# MIMECCA

**Development of Innovative environmental measures for the establishment of carrying capacity protocols to ensure sustainable development of aquaculture**

# EXECUTIVE SUMMARY

**PROJECT LEADER:**

ctaqua CENTRO TECNOLÓGICO DE LA ACUICULTURA

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# About the MIMECCA project

MIMECCA is a project to promote the dynamization of marine aquaculture by enhancing its growth through the definition of carrying capacity in two types of marine finfish aquaculture operations: floating cages and semi-intensive production in earthen ponds. This has been done by means of the identification of environmental, socio-economic and productive interactions affecting aquaculture operations, the identification and prioritization of indicators, and their integration in a carrying capacity model to enable proper and sustainable sizing of the aquaculture sector in the Spanish Mediterranean and southwestern Atlantic coasts.

The **project general objective** is developing innovative measures to be applied in order to set out the carrying capacity in aquaculture, allowing to foster an improved production management through a sustainable planning.

**In order to do this, 5 specific objectives were set out:**

**The general objective is developing innovative measures to be applied in order to set out the carrying capacity in aquaculture, allowing to foster an improved production management through a sustainable planning.**

## specific objectives:

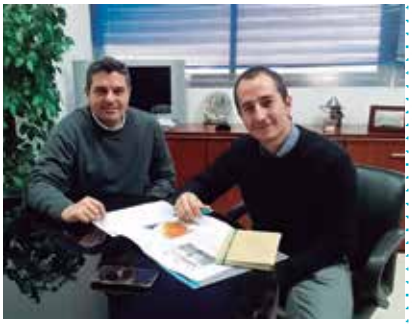
**01** Identify existing environmental, social, and production-related interactions when developing the aquaculture activity.

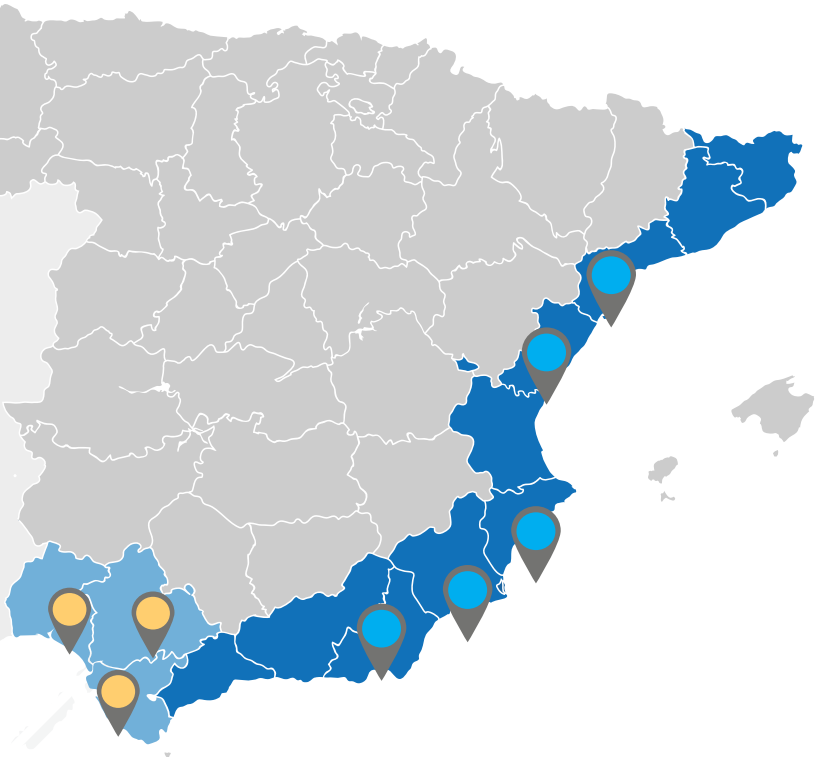
**02** Increase the level of knowledge to improve management within the sector.

**03** Get detailed information on different production models based on physical carrying capacity, production carrying capacity, ecological carrying capacity, and social carrying capacity.

**04** Define and specify different quantitative indicators for every type of carrying capacity.

**05** Integration of sustainability and development indicators from protocols for setting out the carrying capacity.





SEMI-INTENSIVE MARINE AQUACULTURE IN EARTHEN PONDS

MARINE AQUACULTURE IN FLOATING CAGES

# Project LEADER::

## Andalusian Aquaculture Technology Centre, CTAQUA


**CTAQUA was established as a private non-for-profit foundation in 2007 and is located in El Puerto de Santa Maria (Cadiz).**

Its mission is fostering competitive innovation within companies, responding to the business needs arising of aquaculture and sea food industries, by developing an applied research to provide answers for different technical and production processes. At its premises, activities and projects are carried out with different strategic partners, at regional, national, and European level.

CTAQUA boasts an extensive experience in developing projects for which methodological approaches have been made to calculate the carrying capacity. Among them there are several projects on multi-trophic cultures in which an analysis was done on the capacity of assimilating nutrients in various species to select and size up potential supplementary cultures to those existing for fishes. Moreover, studies were carried out on the sizing up of the production capacity in the Bay of Cadiz.

# Partners:

Universitat d'Alacant
Universidad de Alicante

## University of Alicante

Projects carried out by the Department of Marine Sciences and Applied Biology of the University of Alicante cover different aspects of environmental management in marine aquaculture, from the identification of potential environmental or socio-economic interactions up to the monitoring and mitigation of the cited interactions. The project funded by the Counselling Board for Marine Farming (JACUMAR) called "Selection of indicators, determination of baseline values, design of methods and measures for environmental studies in marine aquaculture" implemented from 2008 through 2012 is the most closely related to the present project. On the other hand, the UA participated, accompanied by Norwegian partners, in international projects identifying potential socio-economic interactions between aquaculture and professional fishing. The project "Evaluation of actions to promote sustainable coexistence between salmon culture and coastal fisheries" addressed this issue and became a benchmark for the present project.

UCA Universidad de Cádiz

## University of Cadiz

On behalf of the University of Cadiz, the Analytical Chemistry Group is the one participating, which gathers a great experience in the assessment of the environmental impact caused by production-related activities and the assessment of environmental patterns recording man-made effects produced in water ecosystems originating from different human activities. Particularly they developed projects assessing the environmental impact of aquaculture activities in earthen ponds, and others assessing the optimal conditions for establishing aquaculture activities in coastal areas. On the other hand, the research group SEJ-569 named after Economy, Enterprise, and Society is made up by a series researchers from different areas of knowledge including Economy, Sociology, Financial Economy and Accounting, and Business Organisation. The members in this group are specialised in sector-based studies and analysis, and their main contribution to this study is the analysis of social and economic aspects of the aquaculture sector.

# MIMECCA in numbers

## 01 Analysis of the initial situation

**a. Bibliographic search (137 s**cientific papers, **31** acts and regulations**, 6** hydrological plans**, 4** authorisation procedures)

**b. Request for information** to **4** regional administrations with powers in the aquaculture sector.

**c. Interviews** with public and private stakeholders involved (**3:** ASEMA, APROMAR & AGAPA)

**d. Survey** on the acceptance rate by society of aquaculture (**800 people**).

## 02 Analysis of environmental effects due to developing the aquaculture activity

**a. Interviews** with farmers **(10)**

**b. Analysis of existing data** for sea aquaculture in floating cages (**62** studies)

**c. Environmental characterisation** of the context of semi-intensive marine aquaculture farms in earthen ponds (**9** sampling points in 2 standard farms).

## 03 Definition and quantification of sustainability measures for marine aquaculture developed in earthen ponds and in floating cages

**a. Workshop on carrying capacity for semi-intensive marine aquaculture in earthen ponds (19** attendees).

**b. Workshop on carrying capacity for marine aquaculture in floating cages (21** attendees).

## 04 Integration of sustainability and development measures from protocols on carrying capacity

**a. Sustainability measures** for aquaculture in earthen ponds **(10)** and floating cages **(11)**

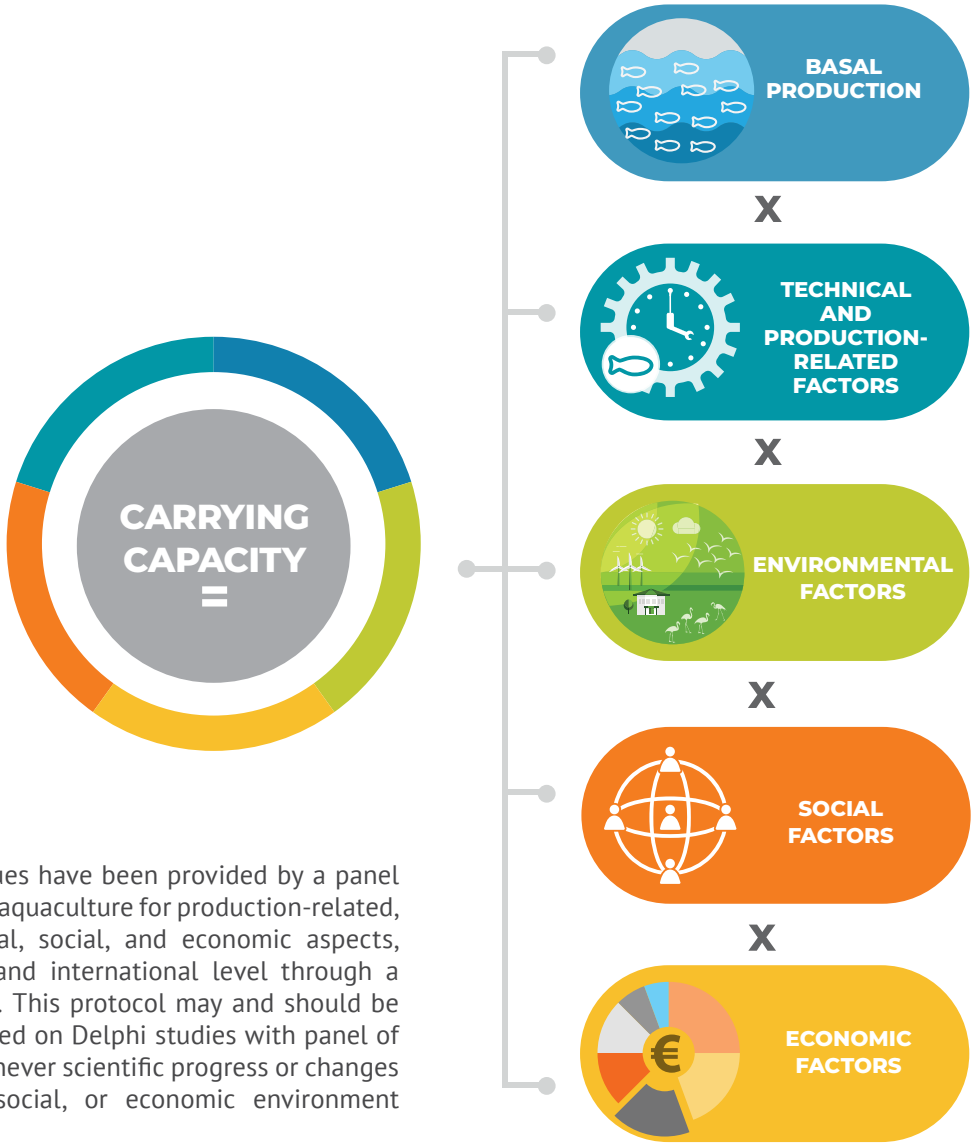
**b. Predictive models on carrying capacity (floating cages: 8** factors, earthen ponds: **6** factors).

**c. Two industry-related committees:**
**1 in El Puerto de Santa Maria** (marine aquaculture in earthen ponds).
**1 in Madrid** (marine aquaculture in floating cages).

**812,895 hectares of the Red Natura 2000 network included in the project's scope.**

# Carrying Capacity Protocols – PREDICTIVE MODELS

On this report, protocols are provided for calculating the carrying capacity of finfish marine aquaculture in Spain, on the one hand, for floating cages off the Mediterranean coastline and, on the other hand, for semi-intensive farms in earthen ponds of the South-Atlantic littoral. They are based on a carrying capacity predictive model having into consideration a basal production in tonnes per hectare. This is multiplied by a series of factors related to technical and production, environmental and social, and economic characteristics of the farm and the surrounding area. For each of the model's factors, a series of ranges are established, each one corresponding to a numeric value. This value will represent the factor in the formula, depending on the specific scenario given for each farm and location.




Numeric values have been provided by a panel of experts in aquaculture for production-related, environmental, social, and economic aspects, at national and international level through a Delphi study. This protocol may and should be modified based on Delphi studies with panel of experts whenever scientific progress or changes in natural, social, or economic environment require so.

# BASAL PRODUCTION

The carrying capacity model is based on a basal production allowed to which multiplication factors are added – this may lead to an increase or reduction of it. Since there is no homogeneous authorised basal production, data provided by administrations and producers were used, and also the advice from sector and coastal systems environmental management experts.

**50** Marine aquaculture in floating cages

**Basal Production (BP) = 50 tonnes/hectare**

**14** Semi-intensive marine aquaculture in earthen ponds

**Basal Production (BP) = 14 tonnes/hectare**

# Carrying capacity model for MARINE AQUACULTURE IN FLOATING CAGES

**Carrying capacity =**

PB x T1 x T2 x T3 x A1 x A2 x A3 x S1 x E1

Basal production · Space arrangement · Food conversion · Distance · Distance to habitats · Depth · Current · Social Acceptance · Investment in R&D

| FACTOR | TYPE | RANGE | VALUE |
|---|---|---|---|
| BP: BASAL PRODUCTION | | N/ | 50 |
| T1 Space arrangement | Technical and production-related | >4* | 1,33 |
| | | 4-3* | 1,14 |
| | | 3-2* | 1,00 |
| | | 2-1* | 0,86 |
| | | <1* | 0,66 |
| T2 Food Conversion Rate (FCR) | Technical and production-related | <1.6* | 1,38 |
| | | 1.6-2* | 1,18 |
| | | 2-2.5* | 1,00 |
| | | 2.5-3* | 0,87 |
| | | >3* | 0,50 |
| T3 Distance between facilities | Technical and production-related | >20 mn | 1,47 |
| | | 10-20 mn | 1,27 |
| | | 2-10 mn | 1,05 |
| | | 1-2 mn | 0,82 |
| | | <1 mn | 0,62 |
| A1 Distance to habitats considered of high-priority for conservation | Environmental | 5-6 mn | 1,48 |
| | | 4-5 mn | 1,32 |
| | | 3-4 mn | 1,10 |
| | | 2-3 mn | 0,97 |
| | | 1-2 mn | 0,72 |
| A2 Depth | Environmental | >60 m | 1,57 |
| | | 50-60 m | 1,32 |
| | | 40-50 m | 1,08 |
| | | 30-40 m | 0,83 |
| | | <30 m | 0,42 |

| FACTOR | TYPE | RANGE | VALUE |
|---|---|---|---|
| A3 Current | Environmental | >10 cm/s | 1,35 |
| | | 10-6 cm/s | 1,18 |
| | | 6-4 cm/s | 1,02 |
| | | 4-2 cm/s | 0,80 |
| | | 2 cm/s | 0,37 |
| S1 Social acceptance | Social | 5* | 1,10 |
| | | 4* | 1,05 |
| | | 3* | 1,00 |
| | | 2* | 0,95 |
| | | 1* | 0,90 |
| E1 Investment in R&D | Economic | >10M€ | 1,09 |
| | | 10-5M€ | 1,04 |
| | | 5-1M€ | 1,00 |
| | | 1-0,5M€ | 0,98 |
| | | <0,5M€ | 0,93 |

*This factor has no associated dimension or it is governed by qualitative or semi-qualitative measures and lacks unit of measurement.

# Carrying capacity model for SEMI-INTENSIVE MARINE AQUACULTURE IN EARTHEN PONDS

**Carrying capacity =**

PB x T1 x T2 x A1 x S1 x S2 x E1

- PB: Basal production
- T1: Food conversion
- T2: % of Decantation Area
- A1: Nitrogen per ha
- S1: Employment quality
- S2: Social acceptance
- E1: Production profitability

| FACTOR | TYPE | RANGE | VALUE |
|---|---|---|---|
| BP: BASAL PRODUCTION | | N/A | 14 |
| T1 Food Conversion Rate (FCR) | Technical and production-related | **<2*** | **1,36** |
| | | 2-2.5* | 1,12 |
| | | 2.5-3* | 0,93 |
| | | 3-3,5* | 0,78 |
| | | >3,5* | 0,70 |
| T2 Decantation area ratio | Technical and production-related | **>55%** | **1,38** |
| | | 45-55% | 1,18 |
| | | 35-45% | 1,03 |
| | | 25-35% | 0,89 |
| | | <25% | 0,75 |
| A1 Nitrogen provided by ha | Environmental | **<5 ton/ha** | **1,28** |
| | | 5-10 ton/ha | 1,09 |
| | | 10-15 ton/ha | 0,90 |
| | | 15-20 ton/ha | 0,74 |
| | | >20 ton/ha | 0,59 |

| FACTOR | TYPE | RANGE | VALUE |
|---|---|---|---|
| S1 Quality of employment provided | Social | **5*** | **1,12** |
| | | 4* | 1,07 |
| | | 3* | 1,03 |
| | | 2* | 0,98 |
| | | 1* | 0,93 |
| S2 Social acceptance | Social | **5*** | **1,13** |
| | | 4* | 1,07 |
| | | 3* | 1,00 |
| | | 2* | 0,96 |
| | | 1* | 0,92 |
| E1 Production profitability | Economic | **16-20%** | **1,09** |
| | | 12-16% | 1,06 |
| | | 8-12% | 1,03 |
| | | 4-8% | 0,98 |
| | | 0-4% | 0,93 |

*This factor has no associated dimension or it is governed by qualitative or semi-qualitative measures and lacks unit of measurement.

# Multiplication factors of carrying capacity

## Multiplication factors of carrying capacity

## TECHNICAL AND PRODUCTION-RELATED

## Space arrangement

**Description:** this factor represents the space arrangement within the leased area.

**Calculation:** average clear area between two mooring systems (group of cages)/average area of a mooring system (implementation of all-in/all-out procedures: x1.25).

**Data collection:** from the facilities' drawings submitted for the project to get the authorisation for sea cultivations and regular updates.

**Application:** marine aquaculture in floating cages.

## Distance between facilities

**Description:** distance between farms is assessed by experts as a technical and production-related factor, having a paramount impact on fish health security, but also on environmental impact due to cumulative effects.

**Calculation:** distance in nautical miles from one facility to the closest one.

**Data collection:** distance between facilities is calculated through geographical information systems (GIS) and with the aid of the public tool by the Ministry for Ecological Transition "ACUIVISOR".

**Application:** marine aquaculture in floating cages.

## Food Conversion Rate (FCR)

**Description:** represents the animal efficiency when converting the food, and in this case, also non-consumed food which is lost.

**Calculation:** kg food provided/kg biomass gained.

**Data collection:** on the project submitted to get the authorisation for sea cultivations, this theoretical datum may be checked, but actual values should be reviewed when the company is operating.

**Application:** marine aquaculture in floating cages and semi-intensive marine aquaculture in earthen ponds.

## Decantation area ratio vs. total water sheet

**Description:** amount of surface destined to decantation of outflow water originating from the area of production, in which other physical and biological processes also take place which improve water quality.

**Calculation:** hectares of permanent water sheet destined to decantation/ total hectares of permanent water sheet inside the farm.

**Data collection:** all necessary data are stated on the project submitted to apply for the authorisation for marine cultivations. These may be completed by the yearly surveys carried out by the administration.

**Application:** semi-intensive marine aquaculture in earthen ponds.

# Multiplication factors of carrying capacity

## ENVIRONMENTAL


### Distance to habitats considered of high-priority for conservation

**Description:** distance between aquaculture farms to habitats considered of high-priority for conservation will be related to the capacity of having an impact on them.

**Calculation:** distance to the closest point considered as an habitat considered of high-priority for conservation (nm).

**Data collection:** cartography including information of the sea floor, atlas on sea grass meadows in Spain (Spanish Institute of Oceanography), on-site confirmation.

**Application:** marine aquaculture in floating cages

## Depth

**Description:** depth has a great effect on the quantity of solid materials deposited on the sea floor. The greater the depth, the greater the possibility of dispersion driven by currents.

**Calculation:** average depth (m) under the facilities of floating cages.

**Data collection:** from the facilities drawings submitted to get the authorisation for marine cultivations and regular updates.

**Application:** marine aquaculture in floating cages

## Current

**Description:** current has a great effect on the quantity of solid materials deposited on the sea floor, as well as depth –the greater the current, the least the deposition.

**Calculation:** annual average current intensity (cm/s) at the farm, at a depth of 15 metres.

**Data collection:** current predictive models of the European system "Copernicus" (http://marine.copernicus.eu/services-portfolio/access-to-products/) available for public use, annual average from daily data. It must be confirmed by on-site measurements.

**Application:** marine aquaculture in floating cages.

## Nitrogen per ha

**Description:** Nitrogen input per hectare reflects, in general terms, the provision of nutrients to the environment, whilst recording changes at trophic level of the cultivated species, depending on the protein content of fish feed.

**Calculation:** tonnes of fish feed per hectare of water sheet per year x content in protein of fodder.

**Data collection:** these data may be collected from the theoretical production plan submitted on the project for the authorisation for marine cultivations. For monitoring an operating company, these can be achieved out of the yearly surveys carried out by competent administrations (tonnes of feed per year) and the farm details (hectares of water sheet).

**Application:** semi-intensive marine aquaculture in earthen ponds.

# Multiplication factors of carrying capacity
# SOCIAL


## Social acceptance

**Description:** the degree of social acceptance is obtained from surveys carried out among local citizens having a knowledge on the aquaculture sector. The question to be made is: "What do you think on the increase or reduction of the aquaculture activity in your area for the years to come?" With two pre-set answers: A: should increase; B: should decrease.

**Calculation:** Dependent on the ratio of answers for each type, a grade from 1 to 5 will be obtained:

1. >60% think it should be reduced
2. >50% think it should be reduced
3. Balanced opinions
4. >50% think it should be increased
5. >60% think it should be increased

**Data collection:** from already existing surveys carried out by the administration or within recent projects.

**Application:** marine aquaculture in floating cages and semi-intensive marine aquaculture in earthen ponds.

## Quality of employment provided

**Description:** the quality of the employment provided by the company is measured according to previous sustainability aquaculture projects and following the recommendations by the European Union.

**Calculation:**

| LOCAL | STABILITY | GENDER EQUALITY |
|---|---|---|
| <70% (+0) | < 1 año (+0) | There are gender equality measures (+1) |
| ≥70% (+1) | 1-3 años (+1) | There is an equality policy at the company (+2) |
| | ≥3 años (+2) | |

Combining all these scenarios concerning the qualitative features of the employment provided, a grade from 1 to 5 may be obtained, which will be used to apply multiplication factors (page 11).

**Data collection:** on yearly basis, the administration collects information on the employment in aquaculture companies through surveys, in which these three features may be included in case they are not.

**Application:** semi-intensive marine aquaculture in earthen ponds.

# Multiplication factors of carrying capacity

# ECONOMIC


## Investment in R&D

**Description:** investment in R&D helps to improve productivity in the activity and reduce environmental impact. Moreover, it reflects the interest of the administrations in the sector and its development.

**Calculation:** according to the following regional investments ranges in R&D:

1. >10 million Euro
2. 10-5 million Euro
3. 5-1 million Euro
4. 1-0.5 million Euro
5. <0.5 million Euro

**Data collection:** from the public budget invested in projects every year (developed at private or public levels), which are directly related to aquaculture.

**Application:** marine aquaculture in floating cages.

## Production profitability

**Description:** profitability in the production of a company represents economic sustainability through its competitive capacity and its capacity to face non-favourable economic periods.

**Calculation:** yearly average profitability for three years not including investments or amortisations.

**Data collection:** from the data provided by the company on the project submitted to apply for the authorisation (economic feasibility study) or through surveys by the administration.

**Application:** semi-intensive marine aquaculture in earthen ponds

# Final considerations

- Mathematical models existing up to now contain a great amount of inputs, which hinders data collection by administrations and companies
- Predictive models from multiplication factors defining the activity and the recipient environment at environmental, social, and economic levels are easy to apply, but they require a great number of experts to be involved.
- Validation by the sector and the administration is crucial for success (sector committees and industry-administration coordination).
- An on-site simulation and evaluation phase will be necessary, including other areas and aquaculture models.

# MIMECCA

**Development of Innovative environmental measures for the establishment of carrying capacity protocols to ensure sustainable development of aquaculture**

This project is carried out in collaboration with the Fundación Biodiversidad, attached to the Ministry for Ecological Transition, through the Pleamar Programme funded by the EMFF.
This initiative is framed into the LIFE IP INTEMARES "Integrated, innovative, and participating management of the Red Natura 2000 network in the sea Spanish environment" project, coordinated by the Ministry, through the Fundación Biodiversidad.

**Further information on this project:**

**WWW.CTAQUA.ES**