

## 7.2 S'ALBUFERA DE MALLORCA, SPAIN

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### 7.2.1 DESCRIPTION OF THE SITE

#### Location, size, physiography

S'Albufera de Mallorca, 39°47'N 3°6'E, is a 1,700 ha coastal wetland in northeast Mallorca, Spain (Figure 7.2.1). The area is flat and just above sea level. The boundaries comprise the sea, tourist urbanisation and agricultural land. An inland band of stabilised dunes partially interrupts the wetland. S'Albufera is part of Sa Pobla Plain, a 30-40 m thick layer of quaternary sediments. It has a typical Mediterranean climate, though somewhat milder and with a slightly higher rainfall than the surrounding area.

#### Wetland types occurring at the site

The Ramsar wetland types comprise: non-forested alkaline fen (Ramsar wetland type U), permanent freshwater marshes/pools (Tp), salt marsh (H), coastal brackish and saline lagoons (J), coastal freshwater lagoons (K), permanent saline, brackish and alkaline marshes and pools (Sp), seasonal saline, brackish and alkaline marshes and pools (Ss), and freshwater springs (Y). One permanent narrow connection and two one-way connections controlled by sluices connect part of the marsh with Alcudia Bay in which three further Ramsar wetland types are represented: permanent shallow marine waters less than six metres deep (A); marine subtidal aquatic beds, of the sea grass *Posidonia oceanica* (B); sand shores, comprising 1.5 km of a 10 km shell sand beach, backed by a 0.5 km wide band of coastal dune which began to form about 10,000 years ago (E). A rocky marine shore habitat (D) is simulated by stone block banks to the canalised connection between marsh and sea. See also Table 7.2.1.

#### Main values of the wetland

Products include a traditional eel fishery; forage resources, now confined to grazing for environmental purposes; and agricultural resources, by retaining a high water table of benefit to cultivations immediately inland and by the action of plants and positive human management to improve and/or maintain water quality. The most important product is wildlife resources, which led to designation as a Natural Park in 1988. This designation recognised the biological richness of the site and its importance to conservation, including conservation education, and to "green tourism".

The biological attributes are numerous, and occur at regional, national and international levels: they include breeding populations of a number of internationally or nationally rare vertebrate species; rare and newly discovered invertebrates; and endemic and nationally rare plant species. At a regional level, S'Albufera augments the rich biological diversity of Mallorca by providing habitats and species not or hardly replicated elsewhere on the

island. The site has an international reputation and attracts large numbers of wildlife enthusiasts from throughout Europe.

S'Albufera has a well documented history from Roman times, when the wetland was much larger. The site has a major place in the folklore and cultural identity of the human population surrounding it, and is appreciated for its roles as a buffer against saltwater intrusion (essential for the farming community) and in its contribution to wildlife tourism which, amongst other attributes, has afforded the region an environmental "quality label" and lengthened the tourist season into the spring and autumn.

### **Land use and main threats**

Land use is restricted to activities compatible with nature conservation. These comprise a small, regulated eel fishery, licensed angling, conservation orientated grazing by livestock, regulated visitor access and scientific research. Previous activities included paper production from reed bed plants, salt production, hunting and rice growing. The last two still occur in wet areas outside the Park. Elsewhere, urbanisation has led to the disappearance of wetland, though two lagoons remain to the north and a water purification plant has been established at the park's southern border.

The declaration of a natural park has removed the threat of development within the designated area. One serious threat is the impact on water quality of nutrient runoff from agricultural land and inputs of phosphates from the extensive tourist urbanisation on the coastal strip. Other tourist impacts include erosion damage to the seaward edge of the protected coastal dunes, litter within those dunes, and an ever-present fire risk. Competition for water supply is an issue, which has extended recently to extractions from the S'Albufera aquifer to provision for human populations elsewhere on the island. The level of pollution from a coal fired power station, situated immediately north of the Park, is unknown.

### **Ownership, legal status and management body**

A total of 1,708.75 ha, including nearly all the current wetland, became the Parc Natural de S'Albufera by Balearic government decree in 1988. Ownership is shared by the Balearic Government, the Spanish Ministry of Agriculture, Fisheries and Food (MAPA), and the Municipality of Muro. There are still private landowners in a small proportion of the Park. The site was declared a Special Protection Area under the EC Birds Directive in September 1987. The Park is administered by the Department of Agriculture and Fisheries of the Balearic Government, and functions under guidelines set out in a Plan for Use and Management, drawn up by the Park directorate and approved by the Park Board (*Junta Rectora*). The *Junta* acts as an advisory body and comprises representatives of governmental and non-governmental bodies with an interest in the site. A small proportion of the wetland, as it now exists, lies outside the protected zone.

### **Other relevant aspects**

Urbanisation is prohibited on the Park's west and southwest borders, otherwise there is no strict buffer zone. The Park is constrained to balance conservation management with some local needs and requirements (e.g. to avoid flooding of adjacent agricultural land).

## **7.2.2 EXISTING MONITORING PROGRAMMES**

Two principal bodies are involved in monitoring: the Park directorate and Project S'Albufera. The University of the Balearic Islands (UIB) assists with some monitoring, and other Universities and scientists from various countries have undertaken research studies.

Monitoring measures by the Park directorate are specified in its management plan. The park has achieved more comprehensive monitoring than its structure and funding would have allowed by cooperating with an international agency, Earthwatch Europe, to instigate a scientific research programme with monitoring as a major theme - supported by a multidisciplinary scientific team, Earthwatch Europe's Project S'Albufera.

### **PROJECT S'ALBUFERA**

Project S'Albufera comprises an independent team of scientists affiliated to Earthwatch Europe, a charitable organisation which provides funds and volunteers for scientific field studies. However, the scheme is a cooperative venture and incorporates monitoring studies undertaken by the project, the Park directorate and the UIB.

#### **Objectives of the monitoring**

The Project defined five objectives, two of which are related to monitoring. The first comprised the collection of baseline information (to assemble full and detailed ecological data to reach an understanding of composition, functioning and dynamics of the ecosystems; to assemble Public Use data, including visitor use and impact of visitor numbers). The second was to provide standardised comparative data for evidence of environmental change, to be re-recorded at intervals of time, to provide a model for other monitoring stations. The other objectives were: to afford material for application in further research and reserve management at S'Albufera and in general conservation practice; to provide resources for comprehensive interpretive programmes and dissemination in all appropriate forms; to serve as a focus for education of residents and visitors of all age-groups and levels and to help in creating environmental awareness and commitment. The Project employs a combination of inventory, monitoring and applied research to achieve its objectives.

#### **Parameters measured and techniques used**

In the six years of the project, over 80 monitoring, surveillance and applied research studies have been undertaken using a variety of parameters and techniques. For the purpose of this pilot study, the parameters and techniques to be used are those which apply to the key issues of wetland monitoring. These are included in the proposed monitoring programme presented in Tables 7.2.3-7.2.6.

#### **Resources available: staff, equipment, cost**

Project S'Albufera comprises teams of scientists and volunteers. Monitoring tasks are also carried out by Park staff. The Principal Investigator, Nick Riddiford, is in charge of Project planning and administration. Some equipment costs are met by Earthwatch Europe. Other equipment needs have been met from major grants or from loans from the UIB. Project funding comes from Earthwatch Europe and the American arm, Earthwatch (Boston), and is mainly drawn from contributions made by participating volunteers. Annual estimates of costs are made for each area of expenditure. The 1996 budget is presented as an example (see Table 7.2.2). Project S'Albufera is an example of what can be done with good resources. Cheap, simple studies with few parameters are equally valid.

## **Methods for data analysis and interpretation**

Although the means and process of data analysis and interpretation were fully considered at the planning stage, it is the responsibility of each scientist to achieve his/her own analysis and interpretation. However, the multidisciplinary nature and expertise of team members assists with ensuring that acceptable methods are used.

## **Use of the results**

The results have been used in a number of ways, which are addressed later in this chapter. Results have been published in a number of journals and reports (see References).

### **7.2.3 MONITORING PROGRAMME OF S'ALBUFERA DE MALLORCA**

The S'Albufera de Mallorca pilot study is based on a site protected since 1988 and with a well developed and wide ranging scientific programme initiated in 1989. Monitoring was identified from the start as a requisite for understanding the ecosystem development and change as well as providing an essential tool in assessing the effect and effectiveness of management. It was also identified that the monitoring programme should respond to the needs of the Park. The site is administered and managed by a team of nine full-time employees assisted by a series of long-term and short-term volunteers. The monitoring programme is undertaken by members of the Park staff and visiting scientists and volunteers, the last mainly through Earthwatch Europe's Project S'Albufera. Responsibility for this pilot study has been taken by Nick Riddiford, Principal Investigator of Project S'Albufera, and Joan Mayol Serra, Wildlife Officer for the Balearic Islands and Director of the Parc Natural de S'Albufera. Project S'Albufera scientists and Park staff, particularly public use coordinator Gabriel Perelló, chief warden Francesc Lillo and ornithologist Pere Vicens, made contributions and comments.

The pilot study comprised the design of a monitoring programme for S'Albufera based on the MedWet methodology as if Project S'Albufera was to be launched in 1996, but drawing heavily on experiences gained since 1989. It was clear at the start that no hypotheses could be established before baseline data had been obtained, and this takes time. The Project experience has been that a great deal of preparatory work is required before enough knowledge is in place for a monitoring programme to be launched.

## **Identification of problems (present and potential)**

In planning the study, evaluation of features, issues and threats pertaining to the site was a key first step followed by their prioritisation for a monitoring programme. Three main problems or issues have been identified, all related to human activities: they comprise alterations to the hydrology; physical/biological alterations affecting the ecosystem; and the impact of tourist and agricultural developments and activities adjacent to the Park. Positive and negative aspects of public use within the Park is also an issue. More information is needed for other potential problems: the impact of climate change on sea levels, and the potential for pollution from the Es Murterar power station adjacent to the Park.

## Identification of objectives

The following priority objectives have been identified.

- i) *Alterations to the hydrology.* Monitor water extraction amounts and evaluate in relation to water levels in the Park; monitor conductivity of water for salinity; reinstate natural flow through sluices, natural revegetation of drains and creation of non-rectilinear channels, then monitor effects by measuring flow rates.
- ii) *Physical/biological alterations.* Monitor changes in salinity; monitor aquatic invertebrate communities as indicators of water quality; monitor the levels of disturbance to waterbirds through illegal human activities.
- iii) *Tourist and agricultural developments and impacts.* Reduce negative impacts by tourists through regular surveillance; monitor level of beach-head erosion; monitor water quality to assess nitrate load and phosphate discharges into Park.
- iv) *Climate change.* Monitor meteorological trends and changes in sea levels which may disrupt or alter the ecosystem.

Much more precise individual objectives have had to be developed for individual monitoring studies addressing these issues. Analysis of studies already undertaken indicate that clear objectives have in most cases been identified and described (e.g. Water level recording in the Gran Canal: objective - to evaluate whether fluctuations in the water levels over a period of time can be used to assess any changes in sea level which might affect S'Albufera).

## Set up the hypothesis

The MedWet monitoring methodology calls for precise hypotheses to be developed. Many of the studies are based on hypotheses, but these may be too general (e.g. Aquatic Invertebrate study: hypothesis - invertebrate species assemblages will change with changes in water quality). Project scientists have been asked to reconsider their objectives and to construct hypotheses which more precisely address the issue.

It is very difficult to know which hypothesis should be applied without considerable baseline knowledge. It is now possible to construct a number of precise hypotheses based on knowledge of S'Albufera Park and its natural environment. This may not be the case for other less well studied sites. The Mediterranean environment is known for naturally occurring large seasonal and longer-term fluctuations and a suite of data collected over a period of years may be necessary before a meaningful hypothesis can be formulated.

## Selection of parameters, and establishment of a baseline

These issues were addressed during the Project's original planning stage. In order to record ecological change, an understanding was needed of the ecosystem. The first requirement was to set up a baseline from which to work. Some information was already available, particularly for water quality and freshwater biology from the work of Martínez (1988) on aquatic macrophytes, while aspects of hydrology, geology and history along with inventories of various taxa, mainly incomplete, had been published by Barceló and Mayol (1980). To extend these baselines, Project S'Albufera embarked on research in priority areas concurrently with establishing more comprehensive inventories. University College London's Ecology and Conservation Unit assisted in the first two years, to give the project an initial impetus. Baseline data were collected under the following priority area

headings: hydrology, ecosystem dynamics and functioning, geophysical information, meteorology, history and the historical archive, vegetation, fauna (birds, mammals, reptiles, amphibians, fish, invertebrates), human impact, and management. The inventories were reinforced by permanent reference material, beginning with the establishment of an herbarium. This was later extended to a specimen collection for various invertebrate groups. Both were augmented by photographs. Photographs were also used to record human artefacts still present in the Park, in conjunction with mapping. The reference collections are seen as a vital resource for the field research. Three years were allocated to establish the baseline, with gaps being filled thereafter - and to this day as new information is gathered or becomes available.

Once a baseline had been established the following priority steps were identified and introduced:

1. multidisciplinary study of processes affecting or dependent on: i) the *Phragmites-Cladium* dominated wetland ecosystem, ii) the hydrological system, iii) the dune systems, iv) the whole catchment of the Park and adjoining coastal waters;
2. the impact of management and related studies;
3. environmental and socio-economic studies;
4. data-processing and the database potential and methodology, including in the light of its wider applicability;
5. long-term monitoring aimed at assessing environmental change;
6. extension of baseline information.

These priorities were identified from information gathered prior to the declaration of the Park, heavily augmented by the first three years' work of Project S'Albufera. Parameters were selected during the baseline data collection period and tested during the pilot study stage. A range of parameters was identified before any fieldwork was carried out; in reality, however, these were modified and in some cases rejected in favour of more useful or sensitive ones during the original baseline and pilot study test periods. Research subjects chosen were those considered most likely to demonstrate ecological change. The hydrological studies were assessed as of utmost importance not just because of the influence of water on the entire ecosystem but also because the marsh's position at, and marginally above, mean sea level makes it extremely vulnerable to sea level changes, particularly rises. Problems of identifying the causes of ecological change are compounded at S'Albufera by local and regional influences and activities. The hydrological study and studies related to hydrology (e.g. freshwater biology) obtained data on water quality, both to assess spatial and temporal variations in salinity and as a first step towards identifying intrusion within the Park of pollutants from nearby farmland and tourist complexes. Data sought in areas of Park management were designed to assist with formulating good management practice and to act as a measure of the impact of management in halting, reversing or promoting change.

### **Selection of techniques and design of sampling methods**

Wherever possible, standard techniques and methodologies have been used. If these had to be adapted, testing ensured that the revised methodology would not introduce new, unwelcome sources of error. Wherever possible, random sampling techniques were used. However, in reality, choices have often had to be made of "best" or "most representative" sample sites. Access, and continuity of access, were other factors influencing the techniques chosen. Once sample sites had been selected, a key issue was to ensure that these sites, or in some cases their boundaries, were clearly described to ensure relocation. Precise written descriptions of the site, including annotated maps, coordinate positions and a visual reference using fixed photography are essential adjuncts to the written methodology and are usually sufficient to allow relocation of the site. The use of

metal markers also allows relocation using metal detectors, if the descriptive information fails.

#### Selection of sampling sites

The number and location of sampling sites took into consideration the following criteria: sufficient sites to provide valid results; the choice of representative locations; and access. Selection was often influenced by work previously done (e. g. selection of sample sites used by Martínez for his doctoral study of aquatic macrophytes and water quality in the 1980s), but only when these were considered representative and sufficient to provide the information required.

#### Sampling frequency

Other factors which also had to be taken into account included sampling frequency in relation to time of year, fieldworker availability and the ability of fieldworkers to accurately collect the required information. These factors inevitably reduce the number of monitoring studies which can reasonably be undertaken (e.g. there is no point undertaking a study which requires year-round information when fieldworkers are only available in spring and autumn). Collecting data from sufficient sample sites to provide statistically valid and usable information is a real problem for a monitoring programme which relies heavily on volunteers available for only short periods. There is often a risk that, with limitations on time and work force, sample sizes are too low and variation too large to detect ecological change.

#### Collecting the data

Considerable thought was given to the collection of information and samples. A clear, but concise written methodology should be produced, particularly when using volunteers. To collect information, uncomplicated data sheets should be prepared before embarking on the study. Implementing the methodology in the field should be done initially by the scientist responsible for the study alongside the volunteers. For some studies, full scientist involvement is required throughout. Otherwise, volunteers should be tested first to ensure that the information collected will be of an acceptable level and quality. The scientist should always check the data sheets carefully for errors or incorrect application of methodology as soon as possible after the data has been collected (normally the same day). All these factors can be assessed by rigorous field testing. Conducting a pilot study frequently reveals flaws and unsuitable methodology or techniques which can be amended or improved before the main study starts.

#### Handling samples for analysis

Where the samples comprise biota or physical materials, considerable pre-planning has proved necessary. This includes ensuring that all the required handling materials (collecting containers, chemicals, etc.) are at hand - which may require ordering several months in advance. Preparation time should also include ensuring that the collectors know the methods of collection, collect in a replicable manner and label the samples clearly and correctly. Thought also needs to be given to the safe transport of samples or, in the case of samples which change or degrade quickly, of having the relevant equipment for immediate on-site testing. Agreements may also be necessary with scientists and/or laboratories to process the samples, notifying them when the samples are due to arrive, and ensuring that transport is available to deliver them. When immediate delivery is not possible, storage must be arranged (which may require on-site deep freeze facilities or a large amount of cool or dark storage space). There is little point collecting samples if the required facilities are not available.

#### Safeguarding the data

Data and information should be checked and filed in an archive which is clearly labelled and cross-referenced for easy relocation of the data. Field data may require transferring to master sheets, but on no account should the original data or the master be left lying around - information can easily be lost, particularly when more than one person is working in the facility or office. Temporary files can be established for unworked data, but these should also be clearly labelled and a list of the contents displayed and cross-referenced. Ideally, a computer database should be established and new data entered as soon as they are collected. Irrespective of access to a computer, the original data (and any worked data, including results) should be kept as a reference. Where raw data have been entered on a master sheet, both sets of data should be kept to allow for checks on errors which analysis might later suggest (though stringent checks should still be made when copying sets of data from one location to another, i.e. to master sheet or computer). The Project S'Albufera main archive is kept at the Park (using an adapted form of the British Nature Conservancy Council's data management system, described in *Site management plans for nature conservation - a working guide*, NCC 1987). For security, an additional copy is lodged with Earthwatch Europe in Oxford, England. Individual scientists hold a third copy pertaining to their own particular study or studies. A number of data sets are also stored on Park, Project or individual scientists' computers.

### **Analysis and interpretation of data**

The key to monitoring at S'Albufera has been the use of volunteers, including volunteer scientists. Although many scientists have been willing to spend some of their holiday time participating in the fieldwork, most of them are very busy and have difficulty finding the time to complete the analysis and interpretation of the data collected. Nevertheless, the Project has a good record of reporting back and most scientists manage to achieve at least a summary of results for publication in the Project's annual report. Many of the visiting scientists are already specialists in their particular line of study and bring to the Project a high level of expertise and previous experience in methodology, statistical analysis and interpretation of results. Many of them stress that they can give preliminary results, but that natural fluctuations and perhaps natural cycles overlie any interpretation of ecological change - so that in a number of cases a long-term programme of study and data collection is required to filter out these fluctuations and cycles.

The process of data analysis and interpretation begins at the planning stage for each study. Key factors which determine the studies undertaken and methodologies used are the availability of specialist scientists, time in relation to season and length of fieldwork period and the extent to which the methodology is volunteer-friendly. Pilot studies are normally done to assess suitability of methodologies within those limitations. Nevertheless, importance is placed on the scientific validity of information collected both in terms of accuracy and statistical viability. Some studies can be done more effectively by volunteers than others (e.g. distribution mapping). Selection of study sites, which often requires a random approach, and the number of samples required to show a statistically valid trend are factors which are addressed at the planning stage. The Project is often confronted, after pilot study, with problems which can only be solved by much greater in-depth research and data collection. This has frequently been overcome by encouraging postgraduate students or scientific institutions (e.g. Aberdeen University's Centre for Remote Sensing and Mapping Science) to tackle the problem with a programme of intensive research which is beyond the expertise, equipment resource, timescale and/or seasonal availability of volunteer teams.

### **Reporting: Publications**

Research at S'Albufera has generated a large number of publications. They include interim reports of individual studies, published in the annual *Monitoring for Environmental*

*Change, the Earthwatch Europe Project S'Albufera Report.* Since 1994, results have also been published in the Park bulletin (*Butlletí del Parc Natural de S'Albufera de Mallorca*). A synthesis of baseline data, covering a range of subjects, has been produced recently as a S'Albufera monograph (Martínez & Mayol 1996) by a team of Park, Project and University scientists with the support of the Balearic Natural History Society. Details of published results relevant to this study are given in the reference list. The Project also produces regular reviews and planning documents, instigates peer review meetings, feeds results into the management planning process, provides illustrative and textual resource materials for education, encourages collaboration with and participation by other international organisations and strives to fulfil its objective of making data compatible with and available to conservation bodies. It should be noted that monitoring results often uncover further problems which need specialist investigation or research.

## **Use of the results**

The S'Albufera monitoring programme has a clear vision of how the results will be used. They are:

### Management

The Park has a well established management programme, clearly defined in the Park's Plan for Use and Management. This plan has recently been updated with the monitoring results incorporated and applied to the management programme for the period of the new plan, 1995-1999. Monitoring and surveillance are considered key aspects in relation to management planning, both in guiding and assessing the impact and effects of management practice. For instance, monitoring of visitors has already been used to improve planning and management of public use.

### Public domain

This addresses two inter-related issues. The first concerns public perception of the Park and its importance for conservation, for preserving and enhancing the natural and cultural heritage and for promoting economically beneficial environmental tourism. The second concerns informing the political decision makers. The scientific element may have a greater impact and be more likely to provoke political action to safeguard the site's ecological values, but a positive perception of those values, particularly locally, may also contribute through public pressure on the decision making bodies.

### Interpretation

The results obtained through the monitoring programme are already being incorporated into interpretation materials - which currently include educational materials (including a CD ROM for schools), booklets, leaflets, posters, permanent displays, audio-visual presentations, and guided interpretive visits for schoolchildren and, increasingly, other groups.

### Guidance for other schemes

It has always been an aim of the S'Albufera monitoring scheme to make results, and experiences gained in obtaining those results, available to other schemes or organisations tackling similar problems and issues.

## **Final considerations: some practical aspects**

### Planning an integrated programme

When Project S'Albufera was launched, the original planning was done from Britain. Early contact was made, however, with the Park authorities and a site visit organised. This confirmed an overwhelming acceptance, enthusiasm and welcome by the Park authorities for such a programme of monitoring, involving a large number of scientists and volunteers external to the Park and unknown to the Park directorate and staff. Other positive factors were the existence of a permanent Park staff which, though restricted by a heavy workload of other duties, was available to fill some of the monitoring gaps that Project S'Albufera was unable to achieve. The Park was also within an hour's driving distance from a University with science departments, a number of which had undertaken research at the Park and/or were willing to do more.

This will not be the case at all Mediterranean wetlands. Access may prove much less straightforward, particularly if the site is not under public, protected ownership and the system of international teams, organised by and involving nationals from other countries, is not possible. Even at S'Albufera, language barriers were at first a problem - particularly for scientists needing local knowledge and expertise to assist the planning of their studies. This problem was overcome by the ability of key members to converse in shared languages (English and French) and the willingness of some participating scientists to reach a reasonable level of spoken Spanish. Another very important aspect was the involvement of local volunteers. These were usually keen young environmentalists from UIB, but also some from mainland Spain. Local/national involvement is essential for any programme which plans to use the S'Albufera model of international participation.

#### Using volunteers

Programmes considering the use of international volunteer assistance should also take into account that Mallorca is a holiday destination serviced by inexpensive flights from many parts of Europe. Thus volunteer scientists, many of whom pay their own travel, are attracted to come. Travel expense to less cheaply accessible sites may, however, be offset by better funding to defray costs than Mallorca can currently attract. The input that a team of enthusiastic volunteers, led by experienced scientists, can make to a monitoring programme is considerable but presents restrictions on the types of information which can be collected, both in terms of techniques which are suitable for collection by volunteers and in sampling methodology - which has to take into account that information can only be gathered during the relatively short periods when teams are in the field. Without funding and with other commitments, volunteer scientists may be unable to come at the best time for their study nor continue for the amount of years required to complete their study. This can be overcome by training assistants or keeping the methodology simple enough for others to replicate. Ideally, those carrying on the study should be local volunteers.

#### Funding

Funding is a major issue which needs to be addressed before embarking on any monitoring programme. Between 50% and 60% of funding for Earthwatch projects is drawn from the contributions made by participating volunteers. However, the multidisciplinary nature of Project S'Albufera makes far greater financial demands than is normally the case with Earthwatch projects. The shortfall was met by Earthwatch Europe during the first five years. Since then they have continued to seek extra funding, through sponsorship deals with companies and other organisations.

The project has been fortunate so far in obtaining the services of scientists, many of them leaders in their fields, without cost. Nevertheless, the project incurs expenses in bringing them to the site, accommodating and feeding them and in providing them with equipment. Equipment is one of the greatest initial costs in a project of this type. A substantial grant to Earthwatch Europe from the World Wide Fund for Nature (WWF) in 1991 was a major factor in meeting this need. It also allowed us to pay the travel expenses and accommodation of leading scientists needed to undertake specific studies within the

Park. A cooperation agreement signed between Earthwatch Europe and UIB in 1990 also gave benefits in allowing for the loan of equipment to the project and other University assistance. Currently, project costs range from £7,000 to £15,000 per annum, though a hidden extra administrative cost is absorbed by the supporting body, Earthwatch. Other costs, including on-site accommodation, logistic support and staff participation in monitoring, are hidden extras borne by the Park.

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Table 7.2.1 Categories and extent of CORINE biotopes in S'Albufera de Mallorca.

<b>CATEGORY</b>	<b>CORINE Code</b>	<b>Area (%)</b>
Fen-sedge ( <i>Cladium mariscus</i> ) beds	53.31	49
Flooded <i>Phragmites</i> beds	53.111	24
Dry <i>Phragmites</i> beds	53.112	10
Giant <i>Phragmites</i> beds	53.113	4
Mediterranean tall rush salt marshes	15.51	1
Mediterranean salt scrubs	15.61	1
Mediterranean halo-psammophile meadows	15.53	0.5
Open water communities:		(10.5)
<i>Chara</i> carpets	22.441	5
Small <i>Potamogeton</i> communities	22.422	2.5
<i>Ruppia</i> communities of brackish and salt waters	23.211	2.5
Eutrophic waters	22.13	0.5

Table 7.2.2 Project S'Albufera budget for 1996; an example of the costs for a monitoring programme using volunteers.

Fieldwork dates

- Team 1: Thursday 11th April to Thursday 25th April
- Team 2: Sunday 28th April to Sunday 12th May
- Team 3: Saturday 26th October to Saturday 9th November

<b>Research Team</b>	<b>Minimum</b>	<b>Maximum</b>
Principal Investigators <sup>1</sup>	1	2
Scientific staff <sup>1</sup>	1	4
Earthwatch volunteers <sup>1</sup>	4	8
Invited local volunteers <sup>1</sup>	1	2
Total team size	7	16
(Number of teams: 3)		
Total Earthwatch volunteers for project	12	24
<b>Field Expenses<sup>2</sup></b>		
Food	2220	4440
Accommodation	700	1400
Equipment/Tools	100	500
Staff salaries	0	0
Transportation for staff to research site	2250	4230
Research team transport in field	1575	1940
Other expenses		
freight	120	150
administration & contingencies	300	500
<b>Total Budget</b>	<b>£ 7265</b>	<b>£13160</b>

Notes:

1. Number per fieldwork team.
2. All budget estimates in UK£.
3. Does not include costs for Park staff or University of the Balearics time and equipment.

Table 7.2.3 Summary of key points of a monitoring programme for s'Albufera de Mallorca: Monitoring of alterations to the water regime at s'Albufera de Mallorca.

<i>General problem/issue</i>	<ul style="list-style-type: none"> <li>a) Water is being taken from the aquifer for agricultural and urban uses, in and beyond the catchment area.</li> <li>b) The digging of a network of drains in the nineteenth century has accelerated the outflow of water and has brought about a compartmentalisation of flows.</li> </ul>
<i>Specific problem/issue</i>	<ul style="list-style-type: none"> <li>ai) Over-abstraction may lead to desiccation of parts of the marsh.</li> <li>aii) Abstraction of water lowers water table and leads to increased salinisation.</li> <li>b) Water is lost too quickly from the marsh into the sea or to pumping stations and has damaged the character of the marsh by increased speed and canalised movement of water.</li> </ul>
<i>Objective</i>	<ul style="list-style-type: none"> <li>ai) Monitor water levels to evaluate the effects of water abstraction.</li> <li>aii) Monitor water quality for salinity; monitor aquatic invertebrate communities as indicators of water quality.</li> <li>b) Reinstate natural flow by sluices, natural revegetation of drains and create non-rectilinear channels, then monitor effects by measuring flow rates.</li> </ul>
<i>Hypothesis</i>	<ul style="list-style-type: none"> <li>ai) Mean water levels should not fall below the lowest mean water level recorded in the last five years.</li> <li>aii) <i>For salinity</i>: conductivity at any one site and season should not exceed the mean levels for conductivity during the 1980s baseline study at the same site and season.</li> <li>aii) <i>For aquatic invertebrate indicators</i>: to be formulated based on presence/absence of key salinity tolerant or intolerant indicator species or assemblages once these have been identified.</li> <li>b) Water flow should be significantly reduced.</li> </ul>
<i>Methods &amp; variables</i>	<ul style="list-style-type: none"> <li>ai) Record water levels from a series of stageboards.</li> <li>aii) <i>For salinity</i>: on-site measurements of conductivity (and pH, oxygen content and temperature of water).</li> <li>aii) <i>For aquatic invertebrate indicators</i>: standardised sweep-net sampling and counting of aquatic invertebrate fauna at water quality sites; results compared with water quality data.</li> <li>b) Measurements of water flow, using flow meter; keep record of when sluices opened and closed; record water levels from stageboards.</li> </ul>
<i>Feasibility/cost effectiveness</i>	<ul style="list-style-type: none"> <li>ai) Simple technique requiring two staff-days per month.</li> <li>aii) <i>For salinity</i>: feasible because of donation of portable electronic meters measuring the above parameters; requires four staff-days per month (also feasible at lower cost using simple conductivity meters).</li> <li>aii) <i>For aquatic invertebrate indicators</i>: cheap for equipment but labour intensive. Only feasible because the Project has ample volunteer labour, and water quality data are available from the water quality monitoring programme.</li> <li>b) Requires purchase of flow meter; staff time.</li> </ul>
<i>Pilot study</i>	<ul style="list-style-type: none"> <li>ai) Five years' data to provide a baseline from which to form hypothesis (was done prior to start of water abstraction away from the catchment). Methodology tested at beginning of</li> </ul>

	<p>baseline study.</p> <p>aii) <i>For salinity</i> : equipment and procedures were tested under field conditions in 1994. Calibration of equipment was done by University (UIB) technicians. Staff trained in use and maintenance of equipment..</p> <p>aii) <i>For aquatic invertebrate indicators</i>: requires initial specialist expertise to establish a baseline reference and identification keys; species may require identification to species level.</p> <p>b) Test feasibility of collecting data, particularly in relation to current staff time availability.</p>
Sampling	<p>ai) Done twice a month at regularly spaced intervals from stageboards positioned strategically throughout the Park.</p> <p>aii) <i>For salinity</i>. staff trained during pilot study. Sampling done at sample sites selected as strategic (junctions of canals, points of water input into the Park, etc.) and, for comparative reasons, at the same locations as chosen for doctoral study into water quality and macrophytes in the 1980s (Martínez 1988). Samples collected at 15 day intervals.</p> <p>aii) <i>For aquatic invertebrate indicators</i>: collections at each site at comparable seasons annually; macro-invertebrates identified, counted and released at the site of origin; some specimens of each species retained as reference and for specialist confirmation of identifications. Training of staff and development of straightforward replicable sampling techniques.</p> <p>b) At 15 day intervals.</p>
Sample analysis	<p>ai) Data stored on Park computer. Statistical analysis done by staff and members of the UIB Limnology Department.</p> <p>aii) <i>For salinity</i>. as ai).</p> <p>aii) <i>For aquatic invertebrate indicators</i>: for each sample site and survey a water quality score is determined and an average score per taxon (ASPT) calculated. Chemical data analysed using Analysis of Variance (ANOVA) and biological/chemical data comparison using Principal Components Analysis (PCA).</p> <p>b) Data stored at Park. Analysis done by Park staff.</p>
Reporting	<p>ai) Data statistically analysed and reported annually in the Park's annual report with conclusions and recommendations for management action and further monitoring.</p> <p>aii) <i>For salinity</i>, as ai).</p> <p>aii) <i>For aquatic invertebrate indicators</i>: data statistically analysed and reported annually in the Project's annual report and/or the S'Albufera Bulletin series, with conclusions and recommendations for management action and further monitoring.</p> <p>b) Data statistically analysed and reported annually in the Park's annual report with conclusions and recommendations for management action and further monitoring. Park handling of data allows immediate re-evaluation and management action if hypothesis is not being achieved.</p>

Table 7.2.4 Summary of key points of a monitoring programme for s'Albufera de Mallorca: Monitoring for water quality.

<i>General problem/issue</i>	<p>a) Water quality in the upper part of the Park is threatened by nitrate runoff from intensive agricultural land immediately west of the Park.</p> <p>b) Water quality in the south of the Park is threatened by organic material and phosphates discharged from tourist developments.</p>
<i>Specific problem/issue</i>	<p>a) Nitrate concentrations threaten eutrophication of water in the Park.</p> <p>b) Though a water purification plant exists south of the Park and treated water from it is discharged away from the aquifer, illegal untreated discharges may still occur.</p>
<i>Objective</i>	<p>a) Monitor water quality to assess nitrate loads entering Park.</p> <p>b) Monitor water quality to assess phosphate discharges into Park.</p>
<i>Hypothesis</i>	<p>a) Nitrogen concentrations at Park sample sites should not exceed 40 µg/l for any sample and mean nitrogen concentrations should not exceed half that level.</p> <p>b) Phosphate levels at Park sample sites should not exceed 4 µg/l for any sample.</p>
<i>Methods &amp; variables</i>	Collect water samples from sites used for water quality monitoring.
<i>Feasibility/cost effectiveness</i>	Expensive. Requires laboratory analysis and chemists' time and expertise. Only possible by cooperation with UIB (Depts. of Limnology, Vegetal Physiology, Analytical Chemistry).
<i>Pilot study</i>	Regular collections from key sample sites throughout the year to establish a baseline.
<i>Sampling</i>	Acceptable intervals for sampling determined by pilot study. Collection of samples possible by Park staff after training but direct transfer of samples to laboratory essential. Collection by UIB scientists and field assistants preferred.
<i>Sample analysis</i>	Data stored on Park computer. Statistical analysis done by staff and members of UIB Departments.
<i>Reporting</i>	Data statistically analysed and reported annually in the Park's annual report with conclusions and recommendations for management action and further monitoring (which may include revision of hypotheses to meet a requirement for lower mean levels than currently stated).

Table 7.2.5 Summary of key points of a monitoring programme for s'Albufera de Mallorca: Monitoring negative impacts of human activities.

<i>General problem/issue</i>	<p>a) Disturbance to wildlife is caused by illegal human activities.</p> <p>b) Large tourist complexes adjacent to the Park create impact on and disturbance to the Park vegetation and wildlife.</p>
<i>Specific problem/issue</i>	<p>a) Illegal fishing and hunting still occurs, though at much lower levels.</p> <p>b) Tourists using the beach and dune systems for recreation. create negative impacts through beach-head dune erosion, litter and accidental or intentional damage such as fires.</p>
<i>Objective</i>	<p>a) Monitor the levels of disturbance to wildlife through illegal human activities.</p> <p>b) Reduce negative impacts by tourists through regular surveillance; monitor level of beach-head dune erosion.</p>
<i>Hypothesis</i>	<p>a) Levels of illegal fishing and hunting should not exceed and continue to decline from levels recorded in 1993-95; numbers of waterbirds should not fall below mean counts established during pilot study.</p> <p>b) Surveillance, publicity and signs will reduce levels of litter and prevent fires; beach-head dune erosion will cease.</p>
<i>Methods &amp; variables</i>	<p>a) Control activities through permits and/or surveillance; record number and locations of incidents; count waterbirds using Park, by location.</p> <p>b) Regular staff patrols to control general disturbance; count numbers using the beach and dune systems and record their activities. Record dates and extent of "events" such as fires. Monitor beach-head erosion using photographic monitoring from fixed points.</p>
<i>Feasibility/cost effectiveness</i>	<p>a) Cost mainly staff time, comprising 3 full-time guards and one ornithologist.</p> <p>b) Main costs are staff time and materials. In summer, staff costs are at least one person daily. Beach-head erosion requires photo equipment and materials, photographic processing.</p>
<i>Pilot study</i>	<p>a) Check previous records for trends. Ensure methodology for waterbird counts clearly defined. Establish what frequency of night-time patrols effective as deterrent.</p> <p>b) Test feasibility of collecting data. Calculate minimum photographic requirements. Locate and accurately describe fixed points for photography. Make archive search for historic record of beach and dune systems, particularly beach-head profile and form.</p>
<i>Sampling</i>	<p>a) Control of activities through daily duties of guards, at least one night-time patrol per week. Waterbird counts monthly. Will be planned to coincide with national/international surveys.</p> <p>b) Photographic monitoring annually at same season initially to establish types and rates of erosion; may be reduced to longer intervals thereafter.</p>
<i>Sample analysis</i>	<p>a) Data stored at Park. Analysis done by Park staff.</p> <p>b) Data stored at Park and with Project scientists. Analysis done by</p>

	Park staff and Project scientists.
<i>Reporting</i>	<p>a) Data statistically analysed and reported annually in the Park's annual report with conclusions and recommendations for management action and further monitoring. Park handling of data allows immediate re-evaluation and management action if disturbance levels rise.</p> <p>b) Data analysed and reported annually in the Project's annual report and/or the S'Albufera Bulletin series, with conclusions and recommendations for management action and further monitoring.</p>

Table 7.2.6 Summary of key points of a monitoring programme for s'Albufera de Mallorca: Monitoring for climate change.

<i>General problem/issue</i>	Climate change may lead to large physical alterations to the wetland, leading to ecological change.
<i>Specific problem/issue</i>	A relatively small sea level rise would lead to invasion by the sea changing the wetland from mainly freshwater to saline lagoon and salt marsh; long-term meteorological changes may disrupt or alter the seasonal variations and climate conditions to which the ecosystem is adapted.
<i>Objective</i>	Monitor climate changes which may disrupt or alter the ecosystem.
<i>Hypothesis</i>	Mean sea levels should not exceed current mean sea levels by more than 0.5 m. Meteorological trends should fall within the levels of variation recorded for the area over the previous 25 year period.
<i>Methods &amp; variables</i>	Collect regular sea level data from the seaward part of the Gran Canal. Collect on-site data daily for sun, precipitation, minimum and maximum temperature, wind speed and direction. Augment these with data from the Instituto Español de Oceanografía, Palma (for Balearic sea level measurements) and Instituto Nacional de Meteorología, (for a fuller suite of meteorological data from Sa Canova - nearest station to S'Albufera).
<i>Feasibility/cost effectiveness</i>	On-site data requires staff time, one hour per day for meteorological data, one hour per week for sea levels. Collection of other data requires cooperation with the Institutes of Oceanography and Meteorology.
<i>Pilot study</i>	Consultation with Institutes to ensure that adequate data are being collected; and that access to that data will be allowed. Staff training in collection of data.
<i>Sampling</i>	On-site by staff. Other data by institutes. Institute information passed to Park monthly (Meteorological) and annually (sea levels). Park data made available to Institute of Meteorology each month.
<i>Sample analysis</i>	Off-site analysis done by Institutes. On-site data stored at Park and analysed by Park staff.
<i>Reporting</i>	Data statistically analysed and reported annually in the Park's annual report with conclusions and recommendations for management action and further monitoring.