

# MONITORING FOR ENVIRONMENTAL CHANGE

## THE EARTHWATCH EUROPE S'ALBUFERA PROJECT

A summary report of the eighth season's work, 1996

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**ANNEX 1**

**MedWet Guide to Monitoring Mediterranean Wetlands: the S'Albufera de Mallorca contribution** by Nick Riddiford and Joan Mayol Serra

*Editor's Note:* In 1995 and 1996, Project scientists and Park staff worked closely with MedWet, in the preparation of a methodological guide to monitoring Mediterranean wetlands, which appeared in June 1996 (Tomas Vives 1996). The guide was part of the work of the MedWet sub-project on Inventory and Monitoring in the Mediterranean, under the auspices of Wetlands International and the Portuguese government nature conservation institute, Instituto da Conservacao da Natureza (ICN). The guide advises on and demonstrates the steps to be taken in preparing and applying a well-planned monitoring programme. S'Albufera input included a paper outlining monitoring priorities at S'Albufera (Riddiford & Mayol 1996) and substantial advice and consultation for the entire guide, particularly

regarding practical matters. The paper, comprising Chapter 7.2 of the guide, is repeated below.

## **7.2 S'ALBUFERA DE MALLORCA, SPAIN**

### **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 conservation body ICONA, 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 (SPA) by the European Commission in September 1987. The Park is administered by the Nature Conservation Service (SECONA) of the Balearic Government's Department of Agriculture and Fisheries 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 Viçens, 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.

We have learnt that 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 have 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 1995) 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.

### **Expected 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.

We have 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.

CATEGORY	CORINE Code	Area (%)
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
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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*	1	2
Scientific staff*	1	4
Earthwatch volunteers*	4	8
Invited local volunteers*	1	2
Total team size	7	16
(Number of teams: 3)		
Total Earthwatch volunteers for project	12	24
<b>Field Expenses*</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.

Tables 7.2.3 to 7.2.6 Summary of key points for a monitoring programme addressing wetland ecological change at s'Albufera de Mallorca.

Table 7.2.3 Monitoring alterations to the water regime.

General problem	<p>a) Water is being taken from the aquifer for agricultural and urban uses, in and beyond the catchment area.</p> <p>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.</p>
Specific problem	<p>ai) Over-abstraction may lead to desiccation of parts of the marsh.</p> <p>aii) Abstraction of water lowers water table and leads to increased salinisation.</p> <p>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.</p>
Objective	<p>ai) Monitor water levels to evaluate the effects of water abstraction.</p> <p>aii) Monitor water quality for salinity; monitor aquatic invertebrate communities as indicators of water quality.</p> <p>b) Reinststate natural flow by sluices, natural revegetation of drains and create non-rectilinear channels, then monitor effects by measuring flow rates.</p>
Hypothesis	<p>ai) Mean water levels should not fall below the lowest mean water level recorded in the last five years.</p> <p>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.</p> <p>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.</p> <p>b) Water flow should be significantly reduced.</p>
Methods & variables	<p>ai) Record water levels from a series of stageboards.</p> <p>aii) <i>For salinity</i>: on-site measurements of conductivity (and pH, oxygen content and temperature of water).</p> <p>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.</p> <p>b) Measurements of water flow, using flow meter; keep record of when sluices opened and closed; record water levels from stageboards.</p>

Feasibility/cost effectiveness	<p>ai) Simple technique requiring two staff-days per month.</p> <p>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).</p> <p>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.</p> <p>b) Requires purchase of flow meter; staff time.</p>
Pilot study	<p>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 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 (Martinez 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>
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Table 7.2.4 Monitoring for water quality.

General problem	<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>
Specific problem	<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>
Objective	<p>a) Monitor water quality to assess nitrate loads entering Park.</p> <p>b) Monitor water quality to assess phosphate discharges into Park.</p>
Hypothesis	<p>a) Nitrogen concentrations at Park sample sites should not exceed 40 Fg/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 Fg/l for any sample.</p>
Methods & variables	Collect water samples from sites used for water quality monitoring.
Feasibility/cost effectiveness	Expensive. Requires laboratory analysis and chemists' time and expertise. Only possible by cooperation with UIB (Depts. of Limnology, Vegetal Physiology, Analytical Chemistry).
Pilot study	Regular collections from key sample sites throughout the year to establish a baseline.
Sampling	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.
Sample analysis	Data stored on Park computer. Statistical analysis done by staff and members of UIB Departments.
Reporting	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 Monitoring negative impacts of human activities.

General problem	<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>
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Specific problem	a) Illegal fishing and hunting still occurs, though at much lower levels. 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.
Objective	a) Monitor the levels of disturbance to wildlife through illegal human activities. b) Reduce negative impacts by tourists through regular surveillance; monitor level of beach-head dune erosion.
Hypothesis	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. b) Surveillance, publicity and signs will reduce levels of litter and prevent fires; beach-head dune erosion will cease.
Methods & variables	a) Control activities through permits and/or surveillance; record number and locations of incidents; count waterbirds using Park, by location. 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.
Feasibility/cost effectiveness	a) Cost mainly staff time, comprising 3 full-time guards and one ornithologist. 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.
Pilot study	a) Check previous records for trends. Ensure methodology for waterbird counts clearly defined. Establish what frequency of night-time patrols effective as deterrent. 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.

Sampling	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. b) Photographic monitoring annually at same season initially to establish types and rates of erosion; may be reduced to longer intervals thereafter.
Sample analysis	a) Data stored at Park. Analysis done by Park staff. b) Data stored at Park and with Project scientists. Analysis done by Park staff and Project scientists.
Reporting	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. 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.

Table 7.2.6 Monitoring for climate change.

General problem	Climate change may lead to large physical alterations to the wetland, leading to ecological change.
Specific problem	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.
Objective	Monitor climate changes which may disrupt or alter the ecosystem.
Hypothesis	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.
Methods & variables	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 Oceanográfico Español, 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).
Feasibility/cost effectiveness	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.
Pilot study	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.
Sampling	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.
Sample analysis	Off-site analysis done by Institutes. On-site data stored at Park and analysed by Park staff.
Reporting	Data statistically analysed and reported annually in the Park's annual report with conclusions and recommendations for management action and further monitoring.

## **MONITORING FOR ENVIRONMENTAL CHANGE**

### **THE EARTHWATCH EUROPE S'ALBUFERA PROJECT**

#### **1. INTRODUCTION**

This report summarises the eighth year of fieldwork for Earthwatch Europe's Project S'Albufera, carried out at the Parc Natural de S'Albufera, Mallorca by teams of ecologists and volunteer fieldworkers. Fieldwork involved Earthwatch and Balearic volunteers assisting and

working alongside specialist scientists for periods of two weeks at a time. In 1996, there were two spring teams and one in the autumn. For a second year, a further team was put into the field in August, implemented through Earthwatch Europe and sponsored by Glaxo Wellcome plc. As in previous years, a number of additional monitoring tasks were carried out by Park staff and resident Mallorcan volunteers outwith the designated Earthwatch Europe sponsored fieldwork periods.

Details of the establishment of the Project and choice of site were given in the first season's report (Newbould & Riddiford 1990) and its first seven years' progress in Newbould & Riddiford (1990), Riddiford & Newbould (1991), Riddiford (1991), Riddiford & Perring (1992), Riddiford (1993), Riddiford & Wells (1994), Riddiford (1995a) and Riddiford (1996).

The objectives of the Project were

- (a) To assemble full & detailed ecological data, including climate, hydrology, soils, pollution, past & present land uses & cultural influences and reconstruction of past conditions to reach an understanding of composition, functioning and dynamics of major ecosystem types.
- (b) To provide standardised comparative data for evidence of local, regional & global change, to be reconciled with aerial photography & space sensory data and to be re-recorded at intervals of time; to provide a model for other global monitoring stations.
- (c) To afford material for application in further research & reserve management at S'Albufera and in general conservation practice.
- (d) To provide resources for comprehensive interpretive programmes & dissemination in all appropriate forms.
- (e) To serve as a focus for education of residents & visitors of all age-groups & levels and to help in creating environmental awareness & commitment.

The 1996 spring teams comprised 4 scientists and 4 volunteers from 11th to 25th April, and 7 scientists and 7 volunteers from 28th April to 12th May. Four post-graduates representing the Wageningen Center for Environment and Climate Studies also participated with Team 2. The autumn team comprised 7 scientists and 9 volunteers from 22nd October to 5th November. The August team comprised 11 volunteers led by 4 scientists. The volunteer composition by country was 13 from the United Kingdom, 5 from Cameroon, 4 from the United States, 2 from the Czech Republic, one from Ireland, one from Uganda, one from Kenya, one from Equatorial Guinea, one from mainland Spain, one from Mallorca and one from Ibiza. The participation of a number of volunteers was assisted by sponsorship and awards: the eleven in August were recipients of Glaxo Wellcome Education Fellowships; the Czech volunteers received assistance from the British Council (Prague); the volunteers from Cameroon, Uganda, Kenya and Equatorial Guinea were recipients of Earthwatch Europe African Fellowship Awards, a scheme made possible by European Union sponsorship; and Barclays Bank sent one of their managers for team work and decision-making experience as part of an Earthwatch Europe pilot scheme. The Project science team was drawn mainly from the United Kingdom but included three from mainland Spain (two attached to the Wageningen

Center for Environment and Climate Studies, Holland), one from Mallorca and three from Holland (two attached to the Wageningen Center).

The presence of such international teams attracted international publicity. The activities of the spring teams were featured by the German TV company, Norddeutscher Rundfunk, and Team 1 members were involved in a live broadcast to Britain on the national BBC Radio 5 in April. Autumn group activities were filmed by Thames Television for the holiday feature programme "Wish You Were Here" to be broadcast on the ITV national network in the spring of 1997; and a series of interviews was done by team members for the local Alcudia TV public television service, which broadcasts in Mallorquin and English.

All teams were also afforded the support of, participation by or advice from: members of the Universitat de les Illes Balears (UIB) and the Institut d'Estudis Avançats de les Illes Balears; visiting scientists; members of the Park staff; and the Park's director, Sr. Joan Mayol. The overall responsibility for planning and supervision was assumed, as normal, by the Project's Principal Investigator, Nick Riddiford. Details of all participants are given in Appendix 1.

## **2. REVIEW OF PROJECT S'ALBUFERA FIELDWORK, 1994-96**

Each annual report has summarised the fieldwork for its particular year. However, it is often difficult to put the year's fieldwork into full context without recourse to former reports. Therefore, in a break with tradition, I have chosen to review 1996 fieldwork in conjunction with the previous two years, to demonstrate how it relates to and has developed from previous work and to portray its significance in relation to the Project's objectives. The establishment, objectives and first five years' work, 1989-93, of Earthwatch Europe's Project S'Albufera were described in the first issue of the Park Bulletin (Riddiford 1994a). This review summarises progress and development since then. Those aspects undertaken in 1996 are given in Section 3 of this report (Fields of Research in 1996).

The project was established to undertake long-term monitoring, and the monitoring work described previously (Riddiford 1994a) has continued. Both the monitoring work, and additional studies and programmes continued or initiated during 1994-1996, have been in response to the original objectives set in 1989 (and repeated in Riddiford 1994a). This has led to the following developments.

First objective: *to assemble full and detailed ecological data to reach an understanding of composition, functioning and dynamics of major ecosystem types.*

Examples of studies designed to achieve this objective were: a survey of the distribution of the Purple Gallinule *Porphyrio porphyrio*; mapping of the distribution and abundance of the alga *Enteromorpha*; a pilot study to assess the temporal and spatial occurrence of Aphids infesting reedbed plants; vegetation re-colonisation of an area of coastal sand dune destroyed by fire; observations of roosting Starlings in relation to habitat and to human and raptor disturbance; reedbed utilisation by small mammals; the composition of aquatic invertebrate communities in relation to water condition and quality. In 1995-96 studies were extended to August, to assess the situation at the period of highest temperatures and lowest water tables. The low water table and dry conditions make August a time of maximum stress for many S'Albufera plants and animals. The Project had not undertaken August fieldwork before, so

new information was collected on a number of topics including distribution and abundance of plants flowering in summer, and faunal records. One particular invertebrate goal was to record Odonata activity and occurrence, and in particular to investigate the continued survival of the rare dragonfly *Selysiotthemis nigra*, a threatened species for which S'Albufera has an international responsibility. It was pleasing to confirm its presence in suitable habitats. During the three year period a number of new records were gathered for flowering plants, bryophytes, fungi, moths and butterflies (Lepidoptera), grasshoppers and crickets (Orthoptera), beetles (Coleoptera), hoverflies (Diptera Syrphidae), lacewings and ant-lions (Neuroptera) and a range of aquatic invertebrates.

Second objective: *to provide standardised comparative data for evidence of local, regional and global change; and to provide a model for global monitoring stations.*

The data collected at S'Albufera have relevance for assessment of environmental change at the local level. But to assess change at regional, national and international levels, data must be compared with similar data from elsewhere. One example of how this is being done is demonstrated by the moth (Lepidoptera) light trap study. After six years of trapping, new moth species are still being discovered. More importantly, the phenological patterns and species composition trends are now becoming known. This information is useful and has the potential to reveal change. However, it is difficult to come to any conclusions regarding the nature of this change without having control sites for comparison. A first step was made to put this right in November 1995 when a visit was made and a portable battery operated trap loaned to the Albufera des Grau Natural Park in Menorca. The visit demonstrated that the wetland part of this site currently has a similar moth fauna to that at S'Albufera, Mallorca. It is hoped that co-operative studies between the two sites may be used to assess whether future changes in species occurrence or composition are the result of local or more universal factors.

The Project's aim to make its data useful internationally has also led to a number of developments. In 1994 a review was made of all the faunal and floral information for the Park and the result was presented to the World Conservation Monitoring Centre (Cambridge, England) as a first step towards establishing S'Albufera as a World Biodiversity Model site. Description of this model (entitled *Project S'Albufera: a biodiversity model in Mallorca*) has recently been published in the first volume of the review document *Biodiversity Assessment, A Guide to Good Practice* (Jermy *et al.* 1995).

Also at the international level, partnerships were formed with the Royal Holloway Institute for Environmental Research (RHIER), University of London, UK and with the Center for Environment and Climate Studies, Wageningen Agricultural University, Holland. Director of RHIER, Professor Ed Maltby, sent one of his team, Dr Chris Baker, to undertake a pilot study into soil nutrient dynamics in May 1995. Dr Dolf de Groot, director of the Center for Environment and Climate Studies, was persuaded by the information and facilities available to use S'Albufera as a model for his own field of study - the functions and values of environmental sites. This began in October 1995 with a pilot study into the functions and socio-economic values of natural ecosystems and protected areas, using S'Albufera as the model. This was expanded in 1996 by a team of five to include biodiversity studies, a GIS study of the functions of S'Albufera's wetland ecosystem as a tool for ecosystem valuation for land use planning, and the preparation of a short course on ecosystem valuation, including assignments, based on S'Albufera - to be used as a model internationally. To complete the list of co-operative ventures, Project scientists and Park staff worked closely with MedWet in both 1995 and 1996, in the preparation of a methodological guide to monitoring

Mediterranean wetlands, which appeared in June 1996 (Tomas Vives 1996). MedWet is a coordinated action programme for Mediterranean wetlands undertaken by a partnership comprising the government conservation bodies of five Mediterranean member countries of the European Union, the Ramsar Convention and a number of non-governmental organisations. The guide was part of the work of the MedWet sub-project on Inventory and Monitoring in the Mediterranean, under the auspices of Wetlands International and the Portuguese government nature conservation institute, Instituto da Conservacao da Natureza (ICN). The guide advises on and demonstrates the steps to be taken in preparing and applying a well-planned monitoring programme. S'Albufera input included a paper outlining monitoring priorities at S'Albufera (Riddiford & Mayol 1996) and substantial advice and consultation for the entire guide, particularly regarding practical matters. The participation of Project Principal Investigator, Nick Riddiford, extended to the role of scientific editor for the guide, which was planned and produced by Pere Tomas Vives of MedWet (formerly a Project participant and Park staff member).

Third objective: *to afford material for application in further research and reserve management and general conservation practice.*

Much of the information gained from study of the processes at work in the ecosystem has direct relevance to conservation management at S'Albufera, and more widely. Typical examples of Project studies which have been established to monitor the success of management, or to provide the information required by Park staff to assist or refine current management planning, are those designed to monitor the impact of grazing by domestic animals. These include co-ordinate mapping of the *Euphorbia terracina* population of Turo de ses Eres to monitor vegetation structure changes in a fossil dune habitat grazed by horses and other mammals; permanent quadrat and census studies of orchid population dynamics; and distribution mapping of key bird species and groups in relation to vegetation structure and management. In addition, the development of aquatic invertebrate studies has taken advantage of Park water chemistry monitoring data to begin assessment of invertebrate communities in relation to water quality. It is hoped that the aquatic invertebrate study will not only assist Park management planning but lead to an understanding of the relationship between communities and water quality, and the development of a methodology which can be adopted at other Mediterranean wetlands where chemical data are not directly available. The study also demonstrates the importance of water quality in maintaining and enhancing biodiversity in aquatic habitats generally.

The herbarium and insect reference collections are an increasingly useful resource, which grows with each period of fieldwork. This reference base has been extended by the establishment of an aquatic invertebrate collection and a bryophyte herbarium. Photographic reference is also used, and was boosted in 1995 by a series of Odonata photographs donated by a dragonfly specialist, who supplied records for early August, thus extending our Odonata baseline at that period.

Other studies, which have the dual purpose of monitoring change and collecting information for use in management planning, have been in response to a series of "events" whose impact has had a marked effect on the Park environment. The first event was a fire which, in April 1994, completely eliminated above ground vegetation within a 3.5 hectare area in the southernmost part of Es Comu coastal dunes. Study is being undertaken of the rate and types of vegetation re-population. This is being done by recording plant species and cover in a

series of randomly selected one-metre quadrats. The second event was an exceptional hailstorm in September 1995 which uprooted trees and flattened much of the reedbed. This gave unparalleled views across much of the marsh, and the opportunity was taken to census the Purple Gallinules *Porphyrio porphyrio* in order to assess their current status and dispersal following a successful re-introduction four years previously. The opportunity was also taken to make a full assessment of the impact of the storm on vegetation structure. Two further impacts came under scrutiny in 1996. The first comprised a survey and preliminary investigation into the health of the Park's white poplar *Populus alba* population, which is currently showing signs of severe stress. The second was in response to observations of heavy erosion of the Es Comu fore-dune where it meets the beach, with its consequent negative effects on pioneer vegetation and, more importantly, on the internationally significant population of *Juniperus oxycedrus macrocarpa* which is mainly confined to the leading edge of the dunes - where it is dominant and a major force in holding together the fixed dune. A study was put into place, comprising a combination of photographic monitoring, description of the condition and diversity of pioneer vegetation and assessment of the amount of dieback suffered by the fore-dune Juniper.

The most important development within objective three was the participation by Project S'Albufera in the consultation process for the Park's second management plan, covering the years 1997-2000. This was at the invitation of Conservation Director, Joan Mayol. The consultation process involved the entire Project S'Albufera scientific team and we were able to submit a series of comments and recommendations based on our observations, studies and results. We were already involved at an informal level, but we were very pleased to extend the level of integration and interchange of views by putting our comments on paper. It was gratifying to be able to apply our results to the planning of future Park management.

Fourth objective: *to provide resources for comprehensive interpretive programmes and dissemination in all appropriate forms.*

The Project continues to use its information base to develop and take part in interpretation initiatives. The most important during the three years was the participation in the preparation of a CD-ROM disk, undertaken by the University of the Balearic Islands and funded by the Balearic Education Department. The object of the work was to produce a CD-ROM which would interpret all aspects of the Park for Balearic schoolchildren through a combination of sound, pictures and text. Project S'Albufera involvement included preparation of texts for common or notable plants and invertebrates and provision of photographs to illustrate the chosen taxa. Project S'Albufera is also represented in the impressive S'Albufera Interpretation and Display Centre, contributing help with the preparation work and text for an illustrative summary of our work. In addition, Dinah McLennan continued with her preparation of thematic illustrations of major Park habitats, following the publication of her first (the freshwater marsh habitat) as a poster in 1994; and Jo Newbould collected further material for botanical interpretation.

Fifth objective: *to serve as a focus for education of residents and visitors of all age groups and levels and to help in creating environmental awareness.*

The Project continued its policy of sponsoring young Balearic and Spanish scientists, conservationists and environmentalists to participate as a volunteers in the Project. This policy is considered a key part of the programme, acting as a training school in field techniques and ensuring local involvement, awareness and knowledge of both the Project and conservation issues generally. Environmental awareness and education were also achieved through the interpretation initiatives described above.

Through the Project, the Park has now become a focus for education at a much wider level. The project has always attracted volunteers from throughout the World - including, for example from New Zealand, the Czech Republic, the United States and several African states in the last three years. This has been extended to include sponsored fieldwork experience and training courses. One such development from 1995 involves British teachers who are recipients of Glaxo Wellcome Education Awards, sponsored by Glaxo Wellcome plc. One of the most important developments in the three years, and one which recognises the scope of the Project and the role it can play in acting as a model for other sites and areas of the World, was the introduction in 1995 of an African Fellows scheme. The African Fellowship programme was established by Earthwatch Europe and sponsored by the European Commission and the Darwin initiative of the UK government. This form of volunteer participation is extremely worthwhile because it integrates the ecological research with the training and education aspects of the Project. The African Fellows are all highly motivated, skilled ecologists, who come with a desire to learn as much as they can about conservation and environment issues. They have all commented on the value and success of this integrated training programme. The programme has even greater benefits because of the co-operation and support of the Park directorate and Balearic government departments, who have provided additional material, consultation and information. This gives the Fellows the opportunity to gain an insight into conservation and the environment in the Mallorcan, Balearic and national context as well as allowing them to place their experience of Project S' Albufera work and activities in a wider perspective. Course members so far have been drawn from Cameroon (6), Kenya, Uganda and Equatorial Guinea. The training programmes are set to continue in 1997.

### Concluding remarks

Project S'Albufera continues to address all its objectives, thanks to the dedication and enthusiasm of its scientific team and volunteers. Local involvement is an essential factor in the success of the Project, and the Project scientists thank all our many Balearic friends for their support and help. This especially applies to the Balearic Conservation Service, the Park directorate and staff who have been enormously supportive throughout.

It was fitting recognition for the first six years' work that the Project was invited to provide practical advice for MedWet's methodological guide to monitoring Mediterranean wetlands and gratifying that Project scientists were able to work together with the Park directorate and staff to prepare that advice. The Parc Natural de S'Albufera has become an international focus in the fields of monitoring and biodiversity studies. This is amply demonstrated by co-operative ventures with European research institutes (Wageningen Center for Environment and Climate Studies; Royal Holloway Institute for Environmental Research); and by the application of Project research to training programmes - most particularly in the

training of African conservationists. The Project science team is working together with the Park directorate and staff to maintain and further develop this international facet of our work.

The work of Project S'Albufera, its role as a resource for the wise management of a rich natural protected area, and the co-operation and support received by the Balearic Conservation Service and Park staff have created a model for protected sites world-wide. This was summed up by a 1995 African Fellow from Cameroon who wrote "It was noteworthy that S'Albufera staff carries out ecological research on a regular basis, results of which Earthwatch Project S'Albufera uses to complement her more methodic and standard but periodic researches. I greatly appreciated the harmonious working of this system and think I should investigate into ways we can adapt it to our own purposes here in Cameroon" (Monya 1995).

### **3. FIELDS OF RESEARCH IN 1996**

The following is a summary, by category, of research studies by Earthwatch Europe's Project S'Albufera in 1996 (and see Appendix 2 for more details).

#### **Ecosystem studies**

**Vegetation repopulation after fire.** For the second consecutive year EarthCorps teams monitored the re-population by vegetation of an area of Es Comú coastal dunes destroyed by fire in 1994. It was carried out by identifying plant species, vegetation cover and proportions of bare ground in a series of one-metre quadrats during the months of April and May. To obtain information about the pre-fire vegetation structure, matching series of data were also collected from an adjacent, undamaged control site. The methodology and a summary of the first season's results are presented in Annex 3 of Riddiford (1996).

**Water quality and aquatic invertebrate communities.** EarthCorps volunteers under the leadership of Michelle Chapman continued to develop the study begun in 1995 of aquatic invertebrate communities in relation to water quality, using standard sampling techniques and combining Park water chemistry data. A report of 1996 fieldwork is presented in Annex 3 of this report; and the methodology and first season's results are presented in Annex 9 of Riddiford (1996). Details of previous aquatic invertebrate work are given in Riddiford (1993) and Riddiford & Wells (1994).

**Water quality and aquatic vegetation.** A pilot study was undertaken in spring and in August to assess whether key plant species could be used as indicators of water quality. The two species chosen were the reedmace *Typha*, considered to be a good indicator of nitrate enrichment due to nutrients entering the Park from agricultural land; and the alga *Enteromorpha*, associated with phosphate enrichment derived from urban sources. A description of the *Enteromorpha* part of the pilot study is given in Annex 5 of this report.

**Egret activities.** A pilot study was launched in 1996 into the behaviour, activities and distribution of Egrets. The study, which was devised and led by Dr Nick Owens, aimed to assess the potential of egrets as indicators of a range of ecosystem features, including

preferences in relation to water quality, vegetation structure, and habitat determined by grazing and other management activities. The methodology and results of the pilot study are described in Annex 4 of this report.

**Reedbed aphids.** Work continued in autumn 1996 to develop a methodology for assessing temporal and spatial variations in aphid populations. The results of a 1995 pilot study are described in Annex 2 of Riddiford (1996).

**Reedbed utilisation by small mammals.** Rob Strachan continued his investigation into the utilisation of habitats, populations and inter-specific relationships for three species of mouse at S'Albufera, again concentrating on their distribution, numbers and diurnal activities in August, at the end of a period of low rainfall and water levels. Results of his previous study are given in Annex 12 of Riddiford & Wells (1994).

**Reedbed utilisation by roosting birds.** Further information was gathered in autumn 1996 of birds roosting in the S'Albufera reedbeds. The 1996 work concentrated on Starling *Sturnus vulgaris* activities and interactions between this species and potential predators. Notes were also gathered on roosting activities of Corn Bunting *Miliaria calandra* and Marsh Harrier *Circus aeruginosus*. The results of this study are presented in Annex 10 of this report.

### **Impact studies**

**Coastal dune erosion.** A new study was launched in 1996 in response to concerns about the extent of erosion along the coastal fore-dune/beach-head interface, and the consequent damage to the coastal pioneer plant communities and the important *Juniperus oxycedrus macrocarpa* population. A photographic monitoring programme was set up, the distribution, abundance and species composition of pioneer vegetation recorded and the extent of dieback among the coastal band of Juniper measured.

**White poplar *Populus alba* investigation.** At the request of the Park authorities, and in response to perceived ill-health among trees within the Park, a survey and preliminary investigation of the condition of the Park's white poplar *Populus alba* population was conducted by spring and August fieldwork teams. The results of this investigation are presented in Annex 2 of this report.

### **Biodiversity studies**

**Species inventories.** The S'Albufera biodiversity database continues to expand. Additions in 1996 were made for a range of biota, including flowering plants, fungi, bryophytes, a number of insect groups and other invertebrates. Development continued of methodologies aimed at extending inventories to include data on distribution and abundance. Development in 1996 included a pilot study of the distribution and abundance of Odonata and butterflies. The results of this pilot study are presented in Annex 8 of this report.

**Bryophytes.** The British Bryophyte Society's conservation officer, Rod Stern, returned in spring to extend our knowledge of the bryophyte flora of the Park. The results of his 1996 survey is presented in Annex 6 of this report. Previous bryophyte studies are given in Riddiford (1995a) and by Rossello (1994).

**Odonata.** A review paper, incorporating historical records as well as data from Project S'Albufera biodiversity files was prepared in autumn 1996 for publication in the *Buttleti del Parc*. An English version of this paper is presented in Annex 7 of this report.

**Reference materials.** The well-established herbarium of flowering plants was maintained and further additions made. The reference collections of insect groups also continued to grow. EarthCorps volunteers helped reorganise and re-label the Lepidoptera material in 1996 to make the reference more "user-friendly". Following the work of Rod Stern in 1995 and 1996, a substantial working collection of bryophyte specimens has been established and extended at the Park. A working reference collection of aquatic invertebrates is also held on site to assist with the aquatic invertebrates and water quality study.

**Data management.** Work continued to develop and use the model for biodiversity data collection and management outlined in Riddiford (1995a). Description of this model recently been published in the review document Biodiversity Assessment, A Guide to Good Practice (Jermy *et al.* 1995). The guide presented it as an illustration of a model already being applied in the field.

For further details of the structure and other aspects of the S'Albufera biodiversity database and the development of data management systems see Annex 14 of Riddiford & Wells (1994) and Annexes 4 to 7 of Riddiford (1995a).

### **Monitoring studies**

**Birds.** Two bird transects, conducted annually since 1989 and 1990 respectively, were repeated in 1996 during the spring and autumn fieldwork periods. The transects have been designed to obtain temporal and longer-term fluctuations of breeding and migrant birds in a range of habitats. For details of the bird transect methodology see Riddiford & Perring (1992).

EarthCorps volunteers helped gather further information in spring on the body condition of birds using S'Albufera when weight, adipose fat and muscle condition data were collected from a sample of birds trapped at Es Colombar as part of the Mediterranean Islands *Piccole Isole* ringing project.

In autumn, the distribution and numbers of Purple Gallinules *Porphyrio porphyrio* at S'Albufera were surveyed for the second consecutive year. The main objective was to investigate the range of dispersal and colonisation from the points of reintroduction five years earlier. The results of the survey are presented in Annex 9 of this report. For a description of the methodology and results of the initial, 1995, survey, see Annex 1 of Riddiford (1996).

**Mammals.** A mammal transect, established in 1991, and reactivated in 1995 in response to a new development, the arrival from the mainland of a virus which attacks and kills rabbits *Oryctogalus cuniculus*, was conducted regularly during all fieldwork periods in 1996. The transect records all mammals (including humans because of their negative effect on the occurrence of other mammals) but the species of key interest is the rabbit. It is hoped that a run of data will determine whether population changes are occurring in the wake of this virus. Observational data were also collected for this and a range of other species. Rob Strachan's

investigation into the utilisation of habitats, populations and inter-specific relationships for three species of mouse at S'Albufera is described in Ecosystem studies above.

**Butterflies.** Two transects designed to monitor butterfly habitat preferences and population variations, the first established in 1989 and the second in 1991 and both repeated annually thereafter, were conducted regularly in 1996 during all the fieldwork periods. For further details of butterfly transects, including methodologies, see Riddiford & Perring (1992).

**Moths and other insects attracted to light.** Standard insect light traps were used on most nights during fieldwork periods in 1996. In addition, a MedWet technical meeting at S'Albufera in January, attended by several members of the Project team, allowed a trap to be operated for the first time in mid winter, thus extending the sampling period and our knowledge of seasonal changes in the moth community structure. The community structure is now well known in spring and autumn, at least for those species attracted to light, but new species continue to be encountered. A second season of trapping in August was again valuable in augmenting our knowledge for the late summer period. As usual a number of interesting species from other insect groups were trapped during the year. Marga Oifila Pous, biologist at the Parc Natural S'Albufera des Grau, Menorca, visited the Project in November to receive training in light trapping techniques as part of the joint venture between the two Parks to use moths as indicators of environmental change.

**Hydrology and hydrochemistry.** The Park continued to collect water regime and water chemistry data throughout the year from sample sites throughout the Park. The suite of information continues to grow and is an increasingly important resource for setting against a range of Project monitoring and ecosystem studies. Water chemistry analysis is undertaken by Park staff in partnership with members of the Department of Limnology at the University of the Balearic Islands (UIB). The link between the University and Park was further strengthened in 1996 with the appointment of the Park's technical assistant Biel Perelló to Hydrology Demonstrator, attached to the UIB Department of Geography. The sampling technique and equipment used to obtain water quality measurements are described in Annex 3 of Riddiford (1995a).

**Meteorology.** As in all previous years, meteorological data were collected daily by Park staff and made available to the Project and its scientific team.

### **Park management**

**Orchis palustris population.** Monitoring of the marshland orchid *Orchis (laxiflora) palustris*, undertaken annually by EarthCorps volunteers, again took the form of counting and mapping flowering plants in early May. There were some considerable changes in distribution and abundance in 1996, most notably an increase in the population in a grazed area near the western perimeter of the Park. Information was gathered on patterns of grazing and other management activities to assess their impact on *Orchis palustris* population dynamics.

**Fossil dunes.** Further monitoring was undertaken by EarthCorps teams under the direction of Jo Newbould in the spring. The aim of the study is to obtain information about the impact of grazing by horses on the dune vegetation at Turo de Ses Eres, with particular reference to the distribution and development of the *Euphorbia terracina* population, a potential shade

species apparently unpalatable to grazing animals. Details of methods used were reported in Annex 3 of Riddiford & Wells (1994).

**Coastal dunes.** A study of vegetation repopulation in the coastal dunes after fire is described under Ecosystem studies above. For further details of dune studies, see also Wood (1991), Riddiford & Newbould (1991), Riddiford & Perring (1992) and Riddiford (1993).

**Barn Owl boxes.** Following Project scientists' recommendations to the second Park Management Plan that consideration be given to installing artificial nest-sites to encourage the local Barn Owl *Tyto alba* population, the autumn team - led enthusiastically by EarthCorps volunteer Stephen White - constructed two Owl boxes which were erected at suitable sites within the Park.

### **Interpretation and education**

**Botanical interpretation material .** EarthCorps teams assisted Dinah McLennan and Jo Newbould in collecting information with the long-term goal of providing botanical interpretation material. Work for Dinah in 1996 concentrated on the distribution, seasonal appearance and identification of key plant species to be included in a saltmarsh water-colour poster representation whose preparation is at an advanced stage. Jo and Dinah also continued to collect information about the distribution and flowering periods of plants for their S'Albufera flower guide for Park visitors, currently in preparation.

For further details of interpretative work, see Annex 16 and Annex 17 of Riddiford & Wells (1994).

### **Programme development**

**Monitoring at the international level.** In 1995 and early 1996 the Project S'Albufera team undertook a pilot study on behalf of Wetlands International, in partnership with the Park directorate and staff. The study comprised the application of a wetlands monitoring methodology developed by the MedWet sub-project on Inventory and Monitoring in the Mediterranean. The results were destined to appear in a methodological guide to monitoring Mediterranean wetlands, which appeared in June 1996 (Tomas Vives 1996). As mentioned in Section 2 above, S'Albufera input was substantial. The guide received the benefit of advice from the Project team and Park staff, a paper outlining monitoring priorities at S'Albufera (Riddiford & Mayol 1996) and the participation of Project Principal Investigator, Nick Riddiford, as scientific editor to the guide. MedWet is a coordinated action programme for Mediterranean wetlands undertaken by a partnership comprising the government conservation bodies of five Mediterranean member countries of the European Union, the Ramsar Convention and a number of non-governmental organisations. The guide was part of the work of the MedWet sub-project on Inventory and Monitoring in the Mediterranean, under the auspices of Wetlands International and the Portuguese government nature conservation institute, Instituto da Conservacao da Natureza (ICN). The publication now stands as the definitive guide for managers of wetland sites throughout the Mediterranean and has been designed as a practical aid to the steps to be taken in preparing and applying a well-planned monitoring programme.

**Functions and values.** Following the 1995 pilot study assessment of functions and socio-economic values of natural ecosystems and protected areas by research scientist Macarena Mata and the Center for Environment and Climate Studies, Wageningen Agricultural University, using S'Albufera as a model, the Center continued development of the study in 1996. As part of this development the Center sent four research scientists or post-graduate students to join us in spring 1996. Their work consisted of original research and archive study of the Park and Project information banks, in which members of the EarthCorps team were able to assist. The development of the study included a GIS study of the functions of S'Albufera's wetland ecosystem as a tool for ecosystem valuation for land use planning, and the preparation of a short course on ecosystem valuation, including assignments, based on S'Albufera - but to be used as a model internationally. In addition to the spring participants, two further students worked on aspects of the model subsequently, incorporating in their research Project and Park information on aspects of biodiversity and water quality. A description of the pilot study is presented in Annex 7 of Riddiford (1996).

For further details of fieldwork studies undertaken by the Project, see Wood (1989, 1991), Newbould & Riddiford (1990), Riddiford & Newbould (1991), Riddiford & Perring (1992), Riddiford (1993), Riddiford & Wells (1994) and Riddiford (1995a, 1996).

#### **4. ADDITIONAL STUDIES**

In 1996, Project S'Albufera had teams in the field in April, May, August, October and November. A small scientific team also visited in January. Despite the frequency of visits, Project teams are not able to collect data year-round and this inevitably leads to gaps in the information needed to fully interpret some of the fieldwork results. Fortunately, these gaps are plugged by Park staff, to whom we are again grateful for collecting data throughout the year and making these available to us in a number of fields, most notably ornithological, meteorological, hydrological and in aspects of Park management. The same applies to members of the University of the Balearic Islands and Balearic Institute of Advanced Studies, particularly in the spheres of hydrology, limnology and entomology. Park staff undertook monitoring of the Park's management throughout the year.

One major milestone has occurred - the publication of the monograph *S'Albufera de Mallorca* (Martinez Taberner & Mayol Serra 1995). This publication, which appeared too late to be mentioned in the 1995 Project S'Albufera Report, was the culmination of several years' work by the editors, Toni Martinez and Joan Mayol, to bring together a detailed summary of the current state of knowledge about the site. The result was a series of scientific articles by scientists and environmentalists actively researching aspects of the Park. These researchers included Park staff, Institute and University scientists, local naturalists and, of course, members of the Project S'Albufera scientific team. Project S'Albufera contributions included chapters on the Park's botanical importance (Goldsmith 1995), productivity studies of the marshland plants *Phragmites* and *Cladium* (Newbould 1995), invertebrate studies within the Park (Riddiford, McKelvey & Bowey 1995) and a survey and recommendations

for the conservation of the Park's bats (Noblet 1995). Elements derived from Project S'Albufera fieldwork and data also contributed to other chapters. In addition to those already mentioned, the subjects of articles included in the monograph are: the historical derivation and significance of S'Albufera place names (Lillo 1995); a biography of the English engineer, John Frederic Latrobe Bateman, who had such a profound influence on the current character of the wetland (Picornell & Ginard 1995); the geological setting, structural evolution and sedimentology of S'Albufera (Fornos 1995); the fungi of S'Albufera (Siquier, Lillo, Constantino & Perez-de-Gregorio 1995); new and notable botanical records (Alomar 1995); the submerged aquatic vegetation of S'Albufera (Martinez-Taberner, Moya, Forteza, Rita & Pericas 1995); the rotifers of S'Albufera waterbodies (De Manuel 1995); a check-list of crustaceans inhabiting the marshes and lagoons of S'Albufera (Jaume 1995); new and notable fish species for S'Albufera (Riera & Grau 1995); the birds of S'Albufera in relation to Park management (Mayol 1995); the reintroduction of Purple Gallinule *Porphyrio porphyrio*, Red-crested Pochard *Netta rufina* and White-headed Duck *Oxyura leucocephala* (Mayol & Vicens 1995); the lotic environment of S'Albufera (Martinez-Taberner, Moya, Forteza & Ramon 1995); the lentic environment of S'Albufera (Martinez-Taberner, Moya, Forteza & Ramon 1995); the functioning and planktonic communities of the Estany des Cibollar (March, Moya, Quetgles & Reviriego 1995); and finally a management paper assessing the rehabilitation of the aquatic environment in S'Albufera (Martinez-Taberner, Mayol & Ruiz-Perez 1995). The monograph is a fine example of scientific expertise being assembled to produce an masterful overview of the physical, historical and ecological knowledge gained to date about S'Albufera de Mallorca.

Research studies and monitoring carried out by Park staff and independent institutes in partnership with, or assisted by, Project S'Albufera teams are detailed in sections 2 and 3 above.

## **5. PROGRESS AND FUTURE PLANNING**

The summaries of individual studies and fieldwork outlined above clearly demonstrate the continued excellent progress of Project S'Albufera. A further extensive programme of fieldwork is planned for 1997, which will include another Earthwatch Europe Glaxo Wellcome Education team in August. Efforts are being made to attract extra funding, but the Project is kept afloat by the support of Earthwatch and Earthwatch Europe in the form of a steady flow of enthusiastic EarthCorps volunteers and associated sponsorship which has long been the mainstay of the Project. We have other friends and supporters, too, who will be maintaining an interest and involvement in 1997. This is particularly the case for the Wageningen Center for Environment and Climate Studies whose director, Dr Dolf de Groot, continues to identify subjects and researchers to build on the Center's study of functioning and values of the natural environment using S'Albufera as a model. The Project also continues to benefit from the interest and support of the Royal Holloway Institute for Environmental Research, and its director Professor Ed Maltby - links having been strengthened by the RHIER research associate status awarded to Principal Investigator, Nick Riddiford.

Sponsorship by Glaxo Wellcome plc, continues for a third year. This sponsorship takes the form of awards to teachers, under the Glaxo Education scheme, allowing them to attend as volunteer members of a "Glaxo Teachers team", in August. Funding from this source also allowed further important equipment to be obtained, in the guise of Global Positioning System retrievers, to assist with identifying locations and coordinates during distribution studies. The computer purchased from this source in 1995 has also been a real boon.

EarthCorps volunteers have played a key role in loading Project data and material on to the computer 's databases over the last year.

We have Earthwatch Europe to thank for arranging the Glaxo Wellcome sponsorship; and also for an African Fellowship programme sponsored by the European Commission and the Darwin Initiative of the UK government, which we hope will go ahead for a third year in 1997. Finally, Earthwatch Europe and the British Council combined to bring EarthCorps volunteers from the Czech Republic in 1996, and we hope that this opportunity can be extended to other east Europeans in the future.

Finally, I am delighted to report that a start has been made on the European Universities House (*Casa de las Universidades Europeas*). This dedicated on-site research block, currently under construction alongside the *Casa del Parc* headquarters, will include a field laboratory, library and archives and good accommodation for visiting scientists working on the project. Its construction will ensure an enormous improvement to working conditions and living facilities for Project teams and staff alike, as well as encouraging future research by providing scientists with an attractive, well-appointed base. The Spanish and Balearic authorities are to be congratulated for their initiative in financing this venture, which can only benefit and enhance this outstanding and widely used international research area.

Details of the 1997 Project S'Albufera programme are given in Appendix 3.

## **6. ACKNOWLEDGEMENTS**

So many people and organisations have supported and encouraged Project S'Albufera, that it becomes difficult (and lengthy) to thank them all individually. Let me say, therefore, that I am extremely grateful to all the following friends and supporters - without you the Project would not have continued or prospered. Thank you, then, to Joan Mayol, Conservation Director of the Balearic Conselleria de Medi Ambient; to the Conselleria's Minister, Director General and administration; Biel Perelló and all the staff of P.N. S'Albufera; Pat and Dennis Bishop (local friends and supporters); Pere Tomàs-Vives (MedWet); all members of the Project S'Albufera scientific team; Earthwatch and Earthwatch Europe staff; the sponsoring organisations of Glaxo Wellcome plc, Barclays Bank, the European Union, the Darwin Initiative, and the British Council (Prague); Professor Ed Maltby and the Royal Holloway Institute for Environmental Research; Dr Dolf de Groot and his team from the Center for Environment and Climate Studies, Wageningen; Wetlands International through Pere Tomàs and the MedWet project; scientists from several departments of the University of the Balearic Islands, especially Toni Martínez and Hipólito Medrano, and the Balearic Institute for Advanced Studies, especially Enrique Descals; our Mallorcan supporters, the Bonner family, the Friends of S'Albufera, Bernat Bergas, Nicole Smith, Marga Roig and many other individuals; and the Project's special scientific advisors on identification issues, Barry Goater, Rod Stern, Chris Haes and Colin Plant. They all deserve a huge vote of thanks for their help in so many ways. But my final and biggest thanks go to the wonderful band of EarthCorps volunteers, without whose quality and enthusiasm the Project would be nothing.

To everyone above, and advisors, helpers and supporters inadvertently omitted or overlooked, I give my sincerest thanks; which is extended to all participants in, and visitors to, the Project detailed in Appendix 1 below.

## **APPENDIX 1 - List of Participants, 1996**

### **Principal Investigator**

Nick Riddiford

### **Parc Natural de S'Albufera Advisor to Project**

Joan Mayol (Director of Balearic Natural Areas)

### **Parc Natural de S'Albufera Liaison Officer to Project**

Biel Perelló (Conselleria d'Agricultura I Pesca, Estructures Agraries I Medi Natural)

### **Cook**

Margalida Moranta

## **Team I (11th-25th April)**

### *Scientists*

Nick Riddiford (PI), Elizabeth Riddiford (ecological studies), Nik Ward (ornithological studies), Jen Minors (logistics)

### *Volunteers*

Myslibor Chalupa (Czech Republic), Ginny Church (USA) and the Earthwatch European Union sponsored African Fellows: Achilles Byaruhanga (Uganda) and Erustus Mutembei Kanga (Kenya)

## **Team II (28th April-12th May)**

### *Scientists*

Nick Riddiford (PI), Jo Newbould (plant studies, botanical interpretation), Dinah McLennan (plant studies, botanical interpretation/illustrations), Michelle Chapman (aquatic invertebrates and water quality), Rod Stern (bryophytes), María Zas Arregui (logistics; vegetation studies), Gill Barker (logistics) and the Wageningen Center for Environment and Climate Studies (Holland) post-graduate research team: Sas Terpstra, María del Carmen Rodríguez Suárez, Anne Schmidt, Macarena Mata Porras (natural functions and values studies)

### *Volunteers*

Roman Rohacek (Czech Republic), Elisabeth C. Meeker (USA), Patxi Martínez Betanzos (Spain) and the Earthwatch European Union sponsored African Fellows: Enanga Molombe Mary, Ngnegueu Paul Robinson, Mkeng Philip Junji (Cameroon) and Jesús Mba Mba Ayetebe (Equatorial Guinea)

## **Team III (26th October-9th November)**

### *Scientists*

Nick Riddiford (PI), Chris Donnelly (biodiversity studies), Mike Wood (biodiversity studies), Nick Owens (ornithological studies), Ed Cross (aquatic invertebrates and water quality), Petra Slangen (aquatic invertebrates and water quality), Margalida Roig Ramis (logistics)

### *Volunteers*

Grainne Maher (Ireland), Maureen White, Stephen White (USA), Liz Moynihan, Fergus Moynihan (UK), Lina Torres Costa (Ibiza), Ramón Mas Reinders (Mallorca) and the Earthwatch European Union sponsored African Fellows: Nkwanyuo Victor Mbai and Chiabi Lawrence Nsom (Cameroon)

## **Glaxo-Wellcome Education Team (15th-29th August)**

### *Scientists*

Nick Riddiford (PI), Jen Minors (logistics), Michelle Chapman (aquatic invertebrates), Rob Strachan (small mammals)

### *Volunteers*

Paul Lupton, Barbara Patilla, Susan Rice-Oxley, Mairéad Devery, Ianthe Pickles, Bob Collins, Brian K Jordan, Liz Donoghue, Diana Turner, Jane Nicholson, Sue Pull

## **Additional scientist and volunteer contributions**

Louis-Julien de la Bouère (visiting student studying conservation management, France: 15th July to 15th September)

### **Identification advisors in UK**

Barry Goater (Lepidoptera: moths)

E. C. M. (Chris) Haes (Orthoptera/Dictyoptera/Dermaptera: crickets & grasshoppers/mantids & cockroaches/earwigs)

Colin Plant (Neuroptera: lacewings)

Rod Stern (Bryophytes)

### **Visitors to the Project**

Max Nicholson (25th April to 3rd May)

Simon Martyn (Director of Earthwatch Europe, 27th April to 1st May)

Professor Marius G W Hummelinck, WWF Holland (May)

Marga Oifila Pous (Biologist, Parc Natural S'Albufera des Grau, Menorca, November)

Antoni Martínez Taberner, (Dept. Biologia, Univ. Illes Balears)

Pat & Dennis Bishop (Friends of S'Albufera)

Prof. Dr. Bruno Bruderer (Swiss Ornithological Institute, Sempach, Switzerland, August)

Leslie Bonnard, Vera Aerni (Swiss Ornithological Institute researchers studying nocturnal bird migration: 7th August to 15th September)

Representatives of Friends of S'Albufera and the Grupo ornitológico Balears

### **Participants, MedWet Technical Meeting on Monitoring, S'Albufera, 7-10 January 1996**

Patrick Grillas (Station Biologique de la Tour du Valat, France)

Barrie Goldsmith (University College London, UK)

Antonis Mantzavelas (Lake Kerkini pilot study, Greece)

Nick Riddiford (S'Albufera pilot study, Mallorca, Spain)

Joan Mayol I Serra (S'Albufera pilot study)

Gabriel Perelló I Coll (S'Albufera pilot study)

Aura Penloup (Etang de l'Or test site, France)

Sergio Romero (Aiguamolls de l'Empordà test site, France)

Antoni Martínez (Laboratori d'Ecologia, Dept. de Biologia Ambiental, Univ. de les Illes Balears)

Rui Rufino (Sado Estuary pilot study, Portugal)

Nathalie Hecker (MedWet Project-Wetlands International, France)

Pere Tomàs Vives (MedWet Project-Wetlands International, Mallorca)

Chris Donnelly (Earthwatch Europe Project S'Albufera)

Mike Wood (Earthwatch Europe Project S'Albufera)

### **Staff, Parc Natural de S'Albufera**

Joan Mayol - Director of Conservation  
Gabriel J. Perelló - Technical Assistant  
Francesc Lillo - Chief Warden  
Alexandre Forteza - Reception Centre  
Pilar Lacalle - Reception Centre  
Pere Viçens - Ornithologist  
Jaume Gamundí - Guard  
Martí Solivelles - Guard  
Manuel Coello - Maintenance  
Viçens Lillo - Maintenance  
Carlos Martínez - Monitor  
Gabriel Payeras - Monitor  
Margalida Moranta - Cook

*Seconded to Park on non-military national service*

Matias Rebassa Beltran  
Ramón Mas Reinders  
Miquel Torrens Escalas

## **APPENDIX 2 - 1996 Fields of Research**

The following is a catalogue of information collected in 1996. This information, along with 1989-95 material, has been deposited at Earthwatch Europe's Oxford (UK) headquarters. A second set of the material is held at S'Albufera Natural Park. Details of published material are given in Appendix 4.

**Category:** Ecosystem studies

**Title of Work Done:**

Vegetation repopulation after fire.

**Catalogue Reference Number:** 96/10

**Category:** Ecosystem studies

**Title of Work Done:**

Water quality and aquatic invertebrate communities.

**Catalogue Reference Number:** 96/12

**Category:** Ecosystem studies

**Title of Work Done:**

Water quality and aquatic vegetation -*Typha* distribution.

**Catalogue Reference Number:** 96/5

**Category:** Ecosystem studies

**Title of Work Done:**

Water quality and aquatic vegetation - *Enteromorpha* distribution.

**Catalogue Reference Number:** 96/21

**Category:** Ecosystem studies

**Title of Work Done:**

Egret activities.

**Catalogue Reference Number:** 96/18

**Category:** Ecosystem studies

**Title of Work Done:**

Reedbed aphids.

**Catalogue Reference Number:** 96/17

**Category:** Ecosystem studies

**Title of Work Done:**

Reedbed utilisation by small mammals.

**Catalogue Reference Number:** 96/16

**Category:** Ecosystem studies

**Title of Work Done:**

Reedbed utilisation by roosting birds.

**Catalogue Reference Number:** Not allocated - raw data with scientist (Nick Owens)

**Category:** Impact studies

**Title of Work Done:**

Coastal dune erosion.

**Catalogue Reference Number:** 96/14

**Category:** Impact studies

**Title of Work Done:**

White poplar *Populus alba* investigation.

**Catalogue Reference Number:** 96/6

**Category:** Biodiversity studies

**Title of Work Done:**

Species inventories.

Faunal records.

**Catalogue Reference Number:** 96/15

**Category:** Biodiversity studies

**Title of Work Done:**

Distribution of birds in relation to habitat.

**Catalogue Reference Number:** 96/19

**Category:** Biodiversity studies

**Title of Work Done:**

Butterflies and dragonflies.

**Catalogue Reference Number:** 96/20

**Category:** Monitoring studies

**Title of Work Done:**

Bird population surveys: transects 1 and 2.

**Catalogue Reference Number:** 96/3

**Category:** Monitoring studies

**Title of Work Done:**

Mammal studies: mammal observations.

Mammal studies: mammal transect.

**Catalogue Reference Number:** 96/7

**Category:** Monitoring studies

**Title of Work Done:**

Butterfly transects.

**Catalogue Reference Number:** 96/1

**Category:** Monitoring studies

**Title of Work Done:**

Moth and other insects attracted to light.

**Catalogue Reference Number:** 96/2

**Category:** Monitoring studies

**Title of Work Done:**

Hydrochemistry - monitoring water quality.

**Catalogue Reference Number:** Computerised files on site (Park database)

**Category:** Monitoring studies

**Title of Work Done:**

Hydrology - water level readings.

**Catalogue Reference Number:** 96/9

**Category:** Monitoring studies

**Title of Work Done:**

Park meteorological data.

**Catalogue Reference Number:** RP00

**Category:** Park management

**Title of Work Done:**

*Orchis (laxiflora) palustris* survey.

**Catalogue Reference Number:** 96/8

**Category:** Park management

**Title of Work Done:**

The impact of grazing: distribution of *Euphorbia terracina* at Turo de Ses Eres.

**Catalogue Reference Number:** 96/13

**Category:** Programme development

**Title of Work Done:**

MedWet guide to Monitoring Mediterranean Wetlands.

**Catalogue Reference Number:** 96/4

**Category:** Programme development

**Title of Work Done:**

Functions and values of the natural environment.

**Catalogue Reference Number:** 96/11

## **APPENDIX 3 - 1997 programme details**

### **Project Title**

Monitoring for biodiversity and environmental change at S'Albufera, Mallorca.

### **Research Site**

Parc Natural de S'Albufera, Mallorca, Spain.

### **Principal Investigator**

Nick Riddiford

### **Team Dates in Field**

TEAM I	April 12-April 26, 1997
TEAM II	April 29-May 13, 1997
TEAM III	October 26-November 9, 1997

Team Composition: integrated teams of Scientists, EarthCorps Volunteers and Mallorcan Students.

SPECIAL GLAXO EDUCATION TEAM	August 16-August 30, 1997
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Team Composition: integrated teams of Scientists, Earthwatch Europe Glaxo Wellcome Education Fellows and Mallorcan Students.

### **Fields of Research**

#### Ecosystem studies

1. Coastal dune vegetation recovery after fire (Maria Zas; Nick Riddiford).
2. Monitoring of vegetation communities by dune transects (Jo Newbould; Maria Zas).
3. Aquatic invertebrate communities in relation to water quality (Michelle Chapman).

4. Mammal population studies (Rob Strachan: Wildlife Research Conservation Unit, University of Oxford).
5. Egret and Heron population studies (Nick Owens; Mike Wood).
6. Reedbed utilisation by roosting birds (Nick Owens).

#### Biodiversity studies

1. Bird distribution and abundance in relation to habitat (Mike Wood).
2. Distribution and abundance of Odonata in relation to habitat (Chris Donnelly).
3. Lichen distribution and diversity (Alan Fryday).
4. Herbarium development and curation (Jo Newbould; Dinah McLennan).
5. Insect reference collection (Nick Riddiford; Barry Goater).
6. Marine biota baseline (Brian Jordan; Emma Whittingham).

#### Monitoring studies

1. Bird population studies - transects, body condition of migrants (Nick Riddiford).
2. Butterfly and dragonfly transects (Nick Riddiford; Rob Strachan).
3. Mammal transects (Riddiford).
4. Lepidoptera as indicators of environmental change (Dr David Agassiz).
5. Systematic light trapping for moths (Nick Riddiford; Dr Agassiz).

#### Park management

1. The impact of grazing on *Euphorbia terracina* distribution, fossil dunes (Jo Newbould).
2. Abundance and distribution of *Orchis palustris* (Maria Zas).

#### Interpretation and education

1. Plant Illustrations/Preparation of botanical interpretation material (Dinah McLennan).

#### Programme development

1. Functions of the natural environment (Wageningen Center for Environment and Climate Studies).
2. Biodiversity program development for standardised data processing and storage (Nick Riddiford; Chris Donnelly).

## APPENDIX 4 - LIST OF PUBLICATIONS

Details of Project S'Albufera-generated publications are given below. Note that a single asterisk (\*) prefixes publications which have appeared since the last Project S'Albufera report.

- ALOMAR, G. 1995a. Anotacions al Catàleg de la Flora del Parc Natural de s'Albufera de Mallorca. *Butlletí del Parc Natural de s'Albufera de Mallorca* 2: 109-110.
- \*ALOMAR, G. 1995b. Apunts sobre la flora del Parc Natural de S'Albufera de Mallorca. *S'Albufera de Mallorca: Monografies de la Soc. Hist. Nat. Balears* 4: 79-88.
- ANON. 1994. Conclusions de la Primera Reunió nacional sobre la Cel.la marbreca, *Anas angustirostris*. *Butlletí del Parc Natural de s'Albufera de Mallorca* 1: 79-80.
- ASSOCIACIÓ BALEAR D'AMICS DELS PARCS (ed.). 1990a. *Seguiment de l'avifauna del Parc, agost 1989-juliol 1990*. Palma.
- ASSOCIACIÓ BALEAR D'AMICS DELS PARCS (ed.). 1990b. *Parc Natural de S'Albufera de Mallorca: ornithological overview, August 1989-July 1990*. Palma.
- ASSOCIACIÓ BALEAR D'AMICS DELS PARCS (ed.). 1991. *Seguiment de l'avifauna del Parc, agost 1990-juliol 1991*. Palma.
- ASSOCIACIÓ BALEAR D'AMICS DELS PARCS (ed.). 1992. *Seguiment de l'avifauna del Parc, agost 1991-juliol 1992*. Palma.
- BARRINGTON, R. 1993. Mediterranean secret. *Country* 94 (August 1993): 21.
- BONNER, H. 1994. S'Albufera: display materials for the new Visitor Centre. *Earthwatch Europe S'Albufera Project Rep.* 5: 150.
- BORDOY, M. & PERELLÓ, G. 1995. Parc Natural de s'Albufera. Base de dades bibliogràfica. *Butlletí del Parc Natural de s'Albufera de Mallorca* 2: 93-106.
- BOWEY, K. 1993. Mammal Studies at the Parc Natural de S'Albufera, October 1992. *Earthwatch Europe S'Albufera Project Rep.* 4: 146-155.
- BOWEY, K. 1995. Apparent female Moustached Warbler singing. *British Birds* 88: 113.
- BOWEY, K. & RIDDIFORD, N. 1992. Mammal studies, 1991. *Earthwatch Europe S'Albufera Project Rep.* 3: 142-143.
- \*CHAPMAN, M. 1996. Aquatic invertebrates and water quality at S'Albufera. *Earthwatch Europe Project S'Albufera Rep.* 7 (1995): 72-88.
- CROSS, E. 1993. Sampling of Odonata larvae and other aquatic fauna. *Earthwatch Europe S'Albufera Project Rep.* 4: 104-135.
- CROSS, E. 1994. Sampling of Odonata larvae and other aquatic fauna at S'Albufera, Mallorca in October 1992. *Earthwatch Europe S'Albufera Project Rep.* 5: 76-87.
- \*DE MANUEL, J. 1995. Aportació de la fauna de rotífers de les aigües de S'Albufera de Mallorca. *S'Albufera de Mallorca: Monografies de la Soc. Hist. Nat. Balears* 4: 113-118.
- DIRECCIÓ GENERAL D'ESTRUCTURES AGRARIES I MEDI NATURAL. 1994. *Butlletí del Parc Natural de s'Albufera de Mallorca* 1. Govern Balear Conselleria d'Agricultura i Pesca, Palma.
- DONNELLY, C. & RIDDIFORD, N. 1995. A study of roosting birds at the Parc Natural de S'Albufera, autumn 1994. *Earthwatch Europe S'Albufera Project Rep.* 6: 60-73.
- ESTEVE-RAVENTOS, F. & ENDERLE, M. 1992. *Psathyrella halophila* spec. nov., eine neue Art aus der Sektion Spintrigerae (Fr.) Konrad & Maublanc vom Meeresstrand der Insel Mallorca (Spanien). *Zeitschrift für Mykologie* 58: 205-209.

- EQUIP D'EDUCACIÓ AMBIENTAL. (ed.). 1993. *Programació Didàctica: Coneguem el Parc Natural de S'Albufera*. Conselleria d'Agricultura i Pesca, Serveis Forestals de Balears, Palma.
- FERRAGUT, M. A. 1994. L'estudi de papallones diurnes a s'Albufera. *Butlletí del Parc Natural de s'Albufera de Mallorca* 1: 49-50.
- \*FORNOS, J. J. 1995. Enquadrament geològic, evolució estructural i sedimentologia de S'Albufera de Mallorca [Geological setting, structural evolution and sedimentology of the S'Albufera of Mallorca]. *S'Albufera de Mallorca: Monografies de la Soc. Hist. Nat. Balears* 4: 47-58.
- FORTEZA, A. & PERELLÓ, G. 1995. Seguiment meteorològic al Parc Natural de s'Albufera. Estació B-605. *Butlletí del Parc Natural de s'Albufera de Mallorca* 2: 91-92.
- FOX, R. J. P. 1992. *Monitoring Environmental Change at S'Albufera Parc Natural: the role of aquatic invertebrates*. M.Sc. in Conservation dissertation, University College London.
- FRONTERA I SERRA, M. & FORTEZA I PONS, V. 1991. Seguiment dels efectes de la paustura al parc natural de S'Albufera de Mallorca, 1990. *Documents tècnics de Conservació* 4. SECONA, Palma de Mallorca.
- GOATER, B. 1993a. *Archanara geminipuncta, Phragmites australis* and Reed Buntings. *Earthwatch Europe S'Albufera Project Rep.* 4: 66-71.
- GOATER, B. 1993b. Lepidoptera (Heterocera) recorded at S'Albufera Natural Park, 18-30 May 1992. *Earthwatch Europe S'Albufera Project Rep.* 4: 93-101.
- GOATER, B. 1994. Lepidoptera (Heterocera) recorded at s'Albufera Natural Park in 1992-93. *Butlletí del Parc Natural de s'Albufera de Mallorca* 1: 55-60.
- \*GOLDSMITH, F. B. 1995. S'Albufera de Mallorca: a botanical view. *S'Albufera de Mallorca: Monografies de la Soc. Hist. Nat. Balears* 4: 71-77.
- GONZALEZ, M. 1993. *Applications of Landsat 5 TM for inventorying Mediterranean woodlands in Mallorca*. M.Sc. in Environmental Remote Sensing dissertation, Centre for Remote Sensing and Mapping Science, University of Aberdeen.
- GOSLER, A. G., GREENWOOD, J. J. D., BAKER, J. K. & KING, J. R. 1995. A comparison of wing length and primary length as size measures for small passerines: A report to the British Ringing Committee. *Ringing & Migration* 16: 65-78.
- GRAU, A. M. & RIERA, F. 1995. Nota sobre la presència de *Pomatoschistus microps* (Kroyer, 1838) a s'Albufera. *Butlletí del Parc Natural de s'Albufera de Mallorca* 2: 107-108.
- HAFNER, H. & HOFFMANN, L. 1990. *The Albufera de Alcudia (Mallorca): an assessment of the importance of this wetland for colonially nesting Ardeidae*. Station Biologique de la Tour du Valat cyclostyled report.
- HAWKSWELL, S. 1992. Seminar on the computerisation of data for the management of natural areas. *Earthwatch Europe S'Albufera Project Rep.* 3: 145-146.
- HAWKSWELL, S. 1995a. Water level recording in the Gran Canal. *Earthwatch Europe S'Albufera Project Rep.* 6: 74-81.
- HAWKSWELL, S. 1995b. Habitat mapping. *Earthwatch Europe S'Albufera Project Rep.* 6: 82- 88.
- HAWKSWELL, S. & RIDDIFORD, N. 1995. Project S'Albufera data management system. *Earthwatch Europe S'Albufera Project Rep.* 6: 48-49.
- HOWE, C. 1989. *Albufera: Aspects of Hydrology, Vegetation, History and Management*. M.Sc. in Conservation dissertation, University College London.
- \*JAUME, D. 1995. Una llista dels crustacis de S'Albufera. *S'Albufera de Mallorca: Monografies de la Soc. Hist. Nat. Balears* 4: 119-124.

- \*JERMY, A. C., LONG, D., SANDS, M. J. S., STORK, N. E. & WINDSER, S. (Eds.). 1995. *Biodiversity Assessment: a guide to good practice*. Volume 1. Department of the Environment/HMSO, London, UK. [page 176]
- JURADO ESTEVEZ, J. 1992. *The usefulness of Landsat TM data for vegetation discrimination in S'Albufera de Mallorca - a marsh*. M.Sc. in Environmental Remote Sensing dissertation, Centre for Remote Sensing and Mapping Science, University of Aberdeen.
- KING, J. 1993. Ornithological Research based on ringing, S'Albufera 1991-92. *Earthwatch Europe S'Albufera Project Rep.* 4: 185-187.
- \*LILLO, F. 1995. Noves aportacions a la toponímia de S'Albufera. *S'Albufera de Mallorca: Monografies de la Soc. Hist. Nat. Balears* 4: 19-38.
- \*MARCH, J., MOYÀ, G., QUETGLES, G. & REVIRIEGO, B. 1995. L'Estany des Cibollar. *S'Albufera de Mallorca: Monografies de la Soc. Hist. Nat. Balears* 4: 207-214.
- MARCUS, A. 1992. *Estimation of soil's surface physical properties using Landsat TM Data in "Es Pla de Sa Pobla-Muro" (Mallorca)*. M.Sc. in Environmental Remote Sensing dissertation, Centre for Remote Sensing and Mapping Science, University of Aberdeen.
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- MARTÍNEZ TABERNER, A. 1986. Notes florístiques: faneròfits aquàtics de s'Albufera de Mallorca. *Boll. Soc. Hist. Nat. Balears* 30: 155-164.
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- \*MARTÍNEZ TABERNER, A., MAYOL, J. & RUIZ PEREZ, M. 1995. Rehabilitació del medi aquàtic de S'Albufera de Mallorca. *S'Albufera de Mallorca: Monografies de la Soc. Hist. Nat. Balears* 4: 215-228.
- MARTÍNEZ TABERNER, A., MESTRE, I. & RUIZ PEREZ, M. 1990. Model for the Distribution of Submerged Vegetation in a Gradient of Coastal Marsh. Albufera of Mallorca (Balearic Islands). *Rapp. Comm. Int. Mer Médit.* 32: 1.
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### **ANNEX 3**

**A Further Study of Water Quality and Aquatic Invertebrate Communities at S'Albufera, Mallorca in the Spring, Summer and Autumn of 1996** by Michelle Chapman

**Un estudio de la calidad del agua y de las comunidades de invertebrados acuáticos a s'Albufera de Mallorca en primavera, verano y otoño de 1996**

### **Summary**

A survey of the aquatic invertebrate population at S'Albufera was conducted during May, August and October 1996. BMWP and ASPT scores were derived for each site and survey period and compared with the results of 1995. The spring survey showed a general recovery in the invertebrate population from the

summer of 1995 with a repeated fall in summer 1996 and subsequent recovery in October 1996. The number of sites showing water quality concerns were less in 1996, reflecting the less severe drought conditions compared to 1995 and a continued recovery from the effects of leakage from salt water pipes at certain sites. However, the low score obtained in October at one of these sites gave cause for concern that a new leakage may be occurring. In addition, another site that was subjected to sewage pollution in the summer of 1996 was not showing signs of recovery in the autumnal survey. Species richness has not recovered to the spring 1995 maxima at a number of sites and requires further investigation to find the cause.

## **Resumen**

El estudio de las comunidades de invertebrados acuáticos fue llevado a cabo en s'Albufera durante los meses de mayo, agosto y octubre de 1996. Las cuentas de BMWP y ASPT fueron obtenidas para cada sitio y periodo de inspección y fueron comparada con los datos de 1995. El estudio de la primavera mostró una recuperación en general de las comunidades de invertebrados acuáticos del verano de 1995 con una disminución repetida del verano 1996 y subsiguiente recuperación en octubre 1996. Los sitios mostrando una preocupación sobre la calidad del agua fueron menos en 1996, reflejando la reducción en sequía en 1995 y una recuperación de los sitios afectados con agua salada desde tuberías cercanas. No obstante, la cuenta baja de uno sitio obtenida en octubre muestra que una nueva fuga de agua salada ha quizás ocurrido. Además, un otro sitio fue afectado por contaminaciones de aguas residuales en el verano de 1996 y no fue mostrando una recuperación en otoño. El total de especies en algunos sitios no ha recuperado del total de la primavera 1995 y necesita más investigaciones para encontrar la causa.

## **1. Introduction**

A detailed study of the aquatic invertebrate population at s'Albufera based on the biological survey techniques used in the UK Water industry commenced in spring 1995. These techniques have also been demonstrated to be of use in the study of aquatic populations in Spain. (Armitage *et al.* 1990).

The study was continued in 1996 to meet the following objectives:

### **1.1 Objectives**

- To identify species and/or species communities that will show the Parc's state of health
- To monitor aquatic invertebrate communities over time
- To produce an updated inventory of aquatic invertebrate species
- It should be transferable so that it is not dependent upon the availability of a particular survey supervisor

The objective to study the relationship between invertebrates and water quality throughout the Parc will be the subject of a separate report.

## **1.2 Study Area and Sample Sites**

The overall study area is described by Martinez Taberner *et al* (1990). The location of S'Albufera and the sample sites are the same as shown in the report of the 1995 fieldwork (Chapman 1996) and included actual sampling of site 5 for the first time. Sampling of site 28 was discontinued as it is no longer used as a chemical sampling site by the Parc staff (Biel Perollo - personal communication).

## **2. Materials and Methods**

### **2.1 Field Work and Identification**

The method and data recording sheet used are described in Chapman (1996). No replicate samples were taken as volunteer training was undertaken to eliminate operator variability. Counts of

#### **ANNEX 4**

**Study of Egrets: Earthwatch S'Albufera 27/1/96-2/11/96** by Nick Owens

#### **Introduction**

Egrets are a characteristic group of water birds which are easily identified and observed. It was felt that they would make a suitable subject for a detailed study by Earthwatch volunteers. A check-sheet was designed for trials with volunteers at the Autumn 1996 Earthwatch visit to S'Albufera. This paper analyses the results obtained, assesses the success of the project and suggests future work.

#### **Methods**

It was hoped that data would be obtained spread across daylight hours on little egret *Egretta garzetta*, cattle egret *Bubulcus ibis* and great white egret *Egretta alba*. This proved possible only for little egret. Some observations of grey herons *Ardea cinerea* were also made.

Method A. Observers used a check-sheet (Appendix 1) which required them to note the activity of a chosen egret every two minutes, and also the depth of water (if any) in which it fed, the distance to the nearest conspecific, and the number of other egrets of each species at the site (every 10 minutes). Notes were also taken on interactions between egrets and between egrets and raptors.

Volunteers were at first partnered by one of the scientists. Guidance was given on identification and practice with the check sheets and notes were provided on the biology of

egrets (Appendix 2). After the first day or two, most volunteers had no difficulty in filling in the sheets on their own. Most observations were made from hides using binoculars.

Method B. Observers were posted to four sites on 31/10/96, the tower hide, Bishop 1 hide, Cim hide and the platform along the Ses Punes track. Watches occurred at 0800-0830, 1000-1030, 1200-1230 and 1800-1830 hrs. During each watch observers noted every five minutes the number of little egret, cattle egret and grey heron engaged in each of the activities listed on the check sheet used in Method A. An attempt was also made to map birds seen.

Some separate preliminary observations were made of feeding rate by counting the number of pecks at prey items made per minute, watching through a telescope.

## **Results**

### Little egrets

Little egrets were watched for a total of 629 two minute intervals, spread fairly evenly over the day, but with a conspicuous gap at lunch time!

#### *1. Activity patterns* (Table 4)

Method A. Most feeding occurred in the first two hours of the day (0700-0900 hrs) and the hour before they went to roost (1700-1800 hrs). Least feeding occurred between 1500-1700 hrs, when birds mostly rested and preened.

Preening was an important activity throughout the day.

Birds spent a fair amount of time flying from pool to pool. This was often linked to aggression (see below). Flights to and from the roost were probably not recorded during these watches, as these happened before 0700 hrs and after 1800 hrs for the most part.

#### Method B (Table 5)

This confirmed the focus on feeding in the early watch (0800-0830 hrs), though very few little egrets were seen at that time. During the 1000 and 1200 hrs watches more birds were preening, resting and flying. By 1800 hrs it was almost too dark to make records of behaviour.

#### *2. Feeding behaviour*

##### a) Description of feeding behaviour. (see Fig 1).

Five different types of feeding behaviour were distinguishable:

A. Walking steadily through water. Leg shaken/vibrated to stir sediments, then moves forwards. Alternate leg then shaken. Bird's eyes look forwards straight along beak. Bird stabs at anything that moves e.g. *Gambusia*. Sometimes the egret runs forwards through the water, chasing prey.

B. Bird snaps at dragonflies (Odonata) as they pass. This often interrupts other feeding methods. Only occurs when the temperature is fairly warm - not early hours or cloudy days.

C. Bird wades in open clear water, during sunshine. Seeks prey on muddy bottom. This method used to catch earthworms near Bishop 1 hide.

D. Bird walks along bank edge or across matted emergent vegetation, taking prey from near the surface - possibly Gammarid crustacea.

E. Bird waits motionless, like a grey heron, and stabs at passing fish. Seen on Gran Canal.

#### b) Food taken

Not easy to see, but probably included *Gambusia*, Gammarids, earthworms, dragonfly (*Aeshna mixta*).

#### c) Depth of water during feeding. (Table 1)

Data from times when the egrets were not feeding were omitted from this analysis.

96.4% of feeding was in water, 3.6% on land. Of feeding in water, the majority occurred in a depth at least half way up the tarsus (87.7%) and in a depth at the top of or above the tarsus in 47.4% of water feeding. On many occasions water reached the belly of the egret, but we had no category for this.

**Table 1. Depth of water**

Depth category (see check sheet)	1	2	3	4
Water/total min. obs.	1	51	171	187
% of min. obs.	0.2	12	40.3	47.4

When feeding in pools with a mixture of open water and patches with emergent vegetation, little egrets seemed to spend most time in the vegetated patches, probably because these sheltered food items (Fig.2).

#### d) Food items taken per minute

(I) Feeding on earthworms (= feeding method C Fig 1.), Bishop 1000 hrs.

Time watched = 20 min.:

Worms taken = 19; Dragonflies caught = 3; Dragonflies missed = 2

Overall feeding rate = approx 1 per minute.

Conclusion : slow feeding rate, but food items all large. Worms were mostly c.10 cm.

(ii) Feeding on fish, ?gammarids, ? frogs (feeding method A) at Sa Roca, watched from mound. (Table 2)

**Table 2. Little Egret feeding rates**

Time:	0700-0900	1000-1100	1200-1300
Minutes watched	28	31	31
Pecks observed	224	125	221
Pecks per minute: mean	8	4.03	7.13
Pecks per minute: SD	2.96	1.68	2.26

The highest feeding rate occurred in the early morning, but it was much lower at 1000-1100 hrs. Then it (surprisingly) rose again at 1200-1300 hrs.

These results show that measuring pecking rate is quite feasible. It would be easier with two people - one to watch and the other to call out the time and note the results.

When using method A, egrets made very few unsuccessful pecks (perhaps 1 in 20). If this is generally true at other times of the year then pecking rate is likely to be a good measure of food supply and hence water quality.

The occurrence of earthworms beneath the water may be a result of recent flooding. Variability of water levels may be important in providing the best feeding conditions. Feeding conditions were considered to be particularly favourable so far as water levels were concerned during this study (Biel Perello pers. comm.).

#### e) Aggression at feeding sites

Little egrets characteristically flew towards another feeding egret, often making a harsh grating call (similar to that of grey heron) as it approached. The target bird usually flew off to a different pool. If it landed again fairly soon, it was sometimes chased again until it left the area. On one occasion the target egret was seen to fly more than 100 m along the Gran Canal before settling again.

This aggressive behaviour occurred throughout most of the day, and probably accounted for much of the flying activity recorded. During the first 1-1.5 hours of daylight however, birds seemed to fly about much less, and fed intensively without much movement.

Four observers noted independently that the aggressive bird was larger than the aggressed (eg 'my bird chased away by Mike's BIG mean bird' - quote from Steve). Larger birds appeared to be able to displace smaller birds from a feeding site. On many occasions, however, two or more egrets fed close to each other without showing any aggression, as the proximity data suggest.

In summary, it can be postulated that little egrets arrive at feeding sites from the roost at about first light (approx 0700 hrs), spreading out widely in suitable pools. At first, feeding rates are high and the birds are hungry. They concentrate on feeding for 1-2 hours. After this time feeding rates start to fall (but this needs further data). More dominant birds begin to move about, displacing subordinate ones from feeding sites as they do so. This sets off a chain reaction of birds moving from site to site, attempting to maximise their feeding rates and avoid more dominant birds. This continues until about 1500 hrs. Birds are then better fed and spend more of their time resting and preening. There is a final bout of intensive feeding from 1700-1800 hrs before the egrets go to roost.

#### f) Sites utilised by feeding little egrets

Fig. 3 shows places where egrets were seen feeding or resting from 27/10/96-2/11/96. Data were collected during one circuit around the park on cycles, the coordinated watches (Method B on 31/10/96) and other casual observations. No systematic attempt was made to cover the whole park, and there is considerable observer bias. However, the plots serve to show that little egrets were distributed throughout the park wherever there was standing water. They also occurred in small numbers along the Gran Canal. The highest counts away from the roost were of 42 birds on Es Cibollar and 12 at Sa Roca. The brackish conditions at Es Cibollar seemed to be favoured. Little egrets were not seen feeding outside the park boundary, unlike cattle egrets.

### 3. Nearest neighbour distances (Table 3).

**Table 3. Nearest neighbour distances**

Distance to nearest little egret (m.)	0-1	2-5	6-10	11-20	21+
During feeding: no. of observations	10	82	28	24	84
%	4.4	36	12.3	10.5	36.8
When not feeding: no. of obs.	7	28	28	3	99
%	4.2	17	17	1.8	60

Little egrets tended to form loose flocks when feeding, but generally did not approach within 1 m distance. In 36% of minutes watched there was another egret within 2-5 metres of the feeding bird, but they also often fed alone.

When not feeding, egrets tended to be farther from another egret than when they were feeding. It seems that egrets tend to gather in pools where food is plentiful, but are not especially gregarious.

There may be some observer bias in that resting egrets tend to sit up on vegetation, and nearby egrets feeding in pools may not be visible.

#### *4. Reactions to raptors*

Out of 15 incidents when marsh harriers flew nearby, the little egret rose into the air on 11 occasions, became alert but did not rise on one occasion, and showed no response on three, including once when the harrier was 'very close'. On one occasion an osprey flew 15 metres above a little egret, but it showed no response. On two of the occasions when the little egret flew up, it seemed to be disturbed by the ducks flushed by the harrier, rather than the harrier itself.

### Cattle egrets

Too few records were made to assess the activity patterns of cattle egrets. This was because the majority of cattle egrets flew out of the park to feed during the day, returning to the park only to roost.

#### *1. Feeding methods and sites used by cattle egrets*

Figure 4 shows sites where cattle egrets were seen in and around the park. The birds were nearly always associated with either cattle or horses. Typically a bird would perch on the back of an animal as it walked along. When it arrived in an area with relatively short vegetation (not usually in water), the egret alighted on the ground and ran along beside the animal, taking insects disturbed by its hooves.

There was not enough livestock in the park to support many cattle egrets, and vegetation may be too tall in many areas. Up to 100 cattle egrets were observed with sheep to the north west of the park (Ramon Mas, Joan Mayol pers comm.).

Many of the cattle egrets at roost had ochre coloured staining on their feathers at the top of the legs. The colour exactly matched the lateritic earth in the ploughed fields to the west of the park, providing further evidence that birds roosting in the park fed outside its boundary. A scan of roosting cattle egrets at the hide on 29/10/96 showed that 7 out of 35 in one scan and 7 out of 23 in another were stained in this way, i.e. about one quarter of the birds.

## Great white egret

Only one Great white egret (GWE) was present in the park during the week. It spent most of its time in the centre of Es Cibollar, usually in the company of up to 10 grey herons.

### *1. Activity patterns*

Of the 50 two-minute observations made, the following activities were noted:-

Feeding	40%
Preening	32%
Resting	26%
Flying	2%

### *2. Feeding*

All feeding seen was by wading in water. Water depth during feeding was:-

Depth category	1	2	3	4
Number of observations	0	10	5	5

The feeding methods used were similar to grey heron, i.e. slow wading or stationary watching. In 1995 a GWE was seen repeatedly flying up and flapping low over the pool surface with legs dangling, seemingly attempting to spot or shoal fish.

### *3. Nearest neighbours*

The nearest egret/heron to the GWE was:-

Species	Number of observations
Grey heron	40
Little egret	3
Not known	7

## Grey heron

No activity sheets were completed. The coordinated watch on 31/10/96 suggested that grey herons (GH) had an early bout of feeding, and later spent much time being inactive. It may

have been that feeding conditions were so favourable that it was unnecessary for the GH (or GWE) to feed for long periods of time (though the sample sizes were very small).

Grey herons did not seem to join other egrets/herons at the main roost sites. However, there was considerable movement of GHs at dusk. It is possible that GHs feed at night.

Fig. 5 shows sites where GHs were recorded on the coordinated watch, a cycle ride around the park and by a car visit to the water treatment site.

## Roosting

Observations were made of roosting egrets when the opportunity arose, though no systematic counts were made.

(I) 29/10/96 Morning watch , hide site in Tamarisk

0710 hrs: 160 cattle egrets and 5 little egrets present.

0720 hrs: 4 LE departed.

0757 hrs: all remaining egrets (nearly all CE) departed, possibly disturbed by a harrier. 100 flew NE over the pines and away from the park. 60 flew west along the park boundary road.

All the birds in the roost were on Tamarisk and all the roosting trees were surrounded by water. Nearest neighbour distances recorded were.

Distance in metres	Number of birds
0.5	4
1.0	7
1.5	2
2.0	1

Birds attempting to land too close to another egret were pecked at. There appeared to be little room to spare on the available trees.

(ii) 30/10/96 Morning watch, Es Colombar hide roost.

As we arrived at 0700 hrs, there were no egrets at the roost, but 325 flew in from the west. 85 of these flew onwards towards Es Cibollar, thought to be mainly little egrets (LE). 240 settled in the Tamarisk, comprising 227 Cattle Egrets (CE) and 13 LE.

0715 hrs: disturbed by marsh harrier, circle, resettle. Rain starts.

0725 hrs: disturbed by harrier again. Birds circle, 9 fly off towards east. Only 3 LE left now, so it looks as though the LE are leaving first.

0730 hrs: marsh harrier disturbs again. 60 CE fly off over pines to the north-east.

0733 hrs: marsh harrier disturbs again, birds circle and resettle.

0736 hrs: all up again. No harrier visible. Resettle.

0745 hrs: 140 CE left at roost. No LE left. We depart.

(iii) 30/10/96 Evening watch. Es Colombar hide roost.

1810 hrs: egrets present at roost. As we approach they all fly off westwards.

(iv) 31/10/96 Evening watch ,Tower Hide

1810 hrs: 60 egrets already at roost in reedbed in the centre of Es Colombar. Other birds gathered at the Tamarisk at Es Colombar hide roost, and flew over in small flocks to join the reedbed roost. 198 birds were counted moving across from the Es Colombar hide by 1825 hrs, when it was almost too dark to see. A further 70 egrets arrived from the west, having settled first in trees close to the road west of Canal Loco, near Pont de Ferro.

The total counted was 328 egrets. It is uncertain what the species composition of these birds was. From observations over the week, there seem to be fewer LE than CE (perhaps 200+ CE and 100+ LE).

## **Conclusion**

The egrets main roost was at the reedbed in Es Colombar (close to the site of the purple heronry, Pere Vicens pers. comm.). Egrets gathered at pre-roost at Canal Loco and the Es Colombar hide Tamarisks. They also returned to these sites in the mornings to rest and preen, though many of the LE seemed to go straight out to feeding sites from the main roost. Most LE leave the roost to feed at or before 0700 hrs. Cattle egrets stay in the roost/post-roost up to an hour longer.

The reason for the later departure of CE may be the need to wait for their orthopteran prey to warm up and become active before they can feed on them (N.Riddiford pers.comm.).

The adoption of the reedbed site may be a result of the lack of space on the Tamarisks.

The single GWE was not seen at a roost site with other egrets/herons. However, it was observed 'flying towards the power station' at about 6 pm on 31/10/96. One GWE roosted with other egrets at the Es Colombar hide site in 1994 (Donnelly and Riddiford 1994).

## **Evaluation**

Method A, using the check sheets, was very effective. Most volunteers rose to the challenge of mastering the observational skills and seemed to enjoy taking a close look at particular birds. The site count data proved of little value owing to the difficulty of defining the exact boundaries of a site.

Method B (coordinated watches) provided a useful back-up to method A. It provided quick data and a useful overview of the activities of the birds. Mapping of birds and flight directions did not give much useful information, as movements were so complex.

Methods A and B could be used at other times of year and widened to different egret/heron species.

The observations of peck rate could usefully be trialed further and extended to provide a yardstick of aquatic habitat quality in the park in different seasons and years. A standard method could be developed to support the invertebrate index.

Any mapping of birds, even if fairly crude, is likely to be useful. In this study egrets were found feeding throughout the park. This may not be so in other years if water conditions are less favourable.

### **List of contributors**

Nick Riddiford, Chris Donnelly, Mike Wood, Marga Roig Ramis, Lina Torres Costa, Elizabeth and Fergus Moynihan, Stephen and Maureen White, Grainne Maher, Victor Mbai Nkwa

### **Reference**

Donnelly, C. & Riddiford, N. 1995. A study of roosting birds at the Parc Natural de S'Albufera, autumn 1994. *Earthwatch Europe S'Albufera Project Rep.* 6: 60-73

### **ANNEX 5**

**Biodiversity studies: distribution and abundance - a pilot study** by Paul Lupton and Nick Riddiford

This paper describes a study which is being established to obtain information about distribution and abundance of a range of species within the Park, to provide comprehensive data for Wageningen Agricultural University's Institute of Environment and Climate Studies working group on functions and values of the Parc Natural de s'Albufera. It also fulfills our role as a model Biodiversity site, as outlined during the World Conservation Monitoring Centre conference of April 1994.

A huge range and combination of species and/or groups could be surveyed but to get the study under way, the species selected were ones which not only fulfill the objectives above, but were significant for other reasons (e.g. herons and egrets to supplement information being gathered by Louis-Julien de la Bouere for his impact of grazing on Ardeidae study; *Enteromorpha* as a good indicator of water eutrophication, particularly when that eutrophication is being contributed by sewage pollution). This paper concentrates on the *Enteromorpha* study.

## Methods - general

The methods used will differ between species and/or group and techniques will need to be developed for each. This will be done by means of field-based pilot studies. Whatever the techniques employed, the objective is the same - to gather detail of abundance and distribution by collecting quantitative data related to position within the Park, particularly in relation to the Project's UTM based grid. Location of position has always proved difficult in the past but should be made much easier with the introduction of hand-held Global positioning systems (GPS), provided as part of the Glaxo Wellcome grant to the Project.

## *Enteromorpha*

A pilot study was conducted on 19th August 1996 by Paul Lupton and Ianthe Pickles. They chose the entire length of the Gran Canal for the pilot study. The methodology was as follows:

For each stretch of water two indices of *Enteromorpha* distribution were calculated, plant cover from bank to bank (size of patch) and abundance lengthways (linear presence) along the waterway.

- I. Size of patch: the extent to which the *Enteromorpha* covered the surface of the water was recorded by scoring cover using a four category assessment. This comprised 0 (*Enteromorpha* absent); 1 (scattered plants/small patches); 2 (extensive rafts but not complete cover - NB: assume a raft to be one metre or above in diameter); 3 (complete cover for entire width of waterway). The scoring system is presented in tabular form below.

Size of patch -

VALUE	DESCRIPTION
0	Absent
1	Scattered (small patches)
2	50% cover (rafts)
3	100% cover

- II. Assessment of linear presence: for each stretch of waterway an assessment was made of the degree to which the water had been colonised by the plant. This was expressed as percentage colonisation and was calculated by applying the following simple methodology. Take a 10 m stretch of canal and divide it into ten one-metre transverse bands (i.e. bank to bank), then record presence/absence in each band.

#### Calculation of Colonisation Index

The extent of *Enteromorpha* colonisation can be quantified by combining the two methods described above to calculate a colonisation index (C.I.). The C.I. is a measure of the size of the colony and the length of canal affected by the plant. In order to calculate the C.I. the patch size value is multiplied by the % length of colonised waterway.

E.g. Site a - patch size score = 1    % waterway colonised = 50%    **C.I. = 1 x 50 = 50**  
Site b - patch size score = 3    % waterway colonised = 100%    **C.I. = 3 x 100 = 300**  
Site c - patch size score = 2    % waterway colonised = 60%    **C.I. = 2 x 60 = 120**

The maximum score is 300 based on 100% coverage of the water and the minimum 0 for an uncolonised stretch of canal.

There were major access problems in a number of sites. However the samples obtained by survey of all accessible and/or observable sites are considered sufficient to give a realistic picture of the current state of water quality within the Park as it affects *Enteromorpha* growth, and calculations based on means may be made on some stretches of water where a number of sectors are accessible even if it is not possible to survey the entire length. In addition, the accessible areas are particularly important for future monitoring as comparative data will require assured access in subsequent years.

### **ANNEX 6**

#### **Further observations on the bryophytes in the Parc Natural de S'Albufera de Mallorca** by R. C. Stern

#### **Introduction**

A second visit was made to the Parc from 7th-13th May 1996 as a follow-up to the survey carried out in November 1994 (Stern 1995). Bryophytes were recorded on several days during this visit.

#### **Details of survey**

There were certain objectives for this second survey as follows:-

1. To revisit many of the sites inspected in 1994 to record any additional species which might have been overlooked or not have been observable at that time of year (such as certain ephemeral species).

2. To re-find if possible certain species requiring mature sporophytes for their determination, these not having been seen in 1994.
3. To survey additional sites which were not inspected in 1994.

Of the eleven sites surveyed in 1994 (listed in the report of that visit, Stern 1995), sites 1, 4, 6, 8, 9 and 10 were revisited. Two additional areas, as shown on the map (Figure 2.1), were inspected; these are as follows:-

12. Turo de ses Eres. Sections of old walls and stonework.
13. Malaco de na Vento (west of Pont de Ferro). Stony waste ground and rocks in stream.

### Results of survey

Many of the species recorded in 1994 were found in 1996 in sites where they had not been seen previously. In addition, five species were recorded which had not been observed in 1994. However two of these, *Didymodon tophaceus* and *Cephaloziella baumgartneri*, had been seen previously in 1993. The other three, *Weissia brachycarpa* var. *obliqua*, *Bryum donianum* and *Scleropodium tourettii* were new records for the Parc.

A damp shaded wall of a building adjoining the canal at Sa Roca (not examined in 1994) was found to be particularly rich in bryophytes (as well as pteridophytes), including two hepatics *Cephaloziella baumgartneri* and *Southbya nigrella*.

It was hoped that *Fossombronia* plants with capsules would be found so that the species could be determined. After much searching in sites 9 and 10 (Es Comu and Ca'n Picafort woods), a few small patches of dead material were found in site 9. Microscopic examination of these showed that there were remains of capsules present with plenty of spores, enabling the species to be identified as *F. caespitifomis*. This is a common liverwort in the Mediterranean and is the species most likely to occur in the Parc. The only other liverworts seen in 1996 were *Cephaloziella baumgartneri* and *Southbya nigrella*. Other liverworts had been recorded in 1994 and it is possible that additional species could be seen during the winter or very early spring before the dry weather sets in. The same could apply to certain small mosses such as *Pottia* species which require sporophytes to enable them to be identified.

### Conclusions

The total number of taxa recorded in the Parc is now 53. There are no doubt others to be found in the extensive matorral and pine woodland areas of Es Comu and Ca'n Picafort, but probably few if any additional species are likely to be recorded elsewhere in the Parc. It is possible that an improvement in water quality could result in an increase in the amount and diversity of bryoflora in the main part of the Parc.

Thanks are due to N. Riddiford for his continued encouragement and support, and to volunteers who assisted in the recording, Enanga Molombe Mary, Roman Rohacek and Liz Meeker.

The following list comprises the additional species (I. e. those not seen in the 1994 survey) and the additional sites for the species which had been recorded before. Nomenclature is as given in the references in the 1994 report. *F* indicates "fruiting", I. e. with capsules present at one or more of the sites.

### Mosses

*Fissidens viridulus* (Sw.) Wahlenb. Damp shaded wall. 6 *F*.  
*Tortula marginata* (B&S) Spruce. Damp shaded wall. 6 *F*.  
*Tortula muralis* Hedw. Rock in stream. 13 *F*.  
*Barbula unguiculata* Hedw. Stony ground. 13.  
*Barbula convoluta* Hedw. Stony ground and rock in stream. 13.  
    var *commutata* (Jur.) Husn. Stone wall. 12.  
*Leptobarbula iberica* (De Not.) Schimp. Shaded wall and rock face. 10, 12.  
*Didymodon tophaceus* (Brid.) Lisa. Damp stonework. 6.  
*Weissia brachycarpa* (Nees & Hornsch.) Jur.  
    var *obliqua* (Nees & Hornsch.) Hill. Stony ground. 10 *F*.  
*Tortella flavovirens* (Bruch) Broth. Shaded walls. 6, 12 *F*.  
*Timmiella barbuloidea* (Brid.) Monk. Shaded wall. 6 *F*.  
*Funaria hygrometrica* Hedw. Stony ground. 13.  
*Bryum donianum* Grev. Shaded wall and sandy ground. 6, 10 *F*.  
*Bryum caespiticium* Hedw. Stony ground. 13.  
*Bryum radiculosum* Brid. Stone wall and stony ground. 12, 13 *F*.  
*Scorpiurium circinatum* (Brid.) Fleisch & Loeske. 6.  
*Scleropodium touretti* (Brid.) L. Koch. Sandy ground. 10.

### Hepatics

*Fossombronia caespitiformis*. De Not. ex Rabenh. Damp sandy ground. 9 *F*.  
*Southbya nigrella* (De Not.) Henriques. Shaded wall and damp sandy ground. 6, 9.  
*Cephaloziella baumgartneri* Schiffn. Shaded walls. 6, 12.

### **Reference**

Stern. R. C. 1995. Bryophytes in the Parc Natural de S'Albufera. *Earthwatch Europe S'Albufera Project Rep.* 6: 33-38.

### **ANNEX 7**

**The Odonata of the Parc Natural de S'Albufera** by Nick Riddiford and Joan Mayol

### **Introduction**

This paper summarises the data on Odonata collected by Earthwatch Europe Project S'Albufera teams since 1989, in spring, summer and autumn. It also includes the few bibliographic data available. Especially noteworthy are the observations of *Sympetrum sanguineum*, not previously recorded in the Balearic Islands; and new records of the rare

species *Selysiotthemis nigra*. Some spectacular concentrations of *Aeshna mixta* occur in autumn. In all, the Park list stands at 17 species (15 from our own observations) of 26 known for the Islands, making S'Albufera a key site for the biodiversity of this group in the Balearics.

Of all the insect groups, the Odonata (Dragonflies and Damselflies) are one of the most characteristic of wetlands. Since the last century, this group has been studied in the Balearic Islands by a number of authors and the information gathered can be found summarised in articles by Compte (1963) and Garcia-Aviles *et al.* (1995), the latter who studied the larval stages at many localities. Strangely, however, no author undertook a systematic investigation of the zone which includes S'Albufera, although fragmentary data exist (particularly in respect of the repeatedly cited *Selysiotthemis nigra*, of which specimens were taken by the ornithologist Von Jordans in 1921). Also of interest are the notes of the North American specialist N. Lavers (1983, unpublished) who observed in this wetland and whose observations are retained in the archives of one of the current authors. The total number of Odonata species for the Balearics stands at 25 species, to which this current work adds one not previously cited in the Balearic Islands.

Fifteen species of Odonata have been recorded by Earthwatch Europe Project S'Albufera from the Parc Natural de s'Albufera. Twelve are dragonflies belonging to the suborder Anisoptera and three are damsels belonging to the suborder Zygoptera. Records have been maintained of their occurrence by members of the Project team every spring since 1989, in October-November since 1991 and in August 1995-96. The following summary details these observations.

#### Suborder Zygoptera

##### *Cercion lindeni*

There are a number of observations of damselflies with blue and black banded abdomens. The ones which have been identified in the field have all been *Cercion lindeni*, but there is considerable potential for identification error between this and species of *Coenagrion*. Captures are therefore required to confirm the field identifications. The flight period appears to begin in late May with observations also in August.

Observations include adults mating and laying in late May on aquatic vegetation in the Malecó del Canal des Sol near the Pont de Son Carbonell and an adult flying over the Canal des Sol below the Pont de Sa Roca in August.

Compte recorded the species in the environs of Palma. Garcia-Aviles considered it to be very rare (he only found it at Canyamel). Lavers observed it at S'Albufera in the summer of 1981, but not in autumn 1982 nor spring 1983. It may be then that the flight period is restricted to late spring-summer, which accords with our observations.

##### *Ceriagrion tenellum*

This small red-bodied species is not abundant but is nevertheless well established and adults are seen regularly in spring, particularly in rank vegetation alongside tracks such as the Camí de ses Puntetes and Camí d'en Pep.

It has been recorded at s'Albufereta and Capdepera (in Compte). Also observed by Lavers (summer 1981, spring 1983). Garcia-Avila gave it as rare and cited it from the Font de Sant Joan.

### *Ischnura elegans*

This is by far the most abundant damselfly in the Park. It can be seen almost anywhere, but is most abundant in rank vegetation alongside tracks. It is a weak flier and can be recognised by its mainly black abdomen divided near the rear (last segment but one) by a clear blue patch. Adults are present from at least late March, but the highest numbers are in May when densities can exceed 100 per kilometre. Adults are much less frequent in autumn.

Margalef collected this species in May (in Compte) and it is also known from s'Albufereta and many other localities in Mallorca. Lavers, without giving specific records for S'Albufera, considered it common in all wetland habitats.

## Suborder Anisoptera

### *Aeshna mixta*

This species is a well-known migrant and the many thousands which may be seen in the Park in autumn will certainly include individuals from elsewhere. A few have been recorded in August but the peak month is October when tens of thousands may be present, mainly patrolling air space one to 10 metres above the ground and often hovering in one spot. The numbers can be truly phenomenal - there were reports in early October 1991 of "so many that they darkened the sky"! At such times they can be seen everywhere, from the seashore to the fields beyond the marsh. They are active by day, but also on warm humid nights when they may be seen flapping against lighted windows. The scale of this nocturnal activity was demonstrated one night in 1991 when over 70 were caught in a mercury vapour light trap at Sa Roca (Riddiford 1992). It is one of the larger dragonflies with chequered blue and black banding on the abdomen and clear transparent wings.

Though known as a migrant, the species undoubtedly also breeds at S'Albufera as demonstrated by the many mating flights and subsequent egg-laying activities observed during their autumn invasions.

Recorded at Pollensa, Palma, Soller, etc. (Compte). Considered very rare by Garcia-Aviles (recorded Canyamel). Lavers observed thousands up to December, though not specifically mentioning S'Albufera.

### *Aeshna cyanea*

One seen hawking over low matorral in the Es Comú coastal dunes on 15th May 1993 is the only record. The species is similar to *Aeshna mixta* but the colouration on the abdomen is mainly yellow rather than blue.

There is only one previous record for Mallorca, by Novas in 1914 at Pollensa (in Compte).

#### *Aeshna isosceles*

This is one of the earliest dragonflies. In most years a few adults are on the wing by late March. By May the species is common. Smaller numbers have been seen in August. This is one of the largest species in s'Albufera. It is orange-brown with a diagnostic yellow isosceles triangle at the base of the abdomen and green eyes. It is territorial, and is most frequently seen patrolling a short section of track (e.g. Camí d'en Mig, Camí de ses Punes) about 2 metres above the ground.

Recorded previously at Pollensa and in the Serra [northern mountains] (Compte). Lavers observed it at S'Albufera in summer 1981, but not in the autumn. In 1983 he observed the first emergences on 12th April, and he considered it very common here in the summer.

#### *Anax imperator*

A common species generally appearing in April and still present in October-November. It certainly breeds and is most frequently seen hawking over expanses of water with patches of emergent vegetation. Individuals can often be seen over the Gran Canal from the Pont de Sa Roca. This is the largest European dragonfly. It is a powerful flier and hunter and the male has a mainly blue abdomen divided by a black dorsal streak. The thorax is green.

Previously recorded at s'Albufereta and many other parts of the isle (Compte). Garcia-Aviles considered it fairly widely distributed and captured larvae in the Torrent de Sant Miquel (which enters the Parc). Lavers considered it common, but gave no specific localities.

#### *Anax parthenope*

This species is also common, appearing at the same time as *Anax imperator* and in similar places and habitats. It is commonest in May but can be seen into autumn. It is only marginally smaller than *Anax imperator* and rather similar but can be distinguished by brown thorax and generally dark abdomen contrasting strongly with the funnel shaped basal part of the abdomen which is bright blue.

Several previous records, some at Alcudia (Compte). Garcia-Aviles considered it very rare (recorded at Canyamel), but Lavers saw a good number, without indicating localities.

### *Crocothemis erythraea*

A common and sometimes relatively abundant species from late April. It is most numerous in May, but is still present in August. It rather resembles some of the *Sympetrum* species but has a much broader abdomen and the male is vividly red including its eyes.

Widely distributed in Mallorca, including s'Albufereta (Compte). Garcia-Aviles gives 11 localities, none of them associated with S'Albufera. Seen at S'Albufera in summer 1981 by Lavers, who observed it at many other localities.

### *Orthetrum cancellatum*

This species is encountered frequently in spring (earliest record 6th April), August and autumn, though never in large numbers. It is a moderate sized dragonfly (larger than the *Sympetrum* species). The male has a distinctive smokey blue abdomen apart from the last few segments, which are sooty black and give it a "black-tailed" appearance. Females are similar in size but yellowish-green, patterned with diamond shaped black lines.

Known from various localities in Mallorca, including s'Albufereta (Compte). Garcia-Aviles detected it at three localities, none of them in our zone; recorded from S'Albufera by Lavers, in autumn and spring, with first emergence noted on 5th April 1983 and very common thereafter.

### *Orthetrum coerulescens*

One was seen at Ses Punes on 12th April 1991 and a few individuals were seen in August 1995. It may occur more regularly but is certainly much scarcer than *Orthetrum cancellatum*. It can be overlooked as a rather poorly marked *O. cancellatum*, but the male can be identified readily in the field from the only poorly marked blackish tip to its smokey blue abdomen.

Compte gave many localities, including s'Albufereta. Garcia-Aviles considered it very rare (recorded Solleric). Lavers noted that it began to emerge on 5th May 1983 and gave other specific references to S'Albufera.

### *Selysiothemis nigra*

Small numbers were seen regularly in August 1995 along the Canal des Sol behind the Ca'n Bateman Interpretation Centre. They were all seen on or flying weakly between emergent vegetation in the middle of the day. These observations confirm the continued presence of one of Europe's rarer species at s'Albufera. Observations so far suggest that the species has a short emergence period, flies only at the hottest periods of the day and prefers canals with plenty of shade from bankside trees. *Selysiothemis* is a distinctive dragonfly being small and with a narrow dull blackish abdomen.

Compte collected previous S'Albufera records, and studied the species at great length near Palma, at sites associated with the Font de la Vila, which are now gone. Garcia-Aviles failed to find it anywhere. Lavers observed it in the salines at S'Albufera in summer 1981, but not

in subsequent visits. Thus the current records are of great interest, considering the rarity of the species throughout Europe.

### *Sympetrum fonscolombi*

This is a well known migrant species, occurring from August. It can be particularly abundant in some autumns, as in 1995 when thousands were in the Park in October.

Known from s'Albufereta and many other Mallorcan localities (Compte). Garcia-Aviles considered it rare (5 localities, not S' Albufera). Lavers considered it relatively numerous, without specific references to S'Albufera, but less abundant than *S. striolatum*.

### *Sympetrum sanguineum*

This species can be seen in spring, August and October-November but is most abundant in October. It was particularly abundant in October 1996 alongside tracks and canals, when mating and egg-laying was noted throughout the Park.

These are the first Balearic records.

### *Sympetrum striolatum*

At most times of year this is the commonest of the *Sympetrum* species in the Park, being most abundant in May. No adults have been recorded, however, in August. The species undoubtedly breeds.

Very abundant and widespread according to Compte. Garcia Aviles also considered it abundant and widely distributed (49 localities), and Lavers found it abundant at S'Albufera on all visits except January.

Field identification of *Sympetrum* dragonflies is difficult. If good views are obtained, however, most males can be identified. They are similar in size, though *S. fonscolombi* tends to look smaller and weaker. *S. striolatum* is rather duller red than the other two and has a mainly parallel sided abdomen, usually with narrow black streaks on the last two segments. The pterostigma (dark mark three-quarters down the leading edge of each wing) is brown, often with a reddish tone. *S. sanguineum* is best recognised by the appearance of a "waist" where the abdomen narrows slightly below the base (fourth segment) and it has a more vivid red body. Its pterostigma is similar to that of *S. striolatum* but tends to be a brighter red. *S. fonscolombi* also has a bright red abdomen but is best recognised by the normally broad yellow patches at the base of the wings (particularly the hind wings) and, at close quarters, the red colour of the wing veins. The pterostigma is pale, clearly rimmed with black. In addition, *S. sanguineum* has black legs while the legs of the other two species are yellow and black.

### Other species

Lavers also cited *Sympecma fusca* and *Libellula depressa* for S'Albufera.

## Comments

This summary demonstrates that s'Albufera supports a diversity and abundance of Odonata and is also well sited to receive migrants. The list is undoubtedly not complete. A *Lestes* damselfly was seen near the Tower Hide (Camí d'en Mig) in April 1992, but not identified to species; and there was an unconfirmed report of a *Libellula depressa* on 13th May 1990. Further Odonata records may, therefore, be expected. This is particularly true for times of year when Earthwatch Europe Project S'Albufera teams are not present. June, July, early August and September are all outside the current Project fieldwork periods but are all potentially good months for Odonata. We would welcome observations from all periods of the year to increase our knowledge of the extent to which the Parc Natural de s'Albufera supports other species and to widen our understanding of the ecology, temporal and spatial distribution of those species for which we already have information. Finally, it should be noted that Odonata are a key element in the functioning of the wetland. They are important as predators and as a food source as larvae and adults, for instance being a major prey item for the impressive numbers of Eleonora's Falcons *Falco eleonora* which are attracted to the Park in late spring. The well-being and survival of the s'Albufera Odonata populations, including the rare *Selysiothemis nigra* for which the Park has an international importance and responsibility, is largely related to the quality of the aquatic environment. Any loss in water quality would have a major negative effect on these populations and on other elements of the ecosystem in which dragonflies play such an important part. The numbers and variety of dragonflies indicate that the wetland is in good health, but vigilance must be maintained to retain and enhance its quality so that the Park remains a haven for impressive numbers and a key biodiversity site for Odonata.

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