanography and were able to familiarise themselves with the tasks carried out by their fellow students thanks to a programme of talks delivered by the students themselves. Each day, a student told the rest about the objectives of his/her master's dissertation and the methods employed to attain these objectives. All information about the progress and achievements of the *Buque Escuela de Oceanografía-2011* expedition may be consulted at the following website: http://buqueescuela2011.uca.es

Fifteen master's-degree students on the main campaign and the same number on the return journey of the *Sarmiento de Gamboa* give a total of thirty Master's dissertations within the framework of the Malaspina Project 2010, a figure that exceeds the most optimistic expectations for this basic training section. Most of these master's dissertations will be read before a tribunal at the end of 2011, the same year as the campaigns. Indeed, before the campaign began the first Malaspina Project dissertation, entitled *Development of a Strategy to Sample Gelatinous Zooplankton during a Global Biodiversity Baseline Expedition (Malaspina)* was defended in mid-2010 by Axayacatl Molina Ramírez at Oviedo University.

▸Doctoral theses and the role of the BBVA Foundation

After master's-degree students, the second echelon in the training programme comprises PhD students, who are preparing their theses under the umbrella of the Malaspina 2010 project. Of the approximately 55 doctorate students involved in the project, five are sponsored by the BBVA Foundation through JAE-DOC scholarships of the CSIC. Table 2 lists the titles of these doctoral theses, the names of the scholarship-holders, those of their thesis directors and the centres to which the scholarships are assigned. Each of these grants is linked to one of the project's thematic blocks, and to a large extent the theses develop the most integrating aspects of each thematic block.

To foster the generation of knowledge is one of the main aims of the BBVA Foundation, and there is no better way to do so than to nourish the most highly-prized research asset: people. The BBVA Foundation therefore devotes much of its effort not only to funding scientific projects but also to instituting specialist courses, scholarships and awards directed towards both senior researchers and those who are just starting out. There can be no advance in knowledge without a precise combination of experience, freshness, curiosity and creativity.

The Malaspina Expedition will provide a great amount of data with which to face two of the twenty-first century's major global challenges: climate change and research into biodiversity in order to preserve it. It is no coincidence that these areas also constitute the central axes of the BBVA Foundation's

TABLE 2. **The five PhD scholarships funded by the BBVA Foundation**

Block	Student	Master's dissertation title	Directors	Centre
Block 3: Biogeochemistry	Elena Mesa Cano	*Stable isotopes in oceanic DIC and DOC: the traceability of global change*	A. Delgado and C. M. Duarte	Estación Experimental el Zaidín (CSIC-Granada)
Block 4: Pollutants	Belén González Gaya	*Global dynamics of persistent organic pollutants in the oceans*	Jordi Dachs and Begoña Jiménez	Instituto de Investigaciones Químicas y Ambientales (CSIC, Barcelona)
Block 6: Microheterotrophes	Ignacio Pérez Mazuecos	*Microbial transformations and Mo metabolism in the deep ocean*	J. Arístegui, I. Reche and J. Gasol	Universidad de Las Palmas de Gran Canaria
Block 8: History	Mª José Hernández Villalba	*The health question and medical assistance at sea in nineteenth-century Spain*	Marcelo Frías and Andrés Galera	Universidad Carlos III. Madrid
Block 11: Integration	Lara García Corral	*Thermal control of the global ocean ecosystem*	C.M. Duarte and A. López-Urrutia	IMEDEA (CSIC, Mallorca)

activities programme. Evidence of this is the fact that two of the categories of the Premios Fronteras del Conocimiento BBVA Foundation international awards are 'Climate Change' and 'Ecology and Biodiversity Conservation'.

Participation of the BBVA Foundation in the Malaspina Expedition covers a number of areas other than the training programme. The itinerant exhibition assembled on the ship itself culminates with the show at the Real Jardín Botánico once the scientific voyage is over. Furthermore, the BBVA Foundation has drawn up a comprehensive dissemination plan of the project, and has assumed responsibility for producing television and film material which will contribute to bringing the Malaspina Expedition to public knowledge. This is also the objective of the book *Las corbetas del Rey. El viaje alrededor del mundo de Alejandro Malaspina (1789-1794)*, published by the BBVA Foundation, in which the CSIC science historian – and the person in charge of block 8 – Andrés Galera gives a highly-charged narrative account, informed by great historical rigour, of the events that took place during the first Spanish circumnavigation expedition.

▶Other doctoral theses

Besides the five scholarships funded by the BBVA Foundation, a further fifty doctoral theses will be developed as part of the Malaspina project, a number that does not cease to grow, furthermore, as additional scholarships are awarded. A significant example of this increase in the number of theses occurred on board the *Hespérides* during the second stage of the campaign between Rio de Janeiro and Cape Town, when the master's-degree student Patricia de la Fuente learnt that she had been selected for a grant funded by the Generalitat de Cataluña, which allowed her to begin preparing her doctoral thesis. She will be one among approximately one dozen students who will undertake their entire postgraduate training (master's dissertation and doctoral thesis) in the framework of the Malaspina Expedition 2010.

Not all the PhD students ho have taken part in the Malaspina Expedition will use data culled from the expedition for their theses. Some, a minority, have joined it to help gather samples, even though they are working on doctoral theses on other subjects. The majority are preparing doctoral theses liked to a greater or lesser extent to the objectives of the project. There are scholarship holders financed by the Ministerio de Ciencia e Innovación (FPI, FPU), by autonomous communities (specifically those of the Balearics, Catalonia, the Basque Country and the Canaries), foundations (besides the BBVA Foundation, others such as the Fundación Ciudad de la Energía), scholarship holders from institutions like the CSIC (JAE-Doc grants), the Instituto Español de Oceanografía and a number of universities (such as those of Cadiz, Granada and Carlos III). Moreover, a number of students participating in the campaign are foreigners with scholarships granted by their own countries, although they are linked to Spanish laboratories at which they are preparing their doctoral theses. On the second stage of the campaign between Rio de Janeiro and Cape Town we have had on board two Chilean PhD students, one from Canada, one from Portugal and one from France. In this second stage of the campaign 14 students participated, practically half the 33 places for scientists on board, and this high percentage was a constant throughout the entire voyage of circumnavigation.

The students linked to the Malaspina Project do not constitute a closed number. The training programme continues to increase in participants with the incorporation of new students who compete for and obtain scholarships related to the project. This occurs, for example, in the case of a number of master's-degree students who are attaining grants to prepare their doctoral theses. The project's principal campaign ended in mid 2011, but the analysis of data and samples will continue for a few years more in the life of the project and for decades if we take into account the commitment to keep a number of samples in store to be analysed by future generations in what is called the 'Malaspina Collection'. Bearing this commitment in mind, it is not hard to imagine a slow trickle of theses linked to the project for a long period that goes far beyond the time scale in which a project like Malaspina 2010 is developed. Malaspina theses will be defended by scientists from future generations, perhaps by people who have yet to be born and, why not?, perhaps directed by some of the current project students.

▶The Malaspina students: an interdisciplinary, planetary view of the marine sciences

Students endow the ship, the campaign and the project with life. They are more than eighty young people with the enthusiastic desire to embark on a scientific career. They have the opportunity to share the small space of on oceanographic ship with some of Spain's best researchers into the marine sciences, a contact from which they may obtain many benefits. They also share this space and this experience among themselves, and given the fact that this is an interdisciplinary project in which biologists, chemists, physicists and so on work together in the study of pollutants, microorganisms, biogeochemistry, plankton and even history, students have an extraordinary opportunity to learn much more than the limits of their own theses. The Malaspina Project generates a tightly-knit network of communication between the researchers involved and, in the case of the students, provides an extraordinary opportunity to consolidate a research career with global perspectives.