

MONITORING FOR ENVIRONMENTAL CHANGE

THE EARTHWATCH EUROPE S'ALBUFERA PROJECT

A summary report of the fourth season's work 1992

by NICK RIDDIFORD

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MONITORING FOR ENVIRONMENTAL CHANGE

THE EARTHWATCH EUROPE S'ALBUFERA PROJECT

1. INTRODUCTION

This report outlines the fourth season of fieldwork for Earthwatch Europe's Project S'Albufera, carried out at S'Albufera Natural Park, Mallorca by a team of ecologists and volunteer fieldworkers. Fieldwork again involved Earthwatch and Mallorcan volunteers assisting and working alongside specialist scientists in spring and for two weeks in autumn. In addition, a number of studies and monitoring tasks were carried out by scientists 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 three years' progress in Newbould & Riddiford (1990), Riddiford & Newbould (1991), Riddiford (1991a) and Riddiford & Perring (1992). 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.

Spring fieldwork in 1992 comprised three periods of two weeks, each separated by two days reserved for review of information gathered and further planning. The first team comprised 7 supervising scientists and 6 volunteers. There were 4 scientists and 4 volunteers in the second, and 7 scientists and 8 volunteers in the third. The autumn team comprised 6 scientists and 11 volunteers. Team dates were 13th-27th April, 30th April-14th May, 17th-31st May and 17th-31st October. The international flavour of the Project was again reflected by a mix of nationalities. Volunteers comprised 12 from the United Kingdom, 7 from the United States, one from Canada, 6 from Mallorca and, for the

first time, 3 from peninsular Spain. Scientists were mainly British, but we were fortunate to obtain the services of French specialist of Mediterranean bats, Jean-Francois Noblet and his assistant, Anne Piantanida.

We also took the opportunity, in April, to convene an independent international scientific review of the Project which led to a refinement of our aims and objectives, and also served to increase our contact and co-operation with several members of the Universitat de les Illes Balears (UIB). The responsibility of overall planning and supervision was again shared by Principal Investigators, Dr Franklyn Perring and Nick Riddiford. The studies also benefited from the expert advice and assistance of all participating scientists, in particular Professor Palmer Newbould, the Project's Principal Investigator in 1989-90, Dr Terry Wells (who replaces retiring PI Dr Perring from 1993) and the Park's director, Sr. Joan Mayol. Details of all participants are given in Appendix 1.

2. PROJECT S'ALBUFERA FIELDWORK IN 1992

Baseline work continued, mainly to fill gaps in our knowledge. However, greater emphasis was placed on developing the long-term monitoring of the site, including the study of the processes at work in the ecosystem.

Botanical studies included the influence of grazing by horses and other mammals on the vegetation of the fossil dunes, further research into orchid population dynamics, plant distribution

within each of the Park's compartments, and studies of dune plant hierarchies in the coastal dune compartment of Es Comu. Further baseline work included adding new plants to the already extensive reference herbarium and extending our knowledge of the Park's fungus flora.

Research into the Park's aquatic systems concentrated on developing a working methodology for assessing the diversity and population size of dragonflies (odonata) based on larvae.

For other vertebrates and invertebrates, a series of monitoring tasks, developed during the previous three years, were continued. Monitoring of butterfly numbers and distribution in relation to habitat was conducted using regular transects, while baseline studies of hoverflies (Diptera: Syrphidae) were extended to include more transect work. Bird population dynamics were studied using transects and "constant effort" ringing. Studies of the impact of Park habitats on the bird fauna included the use by bird species of grazed and ungrazed open areas of wetland during the spring migration period, and research into the body condition of migrants and breeding residents. Chris Paul (University of Liverpool) extended our baseline knowledge of the distribution and populations of molluscs within the Park, while we were able to call upon British Lepidoptera expert Barry Goater to greatly extend our knowledge of moths. His finds included several species not recorded before in the Balearic Islands, one species

Archanara dissoluta which appears not to have been recorded before in any part of Spain and, most significantly, healthy numbers of a moth *Pelosia plumosa* currently only known in a very

few sites in southern Spain, north Africa and southern Italy, where it is rare. He also extended our knowledge of the impact of moth larvae on the marshland plant *Phragmites australis*, including identifying the moth species involved. Other invertebrate baseline work included a start on recording Coleoptera and Arachnids, in which we were aided by members of the Balearic Invertebrate Group. Bats, being nocturnal, are frequently undervalued as constituents of any ecosystem. However, French bat specialist, Jean-Francois Noblet, greatly extended our knowledge of the species at S'Albufera and demonstrated that they are an important part of the Park's fauna. His most prominent discovery was that of *Barbastellus barbestellus*, rare in mainland Spain and not previously recorded from Mallorca. He trapped six, suggesting that the species is far from rare at S'Albufera. In the autumn, a preliminary investigation of the small mammal fauna was carried out.

From the start of the Project we have recognised remote sensing, using aerial photographs and satellite imagery, as a potentially powerful tool in studying aspects of the Park and its ecosystems, and in recording development and change. We were at last able to make a start in this area of research in 1992, with the involvement of the University of Aberdeen's Department of Remote Sensing and Mapping Science. Their summer studies of vegetation distribution and aspects of land-use using LANDSAT satellite images were preceded by "ground truthing" work in the spring. Satellite images appear as a series of computer-generated colours. Knowledge of the "ground truth" therefore is an important component of interpretation of these colours. Ground

truth work was continued during the autumn visit, under the supervision of Bernie Young.

The arrival of computer facilities in the Park allowed us to continue development of aspects of the storage and organisation of the data base, under the leadership of Sara Hawkswell of the Royal Society for the Conservation of Nature (UK) who was also able to liaise with Park staff over the computerised recording of management.

3. FIELDS OF RESEARCH

The following is a summary, by category, of research studies by Earthwatch Europe's Project S'Albufera in 1992 (and see Appendix 2 for more details).

Marshes

Studies were conducted in spring and autumn of the amounts and impact of infestation by internal stem-feeding larvae, identified as caterpillars of the moth *Archanara geminipuncta*, on the major marshland plant *Phragmites australis*. The results of these studies are presented in Annex 1 and Annex 2 of this report.

Dunes

a) Coastal dunes. Following work in 1991 to relocate, permanently fix and record coastal dune transect 1, two further transects were established, described, permanently fixed with markers and photographed in May 1992; and detailed recording of the plant

composition of transect 1 was completed. Description of the transects, including location and methodology, are presented in Annex 3 of this report.

b) Fossil dunes . A new study was begun in April 1992, which had a management objective: monitoring 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. The study was conducted over a marked grid using fixed point photography. In addition plants of *Euphorbia terracina* were plotted individually in one small area, and will be re-checked at intervals to observe changes in their distribution and number.

For further details of dune studies, see Wood (1991) and Riddiford & Newbould (1991).

Flora

a) Species populations . British orchid population authority, Terry Wells, continued his study of long-term recruitment and survival rates of orchids, begun in 1991. He again located and mapped the exact position of all orchid plants within three large quadrats, two in the fossil dunes and one in marshland. He also monitored the distribution and population size of the marshland orchid *Orchis palustris* . Results of his work are presented in Annex 14 of this report.

b) Total list . More species were found and added to the herbarium

as part of the work begun in 1989 to draw up a comprehensive list of known S'Albufera flowering plants with accompanying herbarium reference. Further species were also illustrated by drawing and photography. Further information was gathered on plant distribution within the Park and data cross-referenced on index cards. Progress of the herbarium work is reported in Annex 4 of this report.

c) Fungi . Sheila Wells continued her study of S'Albufera fungi in April 1992, and visited again in November with members of the British Mycological Society to collect more information. Results of her work are presented in Annex 15 of this report.

d) Lichens . No work was done on lichens in 1992 but the results of the collections made in 1991, which were received too late to include in the first issues of Riddiford & Perring (1992), are repeated in Annex 5 of this report.

Invertebrates

a) Butterfly transects . Two butterfly transects, the first established in 1989 and the second in 1991, were repeated during regular walks throughout the spring and autumn fieldwork periods. In addition, work was begun to describe the vegetation profile of the transects, with the vegetation description of transect 1 completed in October. For further details of butterfly transects, including methodologies, see Riddiford & Perring (1992).

b) Invertebrate database . The on-site reference collection received a boost from the involvement of British moth authority,

Barry Goater, who made a considerable contribution in identifying moth specimens already in the collection, adding specimens and organising and curating the collection. We were also assisted by members of the Balearic Invertebrate Group, based at the University of the Balearic Islands in Palma, who made regularly collections in spring of beetles (coleoptera) and spiders (arachnida) and deposited at the Park a representative reference collection of Balearic beetles. A computer record of the reference collections was established. The results of the 1992 moth survey are presented in Annex 6 of this report.

c) Hoverfly studies . The hoverfly (diptera: Syrphidae) transect, established in 1991, was repeated by regular walks throughout the spring and autumn fieldwork periods. For further details of hoverfly studies, including transect methodology, see Riddiford & Perring (1992). The results of 1992 work are presented in Annex 7 of this report.

d) Dragonfly studies . In an attempt to obtain better data for dragonflies (odonata), previous attempts to monitor adults by transect were abandoned in favour of studies of the group in their aquatic, larval stages. A pilot study, undertaken by Ed Cross in April 1992, is described in Annex 8 of this report.

e) Molluscs . Following a detailed survey of molluscs at S'Albufera in October 1991, Dr Chris Paul of the University of Liverpool's Department of Earth Sciences returned in May 1992 to investigate aspects of his original study and to assess seasonal differences in molluscs collected. The results of his 1992 work are presented in Annex 9 of this report. For details of his 1991

survey, see Riddiford & Perring (1992).

Vertebrates

a) Birds . Two studies were again used to obtain data for temporal and longer-term fluctuations of breeding and migrant birds. The first comprised two bird transects begun in 1989-90. Both were repeated at regular intervals in 1992 during the spring and autumn fieldwork periods, and coverage for transect 1 was extended throughout the summer by ornithological research worker, Jon King. For details of the bird transect methodology see Riddiford & Perring (1992). The second comprised a constant effort ringing study (CES). This study, following methodology described in the 1991 report (Riddiford and Perring 1992), was again conducted at Ses Puntes but, for comparison and continuity, a second site was added in 1992 on the south-east edge of Es Colombar. Both sites were operated at regular intervals from early spring to mid summer, the extent of coverage being due to the participation of Jon King.

A study of the use by birds of managed and unmanaged open areas, established in 1991, was continued throughout the spring and autumn fieldwork periods. It comprised daily counts of the maximum number of each species seen during a ten minute period within defined areas of grazing marsh from the hide at Sa Roca and in front of the two Bishop hides.

Work begun in 1991 by Jon King on the body condition of birds using S'Albufera was continued. The main focus for research was again the large assemblies of migrant Swallows *Hirundo rustica* in

spring but a suite of useful data was obtained for a number of species, particularly in the autumn from roosts of wintering and/or transient White Wagtails *Motacilla alba* and resident and migrant Reed Buntings *Emberiza schoeniclus*. Collection of data for weight, adipose fat and muscle condition was thus extended to species using the site at or towards the end of their autumn migration as well as extending baseline data on the significance of S'Albufera as a fuelling site for migrants in spring.

Interest in the ecology and morphology of S'Albufera Reed Buntings was stimulated by studies of their role in predated the moth larvae of *Phragmites* stems (the relationship of which was also under investigation as part of the overall study of *Phragmites* autecology). Observations were made of Reed Bunting feeding behaviour and morphological data obtained by trapping. Autumn trapping activities enabled the morphological study to extend to differences between resident and visiting migrant individuals.

Aspects of the ornithological work are presented in Annex 16 of this report.

b) Mammals . The mammal transect established in 1991 was repeated throughout the 1992 fieldwork periods. In October, a preliminary trapping study was made of small mammals in relation to habitat; and observational data were collected for a range of other species. Descriptions of the 1992 mammal studies are given in Annex 10 of this report.

Work to fill a major gap in our baseline information was begun in

May 1992 when French Mediterranean bat authority, Jean-Francois Noblet, undertook a survey of S'Albufera bats, a significant but barely studied component of the Park's vertebrate fauna. His findings, which include recommendations for positive management and conservation of the bat fauna, are presented in Noblet (1992) and in Annex 11 of this report.

Meteorology

Meteorological data, collected daily by Park staff, were made available to the Project. There remains a shortfall in the availability of some meteorological data though the Park directorate continues to make representations to the National Meteorological Office for the installation of a permanent weather station.

Remote Sensing

This major additional research technique was introduced in 1992 with a pilot "ground-truthing" study in early May, two detailed studies by students of the University of Aberdeen's Centre for Remote Sensing and Mapping Science in June-July and follow-up ground-truthing work in October. The results of the pilot study are presented in Annex 12 and Annex 13 of this report; and the results of the Centre for Remote Sensing's studies in Jurado Estevez (1992) and Marcus (1992).

Data Management

Work was continued to develop programs for the storage on

computer and processing of Project S'Albufera data. Development in 1992 concentrated on establishing a computer program for the recording of management practices by the Park staff and the adoption of the Park's numerical system for recording compartments within and at the periphery of the Park. Work was also done to formulate a Geographic Information System (GIS) for the recording of ground features in relation to remote sensing interpretation.

4. ADDITIONAL STUDIES IN 1992

Though volunteers were again major contributors to our spring and autumn fieldwork programme, Earthwatch Europe took the opportunity to expand our seasons and areas of research by supporting specific post-graduate studies. Two of these studies were carried out by members of the University of Aberdeen's Centre for Remote Sensing and Mapping Science and another by a member of University College London's Ecology and Conservation Unit.

The Centre for Remote Sensing and Mapping Science were represented by Mallorcan student Antoni Marcus and Spanish student Jesus Jurado Estevez. Using two LANDSAT images shared by the Centre and Earthwatch Europe, they undertook ground-truthing fieldwork in June-July 1992. One study assessed the usefulness of Landsat TM data for vegetation discrimination in the Park (Jurado Estevez 1992) and the other used the Landsat TM data to estimate soil surface physical properties of the land adjacent to the Park (Marcus 1992). Both studies culminated in Master's dissertations (Jurado Estevez 1992; Marcus 1992), copies of which have been deposited at the Parc Natural de S'Albufera and at Earthwatch

Europe's office in Oxford, England.

The work of Marcus and Jurado Estevez was an achievement for the Project in several spheres. We recognised from the beginning the potential of remote sensing and the need to integrate it into our work. With the 1992 studies we were able to convert a commitment to this approach into reality. We recognised from the beginning that the involvement of Spanish and Balearic nationals was an essential ingredient for the long-term success of the Project. And our first three years' work demonstrated the need to consider the role of the entire catchment area to fully understand the workings of the Park and its ecosystems. The soils and land-use study, in particular, provided important data in that regard.

The University College London researcher was Richard Fox who undertook a detailed survey of S'Albufera's aquatic invertebrates with particular reference to identifying salinity indicator species and devising a straightforward, quantitative methodology for future monitoring. The results of his survey, which took place in July-August 1992, were published in a Master's dissertation (Fox 1992), copies of which have been deposited at the Parc Natural de S'Albufera and at Earthwatch Europe's office in Oxford, England.

Jon King of the Edward Grey Institute of Field Ornithology, University of Oxford, researching into aspects of Fan-tailed Warbler *Cisticola juncidis* breeding behaviour and ecology, was present at S'Albufera throughout the summer and, for the second consecutive year, maintained several of our monitoring tasks. The Project was thus able to benefit from a seasonally extended data

set, particularly for birds.

5. PROGRESS AND FUTURE PLANNING

The objectives of Project S'Albufera and the means of achieving them have been under constant review. Stock was taken of progress in the first three years and published in the document Project S'Albufera, a new model for environmental research (Riddiford 1991a). To ensure that information about the Project and its progress were fully available within the Balearic community and wider afield, the document was also translated into Catalan (Riddiford & Amengual Ramis 1992).

This document was an internal review, but it was felt that true assessment of progress and future direction was best achieved by submitting the Project to independent scientific review. This occurred on site at S'Albufera in April 1992. The international review body which gathered comprised scientists with particular experience and authority in particular elements relating to environmental change. They included Dr Rudolf de Groot, co-ordinator of the Climate Change Research Center, Wageningen, Holland, Dr Frank van der Meulen of the University of Amsterdam, vice-president of the European Union for Coastal Conservation, Dr Michael Sykes, co-ordinator of the UK Institute of Terrestrial Ecology's Environmental Change Network, Dr Joan Mayol, Director of the Parc Natural de S'Albufera and Conservation Director for the Balearic Islands, Dr Enrique Descals of the Consejo Superior de Investigaciones Cientificas (CSIC), several members of the Department of Biology of the University of the Balearic Islands

(UIB) and staff and scientific advisors representing Earthwatch Europe. A number of Project S'Albufera scientists gave written or verbal presentations of aspects of Project work and this was followed by detailed discussion of the Project, with particular reference to defining and refining objectives and planning the best means of achieving them. In summing up, the Dutch members, on behalf of the review group confirmed the value and achievement of the Project so far and made a suite of recommendations for its future development. An account of the meeting was published by Earthwatch Europe (Varley 1992) and the meeting's recommendations are repeated in Appendix 3 of this report.

The recommendations of the review group were accepted and acted upon immediately. The result was a detailed draft plan, ostensibly for the years 1993-94 but forming a blueprint for the Project's long-term direction and progress. A first draft of this plan was published in October 1992 (Riddiford 1992); a revised draft of the research elements is repeated here, in Appendix 4.

Major funding will be required to sustain this programme of work, but the Project owes a debt of gratitude to Earthwatch Europe for their continued support and their efforts to secure such assistance. The Project still receives a considerable amount of enthusiasm and interest from volunteers, scientists, Park staff and other Balearic residents. Their positive impact on the Project has been a major factor in its continued success and well-being. Shared schemes and studies, with Mallorcan and international bodies, scientists and volunteers remain a vital ingredient in the future development of the Project.

Details of the 1993 Project S'Albufera programme are given in Appendix 5.

6. ACKNOWLEDGEMENTS

Volunteers in 1992 were drawn from Britain, the United States, Canada, Mallorca and mainland Spain. They all worked very hard and made great contributions to the Project. I am grateful to Biel Perello and his colleagues for obtaining the services of Mallorcan and Spanish volunteers. They integrated well and were of highest quality. The new venture of involving volunteers from the Spanish mainland was a great success. They were all very welcome.

I also express my thanks and those of my scientific team to Srs. Joan Mayol, Biel Perello and all their colleagues at the Parc Natural de S'Albufera for their continued support, helpfulness and good company. The Estructures Agraries i Medi Natural section of the Balearic Conselleria d'Agricultura i Pesca, continue to afford us every hospitality and assistance and I express my particular thanks to its Director General, Sr. Miguel Angel Borrás Llabrés, Sr. Mateo Castello Mes, and Conservation Director, Sr. Joan Mayol Serra.

The organisations of Earthwatch and Earthwatch Europe, their members and staff in Boston and Oxford were again supportive in every way, not just in matters financial and organisational. The Project and the Park have both benefited from a purpose-built herbarium cabinet, kindly donated by Mrs Roma Parmenter in memory of her late husband, Neville. The Balearic Invertebrate Group

also contributed to the Park's reference material, by donating a fine representative collection of coleoptera; and contributed to our invertebrate work. Mallorcan resident, Tomeu Tomas Vives volunteered his time regularly throughout the summer to maintain one of the Project's grazing studies. Pat and Dennis Bishop were again generous in their help, interest and encouragement. I also gratefully acknowledge the help of officials and members of the Friends of S'Albufera .

I thank all the Project scientists for their input which again demonstrated a high level of expertise and enthusiasm. The smooth day-to-day running of the Project was ensured by logistics co-ordinators Dinah McLennan (April), Sara Hawkswell (early May), Chris Donnelly (late May) and Bea Arroyo (October); and enhanced by the fine meals of Park cook, Margalida Serra.

The Project has benefited enormously from the comments, suggestions and expertise of a range of people. Special thanks in this regard go to the conservationists and scientists of Mallorca and the University of the Balearic Islands, the various institutions and individual researchers who have become involved in our work and, particularly, the scientists contributing to the independent field scientists' review in April 1992. Special thanks, too, to Project advisor, Max Nicholson, for his continual guidance, planning and support. Finally, I am pleased to express my appreciation of fellow PI, Franklyn Perring, who has retired from that position after two years at the helm.

To all these people, and to the many others whose names are listed in Appendix 1, the Project owes an enormous debt of gratitude.

APPENDIX 1 - List of Participants

Principal Investigators

Dr Franklyn Perring and Nick Riddiford

Scientific Assistants

Dr Dinah MacLennan (Botanical illustrations, Logistics), Sara Hawkswell (Computerisation of data, Team II Logistics), Chris Donnelly (Ecological studies, Team III Logistics), Jon King (Ornithological studies), Beatriz Arroyo (Ornithological studies, Team IV Logistics)

Parc Natural de S'Albufera Advisor to Project

Joan Mayol (Director of Balearic Natural Areas, Mallorca)

Parc Natural de S'Albufera Liaison Officer to Project

Biel Perello (Conselleria d'Agricultura i Pesca, Estructures Agraries i Medi Natural)

Cook

Margalida Serra

Team 1 (13th-27th April)

Scientists

Nick Riddiford (PI), Jo Newbould (herbarium), Dinah McLennan (botanical illustrations), Jon King (ornithological studies), Terry Wells (orchid studies), Sheila Wells (mycology), Edward Cross (odonata)

Volunteers

Zanna Cass, Richard Davies, Joyce Tribe (UK), Xesca Crespi Ramis, Joan Rosello i Geli, Tomeu Tomas Vives (Mallorca)

Team 2 (30th April-14th May)

Scientists

Nick Riddiford (PI), Sara Hawkswell (computerisation of data), Jon King (ornithological studies), Bernie Young (ground-truth

studies for remote sensing)

Volunteers

Alexandra Torn (Canada), Patricia Burrows, Zita Whitfield (UK),
Macia Blazquez Salom (Mallorca)

Team 3 (17th-31st May)

Scientists

Franklyn Perring (PI), Nick Riddiford (PI), Jean-Francois Noblet
and Anne Piantanida (bats), Chris Paul (mollusc studies), Jon
King (ornithological studies), Barry Goater (lepidoptera), Chris
Donnelly (ecological studies)

Volunteers

Sarah Kirby, David Lingle, Joan Martel, Larry Vereen (USA), Tim
Berendt (UK), Oswaldo Palenzuela, Mariano Guzman Alfeo, Jesus
Angel Cuevas Moreno (Spain)

Team 4 (17th-31st October)

Scientists

Nick Riddiford (PI), Jon King (ornithological studies), Keith Bowey (mammal studies), Beatriz Arroyo (ornithological studies), Edward Cross (odonata), Bernie Young (ground-truth studies for remote sensing)

Volunteers

Elizabeth Bell, Rhuary MacDonald, Alick Natton, Janet Neve, Chris Porter, Alan Radermacher (UK), Marlene Berkley, Joy Jackson, Carolyn Papke (USA), Pere Bennassar, Maria-Josep Rebassa (Mallorca)

Additional scientist and volunteer contributions

February-October

Jon King (Edward Grey Institute of Field Ornithology, University of Oxford): ornithological studies

June-September

Tomeu Tomas Vives (Mallorca): photographic study of *Euphorbia terracina* in the fossil dunes

June-July

Antoni Marcus, Jesus Jurado Estevez (Centre for Remote Sensing and Mapping Science; University of Aberdeen): remote sensing studies

July-August

Richard Fox (Ecology and Conservation Unit, University College London): aquatic invertebrates study

Participants, Field Scientists Review Meeting

Mrs Pat Bishop (Friends of S'Albufera)

Jane Corbett (Science Programme Director, Earthwatch Europe)

Dr Enrique Descals (CSIC, Palma)

Dr Rudolf de Groot (Climate Change Research Center, Wageningen
Agricultural University, Netherlands)

Sara Hawkswell (RSNC, Project scientist)

Professor Ronald Keay (expert on tropical forests and climate
research)

Jon King (Edward Grey Institute for Field Ornithology, Oxford)

Sr Martin Llobera (Research student, Dept of Biology, UIB)

Dr A Martinez Taberner (Dept of Biology, UIB)

Sr Joan Mayol (Director, Parc Natural de S'Albufera)

Dr Frank van der Meulen (Dept Physical Geography & Soil Science,
Univ. of Amsterdam, Netherlands; vice-president of European
Union for Coastal Conservation)

Professor Palmer Newbould (Project S'Albufera scientific
advisor)

Dr Max Nicholson (Trustee, Earthwatch Europe)

Sr Biel Perello (senior staff member, Parc Natural de
S'Albufera)

Nick Riddiford (Principal Investigator, Project S'Albufera)

Dr Michael Sykes (Institute of Terrestrial Ecology, Merlewood;
co-ordinator of UK Environmental Change Network)

Bernice Young (Project scientist)

Dr Peggy Varley (scientific advisor, Earthwatch Europe)

Dr Terry Wells (Institute of Terrestrial Ecology, Monkswood;

Project scientist)

Visitors to the Project

Antoni Martinez Taberner, Enrique Descals, Jaume Estarellas

(Dept. Biologia, Univ. Illes Balears)

Pat & Dennis Bishop (Friends of S'Albufera)

Hipolito Medrano (Dept Fisiologia Vegetal, UIB)

Xavier Socias (Dept Fisiologia Vegetal, UIB)

John Sibole (Dept Fisiologia Vegetal, UIB)

Catalina Cabot (Dept Fisiologia Vegetal, UIB)

Maria Pou Bordoy (Dept Fisiologia Vegetal, UIB)

David Hill (Botanist/Educator, British Council, Italy)

Sean McMinn (Secretary, British Bird Observatories Council)

Mrs Roma Parmenter (Mallorcan resident and Project benefactor)

Juan Carlos Muntaner Cerda (Treasurer, Friends of the Albufera)

Graham Hearl (Mallorca RSPB/GOB representative)

Representatives of Friends of S'Albufera and the Grupo

Ornitologico Balears

Staff, Parc Natural de S'Albufera

Joan Mayol - Director

Gabriel Perello- Technical Assistant

Andreu Muntaner - Chief Warden

Alexandre Forteza - Reception Centre

Pilar Lacalle - Reception Centre

Pere Vicens - Ornithologist

Jaume Gamundi - Guard

Vicens Lillo - Guard

Manolo Coello - Maintenance

Antoni Rayo - Maintenance

M'Angels Ferragut - Monitor

Toni Verd - Monitor

APPENDIX 2 - 1992 Fields of Research

The following is a catalogue of information collected in 1992. This information, along with 1989-91 material, has been deposited at Earthwatch Europe's Oxford (UK) headquarters. A second set of the material has been established at S'Albufera Natural Park. Details of published material are given in Appendix 6.

Category : Marshes

Title of Work Done :

Phragmites infection by caterpillars.

Catalogue Reference Number : 92/9

Category : Dunes

Title of Work Done :

Coastal dune transects.

Catalogue Reference Number : 92/FHP

Category : Dunes

Title of Work Done :

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

Catalogue Reference Number : 92/17

Category : Flora

Title of Work Done :

Herbarium.

Catalogue Reference Number : 92/6a

Category : Flora

Title of Work Done :

S'Albufera plant list.

S'Albufera plant distribution.

Catalogue Reference Number : 92/6b

Category : Flora

Title of Work Done :

Orchid population studies.

Catalogue Reference Number : 92/7

Category : Flora

Title of Work Done :

Fungi recording.

Catalogue Reference Number : 92/10

Category : Vertebrates

Title of Work Done :

Bird population surveys: grazing marsh study.

Catalogue Reference Number : 92/2a

Category : Vertebrates

Title of Work Done :

Bird population surveys: transects 1 and 2.

Catalogue Reference Number : 92/2b

Category : Vertebrates

Title of Work Done :

Reed Bunting ecology and morphology.

Catalogue Reference Number : 92/4b

Category : Vertebrates

Title of Work Done :

Bird population surveys: constant effort banding.

Catalogue Reference Number : 92/5a

Category : Vertebrates

Title of Work Done :

Condition of migrant birds.

Catalogue Reference Number : 92/5b

Category : Vertebrates

Title of Work Done :

Mammal studies: bats.

Catalogue Reference Number : 92/11a

Category : Vertebrates

Title of Work Done :

Mammal studies: small mammal trapping.

Catalogue Reference Number : 92/11b

Category : Vertebrates

Title of Work Done :

Mammal studies: Mammal observations.

Catalogue Reference Number : 92/11c

Category : Invertebrates

Title of Work Done :

Butterfly transects.

Catalogue Reference Number : 92/8a

Category : Invertebrates

Title of Work Done :

Vegetation description of butterfly transects.

Catalogue Reference Number : 92/8b

Category : Invertebrates

Title of Work Done :

Molluscs: collection, survey.

Catalogue Reference Number : 92/12

Category : Invertebrates

Title of Work Done :

Invertebrate collection: moths, hoverflies and beetles.

Catalogue Reference Number : 92/18a

Category : Invertebrates

Title of Work Done :

Invertebrate collection: list of collection.

S'Albufera moth list.

Catalogue Reference Number : 92/18b

Category : Invertebrates

Title of Work Done :

Hoverfly studies.

Catalogue Reference Number : 92/19a

Category : Invertebrates

Title of Work Done :

Dragonfly (odonata) studies.

Catalogue Reference Number : 92/19b

Category : Invertebrates

Title of Work Done :

Moth (lepidoptera) studies.

Catalogue Reference Number : 92/19c

Category : Meteorology

Title of Work Done :

Park meteorological data.

Catalogue Reference Number : 92/14

Category : Remote Sensing

Title of Work Done :

Pilot "Ground Truthing" study.

Catalogue Reference Number : 92/21

Category : Data Management

Title of Work Done :

Park Compartments: map and description of compartments.

Data storage and organisation.

Catalogue Reference Number : 92/22

APPENDIX 3 - Field Scientists' Review Meeting, 28-30 April 1992:

Recommendations

The following recommendations have been extracted in full from
Project S'Albufera: Report of Field Scientists' Review Meeting,
28-30 April 1992 (Varley 1992).

The wide range of researches and experiments on methodology
during the first three years' work at S'Albufera has been put in
perspective by the independent scientific Review conducted on the
site in April 1992 and the time has arrived to propose a
strategic programme for the long-term development of the
Project.

Guiding considerations which emerge are the need to choose priorities in the light of the Project's demonstrated strong points and of its contribution to advancing scientific knowledge relevant to understanding of the care of the planet, taking into account the specific application of these in the conservation management of the Park and in its educational and interpretive programme.

Further effort must be put into overcoming the difficulties that persons outside the Project have had in grasping its innovative features and towards integrating it in comprehensive and international networks of research and conservation. This involves bringing in reinforcements from universities, institutions and official agencies and establishing a clear place for the Project within global environmental programmes. Only in this way can the necessary expanded resources be attracted and the knowledge gained be put to full use. In the light of these considerations, a detailed plan and budget for the development of the Project over the next two to three years is to be prepared in September 1992 for agreement between the scientific team and EARTHWATCH EUROPE at a meeting in November 1992 which will follow the end of the 1992 field season. The following agenda for the immediate future is put forward at this point:

1. Publication, for limited circulation, of the Review Meeting Report, accompanied by the present recommendations and a brief update of the record of research covering the 1992 spring season.

2. Encouragement of additional university research inputs, especially through more post-graduate studentships filling priority opportunities identified at S'Albufera - following the example set by Oxford University on ornithology and the welcome new three-year award of Ptas 5.5m for research on nutrient exchange between water and sediment at S'Albufera and between S'Albufera and the Bay of Alcudia, by scientists from the Universities of the Balearic Islands and of Barcelona (notified since the Review meeting).

3. Choice of priority strong-point special research projects, namely:

(i) Development of the existing Phragmites - Cladium study to include the rhizome-root system and subaqua aspects and the role of these plants in intercepting and processing pollutants and other extraneous substances.

(ii) Extension of remote-sensor and aerial photographic surveys to cover the entire catchment and adjoining Bay, thus enabling research on the Park to be put in its environmental and socio-economic context.

(iii) Study of the interactions and link-ups between ground-truth surveys and remote sensing.

(iv) A full study of the data-processing and data-base potential and methodology in the light of its wider applicability.

4. Integration with international networks, especially the European Union for Coastal Conservation (EUCC), ECODUNE, the UK Environmental Change Network and ICSU's International Geosphere-Biosphere Programme.

5. Consideration of the advisability of holding a scientific seminar on S'Albufera to explore more fully with relevant specialists the priority studies in progress and perhaps others. The invitation to attend the EUCC's Athens meeting should be accepted and a major presentation made to it.

6. Advantage should be taken of Joan Mayol's offer to host a meeting of a few selected international environmental journalists and other media people at S'Albufera and to brief them in depth. Earthwatch Europe can assist with this.

7. It seems that the time has come to replace the somewhat detached although highly productive relationship with the Park management by a closer working partnership, especially by increasing Mallorcan participation in the Project and increasing the Project input into the Second Park Management Plan and into monitoring and interpretation. Discussions should begin on this with Joan Mayol, and also with the UIB and GOB, if possible also bringing in the local tourist and farming interests. Such developments may well help in enlisting government support from Madrid and, through it, financial aid from the European Community.

8. It is hoped that Spanish and Dutch participation in particular will result in an increase in European volunteers and possibly also in specific grants, perhaps looking to comparison of S'Albufera with other similar areas, following up the twinning arrangement already existing with Audierne, in Brittany, France.

9. Finally, there must be consultation with a view to redefining the responsibilities of Earthwatch Europe and those for the

supervision and conduct of the Project's research programme. In launching the Project, Earthwatch Europe did not contemplate continuing to run it indefinitely. It is clear that the time is approaching when a revised pattern of organisation should be considered, including some kind of partnership between the Mallorcan institutions and interested European institutions. This might well include an ongoing role for an expanded and more widely constituted Earthwatch Europe and a European Earthcorps of volunteers, currently under discussion, during the UK Presidency of the European Community in July to December 1992.

ANNEX 8

Sampling of Odonata larvae and other aquatic fauna at S'Albufera, Mallorca, April 1992 by Edward Cross

Introduction

S'Albufera is a 1700 ha reserve in the north-east of Mallorca in which wetlands are the most widespread habitats. Most of the reserve is made up of beds of *Phragmites* or *Cladium*, but there are also more open habitats such as canals, dykes, old salt pans and grazed areas of marsh. During the summer and early autumn dragonflies (odonata) can occur in large numbers and are known to be part of the diet of Eleonora's Falcons *Falco eleonora* and Fan-tailed Warblers *Cisticola juncidis*.

Originally we intended to investigate dragonfly populations by counting exuviae (the skins left after a flying adult has emerged from a larva) as they can be identified down to individual

species and are a good indication that a site can support a species from egg through to adult (unlike the adults which can fly in from other areas).

On arriving at S'Albufera in mid April it was clear that only a few adult dragonflies had emerged. Exuviae would therefore have been hard to find, so it was decided to look at larvae instead. This was done by sampling a variety of sites to see where larvae occurred. In addition to this the density of larvae was measured at one site.

Odonata larvae go through a series of moults and most can only reliably be identified to individual species when they near maturity. (Askew 1988) records 18 species for Mallorca and at least ten of these may breed at S'Albufera. However, for our April 1992 sampling, it was only possible to divide larvae into three broad groups each consisting of several species. These groups were:

Zygoptera : larvae with long bodies and three gills on the end of the abdomen. Heads wider than the abdomen.

Libellulidae : short, squat larvae with hind leg reaching beyond the end of the abdomen. Labium (or lower lip/jaw) spoon-shaped.

Aeshnidae : larvae with long bodies but head similar width to widest part of the abdomen. Hind leg not reaching beyond the end of the abdomen. Labium flat.

Examples of these are shown in Figure 1. The dragonflies represented by these groups are roughly as follows:

Zygoptera : all the damselflies.

Libellulidae : mainly Darters (*Sympetrum*), Chasers (*Libellula*), and Orthetrum .

Aeshnidae : mainly Emperors (*Anax*) and Hawkers (*Aeshna*).

In addition to the sampling, some larvae were killed for identification later. Some records of flying adults were also obtained.

Methods

10-sweep sampling: Sites representing several habitats were chosen in the reserve. Within an area of roughly 10 m x 10 m at each site ten randomly located, 1 m long sweeps were made using a 33 cm wide, fine-mesh water net. Most sweeps were taken on the floor of the water body, but as little mud as possible was allowed into the net. For each sweep the Odonata larvae were counted, the presence or absence of Gammarus and Isopoda recorded and other fauna counted. Vegetation was recorded (either for each sweep or the site in general), as were water depth, water flow and whether the bottom was soft or solid. The daily temperature range was taken from Park meteorological records.

1m² counts: A frame made of wooden stakes, plastic sheeting and wire mesh (see plate 1) was used to isolate a 1m² area of marsh. Once the four corner stakes were knocked in, loose flaps of sheet

at the bottom of the frame were pressed into the mud to prevent animals moving into or out of the 1m² area. Sweeps were then taken with a water net until ten consecutive sweeps failed to catch anything. For each 1m² area this took between 80 and 120 sweeps. All fauna caught was counted.

Results

10-sweep sampling: 10-sweep samples were taken from twelve sites and a total of 23 sets of sweeps were made. Table 1 shows the total results for each set of sweeps. In this table the figures given for Gammarus and Isopoda are the number of sweeps in which they occurred, not the total number caught. Detailed results are given in Appendix 2; abbreviations and translations are given in Appendix 1. Photographs of selected sites are shown in Appendix 3. Locations of the sampling sites are shown in Figure 2.

1m² counts: three 1m² counts were done in the south-east quarter of Tancat de Sa Roca. The total number of the different types of fauna are given in Table 2.

Discussion of results

10-sweep sampling: the number of Odonata larvae found in ten sweeps varied from 1 to 62. Zygoptera larvae were the most widespread as they were absent from only 3 sets of sweeps and were the commonest larvae in 16 sets. Libellulidae were commonest in two sets and Aeshnidae in five. Gammarus and Isopoda were the most frequent of the other fauna. Isopoda were absent from Las Salinas and Tancat de Sa Roca, whereas Gammarus were found in all

sites. Gammarus outnumbered Isopoda in all sets of sweeps. In Las Salinas, Hemiptera were the most common of the other fauna, while an unidentified Crustacean (called ' otra Isop .' in Table 1) was the most frequent in S'Illot. The capture of eight fish (' Pisc .') in Tancat de Sa Roca was next to the wall of an old aqueduct, so was something of a freak result.

This preliminary study produced a number of results suggesting relationships:

a) Depth: Table 3 shows a selection of results from ten sites (other sites are excluded as they have flowing water etc.). From this data Libellulidae appeared to prefer sites with a water depth of less than 400 mm. Isopoda seemed more frequent at deeper sites and Gammarus were consistently frequent in sites 400 mm or more deep. Zygoptera larvae occurred frequently throughout the depth range.

b) Bottom type: Table 4 presents the results from sites divided into three groups based on bottom stratum - comprising mud which was soft, firm or between the two. They suggest that both Zygoptera and Libellulidae preferred firm-bottomed sites, whereas these were less favoured by Isopoda. In soft sites it was not easy to get close to the mud surface without getting a net full of silt. This could mean some fauna were missed in soft-bottomed sites.

c) Temperature and date: the results from the first four sites in Table 1 seem to show that more larvae and other fauna were caught on hotter days and on later dates. However, the significance of

this result is not known because comparative data were few and other factors, such as water temperature, were not recorded. More information is needed.

d) Aeshnidae larvae of this group seem to have a preference for sites with tall, mature *Phragmites*. Examples of this are Es Ras and alongside the Cami de Ses Punes. In Las Salinas Aeshnidae were caught in *Carex* or *Juncus*, while in S'Illot they were found in tall and dense *Carex*.

e) Ses Punes: this site contained fewer larvae than the nearby sites Tancat de Sa Roca and Cami de Ses Punes, but at Ses Punes there were the highest numbers of both fish and tadpoles (Pisces and larvae of *Rana* respectively).

1m² counts: the three 1m² counts were taken in similar locations to the three 10-sweep samples at Tancat de Sa Roca. A comparison of the results for the two methods show some inconsistencies.

Table 5 shows the proportions of the three Odonata groups caught by the two sampling methods. The results indicate that Libellulidae and Aeshnidae are under-represented in the 10-sweep sampling. This could be due to a difference in the habits of larvae of these two groups compared to Zygoptera larvae, leading to a higher proportion being missed by the less intensive 10-sweep sampling. The 10-sweep sampling also failed to find the Isopoda type 'otra Isop.' and the Chironomidae larvae. Neither Ephemeroptera nor Isopoda were encountered in the 10-sweep samples and both were very scarce in the 1m² counts.

The average number of Odonata larvae found in the 1m² counts was 199, while the average for the 10-sweep samples in Tancat de Sa

Roca was 47. Therefore, in this habitat the 10-sweep samples were catching less than 25% of the Odonata larvae present per 1m².

In the 1m² counts only Gammarus were more common than Odonata larvae. In sample C and possibly also E, Odonata are probably the group with the greatest biomass. Table 6 shows the percentage of the catch that Odonata and Gammarus represented in each 1m² count. The figure of 43% Odonata in Sample C is slightly high as small numbers of Gammarus were left uncaught. Therefore, according to these results Odonata larvae make up about 25% of the fauna living in the open water of Tancat de Sa Roca. This result suggests that, for this marsh, Odonata larvae are important members of the food-chain, both as predators and prey.

Records of flying adults and identifications of Odonata larvae are given in appendices 4 and 5 respectively. Appendix 6 gives a summary of the information about Mallorca's dragonflies given by Askew (1988). These show that, at S'Albufera, some adults appear unusually early. The provisional identifications of larvae of *Sympetrum meridionale* or *Sympetrum sainguineum* and a *Coenagrion* species, not recorded by Askew (1988), suggest that Mallorca's Odonata fauna is under-recorded.

Conclusions

Odonata larvae were found in all habitats sampled at S'Albufera. These included shallow grazed marshes, deep canals, old salt pans, the Grand Canal and beds of both *Cladium* and *Phragmites*. At sites where Odonata larvae are most common they are likely to be

important members of the food chain. An example of this is Tancat de Sa Roca where Odonata larvae were found to represent about 25% of the fauna caught in the open water. At this site the larvae occurred at an average density of about 200/m² and only Gammarus were more numerous. Elsewhere sampling results suggest Gammarus, Isopoda and Hemiptera are the most common invertebrates. Some geographically adjacent sites with apparently similar characteristics (e.g. matching depths of water and presence of grazing, in the case of Ses Puntes and Tancat de Sa Roca) had very different populations of Odonata and other aquatic invertebrates.

Little information about the occurrence of individual species of Odonata was gathered, and sites were only described in general terms regarding vegetation, water depth and mud-type. However, the few species identifications made indicated that Odonata are under-recorded in Mallorca and that the adults of some species are appearing unusually early.

Future work

The methodology employed in April 1992 appeared appropriate for studies of Odonata larvae at S'Albufera, but the following points could be considered:

- i) 10-sweep samples should select just one habitat type in any one site (e.g. in Las Salinas make one set of sweeps in the Carex beds and another set in the open mud).
- ii) for vegetation and fauna more identifications to species level should be made. Odonata larvae preserved for identification

should have wing cases extending beyond the third abdominal segment as this indicates they are nearing maturity.

iii) making 1m² counts in other habitats would provide interesting and relatively detailed information.

iv) Park records could be checked for information about the role of Odonata in the diets of the Park fauna.

v) information may be available about the habitat requirements of some types of fauna caught at the Park. This may help explain some of the differences between sites. A literature search may be required to access this information.

vi) Records of salinity, pH and nutrient levels should be applied to the sampling results.

vii) the presence of fine, silty mud greatly slowed the rate of sampling as it made sorting through the contents of a water net more difficult. If 1m² counts are to be made in soft-bottomed habitats, a quicker method must be found. Nets with a larger mesh could help (the smallest invertebrates counted were young Gammarus and Isopoda).

viii) visits to S'Albufera later in the year may increase the chances of finding exuviae and confirm breeding records to species level at individual sites.

Acknowledgements

My work was assisted throughout by an enthusiastic group of Earthwatch Europe volunteers, as part of their contribution to

the fieldwork of Project S'Albufera 's Team I, 1992. My thanks go to all members of that team for making the work both possible and enjoyable. Particular thanks to Nick Riddiford and Jon King for their advice and field observations, and to Zanna Cass, Xesca Crespi Ramis, Richard Davies, Joan Rosello, Tomeu Tomas Vives and Joyce Tribe for their help with the fieldwork. I am also grateful to Dr. Norman Moore for his advice on methods of studying dragonflies.

Reference

Askew, R.R. 1988. The Dragonflies of Europe . Harley Books, Colchester, U.K.

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Table 5: Percentage of the Odonata catch that each larval type represented for the two sampling methods in Tancat de Sa Roca

	Total no. larvae	%Zygop.	% Libell.	%Aeshni.
10-sweep sampling	149	64.3	35.0	0.7
1m ² sampling	597	44.4	52.4	3.2

Table 6: Percentage of total catch represented by Odonata and Gammarus in each 1m² count

Sample	Total number of fauna caught	% Odonata	% Gammarus
A	988	14	81
B	759	35	51
C	444	43	40
A+B+C	2191	27	62

FIGURE 1 HERE
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Appendix 1: Translations of terms used in Tables 1 & 2, and Appendix 2

agua	- water
al lado de	- beside
blando	- soft
cami	- road, track
circa de	- near to
denso	- dense
disp., disperso	- sparse
E (este)	- east
fecha	- date
flujo	- flow
fondo	- bottom
mues., muestra	- sample
N (norte)	- north
nada	- nothing, none
nivel	- depth
numero en mapa	- number on map
o	- or
O (oeste)	- west

otra	- other
peq., pequeno	- small
plantas aquaticas	- water weeds
rapido	- rapid
S (sur)	- south
siguia	- ditch, canal
situacion	- site
solido	- solid
suave	- gentle
torre (la)	- tower (the)

Abbreviations used in Tables 1 and 2, and in Appendix 2

Aeshni.	- Aeshnidae
Anne	- Annelida
Anur	- Anura
Arach	- Arachnida
Ber	- Berosus
Chir	- Chironomidae
Clad	- Cladium
Cole adult	- adult Coleoptera
Cole larva	- Coleoptera larva
Crus	- Crustacea
Culic	- Culicidae
Dytis	- Dytiscidae
Ephe	- Ephemeroptera
Gamm	- Gammarus
Hemi	- Hemiptera
Isop	- Isopoda
Junc	- Juncus
Libell	- Libellulidae
Moll	- Mollusca
Ner	- Nereis
otra Isop	- Isopoda (another type, as yet unidentified)
Phrag	- Phragmites
Pisc	- Pisces
Zygopt	- Zygoptera

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Introduction

During my first visit (October 1991) I was unable to survey the Park as widely as I would have liked, and I discovered a diverse aquatic mollusc fauna represented by shells only but very few live specimens. The main aims of my second visit (May 1992) were, therefore, to complete the initial survey and to see if aquatic molluscs were more easy to find alive in late spring. As a result of the second visit I increased the number of sites sampled from 44 to 62 (Figure 1) and added slightly to the faunal list for the Park. Live Aquatic molluscs were much more common, but no more diverse. The current aquatic snail fauna consists essentially of five species only, with three more found living in the small pond at Ca'n Picafort. As undisturbed sediment from dredgings in the Grand Canal was available, I investigated the history of the aquatic mollusc fauna by taking sediment samples. These were supplemented by two more, from the Canal des Sol (locality 44) and from a ditch at the SW corner of the Park connected directly to the Font de Son Sant Joan (locality 20). The sediment samples from the Grand Canal suggest the Park was initially brackish lagoon which developed into a marsh. The sample from locality 20 also improved understanding of the fauna by providing abundant examples of some of the rarer forms from my first visit (e.g. *Pisidium* spp.). Finally, between them these sediment samples yielded fresh, translucent shells of all the aquatic species known from the Park, suggesting that the apparent extinction of this fauna is a very recent event.

Sediment samples

Dredgings from the western end of the Grand Canal provided some large (up to 50 cm thick) continuous sections through the Recent sediments of the Park. These showed a clear section from a marl 10 cm thick with obvious common shells of the brackish water bivalve *Cerastoderma*, often in pairs, up through identical marls (20 cm thick) without obvious *Cerastoderma* but with *Hydrobia*, overlain by organic-rich sediments with the roots of modern *Phragmites* (which confirm way up). The succession agrees with the suggested evolution of S'Albufera based on macrophytes (Martinez Taberner et al., 1990). To investigate the molluscan succession I took two small samples (100-150 g) of sediment from (a) the brackish marl with obvious *Cerastoderma* at the base and (b) the upper marl without *Cerastoderma*. An additional sample (c) of approximately the same weight was taken from clays with freshwater shells a little further east along the canal, between the two electricity pylons. Two other sediment samples of subfossil material were also collected. One (d) from locality 44, on the Canal des Sol where recent dredgings revealed a good freshwater fauna, and another (e) from just outside the Park at the SW corner (locality 20) where a recently dredged ditch revealed a similarly rich mollusc fauna. These effectively sample water entering the Park via the three principal river channels.

Sediment samples were thoroughly dried, weighed and dissociated by soaking in water. Samples (a) and (b) from the Grand Canal did not dissociate on wetting and so were frozen and thawed twice to break them up. Dissociated samples were washed through a 63 µm sieve, dried and residues separated into size fractions using a

nest of sieves at 1 phi intervals from 4 mm to 63 um. All gastropod apices and bivalve prodissoconchs found in the fractions >1 mm were identified and counted. Counts were corrected to a standard sample weight of 100 g and results are presented in Table 1.

The counts show that the sediment samples fall into two groups. Samples (a) and (b) have a meagre, brackish-water fauna dominated by *Hydrobia* ; samples (c)-(e) have more diverse freshwater faunas dominated by '*Amnicola*'. Samples (a) and (b) came from the same large lump of marl dredged out of the edge of the Grand Canal. I believe they represent the underlying sediment of much of the marshland in the Park. If so, they reflect a transition from an open, brackish lagoon probably with a direct connection to the sea, up into marshland. The fauna of both is virtually identical, but sample (a) is very much richer in specimens. The freshwater samples (c)-(e) represent dredgings from the canals and ditches themselves and almost certainly post-date the construction of the drainage system through the marsh. Samples (c) and (d) have very similar faunas, typical of the marshland, while sample (e) includes a number of additional species and is very much richer in specimens than the other two. This increase in diversity is real. In particular, *Pisidium* spp., *Ovatella myosotis* and land snail *Cochlicella barbara* are present in too large numbers for their preservation to be an artifact of the larger sample size.

Seriation (Brower & Burroughs, 1982; Brower & Kyle, 1988; Paul, 1989) is a simple technique which will detect a dominant trend in the distribution of data and order both samples and species along the trend. I seriated the data for all taxa present as 1% or more

of any sample (Table 2). From the known ecology of the taxa this trend is controlled by salinity, with *Cerastoderma*, *Abra* and *Hydrobia* brackish water species, while *Pisidium milium* and *P. personatum* are pure freshwater taxa and *C. barbara* is the commonest land snail within the marshland at present. It definitely extends into the marsh and is not confined to the pathways and canal banks as are most land snails in the Park. The only surprise is that *O. myosotis* comes out at the freshwater end of the spectrum. It lives in the marsh, but crawling on mud or up banks of channels not in the water. In Britain it is a snail of salt marshes, never found inland nor in truly freshwater habitats. Nevertheless, there is little doubt that the seriation reveals a salinity trend and, with the odd exception, the order of species in Table 2 reflects their likely salinity tolerances. This being the case, there are effectively four groups of species.

1) *Cerastoderma*, *Abra* and *Hydrobia* are brackish-water molluscs, the last tolerant of more reduced salinities than the former pair.

2) *Physa acuta* and *Ancylus fluviatilis* are freshwater species tolerant of some brackish influence. [*Lymnaea trunculata* and *Trochoidea elegans* are only in the seriation because sample (c) was so poor in specimens. Their occurrences are based on just three shells each, but with a total of just 160 specimens, this constitutes more than 1% of the sample. Similarly, *L. cf. auricularia* and *Ceriuella virgata* are based on just eight shells each in sample (d). Furthermore, *T. elegans* and *C. virgata* are land snails with no known maritime association in

the Mediterranean region. These last four species do not really belong in this association.]

3) Species from *Lymnaea peregra* to *Planorbis planorbis* inclusive are freshwater snails forming the bulk of the fauna of the marsh and they have some slight tolerance of brackish incursions. This group is dominated by '*Amnicola*'. *Oxyloma* is a land snail typical of marshes, living on emergent vegetation just above the water level. It is not known to be salinity tolerant, but again its presence in sample (c) is due to small sample size and is based on just two shells.

4) *Pisidium* spp., *Bithynia leachii*, *Ovatella myosotis* and *Cochlicella barbara*. The former pair are truly stenohaline freshwater taxa, intolerant of any brackish-water influence. As mentioned previously, *Ovatella* is the only unexpected species in this group, while *C. barbara* is a land snail typical of the present day marsh.

The present day aquatic snail fauna consists of *Hydrobia*, *Physa*, *Ancylus*, '*Amnicola*', all species of groups 1 and 2, and *Ovatella*. The first three live in the water, *Hydrobia* predominantly on bottom sediments (usually mud); *Physa* and *Ancylus* predominantly on aquatic vegetation. '*Amnicola*' and *Ovatella* live on mud, but generally out of the water and this may explain their survival. Nevertheless, all five species apparently have considerable tolerance to brackish water (or possibly the ability to avoid it by crawling out of the water). The remaining freshwater fauna (species of groups 3 and 4) is now apparently extinct in the

Park. Since these sediment samples provided fresh, translucent shells of all species, their extinction was probably a very recent event, only 10-15 years ago at most.

One other sample of dead shells was taken from flood debris on the south side of the Grand Canal immediately downstream (on the seaward side) of the barrage at Sa Roca. A concentration of shells was sampled just to see what species were present. This yielded most of the fauna known from the Park, included three marine bivalve species, and added *Euconulus fulvus* to the list of molluscs. *E. fulvus* is a woodland snail occurring in damp habitats. *E. alderi* is more typical of marshes, but more local in occurrence and, I suspect, more common in northern Europe. I doubt if *E. fulvus* lives in the Park, but it might survive in the damper patches of scrubland.

Additions and corrections to the faunal list of molluscs from
S'Albufera Natural Park

Land snails

Family Succineidae

Oxyloma pfeifferi (Rossmassler, 1835) Closer examination of shells collected on both visits suggests there are two forms consistently present. One has a smaller, more pointed apex, a more elongate shell and approaches shells of *O. sarsi* (Esmark, 1886). The other is probably *O. pfeifferi*, although the possibility that *Succinea putris* (Linne, 1758) occurs cannot be excluded. Succineids are exceedingly difficult to identify on

shells alone. The only adult snail I saw in 1991 died before I could preserve it, while in 1992 I saw one live juvenile that had only just hatched out. Until some adults are dissected the identity and number of succineid species present will remain uncertain.

Family Euconulidae

Euconulus (*Euconulus*) *fulvus* (Muller, 1774) A single fresh shell found in flood debris at Sa Roca (locality 17).

Freshwater molluscs

Family Hydrobiidae

Amnicola similis (Draparnaud, 1805) This is probably not the best available name for this species. *Amnicola* s.s. is a North American genus (Altaba, personal communication).

Hydrobia acuta (Draparnaud, 1801) Again this is probably not the best name for this species.

Family Physidae

Isidora contorta (Michaud, 1889) Probably a species of *Bulinus* , but no live specimens have been seen. If it is a *Bulinus* it belongs in the family Planorbidae.

Family Lymnaeidae

Lymnaea (*Radix*) *peregra* (Muller, 1774) Examination of extensive collections of shells, especially from sample (e), demonstrates

that there are consistently two shell shapes present (Figure 2). One is much smaller and more squat, has a flattened upper part to the outer lip and corresponds to *L. ovata* which is usually regarded as a synonym of *L. peregra*. The other is initially more high spired, but later flares out more rapidly and grows larger. In shell shape it is somewhere between typical *L. stagnalis* and typical *L. auricularia*, but smaller than both. The two forms are commonly present together, suggesting that they are two species not ecological variants. It is particularly regrettable that both now seem to be extinct.

Family Sphaeriidae

Sphaerium corneum (Linne, 1758) Recorded in error in my last report based on a pair of valves, damaged in life and therefore somewhat distorted, which appeared to be symmetrical and are smooth and considerably larger than any other sphaeriids seen. The valves have since separated, revealing a hinge typical of *Pisidium*. The specimen is either an extremely large *P. personatum* lacking the typical callus on the hinge (see below), or an unusually smooth and dull form of *P. casertanum*.

Pisidium casertanum (Poli, 1791) With a very large set of specimens available from sample (e), I am now convinced that specimens previously recorded under this name are *P. personatum* without the typical callus on the hinge. All variations from specimens with an obvious callus, through those with very weak callus, to those with no trace of callus occur, but their general shell shape and surface ornament (dull and relatively smooth) are

the same for forms with and without callus in the hinge. Unless the specimen referred to above is *P. casertanum*, I know of no undoubted specimens from S'Albufera. However, *P. casertanum* was recorded by Gasull (1980).

Pisidium personatum Malm, 1855 Recorded by Gasull (1980, p. 198) from the Font de Son Sant Joan and now confirmed within the Park, at least as fresh shells.

Pisidium milium Held, 1836 Not previously recorded from any of the Spanish Mediterranean islands. Some 42 valves, many of them fresh and translucent and occasionally double, recovered from the >1mm fraction of sample (e) at the SW corner of the Park.

References

Brower, J.C. & Burrows, W.A. 1982. A simple method for quantitative biostratigraphy. In Cubitt, J.M. & Reyment, R.A. (eds). *Quantitative stratigraphic correlation*, pp. 61-83, Wileys, Chichester.

Brower, J.C. & Kile, K.M. 1988. Seriation of an original data matrix applied to palaeoecology. *Lethaia* 21: 79-93.

Gasull, L. 1980. Moluscos. In Barcelo, B. & Mayol, J. *Estudio Ecologico de la Albufera de Mallorca*, pp. 195-198, Universitat de les Illes Balears.

Martinez Taberner, A., Moya, G., Ramon, G., & Forteza, V. 1990. Limnological criteria for the rehabilitation of a coastal marsh. The Albufera of Majorca, Balearic Islands. *Ambio* 19: 21-27.

Paul, C.R.C. 1989. The molluscan faunal succession in the Hatherwood Limestone Member (Upper Eocene), Isle of Wight, England. Tertiary Research 10: 147-162.

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TABLE 1 HERE

TABLE 2 HERE
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FIGURE 1 HERE
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FIGURE 2 HERE
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ANNEX 10

Mammal Studies at the Parc Natural de S'Albufera , October 1992 by
Keith Bowey

Introduction

Mammal studies in the Parc Natural S'Albufera in autumn 1992 were intended to follow two broad paths:

- 1) An extensive study which would draw together all "ad hoc" mammal sightings made by observers during the two week study period 17th-31st October 1992: and,
- 2) An intensive study of the small mammals of the Park using standard Longworth Small Mammal traps. The principal aim of this study was to identify all animals caught and to begin to identify the different habitats within the Park utilised by the different species.

Study 1 proceeded as planned and the collated data are given below. There were however a number of logistical problems associated with Study 2, the trapping programme. The principal problem was the non-availability of Longworth traps. Eventually through the good offices of Dr Antoni Alcover of the CSIC (Consejo Superior de Investigaciones Cientificas) a number of

traps were made available for use. After some careful modification, to increase their trapping potential and efficiency, the traps were only available for three full trapping nights. This resulted in a severely restricted trapping programme and a consequent limitation on the usefulness of the results obtained.

Methods

The traps consisted of a small rectangular wire cage, of mesh size approximately 0.8 cm by 0.8 cm, approximately 20 cm in length by 8 cm broad and with a flat wooden floor. The metal door, at one end of the narrow cage, was closed by the action of a spring and the closing action of the trap was governed by the movement of a small wire trigger (upon which bait was skewered) which hooked on to a metal loop extending out from the trap door. The bait employed during all trapping was a single large sunflower seed, with three or four of the same being deposited at the back of the trap as over-night provisioning. The traps, 35 of them, were placed (over a three night period) in four different trapping sites, representing four broadly different habitats. Traps were provisioned, positioned and armed just before dusk (approximately 1700-1730 hrs) on the three trap nights, then left overnight to be inspected soon after first light the following morning. The first night's trapping effort was split between two sites, with 24 traps at one site and 11 at another. This meant that over the period there was a total of 105 trap-nights (i.e. each trap-night comprising one trap at one site for one night). Details of trapping sites and trap configurations, including habitat descriptions, are given below. The location of trapping

sites within the Park is presented in Map 1.

Trap Site 1: along the boardwalk leading to the Xisco Lillo hide.

Date: 27/10/92

Weather: warm overnight, some cloud, light north-west wind. Some dew present in morning on examining traps.

Habitat Description: the traps were set adjacent to the boardwalk which heads north towards the Xisco Lillo hide through Tamarisk scrub (average height 2.5 m, though rising to 3.5 m in places). The Tamarisk was underlain by low, dense, *Arthrocnemum* / *Salicornia* scrub and *Aster tripolium*. Ground vegetation was rather sparse with some grass in the drier eastern side of the boardwalk. On the western side of the boardwalk *Phragmites* became dominant as the ground became wetter 2-3 m from the boardwalk.

Trap configuration details: 24 traps placed at 2 m spacings, three either side of the boardwalk at marked intervals (see trap plan). Location three on the boardwalk had only two traps on the west side and four on the east due to the wet nature of that spot. All traps were set at ground level with the entrances orientated in a random fashion.

Trap Site 2: in Es Cibollar, approximately 800 m along the track towards the power station from Sa Roca.
Date: 27/10/92

Weather: warm overnight, some cloud, light north-west wind. Some dew present in morning on examining traps.

Habitat description: low *Arthrocnemum* / *Salicornia* scrub, average height approximately 30-45 cm over damp ground. Standing water of a few centimetres deep showed beneath the two easternmost traps. A dense *Pistacia* thicket was present some 4 m to the west of the trap site. The trap site was entered by passing through a gap in the old aqueduct wall and squeezing between the strands of a barbed wire fence.

Trap configuration details: 11 traps were positioned, nine on the ground, in three groups of three, set at 60 degrees from each other, with a further two, 5 m due east of the central grouping, at a height of 25 cm in the *Arthrocnemum* / *Salicornia* scrub (see trap plan).

Trap Site 3: in the dry scrub of Ca'n Picafort Woods.

Date: 28/10/92

Weather: warm, strong overnight wind force 5/6 from west. Some cloud but dry.

Habitat description: very low scrub, average height 45-60 cm, with some small interspersed *Pinus halepensis*, average height 1.25 m. Species present included *Asparagus acutifolius*, *Rosmarinus officinalis*, *Cistus* species, *Erica multiflora*, *Pistacia lentiscus* and rather sparse *Brachypodium retusum* on very dry sandy soil. All of this was surrounded by higher canopy pine woodland.

Trap configuration details: the traps were set in three parallel transects at 2 m spacings, with 10 m between each line of traps. The first traps was set some 3 m from the edge of the track which ran north-south on the edge of the area of scrub. For location of the traps see plan below.

Trap Site 4: in Phragmites reeds along mist-net ride close to Ses Puntas dunes.

Date: 29/10/92

Weather: warm, strong north-west wind during the night, very slight dew.

Habitat description: the central portion of the trap transect consisted of trampled Phragmites reed on a relatively dry bank of spoil formed from previous excavations of ditchlines. On either side of this raised bank there was, effectively, a monoculture of Phragmites in approximately 25 to 40 cm of standing water. A small amount of Juncus acutus was scattered sparsely around the trap site.

Trap configuration details: the traps were set in three parallel lines, one line along the centre of the dry "bund", at 3m intervals, and on either side of this were placed two traps, one 2 m to the left and another 3 m to the right (with the exception of the first trap on the right which had to be placed at 2 m due to the standing water). All traps were placed on the substrate with the trap doors orientated randomly. See trap plan below.

Results

Study 1

The following animal species were documented as being present in and around the Parc Natural S'Albufera during the 17/10/92 to 31/10/92 study period. This list was compiled from observations by Earthwatch scientists, volunteers and Park staff.

Kuhl's Pipstrelle *Pipistrellus kuhli*

Two of these, a male and a female, were found dead on the main Puerto Alcudia to Ca'n Picafort road, on 29/10/92. Bats which were thought to belong to this species were observed regularly hunting in the Park workshops at night. During this period the animals were observed feeding, presumably on small insects, in the usual manner but also on a number of occasions they were seen "gleaning" insects, and perhaps other invertebrates, from the whitewashed walls of the building. This is a feeding method quite often employed by *Myotis* bat species.

Ship or Black Rat *Rattus rattus*

Seen daily around the Park especially in and around the duck trap close to the warden's house and Park buildings. A number of *Pinus halepensis* cones, from this year and one year old, apparently processed by this species were collected from Ses Puntas dunes on 24/10/92.

Brown Rat *Rattus norvegicus*

Frequently seen around the buildings. A dead female was found on the main track into the Park on 20/10/92 and a dying individual was found in the Park buildings on 27/10/92.

Rabbit *Oryctogalus cuniculus*

Seen almost daily, principally along the main Park tracks. A number were noted to be suffering from the effects of Myxomatosis.

Weasel *Mustela nivalis*

There was one sighting of this carnivore during the study period, alongside the approach road to the reception centre on 27/10/92.

Domestic Cat *Felis*

Two cats were noted dead on the main Puerto Alcudia to Ca/n Picafort road on 29/10/92; and a feral cat was present around the Park buildings on the evening of 20/10/92.

Study 2

The 105 trap/nights resulted in the capture of 19 small mammals, an 18.1% capture rate.

Table 1 Summary of species caught

House Mouse	Mus musculus	.....	11	(57.9% of total capture)
Algerian Mouse	Mus spretus	.....	7	(36.8% of total capture)
Wood Mouse	Apodemus sylvaticus	....	1	(5.3% of total capture)

Table 2 Summary according to capture site/habitat (showing number of animals caught and capture coefficients of each species in the different habitats)

	M. musculus	M. spretus	A. sylvaticus	No. of Trap/nights
Site 1 (wet/dry)	2 (0.083)	4 (0.167)	0	24
Site 2 (wet)	3 (0.273)	1 (0.091)	0	11
Site 3 (dry)	0	2 (0.057)	1 (0.029)	35
Site 4 (wet)	5 (0.143)	0	0	35

The figures in parentheses in Table 2 represent the capture coefficients for each species at the different sites. This is calculated, rather simply, by dividing the number of captures of each species, in a given habitat, by the number of trap nights in that habitat. The higher the capture coefficient the greater the likelihood of capturing that species in that habitat under the prevailing trapping conditions. Comparison of capture coefficients, rather than numbers caught, should give a more

reliable indication of the true numbers of each species present at each site (i.e. any biases in capture rates resulting from differential trapping effort are, theoretically, removed). However since trapping was undertaken on consecutive nights, differing weather conditions may also have affected the capture efficiency. This potential variation could be eliminated by comparing results from sites trapped on the same night under the same conditions.

Discussion

From examining the above, rather limited, results it would appear that there may be a link between the presence of *Mus musculus* and the degree of wetness of the habitat. The capture coefficients for that species were highest in the reedbed trapping site and the highest for *Mus spretus* were in the mixed wet/dry Site 1. This however is somewhat misleading, for within Site 1 three quarters of the *Mus spretus* captures were in the drier part of the site. By contrast the *Mus musculus* at Site 1 were all caught in the wetter areas, the two left-hand most traps on the first row to the left of the boardwalk where *Phragmites* began to encroach upon the *Arthrocnemum* / *Salicornia* and Tamarisk scrub. In the totally dry dune/woodland habitat of Site 3 no *Mus musculus* were caught, although it should be stressed that capture rates at that site were very low. These initial results suggest that the House Mouse *Mus musculus* is more likely to be caught in the wet habitats of the Park than either of the other two species caught. Indeed it is possible that there may be a degree of isolation by

habitat, within the Park, of the two closely related *Mus* species. However a more wide ranging trapping programme and larger sample sizes are needed to test this hypothesis (see recommendations for further study).

Recommendations for further study

1) Repeat the work detailed above in Study 2 using fixed numbers of Longworth mammal traps, to construct a more detailed picture of habitat use and species distribution within the Park. Small mammals may vary their use of the Park's habitats according to water levels and season. Therefore, there should be a long-term plan to obtain a series of comparable trapping data sets from different times of the year for each habitat.

2) A future trapping programme should include Longworth mammal traps taped, at different heights, to vegetation within *Cladium* and *Phragmites* beds, in both wet and dry situations. This would investigate the three-dimensional aspect of small mammal activity within the Park's reedbeds.

3) Baited Longworth traps should be placed or taped into low scrub and higher trees to discover if Garden Dormouse *Eliomys quercinus* is a constituent of the Park fauna. Ca'n Picafort Woods may be particularly worth investigating.

4) Trapping could be done at a variety of heights within the Tamarisk scrub, close to the Xisco Lillo hide, to investigate any vertical stratification in habitat utilisation between the two *Mus* species in that area.

5) The mark and re-capture of *Mus musculus* , in wet areas, and *Mus spretus* in dry areas should be considered as a means of estimating population size for the two species in relation to habitat.

6) The carrying capacity of different habitats could be examined by establishing two trap sites, with simliar trap configurations and trap effort i.e. number of trap nights as defined above, and running them in tandem on the same nights. The object of this method would be to remove any variation in capture efficiency due to weather conditions or difference in employment of the traps. A series of results from such a programme would allow comparison of species ratios in each habitat. Such a series should also allow the difference in carrying capacity of the habitats to be examined, by comparing the capture coefficients for each species in each habitat. Potential sites for comparative study include Sites 3 and 4, described above.

7) Better data for some mammal species could be obtained by systematic night-time transects, along fixed and repeatable routes, using powerful "lamping" beams. This technique is suitable for largely nocturnal species, such as Rabbit, which are otherwise difficult to monitor. Some sample "lamping" might also be undertaken in the coastal dunes and other habitats. Such a programme might also obtain further information about the status of the Pine Marten *Martes martes* in and around the Park.

ANNEX 11

The Bats of the Albufera Natural Park, Mallorca, Balearic Islands
- Spain by Jean-Francois Noblet

The following is a partial translation of the report *Les chauves-souris du Parc Natural d'Albufera, Majorque, Iles des Balears - Espagne* by J.F. Noblet. The translation has concentrated on the results of his fieldwork from 19th-25th May 1992. Copies of his full report (Noblet 1992), which includes detailed practical management proposals aimed at increasing roost and breeding sites for bats within the Park, have been lodged with the Parc Natural de S'Albufera and at the Earthwatch Europe office at Oxford, England. A translation of the report's contents page, demonstrating the depth and breadth of the study, is given in Appendix 1 below.

Introduction

Mr Nick Riddiford of Earthwatch Europe asked me to draw up an inventory of the bats of the Albufera Natural Park on the island of Mallorca in the Balearics (Spain) and to propose measures for managing these mammals, which are protected by law.

Created in 1988, the Natural Park comprises 1,708 hectares of marshland drained by canals, grazing land, plantations predominantly of white poplar bordering the canals and pine woods.

The majority of the site comprises reed-beds (of *Phragmites australis* and *Cladium mariscus*).

I - Methods used

A) BIBLIOGRAPHY

We were fortunate to have a good quality library at our disposal. We were particularly aided by the work of ALCOVER 1986 (1) and BENZAL Y. DE PAZ 1991 (3), who had already researched existing references and produced excellent synopses of the bats of the Balearics.

The most recent publication (3) gives 14 species as present on Mallorca: Greater Horseshoe Bat *Rhinolophus ferrumequinum*, Lesser Horseshoe Bat *Rhinolophus hipposideros*, Mehely's Horseshoe Bat *Rhinolophus mehelyi*, Large Mouse-eared Bat *Myotis myotis*, Long-fingered Bat *Myotis capaccinii*, Natterer's Bat *Myotis nattereri*, Serotine *Eptesicus serotinus*, Noctule *Nyctalus noctula*, Pipistrelle *Pipistrellus pipistrellus*, Kuhl's Pipistrelle *Pipistrellus kuhli*, Savi's Pipistrelle *Hypsugo savii*,

Grey Long-eared Bat *Plecotus austriacus* , Schreiber's Bat
Miniopterus schreibersi , European Free-tailed Bat *Tadarida*
teniotis . Note that ALCOVER (pers. comm.) doubts the presence of
Nyctalus noctula , the observation of which does not appear to be
sufficiently well documented.

B) SEARCH FOR ROOSTS

We systematically searched for potential roosts within the
perimeter of the Park:

- Under bridges . Only the English Bridge on the main road
had cracks which were irregularly occupied by bats (presence of
guano) .

- Buildings (behind shutters, holes in walls, ruins,
caves, dark unoccupied rooms, under tiles). A single roost was
discovered (*Pipistrellus pipistrellus* in a crack in the toilet
building opposite the Park information centre) .

- Holes in hollow trees . These are very rare. Trees are
not very abundant as it is and the area has no breeding
woodpeckers *Picidae*. Therefore hole-dwelling species are absent
or in very low densities. None of the tree-holes was found to be
occupied by bats.

- Cave . We visited the nearby cave of St. Marti (Alcudia)
on the 21st May 1992. We found large quantities of guano, 1 male
Myotis capaccinii and 3 male *Myotis myotis* .

C) CAPTURES BY MIST NET

This is the most original part of our work.

This technique works well and it proved itself again here. We trapped on 4 nights.

- 19th May 1992 : Under the bridge on the side canal upstream from the Casa Sa Roca: 7 *Pipistrellus pipistrellus* (4 males and 3 females) captured using two 12 metre nets one above the other, between 21hrs and 03hrs.

- 20th May 1992 : Across the Grand Canal upstream from the sluice gates level with the information centre, using two 12 metre nets one above the other: 1 male *Pipistrellus pipistrellus* and 2 *Myotis capaccinii* (1 male and 1 pregnant female) captured between 22hrs and 00.30hrs.

Across a woodland track on a dyke between two White Poplar plantations at the same site as above. Capture of 3 *Pipistrellus pipistrellus* (2 males and 1 female) and 3 *Barbastella barbastellus* (3 females) between 22.30hrs and 00.30hrs.

- 21st May 1992 : Across a woodland track in a pine wood using two 12 metre nets one above the other. Capture of a female *Myotis myotis* , 1 *Pipistrellus kuhli* , 1 *Myotis nattereri* and, very early in the morning, (01hrs, 02hrs, 03hrs) 3 female *Barbastella barbastellus* .

- 23rd May 1992 : At the exit of St Marti's cave using one 6 metre net from 21hrs to midnight. Saw 2 *Rhinolophus hipposideros* , one *Miniopterus schreibersi* . Capture of 7 *Myotis capaccinii* (4 males and 3 pregnant females). The females were returning to the cave towards midnight. Also captured 4 *Myotis myotis* (3 males and 1

pregnant female).

D) DIRECT OBSERVATION

By direct observation at dusk, at dawn and at night with the aid of a light we were able to establish:

- the abundance of bats over the whole area.
- the presence of *Tadarida teniotis* whose audible calls were identified every evening high in the sky above the Park.
- the probable presence of *Nyctalus leisleri* whose audible calls we appeared to recognise without being able to confirm with 100% certainty.
- the occupation of St Marti's cave at Alcudia by isolated *Myotis myotis* individuals, a male *Myotis capaccinii* , 2 *Rhinolophus hipposideros* and one *Miniopterus schreibersi* .

E) FOOD PELLETS

We found a Barn Owl *Tyto alba* nest close to the Park. Dissection of the pellets did not turn up any bat remains amongst the 150 determined prey items (comprising birds, insects, the small mammals *Mus* , *Apodemus* and *Rattus* , the gecko *Tarentola*). Taking into account the percentage of bats found in *Tyto alba* pellets in equivalent circumstances, 1,000 prey specimens would be needed before bat remains were likely to be encountered.

II - Results, list and status of Bats at S'Albufera Natural Park,
Balearic Islands, Spain

A) RHINOLOPHIDAE

1 - RHINOLOPHUS HIPPOSIDEROS : 2 individuals seen in
flight at St Marti cave, Alcudia, 23rd May. Summering.

B) VESPERTILIONIDAE

2 - MYOTIS CAPACCINII : very abundant. Hunts over the
canals. An important breeding colony is cited in the
bibliography[1] for the cave of St Marti, Alcudia.

A lactating, pregnant female was trapped on 20th May
1992. It would be interesting to investigate this species which
has a "threatened" status in the north of its range (FRANCE). A
portion of skull was found in the cave of St Marti, Alcudia.

Parasites collected : Penicillidia d. dufouri , 3 males and
3 females; Nycteribia pedicularia , 11 males and 7 females;
Spinturnix sp.

3 - MYOTIS NATTERERI : A lactating, pregnant female was
captured in the pine wood at midnight on 21st May 1992.

Parasite collected : Spinturnix sp.

4 - MYOTIS MYOTIS : although we only found 3 isolated
individuals along a woodland track on 21st May 1992, we caught a
lactating, pregnant female at 22.45hrs on 21st. On 23rd May we

trapped 4 *Myotis myotis* (3 males and a pregnant female) at the exit to the St Marti cave.

The measurements of those captured are given (in mm) below.

SEX	FORE-WING	THIRD FINGER	FIFTH FINGER	CM3
F	65.7	105.6	83.3	10
F	63	100	76.5	
M	60.5	100.2	78	10
M	61.1	103	79	10.8
M	60.7	97	76	10.7

Parasites collected : *Penicillidia d. dufouri* (Nyct.), 1 male; *Spinturnix myoti* .

5 - *PIPISTRELLUS PIPISTRELLUS* : this is probably the commonest species at S'Albufera. We saw it flying round the buildings, over water and woodland and along the woodland paths.

We also observed *Pipistrellus* bats (not identified to species) hunting at dusk among the stems of the *Phragmites* reed. They probably breed on site, but we were not able to demonstrate this because the breeding season had not yet started.

Note that in 1991 one was found, the victim of a road accident, on a road bordering the Park (Earthwatch data, 1991).

6 - *PIPISTRELLUS KUHLI* : we trapped a female of this species on 21st May 1992 at 23.15hrs. She showed no sign of reproduction.

Parasite collected : *Argas vespertilionis* (1 larva).

7 - *BARBASTELLA BARBASTELLUS* : this was the major discovery of our work.

We caught 6 individual females, all late in the night, at two separate sites: along a woodland track composed of poplars along a raised embankment on 20th May 1992 and a woodland track in a pine wood on sand on 21st May 1992.

Two of the six females were pregnant. These comprise the first record of the species for the Balearic Islands. Clearly the species is not rare at S'Albufera and uses specific habitats (woodland tracks).

To this list we add two species

- *Nyctalus leisleri*
- *Tadarida teniotis* (family: Molossidae)

based on audible calls which were heard every night at the site. The presence of *Tadarida teniotis* is without doubt. The record of *Nyctalus leisleri* is less certain.

Conclusion

As might be expected, S'Albufera Natural Park is a very favorable site for bats.

Water is abundant, as is a food source for insectivorous mammals.

Only roost/breeding sites are lacking. It is probable that more detailed searches will reveal the presence of *Hypsugo savii* , *Plecotus austriacus* and *Eptesicus serotinus* .

III - Future recommendations

A) FOLLOW-UP WORK

One of the roles of the Natural Park is to protect bats. It is therefore necessary to continue collecting information in order to establish status. I advise continuing with mist-net captures throughout the Park in a range of habitats (dunes, reed-beds, areas of open water, etc.) in summer, during the breeding season (June to September).

It would be useful to complement this technique by using ultrasound equipment operated by a specialist in this field. I could find this person.

Finally it would be useful to put up nest boxes for Barn Owls in order to obtain food pellets regularly. It would be possible to construct one in the building which serves as a workshop, in the ruins at Ses Puntetes, and in the signal towers by the sea.

Nest boxes for this species could also be installed in large trees.

V - References

- [1] Alcover, J. A., & Muntaner, J. 1986. Els quiropters de les Balears i Pitiuses: una revisio. Endins , No. 12, 1986. Ciutat de Mallorca.
- [2] Barcelo & Combis. 1875. Apuntes para la fauna balear, catalogo metodico de los mamiferos observados en las islas Baleares. Anales de la Sociedad Espanola de Historia Natural 4: 53. Madrid.
- [3] Benzal, J. & de Paz, O. 1991. Los Murcielagos de Espana y Portugal . Coleccion Tecnica, ICONA.
- [4] Earthwatch. 1991. Project S'Albufera. A new model for environmental research . Earthwatch Europe, Oxford.
- [5] Fernandez, R & Ibanez, D. 1987. Patterns of distribution of bats in the Iberian peninsula. In: European bat research (eds. Hanak, V., Horacek, I. & Gaisler, J. 1989): 357-361. Charles Univ. Press, Praha.
- [6] Anon. 1990. Tadarida teniotis in Magalluf. Papers de la Nature 7, November 1990. Conselleria d'agricultura i pesca.
- [7] Stebbings, R. E. 1986. Distribution and status of bats in Europe . Institute of Terrestrial Ecology/Natural Environmental Research Council.
- [8] Tupinier, Y. 1975. Chiropteres d'Espagne. Systematique, Biogeographie . Doctoral Thesis, Univ. Cl. Bernard (Lyon).

Appendix 1 Translation of the full report's contents page

SUMMARY

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ANNEX 12

The use of Remote Sensing for monitoring environmental change in
the Parc Natural de S'Albufera , Mallorca by Bernice Young

Aims

To utilise remotely sensed data (both Satellite Imagery and
Aerial photography) to monitor changes in vegetation, land-use,
soil moisture and water levels for the whole catchment area of
the Park.

Objectives

a) to establish a method by which Ground Truth data can be collected regularly and systematically by Earthwatch volunteers and any other interested parties.

b) To establish a method of storing the data in such a way that they can be easily disseminated to all interested parties.

c) To establish links with Colleges, Universities and other organisations with the facilities to match and process the Remotely sensed data and the ground-truth data as a means of achieving the aims of the project.

Discussion

Objective (a). The utilisation of satellite imagery is still very much in its infancy in England and much of Europe. However, the number of Academic Institutions which have the equipment and expertise to process this imagery is growing rapidly and it may not be too long before Earthwatch sees a need for such equipment. Meanwhile, satellites are collecting data on a regular basis for those who have the facilities (and the finances) to exploit this means of monitoring the earth's surface. The resolution of this imagery requires that ground-truth data must be available if accurate interpretation of the data is to be achieved. At some time in the future Earthwatch and other organisations interested in the Parc Natural de S'Albufera may find themselves in a position of having historic images of the Park (i.e. those that are being recorded now) but have no ground-truth data for accurate interpretation of the images. Objective (a) will ensure that such data are available. Volunteers on TEAM II in 1992 have

made good progress with objective (a); for more details see Annex 13.

Objective (b). Methods of storing and disseminating collected data are still to be established, something which could be undertaken during forthcoming fieldwork periods.

Objective (c). Links have already been established with Aberdeen University which is sending two students to the Park in June-July to undertake projects in connection with their current studies, the results of which will be available to Earthwatch Europe. Aberdeen University already has one image of the area and Earthwatch is providing a second image which will be utilised by the students. More recently links have been established with the University of the Balearic Islands (UIB) which is showing an interest in the project; indeed one of the volunteers on the pilot study (TEAM II) was a recent graduate of UIB's Department of Geography and provided valuable local knowledge and a great deal of enthusiasm to enable some of the objectives to be achieved. In addition to this, Dr van der Meulen has indicated that students from the University of Amsterdam would be prepared to produce historical vegetation maps from the aerial photography already available at UIB.

Summary of progress

The pilot study undertaken in May 1992 (TEAM II) indicated that the project is feasible. A methodology for the collection of data has been set up and utilised by Earthwatch volunteers and some ground-truth data have already been collected. These data have

already been offered to the students from Aberdeen should they wish to make use of them.

Editor's Footnote

The University of Aberdeen students referred to above were Antoni Marcus and Jesus Jurado Estevez from the University's Centre for Remote Sensing and Mapping Science. Using two LANDSAT images shared by the Centre and Earthwatch Europe, they undertook ground-truthing fieldwork in June-July 1992. Their studies comprised an assessment of the usefulness of Landsat TM data for vegetation discrimination in the Park (Jurado Estevez 1992); and an estimate of soil surface physical properties of the land adjacent to the Park, using the Landsat TM data (Marcus 1992). Both studies culminated in Master's dissertations (Jurado Estevez 1992; Marcus 1992), copies of which have been deposited at the Parc Natural de S'Albufera and at Earthwatch Europe's office in Oxford, England.

ANNEX 13

Parc Natural de S'Albufera - Remote Sensing pilot study by
Bernice Young

Aim

To determine the feasibility of using Earthwatch volunteers to collect the ground-truth data for Remote sensing studies on a regular and systematic basis.

Objectives

(a) To establish a working methodology for collecting data both within the Park and beyond its boundaries but within its catchment area.

(b) To test the methodology in the field and adjust where necessary.

(c) To identify the areas to be surveyed.

(d) To use Earthwatch volunteers to employ the method devised to collect data from the areas identified.

Discussion

Objective (a).

As there were a number of particular avenues of study possible using remote sensing, it was necessary to select the most relevant type of data to collect in relation to the immediate needs of Project S'Albufera . Outside the Park it seemed most feasible to collect land-use/vegetation data as this would provide valuable background information for any type of specialised study (e.g. the soils study planned by the University of Aberdeen). Within the Park the land-use/vegetation is fairly uniform, i.e. open water and reed beds. It was decided that greater detail of vegetation type might be required here, in particular the distribution of the two most dominant species in the Park, *Phragmites australis* and *Cladium mariscus* .

In order to collect data systematically, it was necessary to construct a key to the main land-use/vegetation categories.

Taking into account the fact that many volunteers collecting the data would not be Geographers, Botanists or Agriculturalists, it was important for the key to be as simple as possible and self explanatory. Consequently the volunteers themselves were asked to produce the key, with the valuable assistance of the Mallorcan volunteer who knew the area well. The decision was also made to produce the Mallorcan and Spanish versions of the key so that it was available for use by English-speaking and local people.

Once a provisional key was in place, it was necessary to select the size of area to be surveyed given the method of transport available and access to the area (though car and bicycles were available to transport surveyors to the site, most of the surveying on site needed to be undertaken on foot). In England it is usual to survey 1 km² units in relation to the UTM grid. In Mallorca, where the field sizes are much smaller and the time available for the survey limited to between two and six weeks, it was decided that 0.5 km squares would be most appropriate.

Establishing a methodology for data collection required different approaches to survey inside and outside the Park.

Outside the Park full consideration was needed of the fact that much of the land was private and that local people might be concerned to see strangers making notes with regard to the crops they were growing, etc. Usually survey squares are chosen at random but in this case it was necessary to choose squares that had sufficient public right-of-way for data to be collected without trespassing. A letter was also written in Mallorcan

explaining the nature of the survey, which could be shown to anyone who might challenge the survey team or show concern at their presence. The content of the letter was approved by Biel Perello and printed on Parc Natural de S'Albufera letter headed paper.

Inside the Park consideration had to be given to the difficulties and dangers of working in a marsh. The reeds were tall enough to obscure landmarks and it was easy to lose one's sense of direction. The reedbeds were criss-crossed by deep canals and Park workers reported that on occasions they had slipped into deep holes beneath the reeds. It was theoretically possible to access most of the Park by boat. In practice a number of the canals were choked with vegetation and progress by boat was painfully slow, and often impossible. Squares had to be chosen which were accessible by land or boat without too much difficulty and full consideration of safety had to be incorporated in the methodology devised to record the distribution of vegetation.

Objective (b).

The volunteers were shown how to read grid-references on a map, how to use a compass and once in the field they were shown how to record their observations on the data recording sheets provided. In the land surrounding the Park recording proved fairly straight forward and only a few changes were required to the provisional land-use/vegetation key. Within the Park, working in the marsh proved more problematical until a 100 m rope was purchased and whistles adopted for communication.

Objective (c).

Once working methods had been established and tested, survey squares had to be identified and pro-formas created (without the use of a photo-copier this required a lot of tracing from the map which in itself was time consuming and should not be necessary in future). For the pilot project, squares within cycling distance of Sa Roca were identified from the map (see plan attached).

Four squares were chosen within the Park, one square on the Park boundary and four squares outside the Park. The grid references of the chosen squares (South West Corner) were:

Sa Pobla sheet 671 - 11 1:25.000

1. 0511.5 4403.5 Sand dune/Caseta de ses Salines
2. 0510.5 4402.5 Urban/agricultural area
3. 0509.5 4405.0 Reed beds
4. 0509.5 4402.5 Reed beds (Park boundary)
5. 0509.0 4404.0 Reed beds
6. 0508.5 4406.5 Reed beds
7. 0507.0 4402.5 Residential/marsh Son Monget
8. 0506.0 4406.5 Agricultural
9. 0506.0 4404.0 Residential/agricultural

Objective (d).

Of nine squares chosen, two proved unworkable due to access problems. They were:

Square 6. The canal adjacent to the track was too deep to cross with waders. Access to the square by boat was not possible due to vegetation in the canal. In future this square could only be worked if a small boat were transported by land.

Square 9. Hard to get to by bicycle (Torrent de Muro gets in the

way). Access is possible by car if approached from the south.

Squares 2, 7 and 8 outside the Park were successfully surveyed, each one taking approximately one day and requiring two volunteers.

Squares 4 and 5 within the marsh were completed once a few logistical problems had been overcome. Marsh squares take on average 1.5 days to complete using a minimum of 3 volunteers.

There was not sufficient time to survey squares 1 and 3.

Conclusion

Considering that Team II only had four volunteers and that other work such as bird and butterfly studies was also undertaken, a tremendous amount was accomplished. Three of the volunteers had never undertaken work of this nature before but were very successful in completing squares 2, 7 and 8 without any supervision from the Scientific Team once initial guidance had been given. A lot of the hard work in the marshland was undertaken, with great enthusiasm, by the Mallorcan volunteer (Macia) gallantly assisted by at least one other volunteer and with myself making up the third member of the team on most occasions. The work is hard, wet and dusty, especially in hot weather and a certain amount of stamina is required. (Macia advocates that we should advertise for at least one BIG volunteer for this job). Nevertheless, the work was enjoyed by all and there was never any shortage of volunteers. Many thanks to Patricia, Zita, Alexandra and Macia - and to Sara who got `roped

in' (literally) on occasions. For further details of methodology and data collected, see Annex 12.

ANNEX 13 MAP HERE
(page 220)

ANNEX 14
Monitoring orchids at S'Albufera, Mallorca, 1992 by Terry Wells

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(page 221 to page)
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ANNEX 15
Fungi at S'Albufera by Sheila Wells

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ANNEX 16
Ornithological Research based on ringing, S'Albufera 1991-92 by
Jon King

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ANNEX 1

Archanara geminipuncta , *Phragmites australis* and Reed Buntings by
Barry Goater

Introduction

We were asked to investigate the identity and life history of a
lepidopterous larva inhabiting the stems of Common Reed

Phragmites australis (Cav.), which was stated to be a principal
food of Reed Buntings *Emberiza schoeniclus* (L.) on S'Albufera.
During the period of the investigation, 18-30 May 1992, it was
possible to identify the species concerned as *Archanara*
geminipuncta (Haw.), and to obtain some information on its
distribution in the Park, but a number of important questions
remained unanswered and others arose.

Life cycle of *Archanara geminipuncta* in Northern Europe

The species overwinters as an egg. The precise site of
oviposition is unknown, but is probably near ground level at the
bases of the current year's reed shoots. The larvae hatch in May,
and bore into the terminal section of a young shoot, killing the
terminal leaf and working downwards through one or more
internodes. The burrow behind the growing larva is filled with
frass. In late July, the full-fed larva emerges through a
circular exit-hole just above a node and re-enters the same or
another stem about halfway down the shoot and just above a node;

higher up the same internode, it gnaws an oval "window" c7 mm high and 4.5 mm wide, leaving the epidermis intact, and pupates head up somewhere below the "window". The pupal period lasts about 3 weeks, after which the moth emerges by forcing through the exit "window", leaving the empty pupa-case within.

The situation at S'Albufera in May

Attacks on the stems of *Phragmites* were found to be widespread but localised throughout the reedbeds in the Park. In the second fortnight of May, all the feeding tunnels had been vacated and the majority of larvae had pupated. Infected stems were easily identified by the presence of a dead, brown lead at the top of the reed-stem, and the pupation site was pinpointed by discovery of either the oval exit "window" or by the conspicuous hole marking the point of entry of the larva. Pupae collected on 21 May began to emerge on 12 June, approximately 6-8 weeks earlier than in Britain. Bird-damaged stems were conspicuous from afar, up to 4cm of the pupal internode having been shattered by pecking. Preliminary observations on 19 May suggested that larval infestations occurred in colonies, mainly along the edges of reedbeds abutting tracks or droves and not deep in the beds, and that some colonies had been attacked by birds more intensively than others. Subsequent counts tended to confirm these impressions.

Sampling technique

The team selected a number of "different-looking" sites within the reedbed complex for sampling:

- i) middle of dense stand of Phragmites .
- ii) dense stand of Phragmites mixed with Cladium .
- iii) tall reeds on wet substratum at edge of reedbed.
- iv) tall reeds on dry substratum beside track at edge of reedbed.
- v) short reeds on dry substratum beside track at edge of reedbed.

With the team operating in pairs consisting of a counter and scorer, each site was then sampled by the counters walking through the site and recording every reed stem that came within arm's reach, under the headings Undamaged , Attacked by Larva , Attacked by Bird , until a minimum of 100 stems had been examined (Table 1). It soon became clear that not every stem that had been attacked by a feeding larva contained a larva or pupa in an internode below as a potential target for bird attack, so in a second investigation the proportion of stems containing a pupation chamber below the feeding zone was counted (Table 2).

Table 1: Incidence of *A. geminipuncta* -infested stems

Site	Stems examined	Undamaged	Attacked by larva	Bird-attacked
edge of cycle track (A)	206	84	88	34
edge of cycle track (B)	100	34	48	18
track near mound (A)	119	116	2	1
track near mound (B)	100	86	14	0
edge of broad grassy track (A)	100	92	6	2
edge of broad grassy track (B)	101	56	28	17
middle of reedbed with <i>Cladium</i>	100	92	8	0
walkway between dense reeds	107	73	25	9
edge of broad track (tall reeds)	100	99	1	0
edge of broad track (short reeds)	100	54	39	7

Table 2: Numbers of larvae pupating in stems in which they have fed, sample from 21 May 1992

Number of infested stems examined	106
Larvae still in feeding burrow	0
Feeding burrow attacked by bird	0
Larvae preparing to pupate in an internode below feeding burrow	12

Pupae in an internode below feeding burrow	24
Pupal internode opened by bird	11

Conclusions

The following tentative conclusions are drawn from this preliminary investigation:

i) *Archanara geminipuncta* occurs in scattered colonies throughout the S'Albufera reedbeds, favouring well-grown reeds along the margins of tracks and droves and shunning the dense beds.

ii) The larva is strictly monophagous, and no more than one larva is ever found feeding in a single reed stem.

iii) Damage by the larva is restricted to killing the terminal leaf of the infected shoot and however heavy the infestation the health of the plant is unlikely to be impaired.

iv) When the full-fed larva leaves the feeding burrow, it often pupates in an internode in the same stem, but may enter an adjacent one for this purpose. Hence, many stems showing signs of larval attack contain no pupae, and occasionally two pupae (in different internodes) are found in a single stem below a feeding burrow. There are also likely to be pupae in stems in which no feeding had taken place, but these are much more difficult to find. During the period of investigation, only one such was discovered by chance.

v) No evidence was found of birds attacking larvae in

their feeding burrows, but only after they had entered the pupal internode. The investigation was done at about the time pupation was happening (proportion of pupae: larvae ready for pupation was 2:1). Already there were signs of bird attack (11 out of 47 pupal chambers had been opened by birds), and such attacks would be likely to continue until the moths emerged.

vi) Even so, this particular food-source will be available to birds for a maximum of one month of the year, mid-May to mid-June, unless the moth is double- or multiple-brooded. There is no evidence for this, and the annual cycle of the foodplant, *Phragmites*, makes it most unlikely.

vii) No attacks by birds on infected *Phragmites* stems were seen during the investigation. Damage is attributed by the ornithologists to Reed Buntings *Emberiza schoeniclus*, and they suggest that the S'Albufera population of Reed Buntings have significantly enlarged bills to deal with this particular food-source. Even if the buntings are single-brooded, and the appearance of their young coincides with the availability of *Archanara geminipuncta* pupae, it seems that other factors must have operated in the evolution of a large-billed race of Reed Buntings on S'Albufera.

Matters for further investigation

i) Does *Phragmites* at S'Albufera have an annual cycle similar to that in northern Europe, i.e. does it produce new shoots in the spring and die down in the autumn?

ii) Is *Archanara geminipuncta* single-brooded in Mallorca, and if not, how does it behave during the development of other brood(s)?

iii) Is there hard evidence that a principle food-source of Reed Buntings on S'Albufera in May-June is *Archanara geminipuncta* and that the birds are single-brooded?

iv) What do Reed Buntings feed on during the other 11 months of the year?

Appendix 1: Observations by ornithologists Jon King, Pere Vicens and Nick Riddiford

The points raised by Barry Goater above prompt us to add the following comments.

In relation to Conclusion point v):

We have all observed Reed Buntings removing large larvae from *Phragmites* stems in April and May.

In relation to Conclusion point vi):

Work by Earthwatch Europe volunteers in October 1992 indicated that the moth is at least double- and possibly multiple-brooded at S'Albufera (see Annex 2 for further details).

In relation to Conclusion point vii):

There is no doubting the enlarged bill size of

breeding Reed Buntings at S'Albufera. This was confirmed by a suite of measurements taken at various times of year in 1992 and including, in October, a mixture of local residents and thin-billed European migrants. A few other species at S'Albufera may have the capability of removing larvae from Phragmites stems, particularly Great Tits *Parus major* which are frequently seen foraging in the reed-beds. Reed Buntings are single-brooded at S'Albufera.

Although our observations add to the information needed to understand the complex relationships between Reed Buntings, moth larvae and Phragmites, we agree with the main thrust of his recommendations that further investigation is needed, in relation to the annual cycle of Phragmites at S'Albufera, the population dynamics of *Archanara geminipuncta* at S'Albufera and the feeding ecology of S'Albufera Reed Buntings.

ANNEX 2

A brief study of the growth of *Phragmites* by Alan Radermacher

Aim

To investigate the extent of infection of *Phragmites australis* by the moth *Archanara geminipuncta* .

This was carried out by the volunteers of team 4 between October 17th and October 31st 1992 and coordinated by Alan Radermacher. We selected sites similar to those chosen by Barry Goater (BG) in May 1992 so that a comparison could be made and more could be learned about the life cycle of the moth. The location of the sites is given in Figure 1.

Method

Each site was sampled by regularly spaced metre squares. Over 2000 stems were recorded and over 200 were collected for examination to determine the validity of the field assumptions.

Each metre square was analysed in the following way. Metre rules were held 1.5 m from the ground to delimit the stems. The total number of stems projecting above this level was recorded. Each stem was then assigned to one of four categories.

(1) Healthy mature stem (over 2 m tall).

(2) Infected stem (judged by the presence of a brown terminal leaf and the presence of a green side shoot just below the infected region).

(3) Dead stems (no green leaves and stem often broken).

(4) Young plants (between 1.5 and 2 m tall).

Nothing below 1.5 m was recorded. If a stem was young and infected there was a problem as to which category it should be assigned. There was not a great number of these but they were placed in the 'Infected' category.

Each team usually consisted of three volunteers, one to hold the two rulers, one to call out the stem categories and one to note them down. Ideally a fourth would cut and carry selected stems for examination later.

Site 1 was a recently cut path through a dense reed bed near the Lillo bird hide (no BG equivalent). Carried out on October 22nd.

Site 2 was along the south side of the Grand Canal to the west. Thought to be equivalent to BG's "Edge of broad grassy track". Carried out on October 24th.

Site 3 was along the east side of the track to the fossil dunes by Ses Puntas. Thought to be equivalent to BG's "edge of broad track - short reeds". Carried out on October 27th.

Site 4 - as for 3 but tall reeds on the west side of the track.

Carried out on October 27th. Also referred to by BG.

Site 5 was along the wooden walk way on the south side of the grazing meadow near the horse. Probably equivalent to BG's "walk way between tall reeds". Carried out on October 27th.

Site 6 was the "track by the mound" and the results were combined with site 7, "the cycle track" both referred to by BG.

Results

Site	Healthy	Infected	Dead	Young	Total
1	37	65	201	31	334
2	33	91	252	122	468
3	2	34	159	139	327
4	63	41	94	25	221
5	55	82	78	62	278
6/7	108	162	85	76	431

Site	% infected of mature living stems	% of all stems (excl. young ones) that were dead	% of young stems
1	64	66	10
2	73	67	26
3	24	82	43
4	39	56	11
5	60	36	23
6/7	60	24	17

Comments on results

Site 1

30 stems were collected for examination.

17 stems were classified as 'Infected'. 9 contained a caterpillar and the rest contained frass.

13 stems were classified as 'Dead'. One contained a caterpillar, 4 contained frass and 8 had no evidence of infection.

In addition 2 large pupal cases were found with exit hole at the opposite end of the internode.

All the larvae were small feeding forms.

Site 2

30 stems were collected for examination.

19 stems were classified as 'Infected'. 4 contained a caterpillar, 13 just contained frass and in 2 there was no evidence of infection.

11 stems were classified as 'Dead'. In 5 there was frass and in 6 there was no evidence of infection.

A lot of the 'young' stems were clearly infected in this area and usually showed internal evidence of this as well.

Site 3

Just 8 'Infected' stems were sampled from the young plants along this side of the track.

4 stems were found to contain caterpillars and 4 contained frass.

Few stems were over 2 m hence the low number in the first column.

Site 4

36 stems were collected for examination.

20 stems were classified as `Infected'. 13 contained caterpillars, 1 contained a pupal case, 2 contained frass and 3 appeared uninfected.

16 dead samples were examined. 8 contained caterpillars (small feeding type). 1 stem contained 2 pupal cases, 5 contained frass and 2 appeared uninfected.

Site 5

35 samples were taken.

All were `dead' because it was hoped to find older stages of the caterpillar's life cycle, perhaps `left over' from an earlier generation. 2 large caterpillars were found and 3 moulted skins of small ones.

22 samples had frass and 3 of these were found in 3 separate internodes showing several levels of probable secondary infection. 8 showed no signs of infection.

Sites 6/7

30 stems were collected for examination.

12 were classified as `Infected'. In 5 there was no evidence of infection, 3 had frass and 6 had small feeding caterpillars.

18 were classified as `Dead'. One had a pupa 1.8 cm long that had ceased to develop. One had a large 3 cm caterpillar. 12 had frass showing that secondary occupation had been completed. Exit holes were usually found. In 2 of them secondary infection had occurred at two levels. In 4 of this sample no evidence of

infection was found. Presumably the infected area had been lost or the stem died of other causes. In most sites 'Dead' stems often showed no evidence of infection presumably for this reason.

Conclusion

Many of BG's observations were confirmed but we could find no 'edge' or 'margin' effect in which the suggested infestations spread into the central regions of reed beds. There were however very clear characteristics which were localised. For instance the 'walk way' site was the only place where young moulted caterpillar cases were found. The 'cycle track' and 'mound path' were the only sites where large caterpillars were found.

Exit holes at the top of internodes were often found and measured 6 mm x 3 mm. Smaller holes 2.5 mm x 1.5 mm were also present and presumed to be entry holes for secondary infection. We rarely found 'windows' probably because they had usually been pushed out during exit by the adult.

We agreed that the feeding caterpillar was monophagous but secondary infection often affected one stem at several levels.

The feeding caterpillar was usually 1 cm long and fitted perfectly into the hollow stem equidistant from each node. In the 'walk way' site the size varied more, 0.7 to 1.3 cm, but all were presumably of the same generation. These caterpillars probably infected the young stem (as BG suggests) and grow with the plant. If the egg was laid on the young growing top the tiny larval caterpillar could enter easily and thus the tip (top internode)

is what is observed to die at a later stage. The caterpillar always stimulates a side branch at the base of its node and the effect seems to extend down the stem causing side branches from lower nodes in many cases. Young stems (1.5 m tall) were often clearly infected but shorter stems than these are presumably often infected as well though the outward effects cannot be determined at that stage. We did not search for young stages of the caterpillar on stems shorter than 1.5 m.

'Dead' stems presumably died after a determined growth period and were not caused to die by the caterpillar. As BG states "infection does not seem to impair the healthy growth of the plant".

Discussion

Many interesting investigations suggest themselves. How long is the caterpillar's life cycle? How many generations were there between BG's that hatched on June 12th and those observed in October? When the young caterpillar enters a stem does it adapt to the speed of growth of the stem? Does the stem reach maturity in one season?

Did our large (3 cm) caterpillars represent the left overs of BG's generation? Surely not. We did not often see evidence of bird damage or Reed Buntings feeding. Presumably there were not enough caterpillars of a worthwhile size at this time. Reed Buntings were not seen often but were around and were trapped. About 50% of those ringed were 'continental' winter visitors with a bill depth of 4.8 - 5.3 mm. The others were resident birds with

a bill depth of 5.8-6.5 mm. Does the lignified Phragmites stem with a large caterpillar inside have sufficient selection pressure to favour this size of beak? If there are worthwhile caterpillars inside when other food is scarce perhaps the selection pressure could be great enough. This might occur in November when this generation of caterpillars matures to the pupation stage. However it is not clear when they will reach that stage and if they over-winter as a small 'hibernating' form.

It would be very satisfying if a link could be made between Phragmites growth, caterpillar life cycle and Reed Bunting bill depth but organisms rarely fit into a simple relationship for the satisfaction of their investigators.

Appendix: State of stems recorded in each metre square

Site 1	Healthy	Infected	Dead	Young
1	1	4	12	1
2	1	2	24	3
3	2	3	21	1
4	5	10	30	1
5	4	2	14	1
6	0	6	15	0
7	1	9	8	3
8	2	4	21	2
9	1	9	8	2
10	4	1	9	0
11	3	6	6	3
12	4	1	5	0
13	3	2	10	4
14	3	2	11	5
15	3	4	7	5
Totals	37	65	201	31

Site 2	Healthy	Infected	Dead	Young
1	2	3	9	7
2	0	4	12	7
3	2	2	22	11
4	0	10	24	4
5	0	3	15	10

6	0	2	12	3
7	1	0	21	6
8	2	11	14	2
9	0	3	14	7
10	4	3	11	5
11	2	2	11	9
12	1	6	12	8
13	0	15	8	5
14	4	8	0	9
15	7	4	3	2
16	3	2	21	5
17	1	6	5	6
18	2	4	17	3
19	1	0	14	7
20	1	3	10	7
Totals	33	91	252	122

Site 3	Healthy	Infected	Dead	Young & Healthy
1	1	3	14	22
2	0	5	0	34
3	0	3	15	8
4	1	1	11	16
5	0	3	19	11
6	0	7	19	3
7	0	4	14	15
8	0	4	37	14
9	0	4	28	14
Totals	2	34	159	139

Site 4	Healthy	Infected	Dead	Young
1	3	3	11	1
2	1	10	7	2
3	7	4	13	5
4	6	7	10	4
5	4	3	9	6
6	15	11	17	0
7	15	0	6	1
8	10	0	11	0
9	2	3	10	3
Totals	63	41	94	25

Site 5	Healthy	Infected	Dead	Young
1	7	4	3	6
2	1	6	2	15
3	4	8	8	5

4	10	8	3	3
5	6	8	10	3
6	15	9	1	7
7	5	7	12	3
8	1	21	5	8
9	6	4	16	10
10	6	7	18	2
Totals	55	82	78	62

Site 6	Healthy	Infected	Dead	Young
1	1	3	2	4
2	2	12	2	3
3	4	4	3	2
4	6	4	3	3
5	3	5	5	2
6	5	6	1	3
7	2	6	2	6
8	4	7	7	2
9	3	5	4	3
10	5	4	4	3
Totals	35	56	33	31

Site 7	Healthy	Infected	Dead	Young
1	6	5	2	7
2	8	3	3	5
3	6	3	1	7
4	0	1	1	12
5	2	5	10	2
6	4	6	6	4
7	0	8	7	0
8	5	6	9	1
9	3	6	6	4
10	4	7	7	3
Totals	73	106	52	45

ANNEX 2, FIGURE 1 HERE
(page 114)

ANNEX 3

Recording methods and location for Coastal Dune Transects 1, 2
and 3 by Franklyn Perring

Dune transects 1, 2 and 3 were laid out by Earthwatch Europe
volunteers under the direction of Dr F. H. Perring during the
period 19th-29th May 1992.

Notes on Recording the Transects

1. The 50 m tape can be pulled tight over the metal post caps at
either end of a 50 m stretch by putting a marker pole through
the loop of the tape at 0.0 m and putting a second marker pole
through the handle of the 50 m tape at the 50 m end.
2. All readings of the vegetation are taken to the right hand
side of the tape (south side of these dune transects) when
facing the end of the transect.
3. Records of species which touch a vertical circular pole of 12

mm diameter are made every metre along the transect.

4. Every 10 metres, between the 4.0 and 5.0 m marks (i.e. 4-5 m, 14-15 m, 24-25 m etc.), a one-metre quadrat is laid out, which is divided into twenty-five 20x20 cm squares. In each of these squares the cover of each species present is estimated using the following code system.

A = 1-25% B = 26-50% C = 51-75% D = 76-100%

5. Each plant species found in the dunes has been given a unique code number and these are given, in alphabetical order of genus and species on a code sheet.
6. To record the quadrat efficiently a team of four is needed: one to call out the code numbers; one to write the results on a pro-forma; and two to estimate the cover and hold the quadrat in place on the two sides.
7. As far as possible those working in the quadrats and transect should remain on the N side of the line to avoid damage to the vegetation being recorded.

Dune Transect 1

The starting point is 200 m S of the 24 km post on the Alcudia-Ca'n Picafort road, 10 m E of the E margin of the cycle track. Here is located a metal post c1 m high. This is a marker for the exact starting point which is a buried metal post, capped by a square aluminium collar and a mushroom-shaped head with a magnetic metal insert, which is 45 cm S of the 1 m metal post.

The transect runs towards the S edge of the northernmost of two obelisks which are visible towards the beach on a bearing of 72 degrees. The bearing to the southern obelisk, which is more clearly visible, is 91 degrees.

The transect is marked by further buried metal posts at 50 m intervals and most of these intervals are marked by wooden posts erected in October 1991 and marked EARTHWATCH. These were not located accurately enough and the metal posts are the ones from which measurements must be taken.

The second metal post is at 50 m, 55 cm SE of a wooden post marked `Earthwatch 50 m'.

The third metal post is at 100 m, 10 cm S of a wooden post marked `Earthwatch 100 m'.

The fourth metal post is at 150 m, 10 cm E of a wooden post marked `Earthwatch 150 m'.

The fifth metal post is at 200 m, 10 cm N of a wooden post but the point for measurement is 10 cm W of the metal post (trunk of bush preventing marking of the exact point). It is marked `Earthwatch 200 m'.

The sixth metal post is at 250 m, 30 cm N of the wooden post marked `Earthwatch 250 m'.

The seventh metal post is at 300 m, 50 cm W of a wooden post close to the W side of a path, marked `Earthwatch 300 m'.

The eighth metal post is 29.30 m from the 300 m post from which a direct sighting and route was impossible. This post is 50 m from

the SW edge of the obelisk on a bearing of 252 degrees.

The total length of the transect to the obelisk is therefore 350
+ 29.30 = 379.30 m

The "cliff" drop to the beach is 7.30 m from the SW corner of the
obelisk and the vegetation ceases on the beach 4.40 m beyond the
cliff. The plant nearest the sea was *Matthiola sinuata* .

Total length of Transect 1 was 391.0 m.

Dune Transect 2

The starting point is 20.6 m E of the E edge of the cycle track
almost opposite the 24.5 km post on the Ca'n Picafort road, which
is on the S side of a bend.

The starting point is marked by a metal post sunk into the ground
19 cm W of a wooden post marked 'Earthwatch Trans 2'. There is an
electricity pylon to the W of this starting point. The left hand
side of the main structure is due W on a bearing of 270 degrees.

The bearing of the transect towards the sea is 57 degrees and is
aimed at the crest of a pine tree in the bottom of a U-shaped
belt of pines on the horizon.

The second metal post is at 50 m, 46 cm E of a wooden post marked
'Earthwatch Trans 2, 50 m'. This metal post is the correct mark
from which measurements should be taken.

The third metal post is at 100 m, 33 cm SSE of a wooden post marked `Earthwatch Trans 2, 100 m'.

The fourth metal post is at 150 m, 24 cm N of a wooden post marked `Earthwatch Trans 2, 150 m'.

The fifth metal post is at 200 m, 42 cm S of a wooden post marked `Earthwatch Trans 2, 200 m'.

The sixth metal post is at 250 m, 6 cm W of a wooden post marked `Earthwatch Trans 2, 250 m'.

The seventh metal post is at 300 m, 11 cm E of a wooden post marked `Earthwatch Trans 2, 300 m'.

The eighth metal post is at 342 m, 18 cm W of a wooden post marked `Earthwatch Trans 2, 342 m'.

The transect continues on the same bearing of 57 degrees until it reaches the end of the vegetation on the beach (*Eryngium maritimum*) after a further 16.50 m.

Total length of transect 2 is therefore $342.0 + 16.58 = 358.50$ m.

Dune Transect 3

The starting point is 7.50 m E of the E edge of the cycle track, 180.225 m S of the 25 km post on the E side of the road to Ca'n Picafort in the entrance road to the Albufera Park Hotel, close

to a pine with a distinctly bent trunk.

The starting point is marked by a metal post sunk into the ground, which is 5 cm E of a wooden post marked `Earthwatch Trans 3'.

The Transect runs to the centre of an obelisk on the horizon on a compass bearing of 84.5 degrees.

The second metal post is at 50 m, 3 cm E of a wooden post marked `Earthwatch Trans 3, 50 m'. The metal post is the correct mark from which measurements should be taken.

The third metal post is at 100 m, 10 cm E of a wooden post marked `Earthwatch Trans 3, 100 m'. The metal post is the correct mark.

The fourth metal post is at 150 m, 3 cm E of a wooden post marked `Earthwatch Trans 3, 150 m'.

The fifth metal post is at 200 m, 3 cm E of a wooden post marked `Earthwatch Trans 3, 200 m'.

The first section of the transect ends at the NW corner of the obelisk in a further 38.45 m.

The total length of the first section to the NW corner of the obelisk is therefore 238.45 m.

The second section of Transect 3 starts at the same NW corner of the obelisk and goes towards the sea on a bearing of 33 degrees.

The sixth metal post, the first of this section, is 50 m from the NW corner of the obelisk measured from 1 m above the platform at

compass/theodolite reading height. It is 17 cm W of a wooden post marked `Earthwatch Trans 3, 50 m Sect 2'.

The seventh metal post, the second of this section, is 100 m from the NW corner of the obelisk. It is 18 cm N of a wooden post marked `Earthwatch Trans 3, 100 m Sect 2'.

The end of the transect is a further 36.80 m from the seventh post on a bearing of 33 degrees, which is a cliff face above the beach.

The total length of Section 2 is thus 136.80 m

And the total length of Transect 3 is $238.45 + 136.80 = 375.25$ m

ANNEX 4

The Parc Natural de S'Albufera Herbarium, a progress report by Jo Newbould

The mounted specimens are now very efficiently housed in the purpose-built herbarium cabinet which was very kindly donated by Mrs Roma Parmenter in memory of her late husband, Neville. We are deeply grateful to Mrs Parmenter for this generous gift. The herbarium specimens can be kept in much better conditions than previously.

The herbarium is being extended all the time. In April 1992 about 20 plants were added, in May and October another 45-50, so there are now about 340 plants in the herbarium and another 12 or so are being definitively identified before being incorporated.

The herbarium material is being augmented by photographs, both colour prints and transparencies. In 1992 the expertise of one of the volunteers, a professional photographer, was utilised to this end.

Other scientists, especially Dr Franklyn Perring, have also added to the collection.

There are still a number of plants recorded in the literature which have not yet been located (it is suspected that some of these are misidentifications), whilst 9 plants were found in 1992 which had not previously been recorded from the Park.

ANNEX 5

Lichens of S'Albufera, Mallorca 1991 by Franklyn Perring

In the spring and autumn of 1991 collections were made of the lichens found growing at S'Albufera. Particular attention was given to those on trees (corticolous) and those on walls of buildings and on the ruined aqueducts (saxicolous).

The specimens were taken to England where they were looked at by two lichenologists, Tom Chester on Brackley, and by a colleague D. E. McCutcheon of Blaydon-on-Tyne.

A total of 67 gatherings were examined in which 41 different taxa were identified. Twenty-two were corticolous, 8 were saxicolous

whilst one (*Caloplaca halocarpa*) was found on both trees and stones.

A set of identified specimens was returned to S'Albufera in spring 1992 where they now form the basis of a reference collection in the Park herbarium.

The list of taxa, with their localities and habitats, follows in alphabetical order of genera, for ease of reference.

Arthonia cf radiata

On N side of young pine in open scrub brush, Es Comu.

Caloplaca cerinella

On E side of elm in brushy wood, Gran Canal bank.

Caloplaca citrina

Behind derelict building ("Sevende"), 200 m up track, Salines: on wall outside derelict building c200 m from farm near Ca'n Extut: Ses Puntet track, 400 m from Gran Canal: Ses Puntet track, 800 m from Gran Canal.

Caloplaca flavescens

On N side of sandstone bench, Ses Puntet: on top of E-W wall near Gran Canal: on wall outside derelict building c200 m from farm near Ca'n Extut: on wall on route to Power Station (near Power Station): on aqueduct wall 200 m from Gran Canal, Ses Puntet track.

Caloplaca cf flavescens

On N side of concrete block, Gran Canal bank: on N side of

sandstone wall, Sa Roca ruins: on sandstone roadside wall, Cami de Sa Siurana.

Caloplaca holocarpa

On W side of dead elm in brushy wood, Gran Canal bank: Ses Punes track, 800 m from Gran Canal: on limb intersection of pine in Pine wood, Es Comu.

Caloplaca cf. ochracea

On concrete in brushy wood, Gran Canal bank.

Collema sp

On N side of sandstone bench, Ses Punes.

Conotrema homalotropum

On white poplar, Cami de Sa Siurana: on white poplar in dense vegetation next to canal, Cami de Sa Siurana.

Diploicia canescens

On E side of white poplar in brushy wood, Gran Canal bank: on E side of pine in Pine Wood, Es Comu (fertile): on W side of pine in Pine wood, Es Comu: on N side of sandstone bench, Ses Punes: on N side of elm in brushy wood, Gran Canal bank.

Diptotomma alboatrum

On top of E-W wall near Gran Canal.

Fuscidia lightfootii

On S side of pine tree on edge of open area, Es Comu.

Graphis scripta

On white poplar next to the canal, Cami de Sa Suirana: on dry branch of elm in dense vegetation, Cami de Sa Siurana: on young

elm next to road, Cami de Sa Siurana.

Lecanactis premnea

On N side of elm in brushy wood, Gran Canal bank.

Lecanora albescens

On N side of sandstone wall, Sa Roca ruins.

Lecanora chlarotera

On N side of elm in brushy wood, Gran Canal bank: on N and E sides of white poplar in brushy wood, Gran Canal bank: on N side of white poplar in wood by house, Sa Roca (slug-grazed): on W side of dead elm in brushy wood, Gran Canal bank: on S side of pine in Pine wood next to track, Es Comu.

Lecanora dispersa agg .

On sandstone roadside wall, Cami de Sa Siurana.

Lecanora expallens

On S side of pine in Pine wood, Es Comu.

Lecanora varia

On S side of pine in Pine wood, Es Comu.

Lecidella elaeochroma

On W side of dead elm in brushy wood, Gran Canal bank: on limb intersection of pine in Pine wood, Es Comu.

Opegrapha atra

On twig of white poplar, Cami de Sa Siurana.

Opegrapha herbarum

On E side of white poplar, Gran Canal bank.

Opegrapha cf sorediifera

On E and S sides of pine in Pine wood, Es Comu.

Opegrapha varia

On W side of dead elm in brushy wood, Gran Canal bank.

Physcia ascendens

On S side of pine on edge of open brush, Es Comu: in bark crevices on pine on edge of Pine wood, Es Comu.

Pyrrospora quercea

On E side of pine in Pine wood, Es Comu (fertile): on N and S sides of pines in Pine wood, Es Comu: on S side of pine in wood next to track, Es Comu.

Ramalina evernioides

On twig of pine in Pine Wood, Es Comu: on white poplar in open field near house ruin, Ses Punes.

Ramalina farinacea

On W side of elm and dead elm in brushy wood, Gran Canal bank.

Rinodina cf gennarii

On N side of sandstone wall, Sa Roca ruins.

Solenospora candicans ?

On N side of sandstone bench, Ses Punes.

Squamarina cartilaginea

On N side of sandstone bench, Ses Punes.

Thelotrema subtile

On white poplar, Cami de Sa Siurana: on white poplar in dense

vegetation next to canal, Cami de Sa Siurana.

Verrucaria cf hochstetteri

C50 m from derelict building c200 m from farm near Ca'n Extut:
Ses Puntet track, 300 m beyond pines.

Verrucaria cf muralis

On wall on route to Power Station (near Power Station).

Verrucaria cf nigrescens

On N side of sandstone wall, Sa Roca ruins.

Verrucaria nigrescens

On N side of concrete block, Gran Canal bank: on wall on route to
Power Station (near Power Station): on aqueduct wall 200 m from
Gran Canal, Ses Puntet track: Ses Puntet track, 400 m from Gran
Canal.

Xanthoria parietina

On W side of white poplar in brushy wood, Gran Canal bank: on N
side of elm in brushy wood, Gran Canal bank (shade form): on E
side of elm in brushy wood, Gran Canal bank: on W side of dead
elm in brushy wood, Gran Canal bank: on twig of white poplar,
Cami de Sa Siurana: on dead tree trunk, Cami de Sa Siurana: on S
side of pine tree on edge of open area, Es Comu: on E side of
white poplar on edge of field near house ruin, Ses Puntet.

ANNEX 6

Lepidoptera (Heterocera) recorded at S'Albufera Natural Park,
18-30 May 1992 by Barry Goater

COSSIDAE

Zeuzera pyrina Son Sant Joan, 24/5, female at mercury
vapour (m.v.) light; Sa Roca, 24/5, male
at m.v. light.

ETHMIIDAE

Ethmia bipunctella Sa Roca, 18/5, one at m.v. light.

TORTRICIDAE

Acleris variegana Sa Roca, 18/5, two at m.v. light; few seen subsequently in same locality.

Rhyacionia buoliana Sa Roca, 18/5, one at m.v. light.

PYRALIDAE

Acigona cicatricella Sa Roca, 29/5, one male at m.v. light.

Calamotropha paludella Track by Gran Canal, 28/5, several at m.v. light.

Angustalius malacellus Sa Roca, 23/5, one at m.v. light.

Pediasia contaminella Sa Roca, 19/5, two at m.v. light; few seen subsequently on same site.

Schoenobius gigantella Sa Roca, 20/5, two females at m.v. light. Es Cibollar, 23/5, two females at m.v. light; Son Sant Joan, 24/5, female at m.v. light; track by Gran Canal, 28/5, several of both sexes at m.v. light.

Elophila nympheata Sa Roca, 29/5, one at m.v. light.

Parapoynx stratiotata Sa Roca, 20/5, one female at m.v. light.

Cataclysta lemnata Track by Gran Canal, 28/5, two males at m.v. light.

Sitochroa palealis Sa Roca, 18/5, one netted by day; Es Cibollar, 23/5, one at m.v. light.

Sclerocona acutellus Sa Roca, 18/5, five at m.v. light and seen regularly in small numbers for rest of period; Es Cibollar, 23/5, several at m.v. light; Son Sant Joan, 24/5, one at m.v. light.

Ebulea testacealis Sa Roca, 18/5, one at m.v. light and

regular in small numbers for rest of period; Es Cibollar, 22/5, two at m.v. light.

Mecyna asinalis Sa Roca, 19/5, one at m.v. light and a few subsequently; track by Gran Canal, 28/5, one at m.v. light.

Palpita unionalis Son Sant Joan, 24/5, one at m.v. light.

Dolichartia punctalis Es Comu, 20/5, two at m.v. light and a few subsequently; Son Sant Joan, 24/5, one at m.v. light.

Nomophila noctuella Sa Roca, 29/5, one at m.v. light.

Orthopygia glaucinalis Es Comu, 20/5, one at m.v. light; Es Cibollar, 23/5, one at m.v. light.

Pyralis farinalis Sa Roca, 18/5, one on wall of building.

Endotriche flammealis Es Comu, 20/5, one at m.v. light.

Therapne obsoletalis Sa Roca, 18/5, one at m.v. light and a few subsequently; Es Comu, 20/5, three at m.v. light.

Lamoria anella Es Cibollar, 23/5, two at m.v. light.

Oncocera semirubella Sa Roca, 18/5, several netted by day; Es Cibollar, 22/5 & 23/5, several at m.v. light; track by Gran Canal, 28/5, one at m.v. light. Common in sandy places throughout S'Albufera.

Pempelia numidella
gelinella Sa Roca, 18/5, two at m.v. light and subsequently in small numbers.

Nephoteryx rhenella Sa Roca, 19/5, two at m.v. light and up to three per night subsequently.

Dioryctria mendacella Sa Roca, 18/5, two at m.v. light; Es Comu, 20/5, one at m.v. light.

Epischnia illotella Sa Roca, 18/5, one at m.v. light; a few later in the period.

Acrobasis obliqua Sa Roca, 19/5, two at m.v. light; Es Comu, 20/5, two at m.v. light; Es Cibollar, 22/5, one at m.v. light. Widespread in small numbers.

Myelois circumvoluta Sa Roca, 18/5, two at m.v. light; track by Gran Canal, 28/5, one at m.v. light.

Ectomyelois ceratoniae Sa Roca, 26/5, one at m.v. light.

Euzophera osseatella Sa Roca, singletons at m.v. light, 25/5 & 26/5.

Homeosoma sinuella Sa Roca, 19/5, one at m.v. light.

LASIOCAMPIDAE

Dendrolimus pini Sa Roca, 30/5, pale male at m.v. light.

THYATIRIDAE

Tethea ocularis Sa Roca, 18/5, one at m.v. light and a few subsequently.

GEOMETRIDAE

Microloxia herbaria Es Comu, 20/5, one at m.v. light.

Scopula emutaria Sa Roca, 18/5, two at m.v. light and a few later in the period; Es Cibollar, 22/5 & 23/5, one each night at m.v. light; Son Sant Joan, 24/5, one at m.v.

light; track by Gran Canal, 28/5, one at
m.v. light.

Scopula minorata

ochroleucaria Sa Roca, 18/5, two at m.v. light; a few
subsequently.

Idaea ochrata Track by Gran Canal, 28/5, one at m.v.
light.

Orthonama obstipata Sa Roca, 18/5, one at m.v. light.

Costaconvexa polygrammata Sa Roca, 18/5, one at m.v. light; Son
Sant Joan, 24/5, one at m.v. light.

Thera firmata ulicata Es Comu, 20/5, three at m.v. light.

Horisme vitalbata Es Comu, 20/5, one at m.v. light.

Horisme scorteata Sa Roca, 19/5, one at m.v. light.

Eupithecia breviculata Es Cibollar, 22/5, one at m.v. light.

Semiothisa aestimaria Sa Roca, 18/5, three at m.v. light and
regularly in small numbers for rest of
period; track by Gran Canal, 28/5, one at
m.v. light.

Pachycnemia hippocastanaria Sa Roca, 20/5, one at m.v. light.

Menophra abruptaria Es Comu, 20/5, one at m.v. light; Sa
Roca, 26/5, one at m.v. light.

Peribatodes rhomboidaria Es Comu, 20/5, three at m.v. light.

Aspitates ochrearia Sa Roca, 22/5, one at m.v. light; Es
Cibollar, 23/5, one at m.v. light.

SPHINGIDAE

Macroglossum stellatarum Track by Gran Canal, 28/5, one at m.v.
light.

Hyles euphorbiae dahlia Sa Roca, 18/5, three at m.v. light; Es

Comu, 20/5, one at m.v. light, and one or two on most subsequent nights; Es Cibollar, 22/5, one at m.v. light and three on 23/5; Son Bosc, 29/5, c20 larvae of various sizes on Euphorbia terracina .

Hyles livornica Sa Roca, 18/5, one at m.v. light; Es Comu, 20/5, one at m.v. light; Es Cibollar, 22/5, one at m.v. light; Son Sant Joan, 24/5, two at m.v. light.

Deilephila elpenor Es Cibollar, 22/5, one at m.v. light; Son Sant Joan, 24/5, one at m.v. light.

NOTODONTIDAE

Furcula bifida Sa Roca, 26/5, one at m.v. light.

Cerura iberica Sa Roca, 18/5, six at m.v. light, several more on subsequent nights; Es Comu, 20/5, one at m.v. light. Genitalia checked.

ARCTIIDAE

Pelosia obtusa Sa Roca, 18/5, three at m.v. light; Es Cibollar, 22/5 & 23/5, several at m.v. light; Son Sant Joan, 24/5, several at m.v. light. One of the more interesting resident species in the reedbeds.

Pelosia plumosa Sa Roca, 18/5, two at m.v. light and fairly common subsequently; Es Comu, 20/5, two at m.v. light; Es Cibollar,

22/5 & 23/5, several at m.v. light; Son Sant Joan, 24/5, one at m.v. light; track by Gran Canal, 28/5, three at m.v. light. An obscure but extremely interesting species, known from a few localities in southern Spain, north Africa and southern Italy. Like its congener, living in dense reedbeds. New to Balearic Islands.

Eilema caniola torsteni Es Cibollar, 23/5, one at m.v. light; Son Sant Joan, 24/5, one at m.v. light. Endemic subspecies.

Apaidia mesogona Es Comu, 20/5, three at m.v. light.

Spilosoma urticae Sa Roca, 18/5, three at m.v. light and regularly for rest of period; Es Comu, 20/5, one at m.v. light; Es Cibollar, 22/5 & 23/5, one each night at m.v. light; Son Sant Joan, 24/5, three at m.v. light; track by Gran Canal, 28/5, several at m.v. light.

NOLIDAE

Meganola albula Es Cibollar, 22/5, one at m.v. light; Son Sant Joan, 24/5, one at m.v. light.

Nola squalida Sa Roca, 18/5, four at m.v. light and seen commonly during rest of period at m.v. light and house lights; Es Cibollar, 22/5, five at m.v. light, 23/5, several.

NOCTUIDAE

- Agrotis spinifera* Sa Roca, 29/5, one at m.v. light.
- Agrotis ipsilon* Sa Roca, 18/5, one at m.v. light; track by Gran Canal, 28/5, one at m.v. light.
- Agrotis exclamationis* Track by Gran Canal, 28/5, one at m.v. light.
- Ochropleura leucogaster* Sa Roca, 18/5, one at m.v. light; Es Es Cibollar, 23/5, one at m.v. light; track by Gran Canal, 28/5, one at m.v. light.
- Noctua pronuba* Sa Roca, 18/5, one at m.v. light and in small numbers subsequently; Es Comu, 20/5, one at m.v. light; Es Cibollar, 22/5, one at m.v. light.
- Peridroma saucia* Es Cibollar, 23/5, one at m.v. light; track by Gran Canal, 28/5, one at m.v. light.
- Discestra sodae* Sa Roca, 18/5, one at m.v. light and a few more during following fortnight; Es Cibollar, 22/5 & 23/5, two at m.v. light each night; track by Gran Canal, 28/5, one at m.v. light.
- Mamestra oleracea* Sa Roca, 18/5, one at m.v. light and present in small numbers subsequently; Es Comu, 20/5, two at m.v. light; Es Cibollar, 23/5, two at m.v. light; Son Sant Joan, 24/5, two at m.v. light; track by Gran Canal, 28/5, several at m.v. light.

Hadena bicruris Es Cibollar, 22/5, one at m.v. light. Not recorded by Calle for Balearic Islands.

Hadena confusa Son Sant Joan, 24/5, one at m.v. light.

Mythimna albipuncta Sa Roca, 19/5, one at m.v. light.

Mythimna vitellina Son Sant Joan, 24/5, one at m.v. light.

Mythimna obsoleta Sa Roca, 18/5, common at m.v. light; Es Comu, 20/5, fairly common; Es Cibollar, 22/5 & 23/5, fairly common; Son Sant Joan, 24./5 fairly common; track by Gran Canal, 28/5, fairly common at m.v. light. The commonest species on S'Albufera during the period of study.

Mythimna riparia Sa Roca, 18/5, one at m.v. light and a few more during the next fortnight; Es Cibollar, 23/5, one at m.v. light; track by Gran Canal, 28/5, two at m.v. light. Calle gives no record for the Balearic Islands.

Mythimna l-album Sa Roca, 22/5, one at m.v. light; Es Cibollar, 23/5, one at m.v. light. No record in Calle for the Balearic Islands.

Mythimna joannisi Es Comu, 20/5, one at m.v. light; Es Cibollar, 22/5 two at m.v. light, 23/5, one; Son Sant Joan, 24/5, one at m.v. light; track by Gran Canal, 28/5, two at m.v. light. Known from a few localities in SE Spain and on Corsica, but not

recorded by Calle for the Balearic Islands.

Calophasia platyptera Track by Gran Canal, 28/5, one at m.v. light.

Simyra albovenosa Track by Gran Canal, 28/5, one at m.v. light. Calle gives no previous record for the Balearic Islands.

Acronicta tridens Sa Roca, 22/5, one at m.v. light. No previous record for the Balearic Islands, according to Calle.

Trachea atriplicis Sa Roca, 22/5, one at m.v. light. Calle gives no record for the Balearic Islands.

Nonagria typhae Sa Roca, 18.v, one f. *fraterna* at m.v. light; Son Sant Joan, 24/5, one of the typical form at m.v. light.

Archanara geminipuncta S'Albufera, pupae and occasional larvae locally common in stems of *Phragmites australis*, the subject of a detailed investigation. Moths emerged between 12th and 26th June. Calle gives no previous record for the Balearic Islands.

Archanara dissoluta Es Cibollar, 23/5, one at m.v. light; track by Gran Canal, 28/5, one at m.v. light. Apparently new to both the Balearic Islands and mainland Spain.

Sesamia nonagrioides Sa Roca, 18/5, five at m.v. light and several subsequently; Es Cibollar, 22/5 &

23/5, one each night at m.v. light; track by Gran Canal, 28/5, several at m.v. light.

Hoplodrina ambigua Sa Roca, 18/5, five at m.v. light and common subsequently; Son Sant Joan, 24/5, one at m.v. light; track by Gran Canal, 28/5, one at m.v. light.

Spodoptera exigua Sa Roca, 23/5, one at m.v. light.

Chilodes maritimus Sa Roca, 18/5, two at m.v. light and regularly in small numbers subsequently; Es Comu, 20/5, two at m.v. light; Es Cibollar, 22/5, two at m.v. light, 23/5, one; Son Sant Joan, 24/5, one at m.v. light; track by Gran Canal, 28/5, several at m.v. light. Typical form and abs. nigrostriata , wismariensis and bipunctata all recorded. Calle gives no record for the Balearic Islands.

Athetis hospes Sa Roca, 18/5, three at m.v. light and fairly frequent subsequently; Es Comu, 20/5, one at m.v. light; Es Cibollar, 22/5 & 23/5, one each night at m.v. light; Son Sant Joan, 24/5, one at m.v. light; track by Gran Canal, 28/5, three at m.v. Calle gives no record for the Balearic Islands.

Heliothis peltigera Mouth of Gran Canal, 30/5, one flying by day.

Eublemma ostrina Sa Roca, 22/5, one at m.v. light.

Emmelia trabealis Es Cibollar, 22/5, two at m.v. light; Son Sant Joan, 24/5, three at m.v. light; track by Gran Canal, 28/5, one at m.v. light.

Zebeeba falsalis Es Comu, 20/5, four at m.v. light; Es Cibollar, 22/5, one at m.v. light.

Eutelia adulatrix Es Comu, 20/5, one at m.v. light; Es Cibollar, 23/5, one at m.v. light; track by Gran Canal, 28/5, three at m.v. light.

Autographa gamma Sa Roca, 29/5, one at m.v. light.

Ctenoplusia accentifera Es Cibollar, 22/5, one at m.v. light; Calle gives no record for the Balearic Islands, but a specimen exists in the Project S'Albufera collection.

Ophiusa tirhaca Es Comu, 20/5, one at m.v. light. No record in Calle for the Balearic Islands.

Clytie illunaris Track by Gran Canal, 28/5, one at m.v. light. Calle records the species from Ibiza but not Mallorca.

Dysgonia algira Sa Roca, 18/5, one at m.v. light; Son Sant Joan, 24/5, one at m.v. light; track by Gran Canal, 28/5, one at m.v. light.

Grammodes bifasciata Sa Roca, 18/5, one at m.v. light. Calle gives no record for the Balearic

Islands.

- Aedia leucomelas* Es Cibollar, 22/5, one at m.v. light; Son Sant Joan, 24/5, one at m.v. light; track by Gran Canal, 28/5, four at m.v. light.
- Tyta luctuosa* Sa Roca, 18/5, one at m.v. light and several subsequently; Es Cibollar, 22/5, four at m.v. light.
- Lygephila cracca* Sa Roca, 18/5, one at m.v. light and a few later in the period.
- Pechipogo plumigeralis* Track by Gran Canal, 28/5, two at m.v. light.
- Schrankia costaestrigalis* Sa Roca, 18/5, one at m.v. light.
Unrecorded by Calle for the Balearic Islands.

A few species remain to be identified.

References

- Calle, J.A. (1983). Noctuidos Espanoles . Madrid.
- Leraut, P. (1980). Liste Systematique et Synonymique des Lepidopteres de France, Belgique et Corse .

ANNEX 7

S'Albufera Syrphids (Diptera) in 1992 by Nick Riddiford and Simon McKelvey

Hoverfly studies continued in 1992 with regular transect walks. No comprehensive survey of species was done but a collection was made of all hoverfly species along the transect route on 9th, 19th and 26th May and 23rd October. In October a few additional individuals were obtained during night-time trapping for moths (Lepidoptera). Few hoverflies were recorded in April and October, but there were greater numbers and diversity in May, particularly towards the end of the month. A similar pattern of abundance applied to the transect target species, *Episyrphus balteatus* .

Specimens were collected by NR. May specimens were identified by SMcK, October ones by NR. All identifications were made using Stubbs & Falk (1983). However, due to the presence of Mediterranean taxa additional to those covered by the key, species of *Chrysotoxum* , *Doros* and *Eumerus* were identified only to genera.

Table 1 lists the species recorded.

Table 1. S'Albufera Syrphid list, 1992

SPECIES	DATES, NUMBERS & NOTES
<i>Melanotoma mellinum</i>	19.5.92 (one male, one female).

Chrysotoxum species	9.5.92 (one); 19.5.92 (one).
Dasysyrphus albostriatus	23.10.92 (one in moth trap); 25.10.92 (one in moth trap). Not recorded in 1991.
Doros species	19.5.92 (one). Genus not recorded in 1991.
Episyrphus balteatus	Common in late May.
Meliscaeva auricollis	21.10.92 (one in moth trap).
Syrphus ribesii	9.5.92 (female). Not recorded in 1991.
Syrphus vitripennis	26.5.92 (male). Not recorded in 1991.
Eristalinus aeneus	19.5.92 (female); 26.5.92 (one).
Parahelophilus versicolor	26.5.92 (female).
Eumerus species	9.5.92 (one). Genus not recorded in 1991.
Syrpitta pipiens	9.5.92 (one); 19.5.92 (one male, 2 females); 26.5.92 (one male, 3 females); 23.10.92 (male); 31.10.92 (one in moth trap). Common, particularly in May.

Reference

STUBBS, A.E. & FALK, S.J. 1983. British Hoverflies . BENHS,

London.

□

APPENDIX 4 - Planning for 1993-94 and beyond

Appendix 4 presents a revised version of the research elements

contained in the Project's planning document Project S'Albufera, Planning for 1993-94 and beyond: a discussion paper (Riddiford 1992), which was formulated from the recommendations of the Field Scientists' Review Meeting in April 1992.

Part 1. Introduction

Following the publication in autumn 1991 of Project S'Albufera - A new model for environmental research , a review group of international scientists was invited to S'Albufera in April 1992 to assess progress during the first three years of the Project and to advise on its shape and directions in the future.

This discussion paper while remaining faithful to the overall aims of the Project, clearly defined at the start and continuing to play a central role in the work of the Project, draws heavily from the thoughts and recommendations of the review group, published in Project S'Albufera - Report of field scientists' review meeting, 28-30 April 1992 .

One of the major conclusions emerging from the review group meeting was that priorities need to be recognised and these should draw on the Project's demonstrated strong points. Even within this scenario, the operating costs are enormous and can only be achieved with a large funding commitment outside the normal channels of Earthwatch monetary support. So to match what is needed with what is possible, I have structured the proposed plan of work for 1993-94 (and in some cases beyond) in four

tiers, comprising ongoing studies which may be achieved under Earthwatch Europe tutelage and normal financial support (First Tier), studies which need to be tackled or are ongoing but depend on extra funding (Second Tier), parallel studies by Universities and other bodies in partnership or co-operation with Earthwatch Europe and Project S'Albufera (Third Tier) and those studies which are needed but for which no scientists or means are currently available (Fourth Tier).

The studies proposed within each of these tiers are summarised within Priority categories in Part 3 and listed according to tier in Part 4.

Part 2. Priorities

I see priorities for 1993-94 (and beyond) falling into six categories. They are:

1. Multi-disciplinary study of processes going on, 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. Furtherance of data-processing and the data-base potential and methodology, including development of compatible systems for comparative work and integration into international networks and schemes.
5. Long-term monitoring aimed at assessing environmental change.
6. Extension of baseline information.

Part 3. Studies

There follows a summary of studies which I and others involved in the Project have identified as meeting the above priorities. They are far from comprehensive and are likely to be added to as further fieldwork and consultations with scientists throw up other questions which need to be answered, information which needs to be gathered, etc.; and of course there is the opportunity, too, for scientific input into this current plan, which is also intended to have a consultative role. Most of the studies have been selected because they are already in place or attracting the interest and/or commitment of Universities and other bodies. Other studies suggested have no such linkage at the moment and may serve as notice for inclusion in the future development of the plan beyond 1994.

I have ordered studies under headings which relate to the priorities outlined above. Some studies are of direct relevance

to two or more priority categories and it should be borne in mind that there will be some overlap of categories for nearly all studies (e.g. dune systems studies may have application also in providing information on the impact of management strategies, in supplying data for the interpretation services of the Park and in long-term monitoring for change).

3.1 Studies appropriate to multi-disciplinary study of processes

3.1.1 . The Phragmites - Cladium dominated wetland ecosystem

Much of S'Albufera is wetland dominated by the marshland plants

Phragmites australis and Cladium mariscus . The pioneering work by Professor Newbould on aspects of biomass and productivity for these two species has been recognised as one of the Project's strong points. The interest of several scientists and institutions now gives us the opportunity to extend this work to other areas which will allow a multi-disciplinary study of processes.

3.1.1.1 Autecology of Phragmites and Cladium

Palmer Newbould's work should be developed from his ongoing studies of productivity of Phragmites and Cladium shoots to include the rhizomes and root mass and, to add to the dry weight data, values for the processes of decomposition and nutrient cycling. His work should also be extended to other aspects of the ecology of these plants, including a greater knowledge of their annual cycle. Professor Newbould's continued involvement in these studies will require back-up assistance including better on-site

equipment and facilities and expertise from scientists at the University of the Balearic Islands (UIB) in Palma. There is a particular need for Mallorcan home-based involvement for such aspects as recording the annual cycle.

3.1.1.2 Photosynthesis and productivity of marshland plants

Some of the facilities mentioned in 3.1.1.1 above have been offered by Dr Hipolito Medrano of the UIB. Dr Medrano has an international reputation in photosynthesis research. He specialised until recently in photosynthesis in crops but is now keen to extend that study to plants in more natural situations. He is head of Fisiologia Vegetal (Vegetal Physiology) of UIB's Department of Biology. He has worked in the past with Dr Roger Austen, another photosynthesis expert recently retired from Cambridge University, and they wish to plan a joint study of the Phragmites - Cladium ecosystem concentrating on photosynthesis, plant production and growth - research which they see as complementing and furthering the studies undertaken by Prof. Newbould. As an indication of his interest in the subject, Dr Medrano has already undertaken preliminary studies at S'Albufera with students from his Department, while Dr Austen assessed the potential of the site in May 1992.

3.1.1.3 Heavy metals in marsh plants

A study is currently being done by members of the UIB's Sub-department of Vegetal Physiology, led by Maria Pou Bordoy, Catalina Cabot and John Sibole, into the heavy metal content of

the aquatic macrophyte *Lemna*. This study has been undertaken at the instigation of Joan Mayol, Director of the Park, for conservation reasons: ducks are an important part of the Park's avifauna and *Lemna* is a food source for ducks. The infrastructure and interest is therefore in place to extend this research to other marshland plants.

3.1.1.4 Decomposition of reedbed plants

Dr Enrique Descals of the Consejo Superior de Investigaciones Cientificas (CSIC), based at Palma, has been conducting studies for a number of years on the role of microfungi in the decomposition of dead plant matter in the canals of S'Albufera. Dr Descals, along with Dr Antoni Martinez of the UIB's Department of Biology, Limnology section, have been keen supporters of the Project and its objectives from the start and have given much advice and practical help in that time. These two scientists have the means within their fields of expertise, and those of other members of their and adjacent UIB departments, to extend current studies to encompass this important aspect of the marshland ecosystem. This would complement the work of Prof. Newbould and others.

3.1.1.5 Study of relationships between *Archanara geminipuncta* biology, Reed Bunting feeding and breeding biology and their impact on *Phragmites* reed

Phragmites is attacked by the caterpillars of a wainscot moth *Archanara geminipuncta*. These bore into the stems and consume the inner tissues. Apical growth then ceases but is replaced by

several more slender lateral shoots. Infestation levels up to 80% have been recorded but none in the year following burning of the reedbed. It may take several years for the moth to colonise reed beds after burning. The caterpillar has an impact not only on growth of the plant but on two bird species. The Moustached Warbler *Acrocephalus melanopogon* (for which S'Albufera is one of the World's most important sites) requires reedbeds of two levels, the lower comprising a layer of broken, dead material.

Archanara geminipuncta may play an important part in breaking down the reeds to create a suitable habitat for these birds. In addition, Reed Buntings *Emberiza schoeniclus* have been observed extracting and eating the caterpillars. The local population, in parallel with others of the species occupying SW Mediterranean reedbed sites, have developed a much thicker bill than their central and north European counterparts. This thick-billed Reed Bunting is one of few bird species able to extract the caterpillars, using the bill to strip away the outer casing of

Phragmites stems. The thickness of the bill in this population may be associated with this feeding behaviour (though this may not be the only reason). We have interested Anna Traveset of the Institut d'Estudis Avancats de les Illes Balears (CSIC-UIB) in this subject and she has begun her own investigations, though currently in her spare time away from other commitments. She is based in Palma and is a specialist in insect-plant interactions, currently conducting work on nearby Cabrera.

3.1.1.6 Bird population dynamics

A study of the population dynamics of reedbed species has been

established using constant effort ringing at two older (i.e. not recently burnt) reedbed sites in Es Colombar and near Ses Puntes. This study has been extended beyond the periods of Earthwatch field presence by Jon King, ornithological researcher from the Edward Grey Institute, University of Oxford, who is currently based there. This has allowed collection of data on fledging dates and breeding productivity as well as variations in the structure of the adult community.

3.1.1.7 Ornithological studies: Moustached Warblers

I have been in discussion with Dr Chris Perrins, Director of Oxford University's Edward Grey Institute for Field Ornithology (EGI), regarding the placement of a postgraduate student to study S'Albufera's Moustached Warblers *Acrocephalus melanopogon*. Dr Perrins indicated that it would require an NERC grant and "the right student" and that, though in principal he is in favour, current financial constraints meant the study was not likely to be implemented at the moment. The proposal, written by myself and Jon King is as follows:

"In general the European Acrocephaline warblers have received considerable research interest, principally regarding their mating systems and resource partitioning in reedbed communities. The Moustached Warbler however, confined to extensive reedbeds of the Mediterranean Basin and Middle East, has remained virtually unstudied. Although it is now amongst the rarest birds in Western Europe, many basic facts about its biology are unknown.

The recently-created Parc Natural de S'Albufera, Mallorca holds a population of Moustached Warblers probably in excess of one thousand pairs and consequently may represent the most important site for the species within its known world range. A limited database already exists for the species in the Parc, derived from short studies by the British Trust for Ornithology, University College London and Earthwatch Europe in the last 8 years. These suggest an unusually high longevity for a small passerine, with consequent low population turnover, and a high proportion of 'floating' young males; implications for the mating system of the species are as yet unknown. In one main area of the Parc, a large proportion of the Moustached Warblers are already colour-ringed as a result of this previous work. The presence of two other species of Acrocephaline warbler at S'Albufera would allow original studies on a guild of reedbed warblers to be compared with the extensive literature on this subject.

A further, valuable component of this study would be the opportunity to use Moustached Warbler populations to monitor reedbed management techniques. Active grazing by cattle is increasingly used at S'Albufera, and at similar reserves in the Mediterranean, to open up feeding areas for large non-passerines (herons, wildfowl etc.). However, the impact of this on smaller, reed-dependent species is very unclear. Given the Parc's international responsibility to the Moustached Warbler, and that species' total dependence on the affected habitat, clarification of the ecological relationships involved is urgent.

The facilities at S'Albufera are ideal for housing research scientists, and the Parc's management actively encourage and assist their work. A postgraduate student would gain much

from the growing band of ecologists working at S'Albufera, forming an integrated study of reed productivity (Prof. P. Newbould, Ulster), the Fan-tailed Warbler (J.R. King, EGI) and long-term monitoring of many aspects of the Parc's natural history (Earthwatch Europe, Parc staff)."

I have also been discussing this study with the only scientist involved in Moustached Warbler research, Dr Bernd Leisler of the Max-Planck-Institut fur Verhaltensphysiologie, Germany. He has indicated a willingness to help with advice and with parallel research in his own Austrian study area.

3.1.1.8 Bird predator studies

At varying times of the year Marsh Harriers *Circus aeruginosus* , Ospreys *Pandion haliaetus* , falcons (including the rare Eleonora's Falcon *Falco eleonora*), egrets and herons are common and highly visible components of the Park's avifauna. Because of their size and visibility, and because they are at the top of a food chain, they may prove to be indicator species for the health of the environment. There is a limited variety of fish (though an abundance of those which occur) and mammals (e.g. no voles) so the predators will be obligate feeders on a more restricted diet of readily abundant prey such as eels and frogs. We have done some preliminary work on the diurnal activity patterns and preferred feeding areas of Purple Herons *Ardea purpurea* , using Earthwatch volunteers, but much remains to be done in assessing the impact of bird predators. Earthwatch volunteers would be very useful assistants in observing predator behaviour (and it would

be a popular task for them), but such studies could only be developed fully by detailed research. I identify this as a potential postgraduate research topic, possibly in conjunction with the Tour du Valat Biological Station (and their heron expert, Heinz Hafner).

3.1.2 The hydrological system

3.1.2.1 Hydrogeological study

This is a key area of study for which we still have inadequate data. Our knowledge of the hydrology of the Park was enhanced by the efforts of the University College London's Ecology and Conservation Unit in 1989-90, but their research demonstrated that much more information was needed which could only be achieved by an in-depth study embracing the whole water catchment area, using data collected over a longer period of time and calling on the expertise of specialists and expensive specialised equipment. This was clearly beyond the direct resources of Project S'Albufera. However, it was within the capabilities of the Mallorcan hydrological service, who we identify as the obvious body to obtain these data which are vital not only to the Project but to the Park authorities and, indirectly, to other local interests such as the agriculturalists and hoteliers. We understand from Joan Mayol that an in-depth hydrogeological study is now planned, supported and funded by the Balearic Islands Government.

3.1.2.2 Water quality and pollutants

This is an area for which we have very little data, other than for salinity. However, observations indicate that the water chemistry is a key factor affecting the flora, fauna and ecosystems throughout the Park. Clearly aspects such as geohydrology, water chemistry, plant productivity and decomposition and habitats for birds and other animals are related to each other functionally. Apart from salinity, the ecosystem may be subject to a whole range of water and air borne pollutants. We know nothing of the effects on S'Albufera of emissions from the local power station; run-off from adjacent farmland may be bringing a range of agrochemicals from pesticides to nutrient-rich nitrates and nitrites; and speculation has been made about sewage infiltration into the Park. From 1993 we intend to study water quality, aimed at detecting these chemicals, initially by collecting water samples from selected locations. Drs Martinez and Medrano have indicated that facilities are available to analyse water samples within their departments at UIB. Eventually, the study should be developed, perhaps at postgraduate level, by the UIB where it would tie in with current and recent work by Martinez on the aquatic macrophytes and Medrano on reedbed plant photosynthesis and productivity.

This study is also of direct relevance to a number of other aspects of Project and Park work. For instance it may demonstrate the importance of reedbed plants such as Phragmites in absorbing, and thus acting as a natural cleansing agent for pollutants, reveal the impact of pollutants on biodiversity or the survival of threatened biota and, consequently, influence future management practices.

3.1.2.3 Nutrient exchange

In May 1992 Drs Moya, Ramon and Martinez of the UIB's Department of Biology, and two scientists from the University of Barcelona were awarded a three-year research grant (amounting to ca 5.5 million pesetas) to work on vertical nutrient exchange between water and sediment, and horizontal exchange between S'Albufera and the Bay of Alcludia. Though this constitutes independent research not initiated or suggested by Project S'Albufera, both topics are of interest and direct relevance to our work.

3.1.2.4 Freshwater macrophytes and water quality

Some of the most detailed scientific work done at S'Albufera, involving the distribution of aquatic macrophytes in relation to the physico-chemical dynamics of the water systems, was undertaken by Dr Antoni Martinez for his doctoral thesis in the 1980s. He has maintained a great interest in this subject and in 1990-91 attempted, unsuccessfully, to obtain funding for a study to extend this research. This was to be a joint undertaking with Dr Sven Jonasson, Director of the University of Copenhagen's Institute of Plant Ecology. Both retain a commitment to develop this topic if funding becomes available.

3.1.2.5 Freshwater invertebrates and water quality

Richard Fox, a postgraduate student from University College

London (supervised by Dr Roderick Fisher of UCL's Ecology and Conservation Unit) made a study this summer (1992) of freshwater invertebrate species as indicators of water quality. His intended methodology for the study included implementing the RIVPACS computer program, developed for UK freshwater systems but already tested in amended form in mainland Spain. Eventually he was not able to use this program. However, adaptation of such a system for S'Albufera would be very welcome and of direct relevance to our long-term monitoring objectives and Park management planning as well as providing additional information for studies such as those outlined in 3.1.2.2, 3.1.2.4 and 3.1.2.6.

3.1.2.6 Mollusc studies

Dr Chris Paul of the University of Liverpool's Department of Earth Sciences participated in the Project in October 1991 and May 1992. His task was to set up a baseline for molluscs, to investigate their role as key indicator species and to recommend further research relevant to the Project's objectives. One of the major findings from Dr Paul's survey was that, though shells were present in abundance, live snails were in much lower numbers than anticipated or normal in similar habitats elsewhere. This was particularly the case for aquatic snails. As a result he recommends monitoring of water quality, including salinity, in relation to the abundance of living aquatic molluscs. Apart from its relevance to our interest in water quality and its effects on the fauna and flora of the Park, this study also has an innovative aspect. Dr Paul knows of only one general study of the salinity tolerances of fresh and brackish water molluscs and that

was done nearly 40 years ago. Dr Paul writes: "Jaeckel's (1955) classic study of the molluscs of the Schlei, which drains into the Baltic where maximum salinities are only 16%, is the only general study of which I know. His fauna did not include six of the 15 aquatic species recorded from S'Albufera, including the four commonest species seen alive. Documenting salinity tolerances of the aquatic molluscs in S'Albufera would not only add to knowledge concerning molluscs, but reveal both changes in the hydrology of the marsh and their effects on aquatic molluscs. Such a study might also help explain some distributions, e.g. why live specimens of both Hydrobia and Amnicola are almost confined to the northern part of the Park".

Dr Paul felt that he, in conjunction with his department at Liverpool, could be involved in future researches into molluscs at S'Albufera but probably in partnership with Dr Cristian Altaba. Dr Altaba is an acknowledged expert on Balearic molluscs and is based in Palma with the CSIC. Dr Altaba has expressed an interest in becoming involved in mollusc studies at S'Albufera but stresses that, though the CSIC has offices at UIB, the CSIC comprises government scientists independent of the University and thus not working with students. Access to student participation can be achieved by Dr Paul retaining an involvement; the advantage of Dr Altaba's participation is not just his expertise but the year-round coverage he would be able to offer and which is necessary to further elucidate this and other mollusc problems. Dr Paul makes other very relevant recommendations for future mollusc research which appear under other headings in this document (see 3.1.3.5, 3.5.1.1 and 3.6.7).

3.1.2.7 Frog studies

Frogs *Rana ridibunda* are a visible and very audible component of the wetland fauna at S'Albufera and undoubtedly play an important role both as predators of invertebrates and small fish, and as prey to larger fauna (including birds and mammals). Attempts have been made to come to terms with the frog population, particularly in assessing numbers and distribution, but the results have been poor and are thought to severely underestimate the total population. Even basic facts such as the timing of the annual cycle are poorly known. A much better knowledge of frog populations is urgently needed and best achieved through a postgraduate study. I have not yet approached anyone, but the base for herpetological studies in Britain is at the Sir David Attenborough Laboratories, School of Life Sciences, De Montfort University, Leicester. I was until recently a postgraduate member of these laboratories and am in a position to make further enquiries about the feasibility of such a study. The Mallorca frog is also of interest because it is *R. r. perezii*, a distinctive race (sometimes given full species rank) which is thought to have originated in North Africa.

3.1.2.8 Fish population studies

Professor Newbould identified knowledge of the fish population as high priority from the start and a study using electro-fishing techniques, led by a Spanish scientist, was part of the programme in the first year. Unfortunately, he withdrew at the last moment and we have not been able to obtain the services of a fish

scientist since. It still remains an area we should consider as we strive towards a fuller understanding of the aquatic systems, and it has been suggested that we seek the expertise of the Tour du Valat Biological Station in this area.

3.1.3 The dune systems

3.1.3.1 Orchid population dynamics

Terry Wells has been studying the Park's orchid populations since 1991, using methodology and techniques designed by himself as part of his research into British orchid population dynamics for the Institute of Terrestrial Ecology (ITE). The study, which looks into recruitment and mortality of orchids within fixed quadrats, is currently mainly focussed on the fossil dune area, though he is also monitoring the *Orchis (laxiflora) palustris* populations of the reedbeds. This is a long-term monitoring study of a key group of species.

3.1.3.2 Studies of dune plant hierarchies

The coastal dunes show a succession to climax pine forest. This succession has frequently been arrested by fires. The most recent evidence is in the southern part of the coastal dunes where the vegetation is recovering from fires approximately eight years and fifteen years ago respectively. There are also differences in vegetation composition in relation to aspect, drainage and proximity to the sea. Three permanent transects have been set up and recorded by Dr Franklyn Perring. Dr Perring has indicated a willingness to return and initiate the continuation of this work

in collaboration with other scientists committed to re-recording the vegetation along these transects at regular time intervals.

3.1.3.3 Sand-dune evolution past and present

Dr van der Meulen, member of the scientists' review group present in April 1992, is vice-president of the European Union for Coastal Conservation (EUCC) and a member of the conservation organisation ECODUNE so was, not unnaturally, very interested in the evolution of the sand-dunes, particularly the coastal set. He suggested that the Project should study past, present and future changes in the foreshore (accretion and erosion) using photographic material and techniques. The study should also take into account sea level changes and the role of the sea-grass *Posidonia* in promoting accretion. This study would be of particular relevance to 3.1.3.2 above and, because the rare juniper *Juniperus oxycedrus macrocarpus* is virtually restricted to the coastal zone immediately abutting the beach where it is at risk from erosion, is also of importance for future management planning. It would also, hopefully, give impetus to our request to the Balearic government, through the good offices of Joan Mayol, to install an automatic sea level recorder at S'Albufera.

Dr van der Meulen indicated that he and his department of Physical Geography and Soil Science at the University of Amsterdam would be interested in becoming more closely involved in the Project and this is one area where we may wish to avail

ourselves of his expertise. His participation may also be seen as a step towards integrating our monitoring work into international networks, in this case the EUCC and ECODUNE.

3.1.3.4 Gra zing influence of mammals on fossil dune vegetation

Horses and cattle are grazed on the fossil dunes and the flora may be changing because these avoid *Euphorbia terracina* , which seems to be increasing. To monitor this Jo Newbould set up, in April 1992, a grid designed to determine the current and future distribution of the *Euphorbia* . In addition she has taken photographs of the area from fixed points, as a further means of assessing distribution and change. We do not know whether the impact of *Euphorbia terracina* is of a permanent or merely temporal nature. However, photography has given us the opportunity to follow the plant's annual cycle, thanks to the participation of Mallorcan volunteer, Tomeu Tomas, who has volunteered to repeat the photography on a monthly basis. This study also has relevance to section 3.2 below.

3.1.3.5 Mol lusc studies

Dr Paul (University of Liverpool's Department of Earth Sciences) recognised several questions which need to be answered regarding mollusc distribution in the sand dunes. He writes: "there is a general question as to what characteristics of the dune habitats are essential for the various [mollusc] species of the dune fauna. If it is just drainage, species should be equally at home

on the fossil dunes of Ses Punes and the area NW of Ca'n Picafort as they are on the modern dunes. If proximity to the sea is important, some may survive on the modern dunes but not the fossil ones inland. Another point concerns the vegetation. Are the well wooded parts of the dunes significant? If so, some species may be absent on the bare ridge of Ses Punes, but present in the wooded parts of both the Fossil and Recent dunes".

He recommends that, in conjunction with the dune vegetation transect studies already underway, comparisons should be made between populations of "dune snails" on recent and fossil dunes to assess how stabilization of dunes by vegetation, and the transition from grassland through scrubland to woodland, affects such species. Assessment of the influence of the sea by comparing similar microhabitats between recent and fossil dunes could be undertaken at the same time.

3.1.3.6 Insect studies

A north-south transect has been set up through the centre of the coastal (Es Comu) dunes to record butterflies and dragonflies. The transect has been divided into six sections, each reflecting a different habitat type and/or age after burning. The information gathered will demonstrate use of these habitats by butterflies, and possibly dragonflies, and the effects of vegetation change on their abundance and species' composition.

3.1.3.7 Bird population studies

Part of a longer transect, sampling major Park habitats, has been set up through the centre of the coastal (Es Comu) dunes to record birds. The information gathered will demonstrate use of this habitats by birds and the effects of vegetation change on their abundance and species' composition.

3.1.4 The whole catchment of the Park and adjoining coastal waters

3.1.4.1 Remote Sensing

Work was begun in 1992 to incorporate remote sensing as part of our research. In the spring, Earthwatch volunteers did some "ground-truth" fieldwork in preparation for two studies undertaken in the summer by postgraduate students from the University of Aberdeen's Centre for Remote Sensing and Mapping Science. They undertook field work at S'Albufera based on two Landsat images shared by the Centre and Earthwatch Europe. One student looked at the current and recent distribution of Cladium and Phragmites and the other current and recent soils and land-use on agricultural land abutting the Park. Both studies were successful. Dr Loder of the Centre has indicated that there are many further studies which could be done by his department, in these and allied areas of research. I am very keen to maintain this link. The Centre for Remote Sensing and Mapping Science has an international reputation for remote sensing work, they are keen to participate and, most important of all, they already have a link with Spanish Universities including the UIB's Department of Geography. One of the 1992 studies was undertaken by a

Mallorcan and the other by a Peninsular Spaniard. One of our Mallorcan volunteers, who was instrumental this spring in advising us on "ground truthing" and digitising data in GIS (Geographic Information System) form, has just joined the department at Aberdeen.

One of the essential elements of the remote sensing studies is comparative information in order to monitor long term change on an objective basis. Studies which lend themselves to remote sensing methodology and which The Aberdeen Centre is keen to study include: the input of sediment plus suspended solids to the wetland and release via outflows to the Bay under normal and flood conditions; movement of sediment within the offshore, beach and dune systems; and changes in abundance and distribution of the important *Posidonia* (sea-grass) beds offshore in the Bay of Alcudia.

3.2 The impact of management and related studies

The Project needs to gather data on management events because these may impinge on the ecological and other processes being studied. In addition, some of the research undertaken by Project S'Albufera will have a direct bearing on planning of management and may serve to guide that management in the future.

3.2.1 Current management practices

Sara Hawkswell from the Royal Society for Nature Conservation has initiated work to adapt the British Countryside Management System (CMS) to the S'Albufera situation. This will be of help to the

Park staff and to Project S'Albufera because the system records management of the Park, both past and present. She is aiming to incorporate all types of work being done in the Park including practical management, monitoring, educational visits and research projects. This would ensure access by all interested bodies to relevant data and should begin to bring the different aspects together. Teething problems in setting up this system include time available by Sara and the Park staff to work on it.

3.2.2 Impact of Park habitats on the bird fauna

During fieldwork periods daily counts have been maintained of the maximum number of each bird species during a ten minute period from hides overlooking defined areas of grazed and ungrazed marsh. This study has been designed to compare the use by migrant and resident birds of open areas of marsh managed by grazing with those managed by other means or unmanaged.

3.2.3 Bats studies

Jean-Francois Noblet, a bat expert with specialist knowledge of the Mediterranean island bat fauna of Corsica, joined the Project in May 1992 to compile an inventory of bats present in the Park, to assess their importance as components of Park fauna and to propose future management planning of benefit to bats.

Jean-Francois recorded ten species, including several which are scarce or of restricted European range. His most notable discovery was that S'Albufera supported a population of

Barbastellus barbastellus, an extremely rare species in Spain and not previously recorded from the Balearic Islands. He concluded from his studies that S'Albufera was a very favourable site for

bats, abundant water and invertebrate food associated with the wetland situation being of particular benefit to this group. He found, however, that there was a shortage of roost and breeding sites, compounded by the lack of suitable old buildings within the Park and disturbance at roost caves in the foothills adjacent to the Park. He made a whole series of practical proposals designed to overcome this problem, including better protection of cave sites through well maintained entrance grills and the introduction of purpose built roost/nest boxes under Park bridges, on Park buildings etc.

Jean-Francois considered that there was considerable scope for more extensive work on S'Albufera bats. He pointed out that bats are under pressure from environmental change, loss of breeding and roost sites and the effects of pollution on their insect prey etc. throughout their European range and it was one of the roles of the Parc Natural to afford them protection. He recommended therefore that further studies be conducted. He has offered to extend his work in establishing the composition and role of the bat fauna by visiting during the period of reproduction (June to September) when he would continue to sample the population by mist-netting at night in a wide range of Park habitats. He also recommended that the study would benefit from the employment of a bat ultra-sound detector accompanied by a specialist in its use. He indicated that he could find such a person. In addition, he felt that careful dissection of owl pellets could also throw light on the bat population of S'Albufera but lamented that the removal of the old mill buildings had deprived the bats' major predator, Barn Owl *Tyto alba*, of a breeding site within the Park.

He therefore made a practical proposal (including drawings) for the Park authorities to create an artificial nest site in the old farm building at Ses Puntetes.

3.2.4 Grazing influence of mammals on fossil dune vegetation

This study, described under 3.1.3.4 above, is also relevant to the study of the impact of management.

3.3 Environmental and socio-economic studies

There is some overlap between this category and category 3.1.4 (studies of the whole catchment and immediate marine environment offshore), particularly regarding remote sensing and associated aerial photographic survey work.

3.3.1 Environmental functions and values

At the scientists' review meeting Dr Rudolf de Groot presented a novel way of studying the "value" of natural sites which has immediate appeal both from an environmental and socio-economic viewpoint. His method comprises an analytical approach for assessing the sustainable use of the wetlands by identifying the key environmental functions which it performs and assigning values to these functions. His functions, which he has applied in a number of natural areas in widely scattered parts of the world, are grouped into regulation, carrier, production, and information. Each of these is sub-divided and all the functions can be assessed and evaluated in relation to ecological, social and economic criteria. The management implications can then be

deduced.

S'Albufera lends itself to this new analytical approach and such an assessment would be of benefit to the Project and to the Park authorities. We should explore the possibility of developing this line of study by asking Dr de Groot, through his and other Departments at the Agricultural University of Wageningen, to become more actively involved with the Project - perhaps through a series of studentships designed to collect and analyse the data required.

3.3.2 Land- use and vegetation

Both Dr de Groot and Dr van der Meulen stressed the importance of taking into account the entire catchment area, coastline and immediate offshore in any study of the processes at work in the Park. Dr van der Meulen concluded: "it is clear that events outside the Parc may exert considerable influences within it - and vice versa - so that any attempt at analysis must include the whole catchment and the coastline. For example, the Parc is probably important in regulating the flow of water from the hinterland to the sea; it serves as a recharge area and there may be recycling of nutrients and thus a positive influence on the quality of water leaving the area. In turn, the Parc is affected by the amount and quality of water entering it and activities in the watershed such as horticulture and water abstraction."

Dr van der Meulen indicated that he and his Department of Physical Geography and Soil Science at the University of Amsterdam would be interested in becoming more closely involved in the Project. A number of the studies proposed in this document

are aimed to elucidate aspects of the impact of events described above (e.g. the remote sensing work begun and planned by the University of Aberdeen's Centre for Remote Sensing and Mapping Science). However, Dr van der Meulen has particular knowledge and experience in areas of direct relevance to the Project (e.g. coastal studies) and we should not miss the opportunity to avail ourselves of his expertise. Currently, Dr van der Meulen has proposed that a team of students from his University undertake a mapping study of the vegetation and land-use in and around S'Albufera.

3.3.3 Past History & Land Use

This is a subject which was studied by UCL Ecology and Conservation Unit students. Their findings have been summarised but there is a considerable need for the study to be extended and information collected and collated in much greater detail. This may also be a study suitable for a UCL postgraduate student, but would perhaps be better tackled by a Mallorcan, perhaps a postgraduate of the Department of Geography but specialising in aspects of social geography/demography. This study also has relevance to studies of the evolution of S'Albufera described in 3.6.1 and 3.6.2.

3.3.4 Soils /sediments

Soil studies were undertaken in spring 1991 but the researcher failed to produce any documentation of her results. However, the Project needs detail of soils and sediments. This is best accomplished by bodies such as the University of Aberdeen, University of Amsterdam and University of Liverpool as an

integral part of their studies of land use, remote sensing and the geological past. This study also has relevance to studies of the evolution of S'Albufera described in 3.6.1 and 3.6.2.

3.3.5 Tourist related studies

In 1989 the UCL Ecology and Conservation Unit undertook preliminary studies of visitor impact on the Park, but there is ample scope for this work to be continued and expanded. Indeed, Joan Mayol is very keen to obtain more and better data. To achieve this we would need to seek expertise in the field. This may be an area of research that could be incorporated by Dr de Groot in his integrated socio-economic studies. Alternatively it might be achieved through UCL postgraduate research. Such a study would also be of benefit to the Tourist industry and funds should perhaps be sought from that avenue. Dr Perring has offered to advise.

3.4 Furtherance of data-processing and the data-base potential and methodology, including development of compatible systems for comparative work and integration into international networks and schemes

3.4.1 Storage and organisation of data, use of GIS

Research data should be incorporated in a site database, used also for data collected by Park staff, including meteorological and hydrological data. The importance of historic data and the necessity of making them available in readily accessible

electronic form should be given more attention. A student from the UIB's Department of Geography was instrumental in setting up a GIS recording system for the ground-truthing work done by Bernie Young. The adoption of GIS is a particularly important step towards ensuring wider applicability of Project S'Albufera data. Knowledge and expertise in GIS is clearly available at UIB and this is an area where we should encourage their involvement. We have received strong indications, via Joan Mayol, that UIB's geography department, through their Head and vice-rector of the University Dr Climent Picorell, is interested in becoming more involved with the Project. This department also has close links with the University of Aberdeen's geography department which, through its Centre for Remote Sensing and Mapping Science, is already participating in the Project.

The scientists review meeting recommended that integration through a GIS as a database should be made through the European Environmental Agency (EEA).

3.4.2 Development of ecological data bases

The problems involved in setting up a computer-based package to record management is described in 3.2.1 above. Even more problems beset us with development of a computerised system of storing and processing biological records. Sara Hawkswell indicates that the RECORDER database used in Britain is not suitable for immediate conversion to a system for wide use in Mallorca or Spain. Particular difficulties would arise from changing the species dictionary, codings, language and system maintenance. She recommends that a system should be devised to store all the data

and make them readily available to all users in a variety of formats. In order to accommodate future uses of these data (for example incorporation into a GIS or a network of biological databases), potential data standards should be considered.

This is specialist work, requiring time and commitment. Sara Hawkswell has a full-time job and inevitably does not have the time to commit to develop such a system in the time-scale we would need. I identify this as suitable for a postgraduate studentship, probably by someone in Computer Science with a specific interest in the natural world.

3.4.3 Gridding the Park

The Park Directorate has divided the Park area, for descriptive and mapping purposes, into 30 sectors/compartments. Sara Hawkswell feels that, though a computerised database can deal with records by compartment, this may be insufficient detail for the purposes of Project S'Albufera. There is general agreement among Project scientists that we should seek a more accurate recording system, relating records to UTM (international grid system as used by Ordnance Survey style maps). To do this our options are 1) to grid the Park, 2) to use a global position retriever (satellite-generated location retriever system).

There are a number of problems afflicting the first option. Joan Mayol does not want visible location points (i.e. he does not want visitors to see a series of posts scattered through the Park). We have solved this problem for quadrats and transects by sinking markers to or below surface level which if not visible at

a later date may be located using a metal detector. This may be less appropriate or straightforward for more wide-ranging studies. In addition, very few UTM intersection points occur in suitable locations - the setting up of reference points, visible or otherwise, in the middle of reedbeds is of little use to the Project (as well as a practical impossibility). Even if a grid system was set up, using tracks and other firm ground, this would require a lot of time and the involvement of someone with surveying expertise. The only such person at the Park, Biel Perello, has given indications that he might be able to help, but always his time has been fully usurped by his Park responsibilities. The second option may be more favourable, at least initially, and would prove a useful tool if we progressed to gridding at a future date.

3.4.4 Interpretive and educational

Practical application of data collected by the Project has begun through a collaboration between the Park's Technical Assistant Biel Perello and Project scientists Dinah McLennan and Jo Newbould. They are currently working together to produce display material and hope to follow that with a brochure or more detailed publications based on Jo's studies of the Park's botany, Dinah's artistic skills and Biel's knowledge of the Park and relevant languages. These materials would be directed to interpreting S'Albufera plantlife for visitors to the Park.

3.5 Studies aimed at assessing environmental change

One inevitable by-product of the studies described above will be

information which may be used to assess environmental change. Other studies currently in place or recommended have been specifically designed to achieve that objective. They fit into two sub-categories: 1) in-depth ecological studies; 2) constant or regular long-term monitoring.

3.5.1 Ecological studies

Studies in this category are ones which cannot be achieved by the Project in its present form of "snap-shot" field visits of short duration but which nevertheless are necessary if we are to understand the ecosystems and change. They do, however, make ideal subjects for postgraduate students to tackle.

3.5.1.1 Mollusc studies

Dr Paul (University of Liverpool's Department of Earth Sciences) recommends research topics which would seek more information about the ecological preferences of certain species. He has outlined the following.

1. Establishing basic ecological requirements and life cycles for endemic snails, particularly the operculate snail *Tudorella*, which would involve monitoring selected populations. Since its range has been reduced over the geologically recent past, understanding its ecological requirements may be the key to its continued survival, although it is not a threatened species at present. It is widespread and common in Mallorca and Menorca, but unknown elsewhere in the world. It is recorded as a Pleistocene fossil from Ibiza, Sardinia and possibly southern France. This study, therefore, has an element of change based on

past changes. What ecological conditions exist for the survival of the species in S'Albufera which no longer exist in other areas?

2. The precise ecological preferences of the three species of *Cochlicella* is recommended as an interesting study. Both Dr Paul and a previous observer noted that *C. barbara* was commonest alive within the marsh (though still on dry canal banks), while *C. conoidea* seems to be confined to the dune areas, both fossil and recent. *C. acuta*, the most widespread of the three, may be the most ecologically tolerant though even it was rarely seen by Dr Paul alive away from dunes and well drained paths. How, or even if, *C. acuta* and *C. conoidea* partition the dune habitats would be well worth studying. Such a study could easily be undertaken as a wider part of the dune transect studies already underway. There is probably, for instance, no information about the dominant plant species found at sites where *Cochlicella* is recorded let alone their food preferences or which species of plant they climb up in summer to aestivate.

3. Similar studies could be made of other congeneric species, e.g. why is *Trochidea* (*T.*) *elegans*, the more widespread species, so restricted in its occurrence in S'Albufera, whereas *T.* (*T.*) *trochoides* is more common in the dunes? Equally, what are the precise requirements/ preferences of the three species of *Vallonia* ?

3.5.2 Long-term monitoring

3.5.2.1 Entomological: moth studies

Once a comprehensive inventory of lepidoptera has been established (see 3.6.8), Barry Goater plans to outline a monitoring programme based on light trap captures of moth species which are easy to recognise and likely to be key indicator species (e.g. for their impact at larval stage on major plant species such as *Phragmites*). Barry has already discovered that S'Albufera supports a healthy population of the moth *Pelosia plumosa* , an obscure but extremely interesting species known only from a few localities in southern Spain, north Africa and southern Italy and not recorded before from the Balearic Islands. Regular moth trapping will confirm the importance of S'Albufera for this species and provide information of its future status. Park staff assistance may be required in maintaining a regular trapping regime under guidance from Barry.

3.5.2.2 Entomological: butterfly monitoring

Two transects, one based in the coastal sand dunes and a longer one sampling all major Park habitats, have been established. Both transects are divided into sections, each reflecting a different habitat type. All species are counted within each section. The information gathered will demonstrate variations in the numbers and composition of butterflies and their use of Park habitats.

This study has been set up and is carried out by Nick Riddiford with Earthwatch volunteers. The period of study was extended through the summer in 1991 by a Mallorcan volunteer.

3.5.2.3 Bird population dynamics

Two transects, each of approximately 7 km and sampling all major Park habitats, have been established. Both transects are divided

into sections, each reflecting a different habitat type. All species are counted within each section. The information gathered will demonstrate variations in the numbers and composition of breeding and migrant birds and their use of Park habitats.

This study has been set up by Nick Riddiford but has been extended beyond the periods of Earthwatch field presence by Jon King, ornithological researcher from the Edward Grey Institute, University of Oxford, who is currently based there.

3.5.2.4 Fitness of migrant birds

Passage migrants are counted in April/May and a sample trapped as part of a study of body condition in passage birds. The main "target" species is the Swallow *Hirundo rustica*. This is primarily the work of Jon King and is continued through the year by JK and the Park ornithologist, Pere Vicens. The study aims to elucidate the importance of S'Albufera for migrant birds, particularly in times of poor weather. Like many of the studies carried out as part of Project S'Albufera, this research seeks good, comprehensive meteorological data to assist in the elucidation of processes.

3.5.2.5 Meteorological recording

The Park operates a simple weather station but the data it collects are insufficient for the needs of the Project. The nearest site which collects the quality of data which many of the Project's studies require is several kilometres away near Sa Pobla. Ideally a more sophisticated weather station, in line with

the Environmental Change Network (ECN) sites in the UK, should be installed at S'Albufera.

Dr Toni Martinez has offered to approach Dr Climent Ramis, of the UIB's Department of Meteorology about becoming actively involved in meteorological aspects of the Project. The head of this Department, Dr Sergio Alonso, has an active interest in Climatic Change and has urged the Spanish government to sign the IGBP protocol - which he sees as integrating climatic change studies to produce a vehicle for shaping government environmental policy. He and his Department are active in an ICSU-led initiative to establish a Regional Climate Investigation Centre which will study climatic variations in the Mediterranean and sub-tropical Africa region.

The involvement of this Department would be extremely useful for it may advance our request for the establishment of a sophisticated weather station at S'Albufera. If this is established we may also be able to seek the participation of Dr Rudolf de Groot in his capacity as co-ordinator of the Climate Change Research Centre at the Agricultural University of Wageningen.

3.5.2.6 Other studies

Several studies described elsewhere, for example Orchid population dynamics (3.1.3.1) and Studies of dune plant hierarchies (3.1.3.2), also have a long-term monitoring element.

3.6 Extension of baseline information

3.6.1 Evolution of S'Albufera: coring study for pollen

This study is being conducted by scientists from the Geography departments of the University of Barcelona and UIB. Though this constitutes independent research not initiated or suggested by Project S'Albufera , it is of direct relevance to our work; it will, by relating the pollens found to species and date, give a much clearer understanding of the past evolution of S'Albufera. I have spoken to one of the scientists involved who indicated that the results would be published and thus become available to us. He also indicated that the geological cores from which the pollen analysis would be taken could be made available to Project S'Albufera for parallel studies (see 3.6.2 below).

3.6.2 Evolution of S'Albufera: Diatoms in geological cores

If we do get access to the cores outlined in 3.6.1 above, geological research could be extended by the involvement of the University of Liverpool's Department of Earth Sciences under the leadership of Dr Andy Plater. Dr Plater has indicated that he would be in a position to investigate the Holocene/Pleistocene sediments and, hopefully, return with some material for pollen and diatom analysis. He writes "my primary interest is coastal evolution in relation to Holocene sea-level trends, so this opportunity is very appealing". This study could make an important contribution to our understanding of the past evolution of S'Albufera and its environs.

3.6.3 Flowering Plant distribution by management compartments

This work was begun by Dr Franklyn Perring in 1992 and he has indicated his willingness to continue with the study and produce a plant recording card. The study interrelates with the herbarium work described in 3.6.4 below.

3.6.4 Herbarium

Jo Newbould, assisted by other botanists and Earthwatch volunteers, has continued to build up the herbarium, augmented by a series of photographs, slides and line drawings. She has also drawn up a comprehensive list of known S'Albufera flowering plants which demonstrates that the herbarium is far from complete. The herbarium now has its own dedicated herbarium cupboard which is extensively used by Project workers and Park staff alike. There is also a comprehensive card index for all S'Albufera flowering plants. Jo will continue her responsibility for the herbarium and flowering plant inventory with the aim of making it as comprehensive as possible. Dinah McLennan continues to play an important role in supplementing the reference collection with accurate line drawings. They are planning to use this work as a basis for preparing material which may be used to interpret plantlife for visitors to the Park (see 3.4.4).

3.6.5 Extension of herbarium material to include lichens and mosses

A small collection of lichens has been established at the Park, based on identifications made by Tom Chester of specimens taken

to England. It is far from complete, and no work has been done on the bryophytes. Lichens in particular are known to be sensitive to air quality and may be a key group for this line of study. Work should initially comprise establishing a species inventory with reference material, but eventually there is scope for research, probably at postgraduate level, into lichen distribution and air quality within the Park. Dr P.D. Crittenden of the British Lichen Society and Department of Life Science of the University of Nottingham could be approached.

3.6.6 Fungi

Sheila Wells, wife of Principal Investigator Terry Wells, collected and identified fungi in April 1991 and April and November in 1992. Sheila plans to extend her fungal database on subsequent visits with her husband, including in April and October 1993.

3.6.7 Mollusc studies

Dr Paul (University of Liverpool's Department of Earth Sciences) points out in his report of 1991 work that basic data about life cycle (e.g. are they annual or perennial, when do they mate and lay eggs? etc.) are unknown for the endemic snails and slugs such as *Tudorella* , *Trochoidea* (*Xeroplexa*) *nyeli* , *Limax majoricensis* and probably for several other species (e.g. *Trichia lanuginosa* , *Otala* spp., *Pseudotachea*). Observations on these basic details would be very useful but would require a person with specialist knowledge and year-round access to the site (i.e. a student based at the Park or resident Mallorcan).

3.6.8 Invertebrate baseline studies including collection of reference material

Work to establish an on-site reference collection was given a boost, for lepidoptera, by the participation in May 1992 of British lepidopteran expert, Barry Goater. It is the aim of the Project to achieve a level of reference, including inventories, for invertebrates of a similar quality to that established for flowering plants. The Balearic Invertebrate Group have indicated their willingness to help with this task, e.g. for beetles, and Barry Goater has indicated his willingness to continue his participation - which includes studies and advice on other lepidopteran aspects of the Project (e.g. 3.1.1.4).

Barry has suggested that we expand our lepidopteran studies to include the "micros", the smaller species sometimes thought of as "insignificant" but nevertheless making a considerable impact on vegetation in their larval stages - hence the tag which many carry as "species of economic importance". He has recommended that we invite the Rev David Agassiz to undertake this part of the research.

3.6.9 Entomological: Odonata

Adult dragonflies are a very obvious part of the invertebrate fauna but difficult to study. To overcome this, in 1992 Ed Cross began to develop methodology to monitor the larval stages. Early results are extremely promising and Ed plans to refine his methodology further. His work demonstrates that the total number of dragonflies supported by the marsh at larval stage is very

large, therefore the group will play an important role as predators of other small aquatic fauna and as prey to fishes, frogs, some birds and other fauna. The adults are an important food source for the globally rare Eleonora's Falcon which gathers at S'Albufera to hunt dragonflies prior to its breeding season. The Cross methodology has great potential for monitoring Odonata population dynamics and their role in and interactions with the wetland ecosystem. Future work will also be needed outside the main Earthwatch field seasons, particularly in summer.

3.6.10 Hoverfly studies

This study aims to extend our knowledge of the composition and seasonality of hoverfly (Diptera; Syrphidae) species using the Park and to monitor variations in the abundance of one easily recognisable migrant species, *Episyrphus balteatus*. This is achieved by counting the number of individuals of *Episyrphus balteatus* and recording all other Syrphid species seen within an establish transect route. This study was set up by Simon McKelvey but is currently carried out by Nick Riddiford with advice and identification assistance provided by Simon from his home base.

Hoverflies are often considered in Britain to be key indicator species of the health of wildlife habitats, based on diversity of species.

3.6.11 Invertebrates

A Balearic Invertebrate Group, under the leadership of Josep Antoni Alcover of CSIC and based at UIB in Palma, has been set up

to further research into invertebrates in the Balearic Islands. Sr Alcover has indicated that specialist help would be available to increase our baseline knowledge for a number of groups. This was demonstrated in 1992 by visits from members of this group specialising in beetles and spiders. They set a series of pitfall traps in a number of habitats, which they visited on a regular basis during the spring. All these specialists have research commitments elsewhere and, though their expertise and assistance would be welcome, their involvement with the Project is likely to remain low-key.

3.6.12 Small mammal studies

A pilot small mammal study was done by Keith Bowey in October 1992 and a fuller study is planned by the University of Durham's Department of Biology in spring 1993. In addition to gaining a greater knowledge of small mammal populations and distribution, these studies may obtain comparable data to the small mammal work of Dr Alcover in the early 1980s, and published by Barcelo and Mayol.

Part 4 . Tier structure

4.1 First Tier. Earthwatch funded monitoring

Project S'Albufera is very different from what would be considered the norm for Earthwatch funded research projects. Other projects tend to concentrate on one particular item of research requiring scientific staff levels far below that

demanded by Project S'Albufera lines of research. Project S'Albufera has been much more expensive in a number of areas, but especially in the travel costs of bringing scientific specialists to the Project, providing for their extra equipment needs and their accommodation. Ancillary additional costs include extra for provisions and transport within Mallorca.

To bring this into perspective I have included in Tier 1 a list of those areas of research which can be achieved by strict adherence to the funding possibilities offered by Earthwatch. They are set out below. The numbers in parentheses cross-reference to the summary paragraphs above describing the studies. I have included the scientist/body responsible for each study.

4.1.1 List of studies

1. TITLE: Orchid population dynamics (3.1.3.1)
RESPONSIBILITY: Terry Wells
2. TITLE: Bird population dynamics (3.1.1.6; 3.1.3.7; 3.5.2.3)
RESPONSIBILITY: Nick Riddiford
3. TITLE: Hoverfly studies (3.6.10)
RESPONSIBILITY: Nick Riddiford & Simon McKelvey
4. TITLE: Butterfly monitoring (3.1.3.6 and 3.5.2.2)
RESPONSIBILITY Nick Riddiford

5. TITLE: Impact of Park habitats on the bird fauna (3.2.2)

RESPONSIBILITY: Nick Riddiford

4.2 Second Tier. Studies which need to be tackled but depend on extra funding.

Over the first four years the Project has benefited enormously from the involvement of a series of scientists who have developed their own methodologies for tackling the many problems the Project has met. Many of these scientists remain involved with the Project and have studies in progress and/or which require further work. These studies are set out in Tier 2. The numbers in parentheses cross-reference to the summary paragraphs above describing the studies. As in Tier 1, I have included the scientist/body responsible for each study.

4.2.1 List of studies

1. TITLE: Autecology of Phragmites and Cladium (3.1.1.1)

RESPONSIBILITY: Palmer Newbould (with UIB back-up).

2. TITLE: Studies of dune plant hierarchies (3.1.3.2)

RESPONSIBILITY: Dr Franklyn Perring.

3. TITLE: Grazing influence of mammals on fossil dune vegetation
(3.1.3.4)

RESPONSIBILITY: Jo Newbould (3.1.3.4).

4. TITLE: Current management practices (3.2.1)
RESPONSIBILITY: Sara Hawkswell, RSNC; S'Albufera Park staff.
5. TITLE: Bat studies (3.2.3)
RESPONSIBILITY: Jean-Francois Noblet.
6. TITLE: Interpretive and educational (3.4.4)
RESPONSIBILITY: Biel Perello, Technical Assistant, Parc
Natural de S'Albufera ; Dinah McLennan and Jo Newbould,
Project scientists.
7. TITLE: Entomological: Moth studies (3.5.2.1)
RESPONSIBILITY: Barry Goater, Project scientist; Andreu
Muntaner, Warden, Parc Natural de S'Albufera .
8. TITLE: Plant distribution by management compartments (3.6.3)
RESPONSIBILITY: Jo Newbould; Dr Franklyn Perring.
9. TITLE: Herbarium (3.6.4)
RESPONSIBILITY: Jo Newbould.
10. TITLE: Fungi (3.6.6)
RESPONSIBILITY: Sheila Wells.
11. TITLE: Invertebrate baseline studies including collection of
reference material (3.6.8)
RESPONSIBILITY: Barry Goater; Rev David Agassiz.
12. TITLE: Entomological: Odonata (3.6.9)
RESPONSIBILITY: Ed Cross.
13. TITLE: Small mammal studies (3.6.12)

RESPONSIBILITY: Keith Bowey.

14. TITLE: Remote Sensing (3.1.4.1)

RESPONSIBILITY: John Loder, Centre for Remote Sensing and Mapping Science, University of Aberdeen; Bernie Young.

4.3 Third Tier. Parallel studies planned for 1993-94 by Universities and other bodies.

We have always recognised that much of the more innovative, detailed and temporally extended work should be undertaken by Universities and other bodies in partnership with the Project (and thus in partnership with Earthwatch Europe). Steps towards achieving this were already in place by the time the review group met (e.g. co-operation agreement signed between Earthwatch Europe and the University of the Balearic Islands, Earthwatch Europe sponsored or part-sponsored studies by post-graduate students from University College London and the University of Aberdeen's Centre for Remote Sensing and Mapping Science). However, the review group meeting stimulated an increased interest and commitment from Universities, not least several scientific departments of the UIB - seen by us as an essential development for the future of the Project as the University "on the spot" and with most to gain from involvement in this international venture. The list which follows includes a number of studies suggested or encouraged by scientific members of Project S'Albufera but offered as a direct result of the review group meeting (and in particular the enthusiasm and insistence of the two Dutch scientists in the group who urged UIB scientists to grab what

they saw as a great opportunity to participate in an international project of great potential). As in Tiers 1 & 2, I have included the person/body responsible for each study. The numbers in parentheses cross-reference to the summary paragraphs above describing the studies.

4.3.1 List of studies

1. TITLE: Photosynthesis and productivity of marshland plants (3.1.1.2)

RESPONSIBILITY: Hipolito Medrano, Dept of Vegetal Physiology, UIB; Roger Austen, University of Cambridge.

2. TITLE: Decomposition of reedbed plants (3.1.1.4)

RESPONSIBILITY: Dr Enrique Descals, Department of Environmental Biology & Dr Antoni Martinez, Department of Limnology, UIB.

3. TITLE: Study of relationships between Archanara geminipuncta biology, Reed Bunting feeding and breeding biology and their impact on Phragmites reed (3.1.1.5)

RESPONSIBILITY: Anna Traveset, CSIC, Palma.

4. TITLE: Ornithological studies: Moustached Warblers (3.1.1.7)

RESPONSIBILITY: Dr Chris Perrins, Edward Grey Institute for Field Ornithology, Oxford University; Dr Bernd Leisler Max-Planck-Institut fur Verhaltensphysiologie, Germany.

5. TITLE: Hydrogeological study (3.1.2.1)

RESPONSIBILITY: Dr Alfredo Baron, Balearic Hydrological Service.

6. TITLE: Water quality and pollutants (3.1.2.2)
RESPONSIBILITY: Drs Martinez and Medrano, Department of Biology, UIB.
7. TITLE: Vertical nutrient exchange between water and sediment (3.1.2.3)
RESPONSIBILITY: Drs Moya, Ramon & Martinez, Department of Biology, UIB; two collaborators from the University of Barcelona.

NOTE: Independently funded research study begun in 1992.
8. TITLE: Freshwater macrophytes and water quality (3.1.2.4)
RESPONSIBILITY: Dr Martinez, Department of Biology (Limnology Section), UIB; Dr Enrique Descals, Department of Environmental Biology, UIB; Dr Sven Jonasson, Institute of Plant Ecology, University of Copenhagen.
9. TITLE: Freshwater invertebrates & water quality (3.1.2.5)
RESPONSIBILITY: Dr Roderick Fisher, Ecology and Conservation Unit, University College London.
10. TITLE: Mollusc studies (3.1.2.6; 3.1.3.5; 3.5.1.1; and 3.6.7)
RESPONSIBILITY: Dr Chris Paul, Department of Earth Sciences, University of Liverpool; Dr Cristian Altaba, CSIC, Palma.
11. TITLE: Sand-dune evolution past and present (3.1.3.3)
RESPONSIBILITY: Dr van der Meulen, Department of Physical Geography and Soil Science, University of Amsterdam.

12. TITLE: Remote Sensing (3.1.4.1)
RESPONSIBILITY: John Loder, Centre for Remote Sensing and Mapping Science, University of Aberdeen.
13. TITLE: Environmental functions and values (3.3.1)
RESPONSIBILITY: Dr Rudolf de Groot, Climate Change Research Center, Agricultural University of Wageningen.
14. TITLE: Land-use and vegetation (3.3.2)
RESPONSIBILITY: Dr Frank van der Meulen, Department of Physical Geography and Soil Science, University of Amsterdam.
15. TITLE: Storage & organisation of data, use of GIS (3.4.1)
RESPONSIBILITY: Sara Hawkswell; Dr Climent Picorell, Department of Geography, UIB; Dr John Loder, Centre for Remote Sensing and Mapping Science, University of Aberdeen.
16. TITLE: Fitness of migrant birds (3.5.2.4)
RESPONSIBILITY: Jon King, EGI, University of Oxford; Pere Vicens, Ornithologist, Parc Natural de S'Albufera .
17. TITLE: Evolution of S'Albufera: coring study for pollen (3.6.1)
RESPONSIBILITY: Dr Ramon Julia, Institut Jaume Almera, University of Barcelona
NOTE: Independently funded research study begun in 1992.
18. TITLE: Evolution of S'Albufera: Diatoms in geological cores (3.6.2)

RESPONSIBILITY: Dr Andy Plater, Department of Earth Sciences,
University of Liverpool).

4.4 Fourth Tier. Studies which are needed but for which no
scientists/means are available.

This tier is included for completeness. Although the funding to
meet these extra studies is not currently available we cannot
afford to omit items of research which are key to our full
understanding of the processes and ecosystems. If funding remains
difficult, these studies are at least on paper for consideration
at a later date. In the list which follows, the numbers in
parentheses cross-reference to the summary paragraphs above
describing the studies. Areas of responsibility have been given
but these are proposed rather than indicating acceptance or
commitment by the scientists/organisations involved.

4.4.1 List of studies

1. TITLE: Heavy metals in marsh plants (3.1.1.3)

RESPONSIBILITY: Maria Pou Bordoy, Catalina Cabot and John
Sibole, Department of Vegetal Physiology, UIB.

2. TITLE: Bird predator studies (3.1.1.8)

RESPONSIBILITY: Heinz Hafner, Tour du Valat Biological
Station, Camargue, France.

3. TITLE: Frog studies (3.1.2.7).

RESPONSIBILITY: Herpetological department, Sir David
Attenborough Laboratories, De Montfort University,
Leicester.

4. TITLE: Fish population studies (3.1.2.8)
RESPONSIBILITY: Alain Crivelli, Tour du Valat Biological Station, Camargue, France.
5. TITLE: Past History & Land Use (3.3.3)
RESPONSIBILITY: Dr Climent Picorell, Department of Geography, UIB; or Ecology and Conservation Unit, University College London.
6. TITLE: Soils/sediments (3.3.4)
RESPONSIBILITY: Geography/Earth Science Departments of the University of Aberdeen, University of Amsterdam or University of Liverpool.
7. TITLE: Tourism related studies (3.3.5)
RESPONSIBILITY: Dr de Groot, Agricultural University of Wageningen; or Ecology and Conservation Unit, UCL.
ADVISOR: Dr Franklyn Perring.
8. TITLE: Development of ecological data bases (3.4.2)
RESPONSIBILITY: Sara Hawkswell, RSNC; postgraduate in Computer Science.
9. TITLE: Gridding the Park (3.4.3)
RESPONSIBILITY: ?Park Directorate; specialist surveyor.
10. TITLE: Meteorological recording (3.5.2.5)
RESPONSIBILITY: Dr Climent Ramis, Department of Meteorology, UIB; Dr Rudolf de Groot, Climate Change Research Centre, Agricultural University of Wageningen.

11. TITLE: Extension of herbarium material to include lichens &
mosses (3.6.5)

RESPONSIBILITY: Dr P.D. Crittenden, School of Life Science,
University of Nottingham.

12. TITLE: Invertebrates (3.6.11)

RESPONSIBILITY: members of Balearic Invertebrate Group,
CSIC-UIB, Palma.

APPENDIX 5 - 1993 programme details

Project Title

Monitoring for environmental change at S'Albufera, Mallorca.

Research Site

Parc Natural de S'Albufera , Mallorca, Spain.

Principal Investigators

Nick Riddiford (Teams I-IV)

Dr Terry Wells (Team II)

Team Dates in Field

TEAM I March 28-April 11, 1993

TEAM II April 14-April 28, 1993

TEAM III May 1-May 15, 1993

TEAM IV October 23-November 6, 1993

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

Fields of Research

Botanical

1. Orchid population studies (Terry Wells)
2. Dune transects (Franklyn Perring)
3. Herbarium (Jo Newbould; Perring; Dinah McLennan)
4. P lant Illustrations/Preparation of display material (Dinah
 McLennan)
5. D istribution of Euphorbia terracina in areas of grazing (Dinah
 McLennan)
6. Fungi (Sheila Wells)

Vertebrates

1. B ird population studies (Nick Riddiford; Jon King; Mike Wood)

- transects, point counts, Moustached Warbler distribution,
constant effort site ringing, body condition of migrants

2. Bird foraging studies (Mike Wood)

3. Mammal population studies (University of Durham)

Remote Sensing

1. Ground-truthing census work (Bernie Young as preparation for further work by students of Centre for Remote Sensing and Mapping Science, Department of Geography, University of Aberdeen, Scotland)

Hydrology

1. Preliminary studies of water quality (Alexandra Torn in partnership with UIB's Departments of Vegetal Physiology and Limnology)

Invertebrates

1. Entomology

a) insect reference collection (Riddiford; Goater)

b) studies of Diptera, Syrphidae (Riddiford)

c) butterfly and dragonfly transects (Riddiford)

d) odonata population studies (Ed Cross)

e) monitoring methods for night lepidoptera

Ecology of Phragmites

1. The ecological relationships of Phragmites, moth larvae and birds (Alan Radermacher)

Computerisation of Data

1. Program development for standardised data processing and

storage (Sarah Hawkswell)

Project S'Albufera scientists, 1993

Team I 28 March-April 11

PI - Nick Riddiford

Jon King - ornithology

Alan Radermacher - ecology of Phragmites

Sarah Hawkswell - data programming

Team II 14-28 April

PI - Terry Wells

PI - Nick Riddiford

Sheila Wells - fungi

Jon King - ornithology

Alex andra Torn - water quality studies

Team III 1-15 May

PI - Nick Riddiford

Jon King - ornithology

Dinah McLennan - botany

Ed Cross - odonata studies

Bernie Young - remote sensing

Team IV 23 October-6 November

PI - Nick Riddiford

Barry Goater - lepidoptera

Franklyn Perring - dune transects

APPENDIX 4 - Planning for 1993-94 and beyond

Appendix 4 presents a revised version of the research elements contained in the Project's planning document *Project S'Albufera, Planning for 1993-94 and beyond: a discussion paper* (Riddiford 1992), which was formulated from the recommendations of the Field Scientists' Review Meeting in April 1992.

Part 1. Introduction

Following the publication in autumn 1991 of *Project S'Albufera - A new model for environmental research*, a review group of international scientists was invited to S'Albufera in April 1992 to assess progress during the first three years of the Project and to advise on its shape and directions in the future.

This discussion paper while remaining faithful to the overall aims of the Project, clearly defined at the start and continuing to play a central role in the work of the Project, draws heavily from the thoughts and recommendations of the review group, published in *Project S'Albufera - Report of field scientists' review meeting, 28-30 April 1992*.

One of the major conclusions emerging from the review group meeting was that priorities need to be recognised and these

should draw on the Project's demonstrated strong points. Even within this scenario, the operating costs are enormous and can only be achieved with a large funding commitment outside the normal channels of Earthwatch monetary support. So to match what is needed with what is possible, I have structured the proposed plan of work for 1993-94 (and in some cases beyond) in four tiers, comprising ongoing studies which may be achieved under Earthwatch Europe tutelage and normal financial support (First Tier), studies which need to be tackled or are ongoing but depend on extra funding (Second Tier), parallel studies by Universities and other bodies in partnership or co-operation with Earthwatch Europe and Project S'Albufera (Third Tier) and those studies which are needed but for which no scientists or means are currently available (Fourth Tier).

The studies proposed within each of these tiers are summarised within Priority categories in Part 3 and listed according to tier in Part 4.

Part 2. Priorities

I see priorities for 1993-94 (and beyond) falling into six categories. They are:

1. Multi-disciplinary study of processes going on, 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. Furtherance of data-processing and the data-base potential and methodology, including development of compatible systems for comparative work and integration into international networks and schemes.
5. Long-term monitoring aimed at assessing environmental change.
6. Extension of baseline information.

Part 3. Studies

There follows a summary of studies which I and others involved in the Project have identified as meeting the above priorities. They are far from comprehensive and are likely to be added to as further fieldwork and consultations with scientists throw up other questions which need to be answered, information which needs to be gathered, etc.; and of course there is the opportunity, too, for scientific input into this current plan, which is also intended to have a consultative role. Most of the studies have been selected because they are already in place or

attracting the interest and/or commitment of Universities and other bodies. Other studies suggested have no such linkage at the moment and may serve as notice for inclusion in the future development of the plan beyond 1994.

I have ordered studies under headings which relate to the priorities outlined above. Some studies are of direct relevance to two or more priority categories and it should be borne in mind that there will be some overlap of categories for nearly all studies (e.g. dune systems studies may have application also in providing information on the impact of management strategies, in supplying data for the interpretation services of the Park and in long-term monitoring for change).

3.1 Studies appropriate to multi-disciplinary study of processes

3.1.1 . The Phragmites - Cladium dominated wetland ecosystem

Much of S'Albufera is wetland dominated by the marshland plants *Phragmites australis* and *Cladium mariscus* . The pioneering work by Professor Newbould on aspects of biomass and productivity for these two species has been recognised as one of the Project's strong points. The interest of several scientists and institutions now gives us the opportunity to extend this work to other areas which will allow a multi-disciplinary study of processes.

3.1.1.1 Autecology of *Phragmites* and *Cladium*

Palmer Newbould's work should be developed from his ongoing studies of productivity of *Phragmites* and *Cladium* shoots to

include the rhizomes and root mass and, to add to the dry weight data, values for the processes of decomposition and nutrient cycling. His work should also be extended to other aspects of the ecology of these plants, including a greater knowledge of their annual cycle. Professor Newbould's continued involvement in these studies will require back-up assistance including better on-site equipment and facilities and expertise from scientists at the University of the Balearic Islands (UIB) in Palma. There is a particular need for Mallorcan home-based involvement for such aspects as recording the annual cycle.

3.1.1.2 Photosynthesis and productivity of marshland plants

Some of the facilities mentioned in 3.1.1.1 above have been offered by Dr Hipolito Medrano of the UIB. Dr Medrano has an international reputation in photosynthesis research. He specialised until recently in photosynthesis in crops but is now keen to extend that study to plants in more natural situations. He is head of Fisiologia Vegetal (Vegetal Physiology) of UIB's Department of Biology. He has worked in the past with Dr Roger Austen, another photosynthesis expert recently retired from Cambridge University, and they wish to plan a joint study of the Phragmites - Cladium ecosystem concentrating on photosynthesis, plant production and growth - research which they see as complementing and furthering the studies undertaken by Prof. Newbould. As an indication of his interest in the subject, Dr Medrano has already undertaken preliminary studies at S'Albufera with students from his Department, while Dr Austen assessed the potential of the site in May 1992.

3.1.1.3 Heavy metals in marsh plants

A study is currently being done by members of the UIB's Sub-department of Vegetal Physiology, led by Maria Pou Bordoy, Catalina Cabot and John Sibole, into the heavy metal content of the aquatic macrophyte *Lemna*. This study has been undertaken at the instigation of Joan Mayol, Director of the Park, for conservation reasons: ducks are an important part of the Park's avifauna and *Lemna* is a food source for ducks. The infrastructure and interest is therefore in place to extend this research to other marshland plants.

3.1.1.4 Decomposition of reedbed plants

Dr Enrique Descals of the Consejo Superior de Investigaciones Cientificas (CSIC), based at Palma, has been conducting studies for a number of years on the role of microfungi in the decomposition of dead plant matter in the canals of S'Albufera. Dr Descals, along with Dr Antoni Martinez of the UIB's Department of Biology, Limnology section, have been keen supporters of the Project and its objectives from the start and have given much advice and practical help in that time. These two scientists have the means within their fields of expertise, and those of other members of their and adjacent UIB departments, to extend current studies to encompass this important aspect of the marshland ecosystem. This would complement the work of Prof. Newbould and others.

3.1.1.5 Study of relationships between *Archanara geminipuncta* biology, Reed Bunting feeding and breeding biology and their impact on *Phragmites* reed

Phragmites is attacked by the caterpillars of a wainscot moth *Archanara geminipuncta*. These bore into the stems and consume the inner tissues. Apical growth then ceases but is replaced by several more slender lateral shoots. Infestation levels up to 80% have been recorded but none in the year following burning of the reedbed. It may take several years for the moth to colonise reed beds after burning. The caterpillar has an impact not only on growth of the plant but on two bird species. The Moustached Warbler *Acrocephalus melanopogon* (for which S'Albufera is one of the World's most important sites) requires reedbeds of two levels, the lower comprising a layer of broken, dead material.

Archanara geminipuncta may play an important part in breaking down the reeds to create a suitable habitat for these birds. In addition, Reed Buntings *Emberiza schoeniclus* have been observed extracting and eating the caterpillars. The local population, in parallel with others of the species occupying SW Mediterranean reedbed sites, have developed a much thicker bill than their central and north European counterparts. This thick-billed Reed Bunting is one of few bird species able to extract the caterpillars, using the bill to strip away the outer casing of *Phragmites* stems. The thickness of the bill in this population may be associated with this feeding behaviour (though this may not be the only reason). We have interested Anna Traveset of the Institut d'Estudis Avancats de les Illes Balears (CSIC-UIB) in this subject and she has begun her own investigations, though

currently in her spare time away from other commitments. She is based in Palma and is a specialist in insect-plant interactions, currently conducting work on nearby Cabrera.

3.1.1.6 Bird population dynamics

A study of the population dynamics of reedbed species has been established using constant effort ringing at two older (i.e. not recently burnt) reedbed sites in Es Colombar and near Ses Punes. This study has been extended beyond the periods of Earthwatch field presence by Jon King, ornithological researcher from the Edward Grey Institute, University of Oxford, who is currently based there. This has allowed collection of data on fledging dates and breeding productivity as well as variations in the structure of the adult community.

3.1.1.7 Ornithological studies: Moustached Warblers

I have been in discussion with Dr Chris Perrins, Director of Oxford University's Edward Grey Institute for Field Ornithology (EGI), regarding the placement of a postgraduate student to study S'Albufera's Moustached Warblers *Acrocephalus melanopogon*. Dr Perrins indicated that it would require an NERC grant and "the right student" and that, though in principal he is in favour, current financial constraints meant the study was not likely to be implemented at the moment. The proposal, written by myself and Jon King is as follows:

"In general the European Acrocephaline warblers have received considerable research interest, principally regarding

their mating systems and resource partitioning in reedbed communities. The Moustached Warbler however, confined to extensive reedbeds of the Mediterranean Basin and Middle East, has remained virtually unstudied. Although it is now amongst the rarest birds in Western Europe, many basic facts about its biology are unknown.

The recently-created Parc Natural de S'Albufera, Mallorca holds a population of Moustached Warblers probably in excess of one thousand pairs and consequently may represent the most important site for the species within its known world range. A limited database already exists for the species in the Parc, derived from short studies by the British Trust for Ornithology, University College London and Earthwatch Europe in the last 8 years. These suggest an unusually high longevity for a small passerine, with consequent low population turnover, and a high proportion of 'floating' young males; implications for the mating system of the species are as yet unknown. In one main area of the Parc, a large proportion of the Moustached Warblers are already colour-ringed as a result of this previous work. The presence of two other species of Acrocephaline warbler at S'Albufera would allow original studies on a guild of reedbed warblers to be compared with the extensive literature on this subject.

A further, valuable component of this study would be the opportunity to use Moustached Warbler populations to monitor reedbed management techniques. Active grazing by cattle is increasingly used at S'Albufera, and at similar reserves in the Mediterranean, to open up feeding areas for large non-passerines (herons, wildfowl etc.). However, the impact of this on smaller, reed-dependent species is very unclear. Given the Parc's

international responsibility to the Moustached Warbler, and that species' total dependence on the affected habitat, clarification of the ecological relationships involved is urgent.

The facilities at S'Albufera are ideal for housing research scientists, and the Parc's management actively encourage and assist their work. A postgraduate student would gain much from the growing band of ecologists working at S'Albufera, forming an integrated study of reed productivity (Prof. P. Newbould, Ulster), the Fan-tailed Warbler (J.R. King, EGI) and long-term monitoring of many aspects of the Parc's natural history (Earthwatch Europe, Parc staff)."

I have also been discussing this study with the only scientist involved in Moustached Warbler research, Dr Bernd Leisler of the Max-Planck-Institut für Verhaltensphysiologie, Germany. He has indicated a willingness to help with advice and with parallel research in his own Austrian study area.

3.1.1.8 Bird predator studies

At varying times of the year Marsh Harriers *Circus aeruginosus*, Ospreys *Pandion haliaetus*, falcons (including the rare Eleonora's Falcon *Falco eleonora*), egrets and herons are common and highly visible components of the Park's avifauna. Because of their size and visibility, and because they are at the top of a food chain, they may prove to be indicator species for the health of the environment. There is a limited variety of fish (though an abundance of those which occur) and mammals (e.g. no voles) so the predators will be obligate feeders on a more restricted diet

of readily abundant prey such as eels and frogs. We have done some preliminary work on the diurnal activity patterns and preferred feeding areas of Purple Herons *Ardea purpurea*, using Earthwatch volunteers, but much remains to be done in assessing the impact of bird predators. Earthwatch volunteers would be very useful assistants in observing predator behaviour (and it would be a popular task for them), but such studies could only be developed fully by detailed research. I identify this as a potential postgraduate research topic, possibly in conjunction with the Tour du Valat Biological Station (and their heron expert, Heinz Hafner).

3.1.2 The hydrological system

3.1.2.1 Hydrogeological study

This is a key area of study for which we still have inadequate data. Our knowledge of the hydrology of the Park was enhanced by the efforts of the University College London's Ecology and Conservation Unit in 1989-90, but their research demonstrated that much more information was needed which could only be achieved by an in-depth study embracing the whole water catchment area, using data collected over a longer period of time and calling on the expertise of specialists and expensive specialised equipment. This was clearly beyond the direct resources of Project S'Albufera. However, it was within the capabilities of the Mallorcan hydrological service, who we identify as the obvious body to obtain these data which are vital not only to the Project but to the Park authorities and, indirectly, to other

local interests such as the agriculturalists and hoteliers. We understand from Joan Mayol that an in-depth hydrogeological study is now planned, supported and funded by the Balearic Islands Government.

3.1.2.2 Water quality and pollutants

This is an area for which we have very little data, other than for salinity. However, observations indicate that the water chemistry is a key factor affecting the flora, fauna and ecosystems throughout the Park. Clearly aspects such as geohydrology, water chemistry, plant productivity and decomposition and habitats for birds and other animals are related to each other functionally. Apart from salinity, the ecosystem may be subject to a whole range of water and air borne pollutants. We know nothing of the effects on S'Albufera of emissions from the local power station; run-off from adjacent farmland may be bringing a range of agrochemicals from pesticides to nutrient-rich nitrates and nitrites; and speculation has been made about sewage infiltration into the Park. From 1993 we intend to study water quality, aimed at detecting these chemicals, initially by collecting water samples from selected locations. Drs Martinez and Medrano have indicated that facilities are available to analyse water samples within their departments at UIB. Eventually, the study should be developed, perhaps at postgraduate level, by the UIB where it would tie in with current and recent work by Martinez on the aquatic macrophytes and Medrano on reedbed plant photosynthesis and productivity.

This study is also of direct relevance to a number of other

aspects of Project and Park work. For instance it may demonstrate the importance of reedbed plants such as Phragmites in absorbing, and thus acting as a natural cleansing agent for pollutants, reveal the impact of pollutants on biodiversity or the survival of threatened biota and, consequently, influence future management practices.

3.1.2.3 Nutrient exchange

In May 1992 Drs Moya, Ramon and Martinez of the UIB's Department of Biology, and two scientists from the University of Barcelona were awarded a three-year research grant (amounting to ca 5.5 million pesetas) to work on vertical nutrient exchange between water and sediment, and horizontal exchange between S'Albufera and the Bay of Alcudia. Though this constitutes independent research not initiated or suggested by Project S'Albufera, both topics are of interest and direct relevance to our work.

3.1.2.4 Freshwater macrophytes and water quality

Some of the most detailed scientific work done at S'Albufera, involving the distribution of aquatic macrophytes in relation to the physico-chemical dynamics of the water systems, was undertaken by Dr Antoni Martinez for his doctoral thesis in the 1980s. He has maintained a great interest in this subject and in 1990-91 attempted, unsuccessfully, to obtain funding for a study to extend this research. This was to be a joint undertaking with Dr Sven Jonasson, Director of the University of Copenhagen's

Institute of Plant Ecology. Both retain a commitment to develop this topic if funding becomes available.

3.1.2.5 Freshwater invertebrates and water quality

Richard Fox, a postgraduate student from University College London (supervised by Dr Roderick Fisher of UCL's Ecology and Conservation Unit) made a study this summer (1992) of freshwater invertebrate species as indicators of water quality. His intended methodology for the study included implementing the RIVPACS computer program, developed for UK freshwater systems but already tested in amended form in mainland Spain. Eventually he was not able to use this program. However, adaptation of such a system for S'Albufera would be very welcome and of direct relevance to our long-term monitoring objectives and Park management planning as well as providing additional information for studies such as those outlined in 3.1.2.2, 3.1.2.4 and 3.1.2.6.

3.1.2.6 Mollusc studies

Dr Chris Paul of the University of Liverpool's Department of Earth Sciences participated in the Project in October 1991 and May 1992. His task was to set up a baseline for molluscs, to investigate their role as key indicator species and to recommend further research relevant to the Project's objectives. One of the major findings from Dr Paul's survey was that, though shells were present in abundance, live snails were in much lower numbers than anticipated or normal in similar habitats elsewhere. This was particularly the case for aquatic snails. As a result he

recommends monitoring of water quality, including salinity, in relation to the abundance of living aquatic molluscs. Apart from its relevance to our interest in water quality and its effects on the fauna and flora of the Park, this study also has an innovative aspect. Dr Paul knows of only one general study of the salinity tolerances of fresh and brackish water molluscs and that was done nearly 40 years ago. Dr Paul writes: "Jaeckel's (1955) classic study of the molluscs of the Schlei, which drains into the Baltic where maximum salinities are only 16‰, is the only general study of which I know. His fauna did not include six of the 15 aquatic species recorded from S'Albufera, including the four commonest species seen alive. Documenting salinity tolerances of the aquatic molluscs in S'Albufera would not only add to knowledge concerning molluscs, but reveal both changes in the hydrology of the marsh and their effects on aquatic molluscs. Such a study might also help explain some distributions, e.g. why live specimens of both *Hydrobia* and *Amnicola* are almost confined to the northern part of the Park".

Dr Paul felt that he, in conjunction with his department at Liverpool, could be involved in future researches into molluscs at S'Albufera but probably in partnership with Dr Cristian Altaba. Dr Altaba is an acknowledged expert on Balearic molluscs and is based in Palma with the CSIC. Dr Altaba has expressed an interest in becoming involved in mollusc studies at S'Albufera but stresses that, though the CSIC has offices at UIB, the CSIC comprises government scientists independent of the University and thus not working with students. Access to student participation can be achieved by Dr Paul retaining an involvement; the

advantage of Dr Altaba's participation is not just his expertise but the year-round coverage he would be able to offer and which is necessary to further elucidate this and other mollusc problems. Dr Paul makes other very relevant recommendations for future mollusc research which appear under other headings in this document (see 3.1.3.5, 3.5.1.1 and 3.6.7).

3.1.2.7 Fro g studies

Frogs *Rana ridibunda* are a visible and very audible component of the wetland fauna at S'Albufera and undoubtedly play an important role both as predators of invertebrates and small fish, and as prey to larger fauna (including birds and mammals). Attempts have been made to come to terms with the frog population, particularly in assessing numbers and distribution, but the results have been poor and are thought to severely underestimate the total population. Even basic facts such as the timing of the annual cycle are poorly known. A much better knowledge of frog populations is urgently needed and best achieved through a postgraduate study. I have not yet approached anyone, but the base for herpetological studies in Britain is at the Sir David Attenborough Laboratories, School of Life Sciences, De Montfort University, Leicester. I was until recently a postgraduate member of these laboratories and am in a position to make further enquiries about the feasibility of such a study. The Mallorca frog is also of interest because it is *R. r. perezi*, a distinctive race (sometimes given full species rank) which is thought to have originated in North Africa.

3.1.2.8 Fish population studies

Professor Newbould identified knowledge of the fish population as high priority from the start and a study using electro-fishing techniques, led by a Spanish scientist, was part of the programme in the first year. Unfortunately, he withdrew at the last moment and we have not been able to obtain the services of a fish scientist since. It still remains an area we should consider as we strive towards a fuller understanding of the aquatic systems, and it has been suggested that we seek the expertise of the Tour du Valat Biological Station in this area.

3.1.3 The dune systems

3.1.3.1 Orchid population dynamics

Terry Wells has been studying the Park's orchid populations since 1991, using methodology and techniques designed by himself as part of his research into British orchid population dynamics for the Institute of Terrestrial Ecology (ITE). The study, which looks into recruitment and mortality of orchids within fixed quadrats, is currently mainly focussed on the fossil dune area, though he is also monitoring the *Orchis laxiflora palustris* populations of the reedbeds. This is a long-term monitoring study of a key group of species.

3.1.3.2 Studies of dune plant hierarchies

The coastal dunes show a succession to climax pine forest. This succession has frequently been arrested by fires. The most recent evidence is in the southern part of the coastal dunes where the

vegetation is recovering from fires approximately eight years and fifteen years ago respectively. There are also differences in vegetation composition in relation to aspect, drainage and proximity to the sea. Three permanent transects have been set up and recorded by Dr Franklyn Perring. Dr Perring has indicated a willingness to return and initiate the continuation of this work in collaboration with other scientists committed to re-recording the vegetation along these transects at regular time intervals.

3.1.3.3 San d-dune evolution past and present

Dr van der Meulen, member of the scientists' review group present in April 1992, is vice-president of the European Union for Coastal Conservation (EUCC) and a member of the conservation organisation ECODUNE so was, not unnaturally, very interested in the evolution of the sand-dunes, particularly the coastal set. He suggested that the Project should study past, present and future changes in the foreshore (accretion and erosion) using photographic material and techniques. The study should also take into account sea level changes and the role of the sea-grass *Posidonia* in promoting accretion. This study would be of particular relevance to 3.1.3.2 above and, because the rare juniper *Juniperus oxyedrus macrocarpus* is virtually restricted to the coastal zone immediately abutting the beach where it is at risk from erosion, is also of importance for future management planning. It would also, hopefully, give impetus to our request to the Balearic government, through the good offices of Joan

Mayol, to install an automatic sea level recorder at S'Albufera.

Dr van der Meulen indicated that he and his department of Physical Geography and Soil Science at the University of Amsterdam would be interested in becoming more closely involved in the Project and this is one area where we may wish to avail ourselves of his expertise. His participation may also be seen as a step towards integrating our monitoring work into international networks, in this case the EUCC and ECODUNE.

3.1.3.4 Gra zing influence of mammals on fossil dune vegetation

Horses and cattle are grazed on the fossil dunes and the flora may be changing because these avoid *Euphorbia terracina* , which seems to be increasing. To monitor this Jo Newbould set up, in April 1992, a grid designed to determine the current and future distribution of the *Euphorbia* . In addition she has taken photographs of the area from fixed points, as a further means of assessing distribution and change. We do not know whether the impact of *Euphorbia terracina* is of a permanent or merely temporal nature. However, photography has given us the opportunity to follow the plant's annual cycle, thanks to the participation of Mallorcan volunteer, Tomeu Tomas, who has volunteered to repeat the photography on a monthly basis. This study also has relevance to section 3.2 below.

3.1.3.5 Mol lusc studies

Dr Paul (University of Liverpool's Department of Earth Sciences) recognised several questions which need to be answered regarding mollusc distribution in the sand dunes. He writes: "there is a general question as to what characteristics of the dune habitats are essential for the various [mollusc] species of the dune fauna. If it is just drainage, species should be equally at home on the fossil dunes of Ses Puntas and the area NW of Ca'n Picafort as they are on the modern dunes. If proximity to the sea is important, some may survive on the modern dunes but not the fossil ones inland. Another point concerns the vegetation. Are the well wooded parts of the dunes significant? If so, some species may be absent on the bare ridge of Ses Puntas, but present in the wooded parts of both the Fossil and Recent dunes".

He recommends that, in conjunction with the dune vegetation transect studies already underway, comparisons should be made between populations of "dune snails" on recent and fossil dunes to assess how stabilization of dunes by vegetation, and the transition from grassland through scrubland to woodland, affects such species. Assessment of the influence of the sea by comparing similar microhabitats between recent and fossil dunes could be undertaken at the same time.

3.1.3.6 Insect studies

A north-south transect has been set up through the centre of the coastal (Es Comu) dunes to record butterflies and dragonflies. The transect has been divided into six sections, each reflecting

a different habitat type and/or age after burning. The information gathered will demonstrate use of these habitats by butterflies, and possibly dragonflies, and the effects of vegetation change on their abundance and species' composition.

3.1.3.7 Bird population studies

Part of a longer transect, sampling major Park habitats, has been set up through the centre of the coastal (Es Comu) dunes to record birds. The information gathered will demonstrate use of this habitats by birds and the effects of vegetation change on their abundance and species' composition.

3.1.4 The whole catchment of the Park and adjoining coastal waters

3.1.4.1 Remote Sensing

Work was begun in 1992 to incorporate remote sensing as part of our research. In the spring, Earthwatch volunteers did some "ground-truth" fieldwork in preparation for two studies undertaken in the summer by postgraduate students from the University of Aberdeen's Centre for Remote Sensing and Mapping Science. They undertook field work at S'Albufera based on two Landsat images shared by the Centre and Earthwatch Europe. One student looked at the current and recent distribution of Cladium and Phragmites and the other current and recent soils and land-use on agricultural land abutting the Park. Both studies were successful. Dr Loder of the Centre has indicated that there are many further studies which could be done by his department,

in these and allied areas of research. I am very keen to maintain this link. The Centre for Remote Sensing and Mapping Science has an international reputation for remote sensing work, they are keen to participate and, most important of all, they already have a link with Spanish Universities including the UIB's Department of Geography. One of the 1992 studies was undertaken by a Mallorcan and the other by a Peninsular Spaniard. One of our Mallorcan volunteers, who was instrumental this spring in advising us on "ground truthing" and digitising data in GIS (Geographic Information System) form, has just joined the department at Aberdeen.

One of the essential elements of the remote sensing studies is comparative information in order to monitor long term change on an objective basis. Studies which lend themselves to remote sensing methodology and which The Aberdeen Centre is keen to study include: the input of sediment plus suspended solids to the wetland and release via outflows to the Bay under normal and flood conditions; movement of sediment within the offshore, beach and dune systems; and changes in abundance and distribution of the important *Posidonia* (sea-grass) beds offshore in the Bay of Alcudia.

3.2 The impact of management and related studies

The Project needs to gather data on management events because these may impinge on the ecological and other processes being studied. In addition, some of the research undertaken by Project S'Albufera will have a direct bearing on planning of management

and may serve to guide that management in the future.

3.2.1 Current management practices

Sara Hawkswell from the Royal Society for Nature Conservation has initiated work to adapt the British Countryside Management System (CMS) to the S'Albufera situation. This will be of help to the Park staff and to Project S'Albufera because the system records management of the Park, both past and present. She is aiming to incorporate all types of work being done in the Park including practical management, monitoring, educational visits and research projects. This would ensure access by all interested bodies to relevant data and should begin to bring the different aspects together. Teething problems in setting up this system include time available by Sara and the Park staff to work on it.

3.2.2 Impact of Park habitats on the bird fauna

During fieldwork periods daily counts have been maintained of the maximum number of each bird species during a ten minute period from hides overlooking defined areas of grazed and ungrazed marsh. This study has been designed to compare the use by migrant and resident birds of open areas of marsh managed by grazing with those managed by other means or unmanaged.

3.2.3 Bat studies

Jean-Francois Noblet, a bat expert with specialist knowledge of the Mediterranean island bat fauna of Corsica, joined the Project in May 1992 to compile an inventory of bats present in the Park, to assess their importance as components of Park fauna and to propose future management planning of benefit to bats.

Jean-Francois recorded ten species, including several which are scarce or of restricted European range. His most notable discovery was that S'Albufera supported a population of *Barbastellus barbastellus* , an extremely rare species in Spain and not previously recorded from the Balearic Islands. He concluded from his studies that S'Albufera was a very favourable site for bats, abundant water and invertebrate food associated with the wetland situation being of particular benefit to this group. He found, however, that there was a shortage of roost and breeding sites, compounded by the lack of suitable old buildings within the Park and disturbance at roost caves in the foothills adjacent to the Park. He made a whole series of practical proposals designed to overcome this problem, including better protection of cave sites through well maintained entrance grills and the introduction of purpose built roost/nest boxes under Park bridges, on Park buildings etc.

Jean-Francois considered that there was considerable scope for more extensive work on S'Albufera bats. He pointed out that bats are under pressure from environmental change, loss of breeding and roost sites and the effects of pollution on their insect prey etc. throughout their European range and it was one of the roles of the Parc Natural to afford them protection. He recommended therefore that further studies be conducted. He has offered to extend his work in establishing the composition and role of the bat fauna by visiting during the period of reproduction (June to September) when he would continue to sample the population by mist-netting at night in a wide range of Park habitats. He also recommended that the study would benefit from the employment of a

bat ultra-sound detector accompanied by a specialist in its use. He indicated that he could find such a person. In addition, he felt that careful dissection of owl pellets could also throw light on the bat population of S'Albufera but lamented that the removal of the old mill buildings had deprived the bats' major predator, Barn Owl *Tyto alba*, of a breeding site within the Park. He therefore made a practical proposal (including drawings) for the Park authorities to create an artificial nest site in the old farm building at Ses Puntetes.

3.2.4 Grazing influence of mammals on fossil dune vegetation

This study, described under 3.1.3.4 above, is also relevant to the study of the impact of management.

3.3 Environmental and socio-economic studies

There is some overlap between this category and category 3.1.4 (studies of the whole catchment and immediate marine environment offshore), particularly regarding remote sensing and associated aerial photographic survey work.

3.3.1 Environmental functions and values

At the scientists' review meeting Dr Rudolf de Groot presented a novel way of studying the "value" of natural sites which has immediate appeal both from an environmental and socio-economic viewpoint. His method comprises an analytical approach for assessing the sustainable use of the wetlands by identifying the key environmental functions which it performs and assigning

values to these functions. His functions, which he has applied in a number of natural areas in widely scattered parts of the world, are grouped into regulation, carrier, production, and information. Each of these is sub-divided and all the functions can be assessed and evaluated in relation to ecological, social and economic criteria. The management implications can then be deduced.

S'Albufera lends itself to this new analytical approach and such an assessment would be of benefit to the Project and to the Park authorities. We should explore the possibility of developing this line of study by asking Dr de Groot, through his and other Departments at the Agricultural University of Wageningen, to become more actively involved with the Project - perhaps through a series of studentships designed to collect and analyse the data required.

3.3.2 Land- use and vegetation

Both Dr de Groot and Dr van der Meulen stressed the importance of taking into account the entire catchment area, coastline and immediate offshore in any study of the processes at work in the Parc. Dr van der Meulen concluded: "it is clear that events outside the Parc may exert considerable influences within it - and vice versa - so that any attempt at analysis must include the whole catchment and the coastline. For example, the Parc is probably important in regulating the flow of water from the hinterland to the sea; it serves as a recharge area and there may be recycling of nutrients and thus a positive influence on the quality of water leaving the area. In turn, the Parc is affected by the amount and quality of water entering it and activities in

the watershed such as horticulture and water abstraction."

Dr van der Meulen indicated that he and his Department of Physical Geography and Soil Science at the University of Amsterdam would be interested in becoming more closely involved in the Project. A number of the studies proposed in this document are aimed to elucidate aspects of the impact of events described above (e.g. the remote sensing work begun and planned by the University of Aberdeen's Centre for Remote Sensing and Mapping Science). However, Dr van der Meulen has particular knowledge and experience in areas of direct relevance to the Project (e.g. coastal studies) and we should not miss the opportunity to avail ourselves of his expertise. Currently, Dr van der Meulen has proposed that a team of students from his University undertake a mapping study of the vegetation and land-use in and around S'Albufera.

3.3.3 Past History & Land Use

This is a subject which was studied by UCL Ecology and Conservation Unit students. Their findings have been summarised but there is a considerable need for the study to be extended and information collected and collated in much greater detail. This may also be a study suitable for a UCL postgraduate student, but would perhaps be better tackled by a Mallorcan, perhaps a postgraduate of the Department of Geography but specialising in aspects of social geography/demography. This study also has relevance to studies of the evolution of S'Albufera described in 3.6.1 and 3.6.2.

3.3.4 Soils /sediments

Soil studies were undertaken in spring 1991 but the researcher failed to produce any documentation of her results. However, the Project needs detail of soils and sediments. This is best accomplished by bodies such as the University of Aberdeen, University of Amsterdam and University of Liverpool as an integral part of their studies of land use, remote sensing and the geological past. This study also has relevance to studies of the evolution of S'Albufera described in 3.6.1 and 3.6.2.

3.3.5 Touri sm related studies

In 1989 the UCL Ecology and Conservation Unit undertook preliminary studies of visitor impact on the Park, but there is ample scope for this work to be continued and expanded. Indeed, Joan Mayol is very keen to obtain more and better data. To achieve this we would need to seek expertise in the field. This may be an area of research that could be incorporated by Dr de Groot in his integrated socio-economic studies. Alternatively it might be achieved through UCL postgraduate research. Such a study would also be of benefit to the Tourist industry and funds should perhaps be sought from that avenue. Dr Perring has offered to advise.

3.4 Furtherance of data-processing and the data-base potential and methodology, including development of compatible systems for comparative work and integration into international networks and schemes

3.4.1 Storage and organisation of data, use of GIS

Research data should be incorporated in a site database, used also for data collected by Park staff, including meteorological and hydrological data. The importance of historic data and the necessity of making them available in readily accessible electronic form should be given more attention. A student from the UIB's Department of Geography was instrumental in setting up a GIS recording system for the ground-truthing work done by Bernie Young. The adoption of GIS is a particularly important step towards ensuring wider applicability of Project S'Albufera data. Knowledge and expertise in GIS is clearly available at UIB and this is an area where we should encourage their involvement. We have received strong indications, via Joan Mayol, that UIB's geography department, through their Head and vice-rector of the University Dr Climent Picorell, is interested in becoming more involved with the Project. This department also has close links with the University of Aberdeen's geography department which, through its Centre for Remote Sensing and Mapping Science, is already participating in the Project.

The scientists review meeting recommended that integration through a GIS as a database should be made through the European Environmental Agency (EEA).

3.4.2 Development of ecological data bases

The problems involved in setting up a computer-based package to record management is described in 3.2.1 above. Even more problems beset us with development of a computerised system of storing and

processing biological records. Sara Hawkswell indicates that the RECORDER database used in Britain is not suitable for immediate conversion to a system for wide use in Mallorca or Spain. Particular difficulties would arise from changing the species dictionary, codings, language and system maintenance. She recommends that a system should be devised to store all the data and make them readily available to all users in a variety of formats. In order to accommodate future uses of these data (for example incorporation into a GIS or a network of biological databases), potential data standards should be considered.

This is specialist work, requiring time and commitment. Sara Hawkswell has a full-time job and inevitably does not have the time to commit to develop such a system in the time-scale we would need. I identify this as suitable for a postgraduate studentship, probably by someone in Computer Science with a specific interest in the natural world.

3.4.3 Gridding the Park

The Park Directorate has divided the Park area, for descriptive and mapping purposes, into 30 sectors/compartments. Sara Hawkswell feels that, though a computerised database can deal with records by compartment, this may be insufficient detail for the purposes of Project S'Albufera. There is general agreement among Project scientists that we should seek a more accurate recording system, relating records to UTM (international grid system as used by Ordnance Survey style maps). To do this our options are 1) to grid the Park, 2) to use a global position retriever (satellite-generated location retriever system).

There are a number of problems afflicting the first option. Joan Mayol does not want visible location points (i.e. he does not want visitors to see a series of posts scattered through the Park). We have solved this problem for quadrats and transects by sinking markers to or below surface level which if not visible at a later date may be located using a metal detector. This may be less appropriate or straightforward for more wide-ranging studies. In addition, very few UTM intersection points occur in suitable locations - the setting up of reference points, visible or otherwise, in the middle of reedbeds is of little use to the Project (as well as a practical impossibility). Even if a grid system was set up, using tracks and other firm ground, this would require a lot of time and the involvement of someone with surveying expertise. The only such person at the Park, Biel Perello, has given indications that he might be able to help, but always his time has been fully usurped by his Park responsibilities. The second option may be more favourable, at least initially, and would prove a useful tool if we progressed to gridding at a future date.

3.4.4 Interpretive and educational

Practical application of data collected by the Project has begun through a collaboration between the Park's Technical Assistant Biel Perello and Project scientists Dinah McLennan and Jo Newbould. They are currently working together to produce display material and hope to follow that with a brochure or more detailed publications based on Jo's studies of the Park's botany, Dinah's

artistic skills and Biel's knowledge of the Park and relevant languages. These materials would be directed to interpreting S'Albufera plantlife for visitors to the Park.

3.5 Studies aimed at assessing environmental change

One inevitable by-product of the studies described above will be information which may be used to assess environmental change. Other studies currently in place or recommended have been specifically designed to achieve that objective. They fit into two sub-categories: 1) in-depth ecological studies; 2) constant or regular long-term monitoring.

3.5.1 Ecological studies

Studies in this category are ones which cannot be achieved by the Project in its present form of "snap-shot" field visits of short duration but which nevertheless are necessary if we are to understand the ecosystems and change. They do, however, make ideal subjects for postgraduate students to tackle.

3.5.1.1 Mollusc studies

Dr Paul (University of Liverpool's Department of Earth Sciences) recommends research topics which would seek more information about the ecological preferences of certain species. He has outlined the following.

1. Establishing basic ecological requirements and life cycles for endemic snails, particularly the operculate snail *Tudorella*, which would involve monitoring selected populations. Since its range has been reduced over the geologically recent

past, understanding its ecological requirements may be the key to its continued survival, although it is not a threatened species at present. It is widespread and common in Mallorca and Menorca, but unknown elsewhere in the world. It is recorded as a Pleistocene fossil from Ibiza, Sardinia and possibly southern France. This study, therefore, has an element of change based on past changes. What ecological conditions exist for the survival of the species in S'Albufera which no longer exist in other areas?

2. The precise ecological preferences of the three species of *Cochlicella* is recommended as an interesting study. Both Dr Paul and a previous observer noted that *C. barbara* was commonest alive within the marsh (though still on dry canal banks), while *C. conoidea* seems to be confined to the dune areas, both fossil and recent. *C. acuta*, the most widespread of the three, may be the most ecologically tolerant though even it was rarely seen by Dr Paul alive away from dunes and well drained paths. How, or even if, *C. acuta* and *C. conoidea* partition the dune habitats would be well worth studying. Such a study could easily be undertaken as a wider part of the dune transect studies already underway. There is probably, for instance, no information about the dominant plant species found at sites where *Cochlicella* is recorded let alone their food preferences or which species of plant they climb up in summer to aestivate.

3. Similar studies could be made of other congeneric species, e.g. why is *Trochidea* (*T.*) *elegans*, the more widespread species, so restricted in its occurrence in S'Albufera, whereas *T.* (*T.*) *trochoides* is more common in the dunes? Equally, what are

the precise requirements/ preferences of the three species of Vallonia ?

3.5.2 Long-term monitoring

3.5.2.1 Entomological: moth studies

Once a comprehensive inventory of lepidoptera has been established (see 3.6.8), Barry Goater plans to outline a monitoring programme based on light trap captures of moth species which are easy to recognise and likely to be key indicator species (e.g. for their impact at larval stage on major plant species such as Phragmites). Barry has already discovered that S'Albufera supports a healthy population of the moth Pelosia plumosa , an obscure but extremely interesting species known only from a few localities in southern Spain, north Africa and southern Italy and not recorded before from the Balearic Islands. Regular moth trapping will confirm the importance of S'Albufera for this species and provide information of its future status. Park staff assistance may be required in maintaining a regular trapping regime under guidance from Barry.

3.5.2.2 Entomological: butterfly monitoring

Two transects, one based in the coastal sand dunes and a longer one sampling all major Park habitats, have been established. Both transects are divided into sections, each reflecting a different habitat type. All species are counted within each section. The information gathered will demonstrate variations in the numbers and composition of butterflies and their use of Park habitats.

This study has been set up and is carried out by Nick Riddiford

with Earthwatch volunteers. The period of study was extended through the summer in 1991 by a Mallorcan volunteer.

3.5.2.3 Bird population dynamics

Two transects, each of approximately 7 km and sampling all major Park habitats, have been established. Both transects are divided into sections, each reflecting a different habitat type. All species are counted within each section. The information gathered will demonstrate variations in the numbers and composition of breeding and migrant birds and their use of Park habitats.

This study has been set up by Nick Riddiford but has been extended beyond the periods of Earthwatch field presence by Jon King, ornithological researcher from the Edward Grey Institute, University of Oxford, who is currently based there.

3.5.2.4 Fitness of migrant birds

Passage migrants are counted in April/May and a sample trapped as part of a study of body condition in passage birds. The main "target" species is the Swallow *Hirundo rustica*. This is primarily the work of Jon King and is continued through the year by JK and the Park ornithologist, Pere Vicens. The study aims to elucidate the importance of S'Albufera for migrant birds, particularly in times of poor weather. Like many of the studies carried out as part of Project S'Albufera, this research seeks good, comprehensive meteorological data to assist in the elucidation of processes.

3.5.2.5 Meteorological recording

The Park operates a simple weather station but the data it collects are insufficient for the needs of the Project. The nearest site which collects the quality of data which many of the Project's studies require is several kilometres away near Sa Pobla. Ideally a more sophisticated weather station, in line with the Environmental Change Network (ECN) sites in the UK, should be installed at S'Albufera.

Dr Toni Martinez has offered to approach Dr Climent Ramis, of the UIB's Department of Meteorology about becoming actively involved in meteorological aspects of the Project. The head of this Department, Dr Sergio Alonso, has an active interest in Climatic Change and has urged the Spanish government to sign the IGBP protocol - which he sees as integrating climatic change studies to produce a vehicle for shaping government environmental policy. He and his Department are active in an ICSU-led initiative to establish a Regional Climate Investigation Centre which will study climatic variations in the Mediterranean and sub-tropical Africa region.

The involvement of this Department would be extremely useful for it may advance our request for the establishment of a sophisticated weather station at S'Albufera. If this is established we may also be able to seek the participation of Dr Rudolf de Groot in his capacity as co-ordinator of the Climate Change Research Centre at the Agricultural University of Wageningen.

3.5.2.6 Other studies

Several studies described elsewhere, for example Orchid population dynamics (3.1.3.1) and Studies of dune plant hierarchies (3.1.3.2), also have a long-term monitoring element.

3.6 Extension of baseline information

3.6.1 Evolution of S'Albufera: coring study for pollen

This study is being conducted by scientists from the Geography departments of the University of Barcelona and UIB. Though this constitutes independent research not initiated or suggested by Project S'Albufera, it is of direct relevance to our work; it will, by relating the pollens found to species and date, give a much clearer understanding of the past evolution of S'Albufera. I have spoken to one of the scientists involved who indicated that the results would be published and thus become available to us. He also indicated that the geological cores from which the pollen analysis would be taken could be made available to Project S'Albufera for parallel studies (see 3.6.2 below).

3.6.2 Evolution of S'Albufera: Diatoms in geological cores

If we do get access to the cores outlined in 3.6.1 above, geological research could be extended by the involvement of the University of Liverpool's Department of Earth Sciences under the leadership of Dr Andy Plater. Dr Plater has indicated that he would be in a position to investigate the Holocene/Pleistocene sediments and, hopefully, return with some material for pollen

and diatom analysis. He writes "my primary interest is coastal evolution in relation to Holocene sea-level trends, so this opportunity is very appealing". This study could make an important contribution to our understanding of the past evolution of S'Albufera and its environs.

3.6.3 Flowering Plant distribution by management compartments

This work was begun by Dr Franklyn Perring in 1992 and he has indicated his willingness to continue with the study and produce a plant recording card. The study interrelates with the herbarium work described in 3.6.4 below.

3.6.4 Herbarium

Jo Newbould, assisted by other botanists and Earthwatch volunteers, has continued to build up the herbarium, augmented by a series of photographs, slides and line drawings. She has also drawn up a comprehensive list of known S'Albufera flowering plants which demonstrates that the herbarium is far from complete. The herbarium now has its own dedicated herbarium cupboard which is extensively used by Project workers and Park staff alike. There is also a comprehensive card index for all S'Albufera flowering plants. Jo will continue her responsibility for the herbarium and flowering plant inventory with the aim of making it as comprehensive as possible. Dinah McLennan continues to play an important role in supplementing the reference collection with accurate line drawings. They are planning to use this work as a basis for preparing material which may be used to interpret plantlife for visitors to the Park (see 3.4.4).

3.6.5 Extension of herbarium material to include lichens and mosses

A small collection of lichens has been established at the Park, based on identifications made by Tom Chester of specimens taken to England. It is far from complete, and no work has been done on the bryophytes. Lichens in particular are known to be sensitive to air quality and may be a key group for this line of study. Work should initially comprise establishing a species inventory with reference material, but eventually there is scope for research, probably at postgraduate level, into lichen distribution and air quality within the Park. Dr P.D. Crittenden of the British Lichen Society and Department of Life Science of the University of Nottingham could be approached.

3.6.6 Fungi

Sheila Wells, wife of Principal Investigator Terry Wells, collected and identified fungi in April 1991 and April and November in 1992. Sheila plans to extend her fungal database on subsequent visits with her husband, including in April and October 1993.

3.6.7 Mollusc studies

Dr Paul (University of Liverpool's Department of Earth Sciences) points out in his report of 1991 work that basic data about life cycle (e.g. are they annual or perennial, when do they mate and lay eggs? etc.) are unknown for the endemic snails and slugs such as *Tudorella* , *Trochoidea* (*Xeroplexa*) *nyeli* , *Limax majoricensis*

and probably for several other species (e.g. *Trichia lanuginosa* ,
Otala spp., *Pseudotachea*). Observations on these basic details
would be very useful but would require a person with specialist
knowledge and year-round access to the site (i.e. a student based
at the Park or resident Mallorcan).

3.6.8 Invertebrate baseline studies including collection of reference material

Work to establish an on-site reference collection was given a
boost, for lepidoptera, by the participation in May 1992 of
British lepidopteran expert, Barry Goater. It is the aim of the
Project to achieve a level of reference, including inventories,
for invertebrates of a similar quality to that established for
flowering plants. The Balearic Invertebrate Group have indicated
their willingness to help with this task, e.g. for beetles, and
Barry Goater has indicated his willingness to continue his
participation - which includes studies and advice on other
lepidopteran aspects of the Project (e.g. 3.1.1.4).

Barry has suggested that we expand our lepidopteran studies to
include the "micros", the smaller species sometimes thought of as
"insignificant" but nevertheless making a considerable impact on
vegetation in their larval stages - hence the tag which many
carry as "species of economic importance". He has recommended
that we invite the Rev David Agassiz to undertake this part of
the research.

3.6.9 Entomological: Odonata

Adult dragonflies are a very obvious part of the invertebrate fauna but difficult to study. To overcome this, in 1992 Ed Cross began to develop methodology to monitor the larval stages. Early results are extremely promising and Ed plans to refine his methodology further. His work demonstrates that the total number of dragonflies supported by the marsh at larval stage is very large, therefore the group will play an important role as predators of other small aquatic fauna and as prey to fishes, frogs, some birds and other fauna. The adults are an important food source for the globally rare Eleonora's Falcon which gathers at S'Albufera to hunt dragonflies prior to its breeding season. The Cross methodology has great potential for monitoring Odonata population dynamics and their role in and interactions with the wetland ecosystem. Future work will also be needed outside the main Earthwatch field seasons, particularly in summer.

3.6.10 Hoverfly studies

This study aims to extend our knowledge of the composition and seasonality of hoverfly (Diptera; Syrphidae) species using the Park and to monitor variations in the abundance of one easily recognisable migrant species, *Episyrphus balteatus*. This is achieved by counting the number of individuals of *Episyrphus balteatus* and recording all other Syrphid species seen within an establish transect route. This study was set up by Simon McKelvey but is currently carried out by Nick Riddiford with advice and identification assistance provided by Simon from his home base.

Hoverflies are often considered in Britain to be key indicator species of the health of wildlife habitats, based on diversity of

species.

3.6.11 Invertebrates

A Balearic Invertebrate Group, under the leadership of Josep Antoni Alcover of CSIC and based at UIB in Palma, has been set up to further research into invertebrates in the Balearic Islands. Sr Alcover has indicated that specialist help would be available to increase our baseline knowledge for a number of groups. This was demonstrated in 1992 by visits from members of this group specialising in beetles and spiders. They set a series of pitfall traps in a number of habitats, which they visited on a regular basis during the spring. All these specialists have research commitments elsewhere and, though their expertise and assistance would be welcome, their involvement with the Project is likely to remain low-key.

3.6.12 Small mammal studies

A pilot small mammal study was done by Keith Bowey in October 1992 and a fuller study is planned by the University of Durham's Department of Biology in spring 1993. In addition to gaining a greater knowledge of small mammal populations and distribution, these studies may obtain comparable data to the small mammal work of Dr Alcover in the early 1980s, and published by Barcelo and Mayol.

Part 4 . Tier structure

4.1 First Tier. Earthwatch funded monitoring

Project S'Albufera is very different from what would be considered the norm for Earthwatch funded research projects. Other projects tend to concentrate on one particular item of research requiring scientific staff levels far below that demanded by Project S'Albufera lines of research. Project S'Albufera has been much more expensive in a number of areas, but especially in the travel costs of bringing scientific specialists to the Project, providing for their extra equipment needs and their accommodation. Ancillary additional costs include extra for provisions and transport within Mallorca.

To bring this into perspective I have included in Tier 1 a list of those areas of research which can be achieved by strict adherence to the funding possibilities offered by Earthwatch. They are set out below. The numbers in parentheses cross-reference to the summary paragraphs above describing the studies. I have included the scientist/body responsible for each study.

4.1.1 List of studies

1. TITLE: Orchid population dynamics (3.1.3.1)

RESPONSIBILITY: Terry Wells

2. TITLE: Bird population dynamics (3.1.1.6; 3.1.3.7; 3.5.2.3)

RESPONSIBILITY: Nick Riddiford

3. TITLE: Hoverfly studies (3.6.10)

RESPONSIBILITY: Nick Riddiford & Simon McKelvey

4. TITLE: Butterfly monitoring (3.1.3.6 and 3.5.2.2)

RESPONSIBILITY Nick Riddiford

5. TITLE: Impact of Park habitats on the bird fauna (3.2.2)

RESPONSIBILITY: Nick Riddiford

4.2 Second Tier. Studies which need to be tackled but depend on extra funding.

Over the first four years the Project has benefited enormously from the involvement of a series of scientists who have developed their own methodologies for tackling the many problems the Project has met. Many of these scientists remain involved with the Project and have studies in progress and/or which require further work. These studies are set out in Tier 2. The numbers in parentheses cross-reference to the summary paragraphs above describing the studies. As in Tier 1, I have included the scientist/body responsible for each study.

4.2.1 List of studies

1. TITLE: Autecology of Phragmites and Cladium (3.1.1.1)

RESPONSIBILITY: Palmer Newbould (with UIB back-up).

2. TITLE: Studies of dune plant hierarchies (3.1.3.2)
RESPONSIBILITY: Dr Franklyn Perring.
3. TITLE: Grazing influence of mammals on fossil dune vegetation
(3.1.3.4)
RESPONSIBILITY: Jo Newbould (3.1.3.4).
4. TITLE: Current management practices (3.2.1)
RESPONSIBILITY: Sara Hawkswell, RSNC; S'Albufera Park staff.
5. TITLE: Bat studies (3.2.3)
RESPONSIBILITY: Jean-Francois Noblet.
6. TITLE: Interpretive and educational (3.4.4)
RESPONSIBILITY: Biel Perello, Technical Assistant, Parc
Natural de S'Albufera ; Dinah McLennan and Jo Newbould,
Project scientists.
7. TITLE: Entomological: Moth studies (3.5.2.1)
RESPONSIBILITY: Barry Goater, Project scientist; Andreu
Muntaner, Warden, Parc Natural de S'Albufera .
8. TITLE: Plant distribution by management compartments (3.6.3)
RESPONSIBILITY: Jo Newbould; Dr Franklyn Perring.
9. TITLE: Herbarium (3.6.4)
RESPONSIBILITY: Jo Newbould.
10. TITLE: Fungi (3.6.6)
RESPONSIBILITY: Sheila Wells.
11. TITLE: Invertebrate baseline studies including collection of

reference material (3.6.8)

RESPONSIBILITY: Barry Goater; Rev David Agassiz.

12. TITLE: Entomological: Odonata (3.6.9)

RESPONSIBILITY: Ed Cross.

13. TITLE: Small mammal studies (3.6.12)

RESPONSIBILITY: Keith Bowey.

14. TITLE: Remote Sensing (3.1.4.1)

RESPONSIBILITY: John Loder, Centre for Remote Sensing and Mapping Science, University of Aberdeen; Bernie Young.

4.3 Third Tier. Parallel studies planned for 1993-94 by Universities and other bodies.

We have always recognised that much of the more innovative, detailed and temporally extended work should be undertaken by Universities and other bodies in partnership with the Project (and thus in partnership with Earthwatch Europe). Steps towards achieving this were already in place by the time the review group met (e.g. co-operation agreement signed between Earthwatch Europe and the University of the Balearic Islands, Earthwatch Europe sponsored or part-sponsored studies by post-graduate students from University College London and the University of Aberdeen's Centre for Remote Sensing and Mapping Science). However, the review group meeting stimulated an increased interest and commitment from Universities, not least several scientific departments of the UIB - seen by us as an essential development for the future of the Project as the University "on the spot" and

with most to gain from involvement in this international venture. The list which follows includes a number of studies suggested or encouraged by scientific members of Project S'Albufera but offered as a direct result of the review group meeting (and in particular the enthusiasm and insistence of the two Dutch scientists in the group who urged UIB scientists to grab what they saw as a great opportunity to participate in an international project of great potential). As in Tiers 1 & 2, I have included the person/body responsible for each study. The numbers in parentheses cross-reference to the summary paragraphs above describing the studies.

4.3.1 List of studies

1. TITLE: Photosynthesis and productivity of marshland plants
(3.1.1.2)

RESPONSIBILITY: Hipolito Medrano, Dept of Vegetal Physiology, UIB; Roger Austen, University of Cambridge.

2. TITLE: Decomposition of reedbed plants (3.1.1.4)

RESPONSIBILITY: Dr Enrique Descals, Department of Environmental Biology & Dr Antoni Martinez, Department of Limnology, UIB.

3. TITLE: Study of relationships between *Archanara geminipuncta* biology, Reed Bunting feeding and breeding biology and their impact on *Phragmites* reed (3.1.1.5)

RESPONSIBILITY: Anna Traveset, CSIC, Palma.

4. TITLE: Ornithological studies: Moustached Warblers (3.1.1.7)

RESPONSIBILITY: Dr Chris Perrins, Edward Grey Institute for Field Ornithology, Oxford University; Dr Bernd Leisler

Max-Planck-Institut für Verhaltensphysiologie,
Germany.

5. TITLE: Hydrogeological study (3.1.2.1)

RESPONSIBILITY: Dr Alfredo Baron, Balearic Hydrological
Service.

6. TITLE: Water quality and pollutants (3.1.2.2)

RESPONSIBILITY: Drs Martinez and Medrano, Department of
Biology, UIB.

7. TITLE: Vertical nutrient exchange between water and sediment
(3.1.2.3)

RESPONSIBILITY: Drs Moya, Ramon & Martinez, Department of
Biology, UIB; two collaborators from the University of
Barcelona.

NOTE: Independently funded research study begun in 1992.

8. TITLE: Freshwater macrophytes and water quality (3.1.2.4)

RESPONSIBILITY: Dr Martinez, Department of Biology (Limnology
Section), UIB; Dr Enrique Descals, Department of
Environmental Biology, UIB; Dr Sven Jonasson, Institute
of Plant Ecology, University of Copenhagen.

9. TITLE: Freshwater invertebrates & water quality (3.1.2.5)

RESPONSIBILITY: Dr Roderick Fisher, Ecology and Conservation
Unit, University College London.

10. TITLE: Mollusc studies (3.1.2.6; 3.1.3.5; 3.5.1.1; and
3.6.7)

RESPONSIBILITY: Dr Chris Paul, Department of Earth Sciences,

University of Liverpool; Dr Cristian Altaba, CSIC,
Palma.

11. TITLE: Sand-dune evolution past and present (3.1.3.3)
RESPONSIBILITY: Dr van der Meulen, Department of Physical
Geography and Soil Science, University of Amsterdam.
12. TITLE: Remote Sensing (3.1.4.1)
RESPONSIBILITY: John Loder, Centre for Remote Sensing and
Mapping Science, University of Aberdeen.
13. TITLE: Environmental functions and values (3.3.1)
RESPONSIBILITY: Dr Rudolf de Groot, Climate Change Research
Center, Agricultural University of Wageningen.
14. TITLE: Land-use and vegetation (3.3.2)
RESPONSIBILITY: Dr Frank van der Meulen, Department of
Physical Geography and Soil Science, University of
Amsterdam.
15. TITLE: Storage & organisation of data, use of GIS (3.4.1)
RESPONSIBILITY: Sara Hawkswell; Dr Climent Picorell,
Department of Geography, UIB; Dr John Loder, Centre
for Remote Sensing and Mapping Science, University of
Aberdeen.
16. TITLE: Fitness of migrant birds (3.5.2.4)
RESPONSIBILITY: Jon King, EGI, University of Oxford; Pere
Vicens, Ornithologist, Parc Natural de S'Albufera .
17. TITLE: Evolution of S'Albufera: coring study for pollen
(3.6.1)

RESPONSIBILITY: Dr Ramon Julia, Institut Jaume Almera,
University of Barcelona

NOTE: Independently funded research study begun in 1992.

18. TITLE: Evolution of S'Albufera: Diatoms in geological cores
(3.6.2)

RESPONSIBILITY: Dr Andy Plater, Department of Earth Sciences,
University of Liverpool).

- 4.4 Fourth Tier. Studies which are needed but for which no
scientists/means are available.

This tier is included for completeness. Although the funding to meet these extra studies is not currently available we cannot afford to omit items of research which are key to our full understanding of the processes and ecosystems. If funding remains difficult, these studies are at least on paper for consideration at a later date. In the list which follows, the numbers in parentheses cross-reference to the summary paragraphs above describing the studies. Areas of responsibility have been given but these are proposed rather than indicating acceptance or commitment by the scientists/organisations involved.

4.4.1 List of studies

1. TITLE: Heavy metals in marsh plants (3.1.1.3)

RESPONSIBILITY: Maria Pou Bordoy, Catalina Cabot and John
Sibole, Department of Vegetal Physiology, UIB.

2. TITLE: Bird predator studies (3.1.1.8)

RESPONSIBILITY: Heinz Hafner, Tour du Valat Biological
Station, Camargue, France.

3. TITLE: Frog studies (3.1.2.7).

RESPONSIBILITY: Herpetological department, Sir David
Attenborough Laboratories, De Montfort University,
Leicester.

4. TITLE: Fish population studies (3.1.2.8)

RESPONSIBILITY: Alain Crivelli, Tour du Valat Biological
Station, Camargue, France.

5. TITLE: Past History & Land Use (3.3.3)

RESPONSIBILITY: Dr Climent Picorell, Department of Geography,
UIB; or Ecology and Conservation Unit, University
College London.

6. TITLE: Soils/sediments (3.3.4)

RESPONSIBILITY: Geography/Earth Science Departments of the
University of Aberdeen, University of Amsterdam or
University of Liverpool.

7. TITLE: Tourism related studies (3.3.5)

RESPONSIBILITY: Dr de Groot, Agricultural University of
Wageningen; or Ecology and Conservation Unit, UCL.

ADVISOR: Dr Franklyn Perring.

8. TITLE: Development of ecological data bases (3.4.2)

RESPONSIBILITY: Sara Hawkswell, RSNC; postgraduate in Computer
Science.

9. TITLE: Gridding the Park (3.4.3)

RESPONSIBILITY: ?Park Directorate; specialist surveyor.

10. TITLE: Meteorological recording (3.5.2.5)

RESPONSIBILITY: Dr Climent Ramis, Department of Meteorology,
UIB; Dr Rudolf de Groot, Climate Change Research
Centre, Agricultural University of Wageningen.

11. TITLE: Extension of herbarium material to include lichens &
mosses (3.6.5)

RESPONSIBILITY: Dr P.D. Crittenden, School of Life Science,
University of Nottingham.

12. TITLE: Invertebrates (3.6.11)

RESPONSIBILITY: members of Balearic Invertebrate Group,
CSIC-UIB, Palma.

APPENDIX 5 - 1993 programme details

Project Title

Monitoring for environmental change at S'Albufera, Mallorca.

Research Site

Parc Natural de S'Albufera , Mallorca, Spain.

Principal Investigators

Nick Riddiford (Teams I-IV)

Dr Terry Wells (Team II)

Team Dates in Field

TEAM I March 28-April 11, 1993

TEAM II April 14-April 28, 1993

TEAM III May 1-May 15, 1993

TEAM IV October 23-November 6, 1993

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

Fields of Research

Botanical

1. Orchid population studies (Terry Wells)
2. Dune transects (Franklyn Perring)
3. Herbarium (Jo Newbould; Perring; Dinah McLennan)
4. Plant Illustrations/Preparation of display material (Dinah

McLennan)

5. Distribution of *Euphorbia terracina* in areas of grazing (Dinah McLennan)

6. Fungi (Sheila Wells)

Vertebrates

1. Bird population studies (Nick Riddiford; Jon King; Mike Wood)
 - transects, point counts, Moustached Warbler distribution, constant effort site ringing, body condition of migrants
2. Bird foraging studies (Mike Wood)
3. Mammal population studies (University of Durham)

Remote Sensing

1. Ground-truthing census work (Bernie Young as preparation for further work by students of Centre for Remote Sensing and Mapping Science, Department of Geography, University of Aberdeen, Scotland)

Hydrology

1. Preliminary studies of water quality (Alexandra Torn in partnership with UIB's Departments of Vegetal Physiology and Limnology)

Invertebrates

1. Entomology
 - a) insect reference collection (Riddiford; Goater)
 - b) studies of Diptera, Syrphidae (Riddiford)
 - c) butterfly and dragonfly transects (Riddiford)
 - d) odonata population studies (Ed Cross)
 - e) monitoring methods for night lepidoptera

Ecology of Phragmites

1. The ecological relationships of Phragmites , moth larvae and birds (Alan Radermacher)

Computerisation of Data

1. Program development for standardised data processing and storage (Sarah Hawkswell)

Project S'Albufera scientists, 1993

Team I 28 March-April 11

PI - Nick Riddiford

Jon King - ornithology

Alan Radermacher - ecology of Phragmites

Sarah Hawkswell - data programming

Team II 14-28 April

PI - Terry Wells

PI - Nick Riddiford

Sheila Wells - fungi

Jon King - ornithology

Alexandra Torn - water quality studies

Team III 1-15 May

PI - Nick Riddiford

Jon King - ornithology

Dinah McLennan - botany

Ed Cross - odonata studies

Bernie Young - remote sensing

Team IV 23 October-6 November

PI - Nick Riddiford

Barry Goater - lepidoptera

Franklyn Perring - dune transects

APPENDIX 6 - List of publications

Results from the first four seasons' work have contributed to the following publications. An asterisk draws attention to those which have appeared since the last Project S'Albufera report.

- *FOX, R. J. P. 1992. Monitoring Environmental Change at S'Albufera Parc Natural: the role of aquatic invertebrates. University College London M.Sc. in Conservation dissertation.
- 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. SEGONA, Palma de Mallorca.
- 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.
- HOWE, C. 1989. Albufera: Aspects of Hydrology, Vegetation, History and Management. University College London M.Sc. in Conservation dissertation.
- *JURADO ESTEVEZ, J. 1992. The usefulness of Landsat TM data for vegetation discrimination in S'Albufera de Mallorca - a marsh. MSc dissertation, Centre for Remote Sensing and Mapping Science, University of Aberdeen.
- *MARCUS, A. 1992. Estimation of soil's surface physical properties using Landsat TM Data in "Es Pla de Sa Pobla-Muro" (Mallorca). MSc dissertation, Centre for Remote Sensing and

Mapping Science, University of Aberdeen.

MA YOL, J. 1991. Plan d'us i gestio del Parc Natural de S'Albufera de Mallorca. Documents tecnicos de Conservacio 3. SECONA, Palma de Mallorca.

MA YOL, J. 1991. Parc Natural de S'Albufera de Mallorca: Ornithological overview, August 1989-July 1990 . Associacio Balear d'Amics dels Parcs, Ca'n Picafort.

*M AYOL, J. 1992. Plan for the use and management of the Natural Park of S'Albufera, Mallorca, 1990-94. Documents tecnicos de Conservacio 3. SECONA, Palma de Mallorca [English version].

NE WBOULD, P. 1989. The Albufera as a Global Monitoring Station . Earthwatch Europe cyclostyled report.

NE WBOULD, P. 1990. The Albufera, Mallorca, as a Global Observatory. Jornades del Medi Ambient de les Balears 2: 173-174.

NE WBOULD, P. 1991. Phragmites and Cladium on Albufera . Manuscript.

NE WBOULD, P. J., RIDDIFORD, N. J. and GRACE, E. 1989. Consumption of Phragmites australis at S'Albufera, Mallorca. In The Albufera as a Global Monitoring Station (Newbould 1989).

NE WBOULD, P. J. and RIDDIFORD, N. J. 1990. Monitoring for Global Change: The Earthwatch Europe S'Albufera Project . Earthwatch Europe, Oxford.

*N OBLET, J. F. 1992. Les chauves-souris du Parc Natural d'Albufera, Majorque, Iles des Balears - Espagne . Report to Earthwatch Europe.

PE RELLO, G. 1991. Seguiment de l'avifauna del Parc, agost

1990-juliol 1991 . Associacio Balear d'Amics dels Parcs, Can Picafort.

- *P ERELLO COLL, G. 1992. Geografia y educacion ambiental: el parque natural de S'Albufera de Mallorca. Boletin de la Asociacion de Geografos Espanoles 14: 111-120.
- *P ERELLO, G., MAYOL, J. & VICENS, P. 1992. Seguiment de l'avifauna del Parc, agost 1991-juliol 1992 . Associacio Balear d'Amics dels Parcs, Can Picafort.
- RI DDIFORD, N. 1991a. Project S'Albufera: A new model for environmental research . Earthwatch Europe, Oxford.
- RI DDIFORD, N. 1991b. A small influx of the Long-tailed Blue Lampides boeticus at S'Albufera Natural Park, Mallorca. Bull. Amat. Ent. Soc . 50: 164.
- *R IDDIFORD, N. 1992a. Project S'Albufera: Planning for 1993-94 and beyond: a discussion paper . Earthwatch Europe cyclostyled report, Oxford.
- *R IDDIFORD, N. 1992b. Dragonflies attracted to light. Bull. Amat. Ent. Soc . 51: 139-140.
- *R IDDIFORD, N. & AMENGUAL RAMIS, J. F. 1992. El Projecte S'Albufera a carrec d'Earthwatch Europe: un nou model de recerca medioambiental . Earthwatch Europe, Oxford.
- RI DDIFORD, N. & NEWBOULD, P. 1991. Monitoring for Environmental Change : The Earthwatch Europe S'Albufera Project - a summary report of the second season's work 1990 . Earthwatch Europe, Oxford.
- *R IDDIFORD, N. & PERRING, F. 1992. Monitoring for Environmental Change : The Earthwatch Europe S'Albufera Project - a summary report of the third season's work at S'Albufera Natural Park,

Mallorca . Earthwatch Europe, Oxford.

*V ARLEY, M. E. (ed.). 1992. Project S'Albufera: Report of Field Scientists' Review Meeting, 28-30 April 1992 . Earthwatch Europe cyclostyled report, Oxford.

WOOD, B. (ed.). 1989. A monitoring programme for S'Albufera, Mallorca. Discussion Papers in Conservation No. 52. Ecology & Conservation Unit, University College London.

WOOD, B. (ed.). 1991. Further studies towards a monitoring programme for S'Albufera de Mallorca. Discussion Papers in Conservation No. 55. Ecology & Conservation Unit, University College London.

□

APPENDIX 4 - Planning for 1993-94 and beyond

Appendix 4 presents a revised version of the research elements contained in the Project's planning document Project S'Albufera, Planning for 1993-94 and beyond: a discussion paper (Riddiford 1992), which was formulated from the recommendations of the Field Scientists' Review Meeting in April 1992.

Part 1. Introduction

Following the publication in autumn 1991 of Project S'Albufera - A new model for environmental research , a review group of international scientists was invited to S'Albufera in April 1992

to assess progress during the first three years of the Project and to advise on its shape and directions in the future.

This discussion paper while remaining faithful to the overall aims of the Project, clearly defined at the start and continuing to play a central role in the work of the Project, draws heavily from the thoughts and recommendations of the review group, published in Project S'Albufera - Report of field scientists' review meeting, 28-30 April 1992 .

One of the major conclusions emerging from the review group meeting was that priorities need to be recognised and these should draw on the Project's demonstrated strong points. Even within this scenario, the operating costs are enormous and can only be achieved with a large funding commitment outside the normal channels of Earthwatch monetary support. So to match what is needed with what is possible, I have structured the proposed plan of work for 1993-94 (and in some cases beyond) in four tiers, comprising ongoing studies which may be achieved under Earthwatch Europe tutelage and normal financial support (First Tier), studies which need to be tackled or are ongoing but depend on extra funding (Second Tier), parallel studies by Universities and other bodies in partnership or co-operation with Earthwatch Europe and Project S'Albufera (Third Tier) and those studies which are needed but for which no scientists or means are currently available (Fourth Tier).

The studies proposed within each of these tiers are summarised within Priority categories in Part 3 and listed according to tier in Part 4.

Part 2. Priorities

I see priorities for 1993-94 (and beyond) falling into six categories. They are:

1. Multi-disciplinary study of processes going on, 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. Furtherance of data-processing and the data-base potential and methodology, including development of compatible systems for comparative work and integration into international networks and schemes.
5. Long-term monitoring aimed at assessing environmental change.
6. Extension of baseline information.

Part 3. Studies

There follows a summary of studies which I and others involved in the Project have identified as meeting the above priorities. They are far from comprehensive and are likely to be added to as further fieldwork and consultations with scientists throw up other questions which need to be answered, information which needs to be gathered, etc.; and of course there is the opportunity, too, for scientific input into this current plan, which is also intended to have a consultative role. Most of the studies have been selected because they are already in place or attracting the interest and/or commitment of Universities and other bodies. Other studies suggested have no such linkage at the moment and may serve as notice for inclusion in the future development of the plan beyond 1994.

I have ordered studies under headings which relate to the priorities outlined above. Some studies are of direct relevance to two or more priority categories and it should be borne in mind that there will be some overlap of categories for nearly all studies (e.g. dune systems studies may have application also in providing information on the impact of management strategies, in supplying data for the interpretation services of the Park and in long-term monitoring for change).

3.1 Studies appropriate to multi-disciplinary study of processes

3.1.1 . The Phragmites - Cladium dominated wetland ecosystem

Much of S'Albufera is wetland dominated by the marshland plants

Phragmites australis and Cladium mariscus . The pioneering work by

Professor Newbould on aspects of biomass and productivity for these two species has been recognised as one of the Project's strong points. The interest of several scientists and institutions now gives us the opportunity to extend this work to other areas which will allow a multi-disciplinary study of processes.

3.1.1.1 Autecology of Phragmites and Cladium

Palmer Newbould's work should be developed from his ongoing studies of productivity of Phragmites and Cladium shoots to include the rhizomes and root mass and, to add to the dry weight data, values for the processes of decomposition and nutrient cycling. His work should also be extended to other aspects of the ecology of these plants, including a greater knowledge of their annual cycle. Professor Newbould's continued involvement in these studies will require back-up assistance including better on-site equipment and facilities and expertise from scientists at the University of the Balearic Islands (UIB) in Palma. There is a particular need for Mallorcan home-based involvement for such aspects as recording the annual cycle.

3.1.1.2 Photosynthesis and productivity of marshland plants

Some of the facilities mentioned in 3.1.1.1 above have been offered by Dr Hipolito Medrano of the UIB. Dr Medrano has an international reputation in photosynthesis research. He specialised until recently in photosynthesis in crops but is now keen to extend that study to plants in more natural situations.

He is head of Fisiologia Vegetal (Vegetal Physiology) of UIB's Department of Biology. He has worked in the past with Dr Roger Austen, another photosynthesis expert recently retired from Cambridge University, and they wish to plan a joint study of the Phragmites - Cladium ecosystem concentrating on photosynthesis, plant production and growth - research which they see as complementing and furthering the studies undertaken by Prof. Newbould. As an indication of his interest in the subject, Dr Medrano has already undertaken preliminary studies at S'Albufera with students from his Department, while Dr Austen assessed the potential of the site in May 1992.

3.1.1.3 Heavy metals in marsh plants

A study is currently being done by members of the UIB's Sub-department of Vegetal Physiology, led by Maria Pou Bordoy, Catalina Cabot and John Sibole, into the heavy metal content of the aquatic macrophyte Lemna . This study has been undertaken at the instigation of Joan Mayol, Director of the Park, for conservation reasons: ducks are an important part of the Park's avifauna and Lemna is a food source for ducks. The infrastructure and interest is therefore in place to extend this research to other marshland plants.

3.1.1.4 Decomposition of reedbed plants

Dr Enrique Descals of the Consejo Superior de Investigaciones Cientificas (CSIC), based at Palma, has been conducting studies for a number of years on the role of microfungi in the decomposition of dead plant matter in the canals of S'Albufera.

Dr Descals, along with Dr Antoni Martinez of the UIB's Department of Biology, Limnology section, have been keen supporters of the Project and its objectives from the start and have given much advice and practical help in that time. These two scientists have the means within their fields of expertise, and those of other members of their and adjacent UIB departments, to extend current studies to encompass this important aspect of the marshland ecosystem. This would complement the work of Prof. Newbould and others.

3.1.1.5 Study of relationships between *Archanara geminipuncta* biology, Reed Bunting feeding and breeding biology and their impact on *Phragmites* reed

Phragmites is attacked by the caterpillars of a wainscot moth *Archanara geminipuncta*. These bore into the stems and consume the inner tissues. Apical growth then ceases but is replaced by several more slender lateral shoots. Infestation levels up to 80% have been recorded but none in the year following burning of the reedbed. It may take several years for the moth to colonise reed beds after burning. The caterpillar has an impact not only on growth of the plant but on two bird species. The Moustached Warbler *Acrocephalus melanopogon* (for which S'Albufera is one of the World's most important sites) requires reedbeds of two levels, the lower comprising a layer of broken, dead material.

Archanara geminipuncta may play an important part in breaking down the reeds to create a suitable habitat for these birds. In addition, Reed Buntings *Emberiza schoeniclus* have been observed extracting and eating the caterpillars. The local population, in

parallel with others of the species occupying SW Mediterranean reedbed sites, have developed a much thicker bill than their central and north European counterparts. This thick-billed Reed Bunting is one of few bird species able to extract the caterpillars, using the bill to strip away the outer casing of Phragmites stems. The thickness of the bill in this population may be associated with this feeding behaviour (though this may not be the only reason). We have interested Anna Traveset of the Institut d'Estudis Avancats de les Illes Balears (CSIC-UIB) in this subject and she has begun her own investigations, though currently in her spare time away from other commitments. She is based in Palma and is a specialist in insect-plant interactions, currently conducting work on nearby Cabrera.

3.1.1.6 Bird population dynamics

A study of the population dynamics of reedbed species has been established using constant effort ringing at two older (i.e. not recently burnt) reedbed sites in Es Colombar and near Ses Puntes. This study has been extended beyond the periods of Earthwatch field presence by Jon King, ornithological researcher from the Edward Grey Institute, University of Oxford, who is currently based there. This has allowed collection of data on fledging dates and breeding productivity as well as variations in the structure of the adult community.

3.1.1.7 Ornithological studies: Moustached Warblers

I have been in discussion with Dr Chris Perrins, Director of

Oxford University's Edward Grey Institute for Field Ornithology (EGI), regarding the placement of a postgraduate student to study S'Albufera's Moustached Warblers *Acrocephalus melanopogon*. Dr Perrins indicated that it would require an NERC grant and "the right student" and that, though in principal he is in favour, current financial constraints meant the study was not likely to be implemented at the moment. The proposal, written by myself and Jon King is as follows:

"In general the European Acrocephaline warblers have received considerable research interest, principally regarding their mating systems and resource partitioning in reedbed communities. The Moustached Warbler however, confined to extensive reedbeds of the Mediterranean Basin and Middle East, has remained virtually unstudied. Although it is now amongst the rarest birds in Western Europe, many basic facts about its biology are unknown.

The recently-created Parc Natural de S'Albufera, Mallorca holds a population of Moustached Warblers probably in excess of one thousand pairs and consequently may represent the most important site for the species within its known world range. A limited database already exists for the species in the Parc, derived from short studies by the British Trust for Ornithology, University College London and Earthwatch Europe in the last 8 years. These suggest an unusually high longevity for a small passerine, with consequent low population turnover, and a high proportion of 'floating' young males; implications for the mating system of the species are as yet unknown. In one main area of the Parc, a large proportion of the Moustached Warblers are already

colour-ringed as a result of this previous work. The presence of two other species of Acrocephaline warbler at S'Albufera would allow original studies on a guild of reedbed warblers to be compared with the extensive literature on this subject.

A further, valuable component of this study would be the opportunity to use Moustached Warbler populations to monitor reedbed management techniques. Active grazing by cattle is increasingly used at S'Albufera, and at similar reserves in the Mediterranean, to open up feeding areas for large non-passerines (herons, wildfowl etc.). However, the impact of this on smaller, reed-dependent species is very unclear. Given the Parc's international responsibility to the Moustached Warbler, and that species' total dependence on the affected habitat, clarification of the ecological relationships involved is urgent.

The facilities at S'Albufera are ideal for housing research scientists, and the Parc's management actively encourage and assist their work. A postgraduate student would gain much from the growing band of ecologists working at S'Albufera, forming an integrated study of reed productivity (Prof. P. Newbould, Ulster), the Fan-tailed Warbler (J.R. King, EGI) and long-term monitoring of many aspects of the Parc's natural history (Earthwatch Europe, Parc staff)."

I have also been discussing this study with the only scientist involved in Moustached Warbler research, Dr Bernd Leisler of the Max-Planck-Institut für Verhaltensphysiologie, Germany. He has indicated a willingness to help with advice and with parallel research in his own Austrian study area.

3.1.1.8 Bird predator studies

At varying times of the year Marsh Harriers *Circus aeruginosus* , Ospreys *Pandion haliaetus* , falcons (including the rare Eleonora's Falcon *Falco eleonora*), egrets and herons are common and highly visible components of the Park's avifauna. Because of their size and visibility, and because they are at the top of a food chain, they may prove to be indicator species for the health of the environment. There is a limited variety of fish (though an abundance of those which occur) and mammals (e.g. no voles) so the predators will be obligate feeders on a more restricted diet of readily abundant prey such as eels and frogs. We have done some preliminary work on the diurnal activity patterns and preferred feeding areas of Purple Herons *Ardea purpurea* , using Earthwatch volunteers, but much remains to be done in assessing the impact of bird predators. Earthwatch volunteers would be very useful assistants in observing predator behaviour (and it would be a popular task for them), but such studies could only be developed fully by detailed research. I identify this as a potential postgraduate research topic, possibly in conjunction with the Tour du Valat Biological Station (and their heron expert, Heinz Hafner).

3.1.2 The hydrological system

3.1.2.1 Hydrogeological study

This is a key area of study for which we still have inadequate data. Our knowledge of the hydrology of the Park was enhanced by the efforts of the University College London's Ecology and

Conservation Unit in 1989-90, but their research demonstrated that much more information was needed which could only be achieved by an in-depth study embracing the whole water catchment area, using data collected over a longer period of time and calling on the expertise of specialists and expensive specialised equipment. This was clearly beyond the direct resources of Project S'Albufera . However, it was within the capabilities of the Mallorcan hydrological service, who we identify as the obvious body to obtain these data which are vital not only to the Project but to the Park authorities and, indirectly, to other local interests such as the agriculturalists and hoteliers. We understand from Joan Mayol that an in-depth hydrogeological study is now planned, supported and funded by the Balearic Islands Government.

3.1.2.2 Water quality and pollutants

This is an area for which we have very little data, other than for salinity. However, observations indicate that the water chemistry is a key factor affecting the flora, fauna and ecosystems throughout the Park. Clearly aspects such as geohydrology, water chemistry, plant productivity and decomposition and habitats for birds and other animals are related to each other functionally. Apart from salinity, the ecosystem may be subject to a whole range of water and air borne pollutants. We know nothing of the effects on S'Albufera of emissions from the local power station; run-off from adjacent farmland may be bringing a range of agrochemicals from pesticides to nutrient-rich nitrates and nitrites; and speculation has been

made about sewage infiltration into the Park. From 1993 we intend to study water quality, aimed at detecting these chemicals, initially by collecting water samples from selected locations. Drs Martinez and Medrano have indicated that facilities are available to analyse water samples within their departments at UIB. Eventually, the study should be developed, perhaps at postgraduate level, by the UIB where it would tie in with current and recent work by Martinez on the aquatic macrophytes and Medrano on reedbed plant photosynthesis and productivity.

This study is also of direct relevance to a number of other aspects of Project and Park work. For instance it may demonstrate the importance of reedbed plants such as Phragmites in absorbing, and thus acting as a natural cleansing agent for pollutants, reveal the impact of pollutants on biodiversity or the survival of threatened biota and, consequently, influence future management practices.

3.1.2.3 Nutrient exchange

In May 1992 Drs Moya, Ramon and Martinez of the UIB's Department of Biology, and two scientists from the University of Barcelona were awarded a three-year research grant (amounting to ca 5.5 million pesetas) to work on vertical nutrient exchange between water and sediment, and horizontal exchange between S'Albufera and the Bay of Alcludia. Though this constitutes independent research not initiated or suggested by Project S'Albufera, both topics are of interest and direct relevance to our work.

3.1.2.4 Freshwater macrophytes and water quality

Some of the most detailed scientific work done at S'Albufera, involving the distribution of aquatic macrophytes in relation to the physico-chemical dynamics of the water systems, was undertaken by Dr Antoni Martinez for his doctoral thesis in the 1980s. He has maintained a great interest in this subject and in 1990-91 attempted, unsuccessfully, to obtain funding for a study to extend this research. This was to be a joint undertaking with Dr Sven Jonasson, Director of the University of Copenhagen's Institute of Plant Ecology. Both retain a commitment to develop this topic if funding becomes available.

3.1.2.5 Freshwater invertebrates and water quality

Richard Fox, a postgraduate student from University College London (supervised by Dr Roderick Fisher of UCL's Ecology and Conservation Unit) made a study this summer (1992) of freshwater invertebrate species as indicators of water quality. His intended methodology for the study included implementing the RIVPACS computer program, developed for UK freshwater systems but already tested in amended form in mainland Spain. Eventually he was not able to use this program. However, adaptation of such a system for S'Albufera would be very welcome and of direct relevance to our long-term monitoring objectives and Park management planning as well as providing additional information for studies such as those outlined in 3.1.2.2, 3.1.2.4 and 3.1.2.6.

3.1.2.6 Mollusc studies

Dr Chris Paul of the University of Liverpool's Department of Earth Sciences participated in the Project in October 1991 and May 1992. His task was to set up a baseline for molluscs, to investigate their role as key indicator species and to recommend further research relevant to the Project's objectives. One of the major findings from Dr Paul's survey was that, though shells were present in abundance, live snails were in much lower numbers than anticipated or normal in similar habitats elsewhere. This was particularly the case for aquatic snails. As a result he recommends monitoring of water quality, including salinity, in relation to the abundance of living aquatic molluscs. Apart from its relevance to our interest in water quality and its effects on the fauna and flora of the Park, this study also has an innovative aspect. Dr Paul knows of only one general study of the salinity tolerances of fresh and brackish water molluscs and that was done nearly 40 years ago. Dr Paul writes: "Jaeckel's (1955) classic study of the molluscs of the Schlei, which drains into the Baltic where maximum salinities are only 16‰, is the only general study of which I know. His fauna did not include six of the 15 aquatic species recorded from S'Albufera, including the four commonest species seen alive. Documenting salinity tolerances of the aquatic molluscs in S'Albufera would not only add to knowledge concerning molluscs, but reveal both changes in the hydrology of the marsh and their effects on aquatic molluscs. Such a study might also help explain some distributions, e.g. why live specimens of both *Hydrobia* and *Amnicola* are almost confined to the northern part of the Park".

Dr Paul felt that he, in conjunction with his department at Liverpool, could be involved in future researches into molluscs at S'Albufera but probably in partnership with Dr Cristian Altaba. Dr Altaba is an acknowledged expert on Balearic molluscs and is based in Palma with the CSIC. Dr Altaba has expressed an interest in becoming involved in mollusc studies at S'Albufera but stresses that, though the CSIC has offices at UIB, the CSIC comprises government scientists independent of the University and thus not working with students. Access to student participation can be achieved by Dr Paul retaining an involvement; the advantage of Dr Altaba's participation is not just his expertise but the year-round coverage he would be able to offer and which is necessary to further elucidate this and other mollusc problems. Dr Paul makes other very relevant recommendations for future mollusc research which appear under other headings in this document (see 3.1.3.5, 3.5.1.1 and 3.6.7).

3.1.2.7 Frog studies

Frogs *Rana ridibunda* are a visible and very audible component of the wetland fauna at S'Albufera and undoubtedly play an important role both as predators of invertebrates and small fish, and as prey to larger fauna (including birds and mammals). Attempts have been made to come to terms with the frog population, particularly in assessing numbers and distribution, but the results have been poor and are thought to severely underestimate the total population. Even basic facts such as the timing of the annual cycle are poorly known. A much better knowledge of frog populations is urgently needed and best achieved through a

postgraduate study. I have not yet approached anyone, but the base for herpetological studies in Britain is at the Sir David Attenborough Laboratories, School of Life Sciences, De Montfort University, Leicester. I was until recently a postgraduate member of these laboratories and am in a position to make further enquiries about the feasibility of such a study. The Mallorca frog is also of interest because it is *R. r. perezii*, a distinctive race (sometimes given full species rank) which is thought to have originated in North Africa.

3.1.2.8 Fish population studies

Professor Newbould identified knowledge of the fish population as high priority from the start and a study using electro-fishing techniques, led by a Spanish scientist, was part of the programme in the first year. Unfortunately, he withdrew at the last moment and we have not been able to obtain the services of a fish scientist since. It still remains an area we should consider as we strive towards a fuller understanding of the aquatic systems, and it has been suggested that we seek the expertise of the Tour du Valat Biological Station in this area.

3.1.3 The dune systems

3.1.3.1 Orchid population dynamics

Terry Wells has been studying the Park's orchid populations since 1991, using methodology and techniques designed by himself as part of his research into British orchid population dynamics for the Institute of Terrestrial Ecology (ITE). The study, which

looks into recruitment and mortality of orchids within fixed quadrats, is currently mainly focussed on the fossil dune area, though he is also monitoring the *Orchis (laxiflora) palustris* populations of the reedbeds. This is a long-term monitoring study of a key group of species.

3.1.3.2 Studies of dune plant hierarchies

The coastal dunes show a succession to climax pine forest. This succession has frequently been arrested by fires. The most recent evidence is in the southern part of the coastal dunes where the vegetation is recovering from fires approximately eight years and fifteen years ago respectively. There are also differences in vegetation composition in relation to aspect, drainage and proximity to the sea. Three permanent transects have been set up and recorded by Dr Franklyn Perring. Dr Perring has indicated a willingness to return and initiate the continuation of this work in collaboration with other scientists committed to re-recording the vegetation along these transects at regular time intervals.

3.1.3.3 Sand-dune evolution past and present

Dr van der Meulen, member of the scientists' review group present in April 1992, is vice-president of the European Union for Coastal Conservation (EUCC) and a member of the conservation organisation ECODUNE so was, not unnaturally, very interested in the evolution of the sand-dunes, particularly the coastal set.

He suggested that the Project should study past, present and future changes in the foreshore (accretion and erosion) using photographic material and techniques. The study should also take into account sea level changes and the role of the sea-grass *Posidonia* in promoting accretion. This study would be of particular relevance to 3.1.3.2 above and, because the rare juniper *Juniperus oxycedrus macrocarpus* is virtually restricted to the coastal zone immediately abutting the beach where it is at risk from erosion, is also of importance for future management planning. It would also, hopefully, give impetus to our request to the Balearic government, through the good offices of Joan Mayol, to install an automatic sea level recorder at S'Albufera.

Dr van der Meulen indicated that he and his department of Physical Geography and Soil Science at the University of Amsterdam would be interested in becoming more closely involved in the Project and this is one area where we may wish to avail ourselves of his expertise. His participation may also be seen as a step towards integrating our monitoring work into international networks, in this case the EUCC and ECODUNE.

3.1.3.4 Grazing influence of mammals on fossil dune vegetation

Horses and cattle are grazed on the fossil dunes and the flora may be changing because these avoid *Euphorbia terracina*, which seems to be increasing. To monitor this Jo Newbould set up, in April 1992, a grid designed to determine the current and future distribution of the *Euphorbia*. In addition she has taken

photographs of the area from fixed points, as a further means of assessing distribution and change. We do not know whether the impact of *Euphorbia terracina* is of a permanent or merely temporal nature. However, photography has given us the opportunity to follow the plant's annual cycle, thanks to the participation of Mallorcan volunteer, Tomeu Tomas, who has volunteered to repeat the photography on a monthly basis. This study also has relevance to section 3.2 below.

3.1.3.5 Mollusc studies

Dr Paul (University of Liverpool's Department of Earth Sciences) recognised several questions which need to be answered regarding mollusc distribution in the sand dunes. He writes: "there is a general question as to what characteristics of the dune habitats are essential for the various [mollusc] species of the dune fauna. If it is just drainage, species should be equally at home on the fossil dunes of Ses Puntas and the area NW of Ca'n Picafort as they are on the modern dunes. If proximity to the sea is important, some may survive on the modern dunes but not the fossil ones inland. Another point concerns the vegetation. Are the well wooded parts of the dunes significant? If so, some species may be absent on the bare ridge of Ses Puntas, but present in the wooded parts of both the Fossil and Recent dunes".

He recommends that, in conjunction with the dune vegetation transect studies already underway, comparisons should be made between populations of "dune snails" on recent and fossil dunes

to assess how stabilization of dunes by vegetation, and the transition from grassland through scrubland to woodland, affects such species. Assessment of the influence of the sea by comparing similar microhabitats between recent and fossil dunes could be undertaken at the same time.

3.1.3.6 Insect studies

A north-south transect has been set up through the centre of the coastal (Es Comu) dunes to record butterflies and dragonflies. The transect has been divided into six sections, each reflecting a different habitat type and/or age after burning. The information gathered will demonstrate use of these habitats by butterflies, and possibly dragonflies, and the effects of vegetation change on their abundance and species' composition.

3.1.3.7 Bird population studies

Part of a longer transect, sampling major Park habitats, has been set up through the centre of the coastal (Es Comu) dunes to record birds. The information gathered will demonstrate use of this habitats by birds and the effects of vegetation change on their abundance and species' composition.

3.1.4 The whole catchment of the Park and adjoining coastal waters

3.1.4.1 Remote Sensing

Work was begun in 1992 to incorporate remote sensing as part of

our research. In the spring, Earthwatch volunteers did some "ground-truth" fieldwork in preparation for two studies undertaken in the summer by postgraduate students from the University of Aberdeen's Centre for Remote Sensing and Mapping Science. They undertook field work at S'Albufera based on two Landsat images shared by the Centre and Earthwatch Europe. One student looked at the current and recent distribution of Cladium and Phragmites and the other current and recent soils and land-use on agricultural land abutting the Park. Both studies were successful. Dr Loder of the Centre has indicated that there are many further studies which could be done by his department, in these and allied areas of research. I am very keen to maintain this link. The Centre for Remote Sensing and Mapping Science has an international reputation for remote sensing work, they are keen to participate and, most important of all, they already have a link with Spanish Universities including the UIB's Department of Geography. One of the 1992 studies was undertaken by a Mallorcan and the other by a Peninsular Spaniard. One of our Mallorcan volunteers, who was instrumental this spring in advising us on "ground truthing" and digitising data in GIS (Geographic Information System) form, has just joined the department at Aberdeen.

One of the essential elements of the remote sensing studies is comparative information in order to monitor long term change on an objective basis. Studies which lend themselves to remote sensing methodology and which The Aberdeen Centre is keen to study include: the input of sediment plus suspended solids to the wetland and release via outflows to the Bay under normal and

flood conditions; movement of sediment within the offshore, beach and dune systems; and changes in abundance and distribution of the important *Posidonia* (sea-grass) beds offshore in the Bay of Alcudia.

3.2 The impact of management and related studies

The Project needs to gather data on management events because these may impinge on the ecological and other processes being studied. In addition, some of the research undertaken by Project S'Albufera will have a direct bearing on planning of management and may serve to guide that management in the future.

3.2.1 Current management practices

Sara Hawkswell from the Royal Society for Nature Conservation has initiated work to adapt the British Countryside Management System (CMS) to the S'Albufera situation. This will be of help to the Park staff and to Project S'Albufera because the system records management of the Park, both past and present. She is aiming to incorporate all types of work being done in the Park including practical management, monitoring, educational visits and research projects. This would ensure access by all interested bodies to relevant data and should begin to bring the different aspects together. Teething problems in setting up this system include time available by Sara and the Park staff to work on it.

3.2.2 Impact of Park habitats on the bird fauna

During fieldwork periods daily counts have been maintained of the maximum number of each bird species during a ten minute period from hides overlooking defined areas of grazed and ungrazed

marsh. This study has been designed to compare the use by migrant and resident birds of open areas of marsh managed by grazing with those managed by other means or unmanaged.

3.2.3 Bat s tudies

Jean-Francois Noblet, a bat expert with specialist knowledge of the Mediterranean island bat fauna of Corsica, joined the Project in May 1992 to compile an inventory of bats present in the Park, to assess their importance as components of Park fauna and to propose future management planning of benefit to bats.

Jean-Francois recorded ten species, including several which are scarce or of restricted European range. His most notable discovery was that S'Albufera supported a population of

Barbastellus barbastellus , an extremely rare species in Spain and not previously recorded from the Balearic Islands. He concluded from his studies that S'Albufera was a very favourable site for bats, abundant water and invertebrate food associated with the wetland situation being of particular benefit to this group. He found, however, that there was a shortage of roost and breeding sites, compounded by the lack of suitable old buildings within the Park and disturbance at roost caves in the foothills adjacent to the Park. He made a whole series of practical proposals designed to overcome this problem, including better protection of cave sites through well maintained entrance grills and the introduction of purpose built roost/nest boxes under Park bridges, on Park buildings etc.

Jean-Francois considered that there was considerable scope for

more extensive work on S'Albufera bats. He pointed out that bats are under pressure from environmental change, loss of breeding and roost sites and the effects of pollution on their insect prey etc. throughout their European range and it was one of the roles of the Parc Natural to afford them protection. He recommended therefore that further studies be conducted. He has offered to extend his work in establishing the composition and role of the bat fauna by visiting during the period of reproduction (June to September) when he would continue to sample the population by mist-netting at night in a wide range of Park habitats. He also recommended that the study would benefit from the employment of a bat ultra-sound detector accompanied by a specialist in its use. He indicated that he could find such a person. In addition, he felt that careful dissection of owl pellets could also throw light on the bat population of S'Albufera but lamented that the removal of the old mill buildings had deprived the bats' major predator, Barn Owl *Tyto alba*, of a breeding site within the Park. He therefore made a practical proposal (including drawings) for the Park authorities to create an artificial nest site in the old farm building at Ses Puntetes.

3.2.4 Grazing influence of mammals on fossil dune vegetation

This study, described under 3.1.3.4 above, is also relevant to the study of the impact of management.

3.3 Environmental and socio-economic studies

There is some overlap between this category and category 3.1.4 (studies of the whole catchment and immediate marine environment

offshore), particularly regarding remote sensing and associated aerial photographic survey work.

3.3.1 Environmental functions and values

At the scientists' review meeting Dr Rudolf de Groot presented a novel way of studying the "value" of natural sites which has immediate appeal both from an environmental and socio-economic viewpoint. His method comprises an analytical approach for assessing the sustainable use of the wetlands by identifying the key environmental functions which it performs and assigning values to these functions. His functions, which he has applied in a number of natural areas in widely scattered parts of the world, are grouped into regulation, carrier, production, and information. Each of these is sub-divided and all the functions can be assessed and evaluated in relation to ecological, social and economic criteria. The management implications can then be deduced.

S'Albufera lends itself to this new analytical approach and such an assessment would be of benefit to the Project and to the Park authorities. We should explore the possibility of developing this line of study by asking Dr de Groot, through his and other Departments at the Agricultural University of Wageningen, to become more actively involved with the Project - perhaps through a series of studentships designed to collect and analyse the data required.

3.3.2 Land- use and vegetation

Both Dr de Groot and Dr van der Meulen stressed the importance of

taking into account the entire catchment area, coastline and immediate offshore in any study of the processes at work in the Parc. Dr van der Meulen concluded: "it is clear that events outside the Parc may exert considerable influences within it - and vice versa - so that any attempt at analysis must include the whole catchment and the coastline. For example, the Parc is probably important in regulating the flow of water from the hinterland to the sea; it serves as a recharge area and there may be recycling of nutrients and thus a positive influence on the quality of water leaving the area. In turn, the Parc is affected by the amount and quality of water entering it and activities in the watershed such as horticulture and water abstraction."

Dr van der Meulen indicated that he and his Department of Physical Geography and Soil Science at the University of Amsterdam would be interested in becoming more closely involved in the Project. A number of the studies proposed in this document are aimed to elucidate aspects of the impact of events described above (e.g. the remote sensing work begun and planned by the University of Aberdeen's Centre for Remote Sensing and Mapping Science). However, Dr van der Meulen has particular knowledge and experience in areas of direct relevance to the Project (e.g. coastal studies) and we should not miss the opportunity to avail ourselves of his expertise. Currently, Dr van der Meulen has proposed that a team of students from his University undertake a mapping study of the vegetation and land-use in and around S'Albufera.

3.3.3 Past History & Land Use

This is a subject which was studied by UCL Ecology and

Conservation Unit students. Their findings have been summarised but there is a considerable need for the study to be extended and information collected and collated in much greater detail. This may also be a study suitable for a UCL postgraduate student, but would perhaps be better tackled by a Mallorcan, perhaps a postgraduate of the Department of Geography but specialising in aspects of social geography/demography. This study also has relevance to studies of the evolution of S'Albufera described in 3.6.1 and 3.6.2.

3.3.4 Soils /sediments

Soil studies were undertaken in spring 1991 but the researcher failed to produce any documentation of her results. However, the Project needs detail of soils and sediments. This is best accomplished by bodies such as the University of Aberdeen, University of Amsterdam and University of Liverpool as an integral part of their studies of land use, remote sensing and the geological past. This study also has relevance to studies of the evolution of S'Albufera described in 3.6.1 and 3.6.2.

3.3.5 Tourism related studies

In 1989 the UCL Ecology and Conservation Unit undertook preliminary studies of visitor impact on the Park, but there is ample scope for this work to be continued and expanded. Indeed, Joan Mayol is very keen to obtain more and better data. To achieve this we would need to seek expertise in the field. This may be an area of research that could be incorporated by Dr de

Groot in his integrated socio-economic studies. Alternatively it might be achieved through UCL postgraduate research. Such a study would also be of benefit to the Tourist industry and funds should perhaps be sought from that avenue. Dr Perring has offered to advise.

3.4 Furtherance of data-processing and the data-base potential and methodology, including development of compatible systems for comparative work and integration into international networks and schemes

3.4.1 Storage and organisation of data, use of GIS

Research data should be incorporated in a site database, used also for data collected by Park staff, including meteorological and hydrological data. The importance of historic data and the necessity of making them available in readily accessible electronic form should be given more attention. A student from the UIB's Department of Geography was instrumental in setting up a GIS recording system for the ground-truthing work done by Bernie Young. The adoption of GIS is a particularly important step towards ensuring wider applicability of Project S'Albufera data. Knowledge and expertise in GIS is clearly available at UIB and this is an area where we should encourage their involvement. We have received strong indications, via Joan Mayol, that UIB's geography department, through their Head and vice-rector of the University Dr Climent Picorell, is interested in becoming more involved with the Project. This department also has close links with the University of Aberdeen's geography department which,

through its Centre for Remote Sensing and Mapping Science, is already participating in the Project.

The scientists review meeting recommended that integration through a GIS as a database should be made through the European Environmental Agency (EEA).

3.4.2 Development of ecological data bases

The problems involved in setting up a computer-based package to record management is described in 3.2.1 above. Even more problems beset us with development of a computerised system of storing and processing biological records. Sara Hawkswell indicates that the RECORDER database used in Britain is not suitable for immediate conversion to a system for wide use in Mallorca or Spain. Particular difficulties would arise from changing the species dictionary, codings, language and system maintenance. She recommends that a system should be devised to store all the data and make them readily available to all users in a variety of formats. In order to accommodate future uses of these data (for example incorporation into a GIS or a network of biological databases), potential data standards should be considered.

This is specialist work, requiring time and commitment. Sara Hawkswell has a full-time job and inevitably does not have the time to commit to develop such a system in the time-scale we would need. I identify this as suitable for a postgraduate studentship, probably by someone in Computer Science with a specific interest in the natural world.

3.4.3 Griding the Park

The Park Directorate has divided the Park area, for descriptive and mapping purposes, into 30 sectors/compartments. Sara Hawkswell feels that, though a computerised database can deal with records by compartment, this may be insufficient detail for the purposes of Project S'Albufera . There is general agreement among Project scientists that we should seek a more accurate recording system, relating records to UTM (international grid system as used by Ordnance Survey style maps). To do this our options are 1) to grid the Park, 2) to use a global position retriever (satellite-generated location retriever system).

There are a number of problems afflicting the first option. Joan Mayol does not want visible location points (i.e. he does not want visitors to see a series of posts scattered through the Park). We have solved this problem for quadrats and transects by sinking markers to or below surface level which if not visible at a later date may be located using a metal detector. This may be less appropriate or straightforward for more wide-ranging studies. In addition, very few UTM intersection points occur in suitable locations - the setting up of reference points, visible or otherwise, in the middle of reedbeds is of little use to the Project (as well as a practical impossibility). Even if a grid system was set up, using tracks and other firm ground, this would require a lot of time and the involvement of someone with surveying expertise. The only such person at the Park, Biel Perello, has given indications that he might be able to help, but always his time has been fully usurped by his Park responsibilities. The second option may be more favourable, at

least initially, and would prove a useful tool if we progressed to gridding at a future date.

3.4.4 Interpretive and educational

Practical application of data collected by the Project has begun through a collaboration between the Park's Technical Assistant Biel Perello and Project scientists Dinah McLennan and Jo Newbould. They are currently working together to produce display material and hope to follow that with a brochure or more detailed publications based on Jo's studies of the Park's botany, Dinah's artistic skills and Biel's knowledge of the Park and relevant languages. These materials would be directed to interpreting S'Albufera plantlife for visitors to the Park.

3.5 Studies aimed at assessing environmental change

One inevitable by-product of the studies described above will be information which may be used to assess environmental change. Other studies currently in place or recommended have been specifically designed to achieve that objective. They fit into two sub-categories: 1) in-depth ecological studies; 2) constant or regular long-term monitoring.

3.5.1 Ecological studies

Studies in this category are ones which cannot be achieved by the Project in its present form of "snap-shot" field visits of short duration but which nevertheless are necessary if we are to understand the ecosystems and change. They do, however, make

ideal subjects for postgraduate students to tackle.

3.5.1.1 Mollusc studies

Dr Paul (University of Liverpool's Department of Earth Sciences) recommends research topics which would seek more information about the ecological preferences of certain species. He has outlined the following.

1. Establishing basic ecological requirements and life cycles for endemic snails, particularly the operculate snail *Tudorella*, which would involve monitoring selected populations. Since its range has been reduced over the geologically recent past, understanding its ecological requirements may be the key to its continued survival, although it is not a threatened species at present. It is widespread and common in Mallorca and Menorca, but unknown elsewhere in the world. It is recorded as a Pleistocene fossil from Ibiza, Sardinia and possibly southern France. This study, therefore, has an element of change based on past changes. What ecological conditions exist for the survival of the species in S'Albufera which no longer exist in other areas?

2. The precise ecological preferences of the three species of *Cochlicella* is recommended as an interesting study. Both Dr Paul and a previous observer noted that *C. barbara* was commonest alive within the marsh (though still on dry canal banks), while *C. conoidea* seems to be confined to the dune areas, both fossil and recent. *C. acuta*, the most widespread of the three, may be the most ecologically tolerant though even it was rarely seen by Dr Paul alive away from dunes and well drained paths. How, or even if, *C. acuta* and *C. conoidea* partition the

dune habitats would be well worth studying. Such a study could easily be undertaken as a wider part of the dune transect studies already underway. There is probably, for instance, no information about the dominant plant species found at sites where *Cochlicella* is recorded let alone their food preferences or which species of plant they climb up in summer to aestivate.

3. Similar studies could be made of other congeneric species, e.g. why is *Trochidea* (*T.*) *elegans*, the more widespread species, so restricted in its occurrence in S'Albufera, whereas *T.* (*T.*) *trochoides* is more common in the dunes? Equally, what are the precise requirements/ preferences of the three species of *Vallonia* ?

3.5.2 Long-term monitoring

3.5.2.1 Entomological: moth studies

Once a comprehensive inventory of lepidoptera has been established (see 3.6.8), Barry Goater plans to outline a monitoring programme based on light trap captures of moth species which are easy to recognise and likely to be key indicator species (e.g. for their impact at larval stage on major plant species such as *Phragmites*). Barry has already discovered that S'Albufera supports a healthy population of the moth *Pelosia plumosa*, an obscure but extremely interesting species known only from a few localities in southern Spain, north Africa and southern Italy and not recorded before from the Balearic Islands. Regular moth trapping will confirm the importance of S'Albufera for this species and provide information of its future status.

Park staff assistance may be required in maintaining a regular trapping regime under guidance from Barry.

3.5.2.2 Entomological: butterfly monitoring

Two transects, one based in the coastal sand dunes and a longer one sampling all major Park habitats, have been established. Both transects are divided into sections, each reflecting a different habitat type. All species are counted within each section. The information gathered will demonstrate variations in the numbers and composition of butterflies and their use of Park habitats.

This study has been set up and is carried out by Nick Riddiford with Earthwatch volunteers. The period of study was extended through the summer in 1991 by a Mallorcan volunteer.

3.5.2.3 Bird population dynamics

Two transects, each of approximately 7 km and sampling all major Park habitats, have been established. Both transects are divided into sections, each reflecting a different habitat type. All species are counted within each section. The information gathered will demonstrate variations in the numbers and composition of breeding and migrant birds and their use of Park habitats.

This study has been set up by Nick Riddiford but has been extended beyond the periods of Earthwatch field presence by Jon King, ornithological researcher from the Edward Grey Institute, University of Oxford, who is currently based there.

3.5.2.4 Fitness of migrant birds

Passage migrants are counted in April/May and a sample trapped as

part of a study of body condition in passage birds. The main "target" species is the Swallow *Hirundo rustica*. This is primarily the work of Jon King and is continued through the year by JK and the Park ornithologist, Pere Vicens. The study aims to elucidate the importance of S'Albufera for migrant birds, particularly in times of poor weather. Like many of the studies carried out as part of Project S'Albufera, this research seeks good, comprehensive meteorological data to assist in the elucidation of processes.

3.5.2.5 Meteorological recording

The Park operates a simple weather station but the data it collects are insufficient for the needs of the Project. The nearest site which collects the quality of data which many of the Project's studies require is several kilometres away near Sa Pobla. Ideally a more sophisticated weather station, in line with the Environmental Change Network (ECN) sites in the UK, should be installed at S'Albufera.

Dr Toni Martinez has offered to approach Dr Climent Ramis, of the UIB's Department of Meteorology about becoming actively involved in meteorological aspects of the Project. The head of this Department, Dr Sergio Alonso, has an active interest in Climatic Change and has urged the Spanish government to sign the IGBP protocol - which he sees as integrating climatic change studies to produce a vehicle for shaping government environmental policy. He and his Department are active in an ICSU-led initiative to establish a Regional Climate Investigation Centre which will

study climatic variations in the Mediterranean and sub-tropical Africa region.

The involvement of this Department would be extremely useful for it may advance our request for the establishment of a sophisticated weather station at S'Albufera. If this is established we may also be able to seek the participation of Dr Rudolf de Groot in his capacity as co-ordinator of the Climate Change Research Centre at the Agricultural University of Wageningen.

3.5.2.6 Other studies

Several studies described elsewhere, for example Orchid population dynamics (3.1.3.1) and Studies of dune plant hierarchies (3.1.3.2), also have a long-term monitoring element.

3.6 Extension of baseline information

3.6.1 Evolution of S'Albufera: coring study for pollen

This study is being conducted by scientists from the Geography departments of the University of Barcelona and UIB. Though this constitutes independent research not initiated or suggested by Project S'Albufera, it is of direct relevance to our work; it will, by relating the pollens found to species and date, give a much clearer understanding of the past evolution of S'Albufera. I have spoken to one of the scientists involved who indicated that the results would be published and thus become available to us. He also indicated that the geological cores from which the pollen

analysis would be taken could be made available to Project S'Albufera for parallel studies (see 3.6.2 below).

3.6.2 Evolution of S'Albufera: Diatoms in geological cores

If we do get access to the cores outlined in 3.6.1 above, geological research could be extended by the involvement of the University of Liverpool's Department of Earth Sciences under the leadership of Dr Andy Plater. Dr Plater has indicated that he would be in a position to investigate the Holocene/Pleistocene sediments and, hopefully, return with some material for pollen and diatom analysis. He writes "my primary interest is coastal evolution in relation to Holocene sea-level trends, so this opportunity is very appealing". This study could make an important contribution to our understanding of the past evolution of S'Albufera and its environs.

3.6.3 Flowering Plant distribution by management compartments

This work was begun by Dr Franklyn Perring in 1992 and he has indicated his willingness to continue with the study and produce a plant recording card. The study interrelates with the herbarium work described in 3.6.4 below.

3.6.4 Herbarium

Jo Newbould, assisted by other botanists and Earthwatch volunteers, has continued to build up the herbarium, augmented by a series of photographs, slides and line drawings. She has also drawn up a comprehensive list of known S'Albufera flowering

plants which demonstrates that the herbarium is far from complete. The herbarium now has its own dedicated herbarium cupboard which is extensively used by Project workers and Park staff alike. There is also a comprehensive card index for all S'Albufera flowering plants. Jo will continue her responsibility for the herbarium and flowering plant inventory with the aim of making it as comprehensive as possible. Dinah McLennan continues to play an important role in supplementing the reference collection with accurate line drawings. They are planning to use this work as a basis for preparing material which may be used to interpret plantlife for visitors to the Park (see 3.4.4).

3.6.5 Extension of herbarium material to include lichens and mosses

A small collection of lichens has been established at the Park, based on identifications made by Tom Chester of specimens taken to England. It is far from complete, and no work has been done on the bryophytes. Lichens in particular are known to be sensitive to air quality and may be a key group for this line of study. Work should initially comprise establishing a species inventory with reference material, but eventually there is scope for research, probably at postgraduate level, into lichen distribution and air quality within the Park. Dr P.D. Crittenden of the British Lichen Society and Department of Life Science of the University of Nottingham could be approached.

3.6.6 Fungi

Sheila Wells, wife of Principal Investigator Terry Wells,

collected and identified fungi in April 1991 and April and November in 1992. Sheila plans to extend her fungal database on subsequent visits with her husband, including in April and October 1993.

3.6.7 Mollusc studies

Dr Paul (University of Liverpool's Department of Earth Sciences) points out in his report of 1991 work that basic data about life cycle (e.g. are they annual or perennial, when do they mate and lay eggs? etc.) are unknown for the endemic snails and slugs such as *Tudorella* , *Trochoidea* (*Xeroplexa*) *nyeli* , *Limax majoricensis* and probably for several other species (e.g. *Trichia lanuginosa* , *Otala* spp., *Pseudotachea*). Observations on these basic details would be very useful but would require a person with specialist knowledge and year-round access to the site (i.e. a student based at the Park or resident Mallorcan).

3.6.8 Invertebrate baseline studies including collection of reference material

Work to establish an on-site reference collection was given a boost, for lepidoptera, by the participation in May 1992 of British lepidopteran expert, Barry Goater. It is the aim of the Project to achieve a level of reference, including inventories, for invertebrates of a similar quality to that established for flowering plants. The Balearic Invertebrate Group have indicated their willingness to help with this task, e.g. for beetles, and Barry Goater has indicated his willingness to continue his participation - which includes studies and advice on other lepidopteran aspects of the Project (e.g. 3.1.1.4).

Barry has suggested that we expand our lepidopteran studies to include the "micros", the smaller species sometimes thought of as "insignificant" but nevertheless making a considerable impact on vegetation in their larval stages - hence the tag which many carry as "species of economic importance". He has recommended that we invite the Rev David Agassiz to undertake this part of the research.

3.6.9 Entomological: Odonata

Adult dragonflies are a very obvious part of the invertebrate fauna but difficult to study. To overcome this, in 1992 Ed Cross began to develop methodology to monitor the larval stages. Early results are extremely promising and Ed plans to refine his methodology further. His work demonstrates that the total number of dragonflies supported by the marsh at larval stage is very large, therefore the group will play an important role as predators of other small aquatic fauna and as prey to fishes, frogs, some birds and other fauna. The adults are an important food source for the globally rare Eleonora's Falcon which gathers at S'Albufera to hunt dragonflies prior to its breeding season. The Cross methodology has great potential for monitoring Odonata population dynamics and their role in and interactions with the wetland ecosystem. Future work will also be needed outside the main Earthwatch field seasons, particularly in summer.

3.6.10 Hoverfly studies

This study aims to extend our knowledge of the composition and

seasonality of hoverfly (Diptera; Syrphidae) species using the Park and to monitor variations in the abundance of one easily recognisable migrant species, *Episyrphus balteatus*. This is achieved by counting the number of individuals of *Episyrphus balteatus* and recording all other Syrphid species seen within an establish transect route. This study was set up by Simon McKelvey but is currently carried out by Nick Riddiford with advice and identification assistance provided by Simon from his home base.

Hoverflies are often considered in Britain to be key indicator species of the health of wildlife habitats, based on diversity of species.

3.6.11 Invertebrates

A Balearic Invertebrate Group, under the leadership of Josep Antoni Alcover of CSIC and based at UIB in Palma, has been set up to further research into invertebrates in the Balearic Islands. Sr Alcover has indicated that specialist help would be available to increase our baseline knowledge for a number of groups. This was demonstrated in 1992 by visits from members of this group specialising in beetles and spiders. They set a series of pitfall traps in a number of habitats, which they visited on a regular basis during the spring. All these specialists have research commitments elsewhere and, though their expertise and assistance would be welcome, their involvement with the Project is likely to remain low-key.

3.6.12 Small mammal studies

A pilot small mammal study was done by Keith Bowey in October 1992 and a fuller study is planned by the University of Durham's Department of Biology in spring 1993. In addition to gaining a greater knowledge of small mammal populations and distribution, these studies may obtain comparable data to the small mammal work of Dr Alcover in the early 1980s, and published by Barcelo and Mayol.

Part 4 . Tier structure

4.1 First Tier. Earthwatch funded monitoring

Project S'Albufera is very different from what would be considered the norm for Earthwatch funded research projects. Other projects tend to concentrate on one particular item of research requiring scientific staff levels far below that demanded by Project S'Albufera lines of research. Project S'Albufera has been much more expensive in a number of areas, but especially in the travel costs of bringing scientific specialists to the Project, providing for their extra equipment needs and their accommodation. Ancillary additional costs include extra for provisions and transport within Mallorca.

To bring this into perspective I have included in Tier 1 a list of those areas of research which can be achieved by strict adherence to the funding possibilities offered by Earthwatch. They are set out below. The numbers in parentheses cross-reference to the summary paragraphs above describing the

studies. I have included the scientist/body responsible for each study.

4.1.1 List of studies

1. TITLE: Orchid population dynamics (3.1.3.1)
RESPONSIBILITY: Terry Wells
2. TITLE: Bird population dynamics (3.1.1.6; 3.1.3.7; 3.5.2.3)
RESPONSIBILITY: Nick Riddiford
3. TITLE: Hoverfly studies (3.6.10)
RESPONSIBILITY: Nick Riddiford & Simon McKelvey
4. TITLE: Butterfly monitoring (3.1.3.6 and 3.5.2.2)
RESPONSIBILITY Nick Riddiford
5. TITLE: Impact of Park habitats on the bird fauna (3.2.2)
RESPONSIBILITY: Nick Riddiford

4.2 Second Tier. Studies which need to be tackled but depend on extra funding.

Over the first four years the Project has benefited enormously from the involvement of a series of scientists who have developed their own methodologies for tackling the many problems the Project has met. Many of these scientists remain involved with the Project and have studies in progress and/or which require

further work. These studies are set out in Tier 2. The numbers in parentheses cross-reference to the summary paragraphs above describing the studies. As in Tier 1, I have included the scientist/body responsible for each study.

4.2.1 List of studies

1. TITLE: Autecology of Phragmites and Cladium (3.1.1.1)
RESPONSIBILITY: Palmer Newbould (with UIB back-up).
2. TITLE: Studies of dune plant hierarchies (3.1.3.2)
RESPONSIBILITY: Dr Franklyn Perring.
3. TITLE: Grazing influence of mammals on fossil dune vegetation
(3.1.3.4)
RESPONSIBILITY: Jo Newbould (3.1.3.4).
4. TITLE: Current management practices (3.2.1)
RESPONSIBILITY: Sara Hawkswell, RSNC; S'Albufera Park staff.
5. TITLE: Bat studies (3.2.3)
RESPONSIBILITY: Jean-Francois Noblet.
6. TITLE: Interpretive and educational (3.4.4)
RESPONSIBILITY: Biel Perello, Technical Assistant, Parc
Natural de S'Albufera ; Dinah McLennan and Jo Newbould,
Project scientists.
7. TITLE: Entomological: Moth studies (3.5.2.1)
RESPONSIBILITY: Barry Goater, Project scientist; Andreu
Muntaner, Warden, Parc Natural de S'Albufera .

8. TITLE: Plant distribution by management compartments (3.6.3)
RESPONSIBILITY: Jo Newbould; Dr Franklyn Perring.
9. TITLE: Herbarium (3.6.4)
RESPONSIBILITY: Jo Newbould.
10. TITLE: Fungi (3.6.6)
RESPONSIBILITY: Sheila Wells.
11. TITLE: Invertebrate baseline studies including collection of
reference material (3.6.8)
RESPONSIBILITY: Barry Goater; Rev David Agassiz.
12. TITLE: Entomological: Odonata (3.6.9)
RESPONSIBILITY: Ed Cross.
13. TITLE: Small mammal studies (3.6.12)
RESPONSIBILITY: Keith Bowey.
14. TITLE: Remote Sensing (3.1.4.1)
RESPONSIBILITY: John Loder, Centre for Remote Sensing and
Mapping Science, University of Aberdeen; Bernie
Young.

4.3 Third Tier. Parallel studies planned for 1993-94 by
Universities and other bodies.

We have always recognised that much of the more innovative,
detailed and temporally extended work should be undertaken by
Universities and other bodies in partnership with the Project

(and thus in partnership with Earthwatch Europe). Steps towards achieving this were already in place by the time the review group met (e.g. co-operation agreement signed between Earthwatch Europe and the University of the Balearic Islands, Earthwatch Europe sponsored or part-sponsored studies by post-graduate students from University College London and the University of Aberdeen's Centre for Remote Sensing and Mapping Science). However, the review group meeting stimulated an increased interest and commitment from Universities, not least several scientific departments of the UIB - seen by us as an essential development for the future of the Project as the University "on the spot" and with most to gain from involvement in this international venture. The list which follows includes a number of studies suggested or encouraged by scientific members of Project S'Albufera but offered as a direct result of the review group meeting (and in particular the enthusiasm and insistence of the two Dutch scientists in the group who urged UIB scientists to grab what they saw as a great opportunity to participate in an international project of great potential). As in Tiers 1 & 2, I have included the person/body responsible for each study. The numbers in parentheses cross-reference to the summary paragraphs above describing the studies.

4.3.1 List of studies

1. TITLE: Photosynthesis and productivity of marshland plants

(3.1.1.2)

RESPONSIBILITY: Hipolito Medrano, Dept of Vegetal Physiology,
UIB; Roger Austen, University of Cambridge.

2. TITLE: Decomposition of reedbed plants (3.1.1.4)
RESPONSIBILITY: Dr Enrique Descals, Department of Environmental Biology & Dr Antoni Martinez, Department of Limnology, UIB.
3. TITLE: Study of relationships between *Archanara geminipuncta* biology, Reed Bunting feeding and breeding biology and their impact on *Phragmites* reed (3.1.1.5)
RESPONSIBILITY: Anna Traveset, CSIC, Palma.
4. TITLE: Ornithological studies: Moustached Warblers (3.1.1.7)
RESPONSIBILITY: Dr Chris Perrins, Edward Grey Institute for Field Ornithology, Oxford University; Dr Bernd Leisler Max-Planck-Institut fur Verhaltensphysiologie, Germany.
5. TITLE: Hydrogeological study (3.1.2.1)
RESPONSIBILITY: Dr Alfredo Baron, Balearic Hydrological Service.
6. TITLE: Water quality and pollutants (3.1.2.2)
RESPONSIBILITY: Drs Martinez and Medrano, Department of Biology, UIB.
7. TITLE: Vertical nutrient exchange between water and sediment (3.1.2.3)
RESPONSIBILITY: Drs Moya, Ramon & Martinez, Department of Biology, UIB; two collaborators from the University of Barcelona.

NOTE: Independently funded research study begun in 1992.
8. TITLE: Freshwater macrophytes and water quality (3.1.2.4)
RESPONSIBILITY: Dr Martinez, Department of Biology (Limnology

Section), UIB; Dr Enrique Descals, Department of Environmental Biology, UIB; Dr Sven Jonasson, Institute of Plant Ecology, University of Copenhagen.

9. TITLE: Freshwater invertebrates & water quality (3.1.2.5)

RESPONSIBILITY: Dr Roderick Fisher, Ecology and Conservation Unit, University College London.

10. TITLE: Mollusc studies (3.1.2.6; 3.1.3.5; 3.5.1.1; and 3.6.7)

RESPONSIBILITY: Dr Chris Paul, Department of Earth Sciences, University of Liverpool; Dr Cristian Altaba, CSIC, Palma.

11. TITLE: Sand-dune evolution past and present (3.1.3.3)

RESPONSIBILITY: Dr van der Meulen, Department of Physical Geography and Soil Science, University of Amsterdam.

12. TITLE: Remote Sensing (3.1.4.1)

RESPONSIBILITY: John Loder, Centre for Remote Sensing and Mapping Science, University of Aberdeen.

13. TITLE: Environmental functions and values (3.3.1)

RESPONSIBILITY: Dr Rudolf de Groot, Climate Change Research Center, Agricultural University of Wageningen.

14. TITLE: Land-use and vegetation (3.3.2)

RESPONSIBILITY: Dr Frank van der Meulen, Department of Physical Geography and Soil Science, University of Amsterdam.

15. TITLE: Storage & organisation of data, use of GIS (3.4.1)

RESPONSIBILITY: Sara Hawkswell; Dr Climent Picorell,
Department of Geography, UIB; Dr John Loder, Centre
for Remote Sensing and Mapping Science, University of
Aberdeen.

16. TITLE: Fitness of migrant birds (3.5.2.4)

RESPONSIBILITY: Jon King, EGI, University of Oxford; Pere
Vicens, Ornithologist, Parc Natural de S'Albufera .

17. TITLE: Evolution of S'Albufera: coring study for pollen
(3.6.1)

RESPONSIBILITY: Dr Ramon Julia, Institut Jaume Almera,
University of Barcelona

NOTE: Independently funded research study begun in 1992.

18. TITLE: Evolution of S'Albufera: Diatoms in geological cores
(3.6.2)

RESPONSIBILITY: Dr Andy Plater, Department of Earth Sciences,
University of Liverpool).

4.4 Fourth Tier. Studies which are needed but for which no
scientists/means are available.

This tier is included for completeness. Although the funding to
meet these extra studies is not currently available we cannot
afford to omit items of research which are key to our full
understanding of the processes and ecosystems. If funding remains
difficult, these studies are at least on paper for consideration
at a later date. In the list which follows, the numbers in

parentheses cross-reference to the summary paragraphs above describing the studies. Areas of responsibility have been given but these are proposed rather than indicating acceptance or commitment by the scientists/organisations involved.

4.4.1 List of studies

1. TITLE: Heavy metals in marsh plants (3.1.1.3)

RESPONSIBILITY: Maria Pou Bordoy, Catalina Cabot and John Sibole, Department of Vegetal Physiology, UIB.

2. TITLE: Bird predator studies (3.1.1.8)

RESPONSIBILITY: Heinz Hafner, Tour du Valat Biological Station, Camargue, France.

3. TITLE: Frog studies (3.1.2.7).

RESPONSIBILITY: Herpetological department, Sir David Attenborough Laboratories, De Montfort University, Leicester.

4. TITLE: Fish population studies (3.1.2.8)

RESPONSIBILITY: Alain Crivelli, Tour du Valat Biological Station, Camargue, France.

5. TITLE: Past History & Land Use (3.3.3)

RESPONSIBILITY: Dr Climent Picorell, Department of Geography, UIB; or Ecology and Conservation Unit, University College London.

6. TITLE: Soils/sediments (3.3.4)

RESPONSIBILITY: Geography/Earth Science Departments of the University of Aberdeen, University of Amsterdam or

University of Liverpool.

7. TITLE: Tourism related studies (3.3.5)

RESPONSIBILITY: Dr de Groot, Agricultural University of
Wageningen; or Ecology and Conservation Unit, UCL.

ADVISOR: Dr Franklyn Perring.

8. TITLE: Development of ecological data bases (3.4.2)

RESPONSIBILITY: Sara Hawkswell, RSNC; postgraduate in Computer
Science.

9. TITLE: Gridding the Park (3.4.3)

RESPONSIBILITY: ?Park Directorate; specialist surveyor.

10. TITLE: Meteorological recording (3.5.2.5)

RESPONSIBILITY: Dr Climent Ramis, Department of Meteorology,
UIB; Dr Rudolf de Groot, Climate Change Research
Centre, Agricultural University of Wageningen.

11. TITLE: Extension of herbarium material to include lichens &
mosses (3.6.5)

RESPONSIBILITY: Dr P.D. Crittenden, School of Life Science,
University of Nottingham.

12. TITLE: Invertebrates (3.6.11)

RESPONSIBILITY: members of Balearic Invertebrate Group,
CSIC-UIB, Palma.

APPENDIX 5 - 1993 programme details

Project Title

Monitoring for environmental change at S'Albufera, Mallorca.

Research Site

Parc Natural de S'Albufera , Mallorca, Spain.

Principal Investigators

Nick Riddiford (Teams I-IV)

Dr Terry Wells (Team II)

Team Dates in Field

TEAM I March 28-April 11, 1993

TEAM II April 14-April 28, 1993

TEAM III May 1-May 15, 1993

TEAM IV October 23-November 6, 1993

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

Fields of Research

Botanical

1. Orchid population studies (Terry Wells)
2. Dune transects (Franklyn Perring)
3. Herbarium (Jo Newbould; Perring; Dinah McLennan)
4. Plant Illustrations/Preparation of display material (Dinah McLennan)
5. Distribution of *Euphorbia terracina* in areas of grazing (Dinah McLennan)
6. Fungi (Sheila Wells)

Vertebrates

1. Bird population studies (Nick Riddiford; Jon King; Mike Wood)
- transects, point counts, Moustached Warbler distribution,
constant effort site ringing, body condition of migrants
2. Bird foraging studies (Mike Wood)
3. Mammal population studies (University of Durham)

Remote Sensing

1. Ground-truthing census work (Bernie Young as preparation for
further work by students of Centre for Remote Sensing and
Mapping Science, Department of Geography, University of
Aberdeen, Scotland)

Hydrology

1. Preliminary studies of water quality (Alexandra Torn in

partnership with UIB's Departments of Vegetal Physiology and
Limnology)

Invertebrates

1. Entomology

- a) insect reference collection (Riddiford; Goater)
- b) studies of Diptera, Syrphidae (Riddiford)
- c) butterfly and dragonfly transects (Riddiford)
- d) odonata population studies (Ed Cross)
- e) monitoring methods for night lepidoptera

Ecology of Phragmites

- 1. The ecological relationships of Phragmites , moth larvae and
birds (Alan Radermacher)

Computerisation of Data

- 1. Program development for standardised data processing and
storage (Sarah Hawkswell)

Project S'Albufera scientists, 1993

Team I 28 March-April 11

PI - Nick Riddiford

Jon King - ornithology

Alan Radermacher - ecology of Phragmites

Sarah Hawkswell - data programming

Team II 14-28 April

PI - Terry Wells

PI - Nick Riddiford

Sheila Wells - fungi

Jon King - ornithology

Alex andra Torn - water quality studies

Team III 1-15 May

PI - Nick Riddiford

Jon King - ornithology

Dinah McLennan - botany

Ed Cross - odonata studies

Bernie Young - remote sensing

Team IV 23 October-6 November

PI - Nick Riddiford

Barry Goater - lepidoptera

Franklyn Perring - dune transects

APPENDIX 6 - List of publications

Results from the first four seasons' work have contributed to the following publications. An asterisk draws attention to those which have appeared since the last Project S'Albufera report.

*FOX, R. J. P. 1992. Monitoring Environmental Change at

S'Albufera Parc Natural: the role of aquatic invertebrates.

University College London M.Sc. in Conservation dissertation.

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.

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.
- HO WE, C. 1989. Albufera: Aspects of Hydrology, Vegetation, History and Management . University College London M.Sc. in Conservation dissertation.
- *J URADO ESTEVEZ, J. 1992. The usefulness of Landsat TM data for vegetation discrimination in S'Albufera de Mallorca - a marsh . MSc dissertation, Centre for Remote Sensing and Mapping Science, University of Aberdeen.
- *M ARCUS, A. 1992. Estimation of soil's surface physical properties using Landsat TM Data in "Es Pla de Sa Pobla-Muro" (Mallorca) . MSc dissertation, Centre for Remote Sensing and Mapping Science, University of Aberdeen.
- MA YOL, J. 1991. Plan d'us i gestio del Parc Natural de S'Albufera de Mallorca. Documents tecnicos de Conservacio 3. SECONA, Palma de Mallorca.
- MA YOL, J. 1991. Parc Natural de S'Albufera de Mallorca: Ornithological overview, August 1989-July 1990 . Associacio Balear d'Amics dels Parcs, Ca'n Picafort.
- *M AYOL, J. 1992. Plan for the use and management of the Natural Park of S'Albufera, Mallorca, 1990-94. Documents tecnicos de Conservacio 3. SECONA, Palma de Mallorca [English version].
- NE WBOULD, P. 1989. The Albufera as a Global Monitoring Station . Earthwatch Europe cyclostyled report.
- NE WBOULD, P. 1990. The Albufera, Mallorca, as a Global Observatory. Jornades del Medi Ambient de les Balears 2: 173-174.
- NE WBOULD, P. 1991. Phragmites and Cladium on Albufera . Manuscript.

- NE WBOULD, P. J., RIDDIFORD, N. J. and GRACE, E. 1989. Consumption of *Phragmites australis* at S'Albufera, Mallorca. In *The Albufera as a Global Monitoring Station* (Newbould 1989).
- NE WBOULD, P. J. and RIDDIFORD, N. J. 1990. *Monitoring for Global Change: The Earthwatch Europe S'Albufera Project*. Earthwatch Europe, Oxford.
- *N OBLET, J. F. 1992. *Les chauves-souris du Parc Natural d'Albufera, Majorque, Iles des Baleares - Espagne*. Report to Earthwatch Europe.
- PE RELLO, G. 1991. *Seguiment de l'avifauna del Parc, agost 1990-juliol 1991*. Associacio Balear d'Amics dels Parcs, Can Picafort.
- *P ERELLO COLL, G. 1992. *Geografia y educacion ambiental: el parque natural de S'Albufera de Mallorca*. Boletin de la Asociacion de Geografos Espanoles 14: 111-120.
- *P ERELLO, G., MAYOL, J. & VICENS, P. 1992. *Seguiment de l'avifauna del Parc, agost 1991-juliol 1992*. Associacio Balear d'Amics dels Parcs, Can Picafort.
- RI DDIFORD, N. 1991a. *Project S'Albufera: A new model for environmental research*. Earthwatch Europe, Oxford.
- RI DDIFORD, N. 1991b. *A small influx of the Long-tailed Blue Lampides boeticus at S'Albufera Natural Park, Mallorca*. Bull. Amat. Ent. Soc. 50: 164.
- *R IDIFORD, N. 1992a. *Project S'Albufera: Planning for 1993-94 and beyond: a discussion paper*. Earthwatch Europe cyclostyled report, Oxford.
- *R IDIFORD, N. 1992b. *Dragonflies attracted to light*. Bull. Amat.

Ent. Soc . 51: 139-140.

- *R IDDIFORD, N. & AMENGUAL RAMIS, J. F. 1992. El Projecte S'Albufera a carrec d'Earthwatch Europe: un nou model de recerca medioambiental . Earthwatch Europe, Oxford.
- RI DDIFORD, N. & NEWBOULD, P. 1991. Monitoring for Environmental Change : The Earthwatch Europe S'Albufera Project - a summary report of the second season's work 1990 . Earthwatch Europe, Oxford.
- *R IDDIFORD, N. & PERRING, F. 1992. Monitoring for Environmental Change : The Earthwatch Europe S'Albufera Project - a summary report of the third season's work at S'Albufera Natural Park, Mallorca . Earthwatch Europe, Oxford.
- *V ARLEY, M. E. (ed.). 1992. Project S'Albufera: Report of Field Scientists' Review Meeting, 28-30 April 1992 . Earthwatch Europe cyclostyled report, Oxford.
- WO OD, B. (ed.). 1989. A monitoring programme for S'Albufera, Mallorca. Discussion Papers in Conservation No. 52. Ecology & Conservation Unit, University College London.
- WO OD, B. (ed.). 1991. Further studies towards a monitoring programme for S'Albufera de Mallorca. Discussion Papers in Conservation No. 55. Ecology & Conservation Unit, University College London.

□
APPENDIX 4 - Planning for 1993-94 and beyond

Appendix 4 presents a revised version of the research elements contained in the Project's planning document Project S'Albufera,

Planning for 1993-94 and beyond: a discussion paper (Riddiford 1992), which was formulated from the recommendations of the Field Scientists' Review Meeting in April 1992.

Part 1. Introduction

Following the publication in autumn 1991 of Project S'Albufera - A new model for environmental research , a review group of international scientists was invited to S'Albufera in April 1992 to assess progress during the first three years of the Project and to advise on its shape and directions in the future.

This discussion paper while remaining faithful to the overall aims of the Project, clearly defined at the start and continuing to play a central role in the work of the Project, draws heavily from the thoughts and recommendations of the review group, published in Project S'Albufera - Report of field scientists' review meeting, 28-30 April 1992 .

One of the major conclusions emerging from the review group meeting was that priorities need to be recognised and these should draw on the Project's demonstrated strong points. Even within this scenario, the operating costs are enormous and can only be achieved with a large funding commitment outside the normal channels of Earthwatch monetary support. So to match what is needed with what is possible, I have structured the proposed plan of work for 1993-94 (and in some cases beyond) in four tiers, comprising ongoing studies which may be achieved under

Earthwatch Europe tutelage and normal financial support (First Tier), studies which need to be tackled or are ongoing but depend on extra funding (Second Tier), parallel studies by Universities and other bodies in partnership or co-operation with Earthwatch Europe and Project S'Albufera (Third Tier) and those studies which are needed but for which no scientists or means are currently available (Fourth Tier).

The studies proposed within each of these tiers are summarised within Priority categories in Part 3 and listed according to tier in Part 4.

Part 2. Priorities

I see priorities for 1993-94 (and beyond) falling into six categories. They are:

1. Multi-disciplinary study of processes going on, 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. Furtherance of data-processing and the data-base potential and methodology, including development of

compatible systems for comparative work and
integration into international networks and schemes.

5. Long-term monitoring aimed at assessing environmental
change.

6. Extension of baseline information.

Part 3. Studies

There follows a summary of studies which I and others involved in the Project have identified as meeting the above priorities. They are far from comprehensive and are likely to be added to as further fieldwork and consultations with scientists throw up other questions which need to be answered, information which needs to be gathered, etc.; and of course there is the opportunity, too, for scientific input into this current plan, which is also intended to have a consultative role. Most of the studies have been selected because they are already in place or attracting the interest and/or commitment of Universities and other bodies. Other studies suggested have no such linkage at the moment and may serve as notice for inclusion in the future development of the plan beyond 1994.

I have ordered studies under headings which relate to the priorities outlined above. Some studies are of direct relevance to two or more priority categories and it should be borne in mind

that there will be some overlap of categories for nearly all studies (e.g. dune systems studies may have application also in providing information on the impact of management strategies, in supplying data for the interpretation services of the Park and in long-term monitoring for change).

3.1 Studies appropriate to multi-disciplinary study of processes

3.1.1 . The Phragmites - Cladium dominated wetland ecosystem

Much of S'Albufera is wetland dominated by the marshland plants *Phragmites australis* and *Cladium mariscus* . The pioneering work by Professor Newbould on aspects of biomass and productivity for these two species has been recognised as one of the Project's strong points. The interest of several scientists and institutions now gives us the opportunity to extend this work to other areas which will allow a multi-disciplinary study of processes.

3.1.1.1 Autecology of *Phragmites* and *Cladium*

Palmer Newbould's work should be developed from his ongoing studies of productivity of *Phragmites* and *Cladium* shoots to include the rhizomes and root mass and, to add to the dry weight data, values for the processes of decomposition and nutrient cycling. His work should also be extended to other aspects of the ecology of these plants, including a greater knowledge of their annual cycle. Professor Newbould's continued involvement in these studies will require back-up assistance including better on-site equipment and facilities and expertise from scientists at the

University of the Balearic Islands (UIB) in Palma. There is a particular need for Mallorcan home-based involvement for such aspects as recording the annual cycle.

3.1.1.2 Photosynthesis and productivity of marshland plants

Some of the facilities mentioned in 3.1.1.1 above have been offered by Dr Hipolito Medrano of the UIB. Dr Medrano has an international reputation in photosynthesis research. He specialised until recently in photosynthesis in crops but is now keen to extend that study to plants in more natural situations. He is head of Fisiologia Vegetal (Vegetal Physiology) of UIB's Department of Biology. He has worked in the past with Dr Roger Austen, another photosynthesis expert recently retired from Cambridge University, and they wish to plan a joint study of the Phragmites - Cladium ecosystem concentrating on photosynthesis, plant production and growth - research which they see as complementing and furthering the studies undertaken by Prof. Newbould. As an indication of his interest in the subject, Dr Medrano has already undertaken preliminary studies at S'Albufera with students from his Department, while Dr Austen assessed the potential of the site in May 1992.

3.1.1.3 Heavy metals in marsh plants

A study is currently being done by members of the UIB's Sub-department of Vegetal Physiology, led by Maria Pou Bordoy, Catalina Cabot and John Sibole, into the heavy metal content of the aquatic macrophyte Lemna. This study has been undertaken at the instigation of Joan Mayol, Director of the Park, for

conservation reasons: ducks are an important part of the Park's avifauna and Lemna is a food source for ducks. The infrastructure and interest is therefore in place to extend this research to other marshland plants.

3.1.1.4 Decomposition of reedbed plants

Dr Enrique Descals of the Consejo Superior de Investigaciones Cientificas (CSIC), based at Palma, has been conducting studies for a number of years on the role of microfungi in the decomposition of dead plant matter in the canals of S'Albufera. Dr Descals, along with Dr Antoni Martinez of the UIB's Department of Biology, Limnology section, have been keen supporters of the Project and its objectives from the start and have given much advice and practical help in that time. These two scientists have the means within their fields of expertise, and those of other members of their and adjacent UIB departments, to extend current studies to encompass this important aspect of the marshland ecosystem. This would complement the work of Prof. Newbould and others.

3.1.1.5 Study of relationships between Archanara geminipuncta biology, Reed Bunting feeding and breeding biology and their impact on Phragmites reed

Phragmites is attacked by the caterpillars of a wainscot moth Archanara geminipuncta. These bore into the stems and consume the inner tissues. Apical growth then ceases but is replaced by several more slender lateral shoots. Infestation levels up to 80%

have been recorded but none in the year following burning of the reedbed. It may take several years for the moth to colonise reed beds after burning. The caterpillar has an impact not only on growth of the plant but on two bird species. The Moustached Warbler *Acrocephalus melanopogon* (for which S'Albufera is one of the World's most important sites) requires reedbeds of two levels, the lower comprising a layer of broken, dead material.

Archanara geminipuncta may play an important part in breaking down the reeds to create a suitable habitat for these birds. In addition, Reed Buntings *Emberiza schoeniclus* have been observed extracting and eating the caterpillars. The local population, in parallel with others of the species occupying SW Mediterranean reedbed sites, have developed a much thicker bill than their central and north European counterparts. This thick-billed Reed Bunting is one of few bird species able to extract the caterpillars, using the bill to strip away the outer casing of

Phragmites stems. The thickness of the bill in this population may be associated with this feeding behaviour (though this may not be the only reason). We have interested Anna Traveset of the Institut d'Estudis Avancats de les Illes Balears (CSIC-UIB) in this subject and she has begun her own investigations, though currently in her spare time away from other commitments. She is based in Palma and is a specialist in insect-plant interactions, currently conducting work on nearby Cabrera.

3.1.1.6 Bird population dynamics

A study of the population dynamics of reedbed species has been established using constant effort ringing at two older (i.e. not

recently burnt) reedbed sites in Es Colombar and near Ses Punes. This study has been extended beyond the periods of Earthwatch field presence by Jon King, ornithological researcher from the Edward Grey Institute, University of Oxford, who is currently based there. This has allowed collection of data on fledging dates and breeding productivity as well as variations in the structure of the adult community.

3.1.1.7 Ornithological studies: Moustached Warblers

I have been in discussion with Dr Chris Perrins, Director of Oxford University's Edward Grey Institute for Field Ornithology (EGI), regarding the placement of a postgraduate student to study S'Albufera's Moustached Warblers *Acrocephalus melanopogon*. Dr Perrins indicated that it would require an NERC grant and "the right student" and that, though in principal he is in favour, current financial constraints meant the study was not likely to be implemented at the moment. The proposal, written by myself and Jon King is as follows:

"In general the European Acrocephaline warblers have received considerable research interest, principally regarding their mating systems and resource partitioning in reedbed communities. The Moustached Warbler however, confined to extensive reedbeds of the Mediterranean Basin and Middle East, has remained virtually unstudied. Although it is now amongst the rarest birds in Western Europe, many basic facts about its biology are unknown.

The recently-created Parc Natural de S'Albufera, Mallorca holds a population of Moustached Warblers probably in excess of

one thousand pairs and consequently may represent the most important site for the species within its known world range. A limited database already exists for the species in the Parc, derived from short studies by the British Trust for Ornithology, University College London and Earthwatch Europe in the last 8 years. These suggest an unusually high longevity for a small passerine, with consequent low population turnover, and a high proportion of 'floating' young males; implications for the mating system of the species are as yet unknown. In one main area of the Parc, a large proportion of the Moustached Warblers are already colour-ringed as a result of this previous work. The presence of two other species of Acrocephaline warbler at S'Albufera would allow original studies on a guild of reedbed warblers to be compared with the extensive literature on this subject.

A further, valuable component of this study would be the opportunity to use Moustached Warbler populations to monitor reedbed management techniques. Active grazing by cattle is increasingly used at S'Albufera, and at similar reserves in the Mediterranean, to open up feeding areas for large non-passerines (herons, wildfowl etc.). However, the impact of this on smaller, reed-dependent species is very unclear. Given the Parc's international responsibility to the Moustached Warbler, and that species' total dependence on the affected habitat, clarification of the ecological relationships involved is urgent.

The facilities at S'Albufera are ideal for housing research scientists, and the Parc's management actively encourage and assist their work. A postgraduate student would gain much from the growing band of ecologists working at S'Albufera,

forming an integrated study of reed productivity (Prof. P. Newbould, Ulster), the Fan-tailed Warbler (J.R. King, EGI) and long-term monitoring of many aspects of the Parc's natural history (Earthwatch Europe, Parc staff)."

I have also been discussing this study with the only scientist involved in Moustached Warbler research, Dr Bernd Leisler of the Max-Planck-Institut für Verhaltensphysiologie, Germany. He has indicated a willingness to help with advice and with parallel research in his own Austrian study area.

3.1.1.8 Bird predator studies

At varying times of the year Marsh Harriers *Circus aeruginosus*, Ospreys *Pandion haliaetus*, falcons (including the rare Eleonora's Falcon *Falco eleonora*), egrets and herons are common and highly visible components of the Park's avifauna. Because of their size and visibility, and because they are at the top of a food chain, they may prove to be indicator species for the health of the environment. There is a limited variety of fish (though an abundance of those which occur) and mammals (e.g. no voles) so the predators will be obligate feeders on a more restricted diet of readily abundant prey such as eels and frogs. We have done some preliminary work on the diurnal activity patterns and preferred feeding areas of Purple Herons *Ardea purpurea*, using Earthwatch volunteers, but much remains to be done in assessing the impact of bird predators. Earthwatch volunteers would be very useful assistants in observing predator behaviour (and it would be a popular task for them), but such studies could only be developed fully by detailed research. I identify this as a

potential postgraduate research topic, possibly in conjunction with the Tour du Valat Biological Station (and their heron expert, Heinz Hafner).

3.1.2 The hydrological system

3.1.2.1 Hydrogeological study

This is a key area of study for which we still have inadequate data. Our knowledge of the hydrology of the Park was enhanced by the efforts of the University College London's Ecology and Conservation Unit in 1989-90, but their research demonstrated that much more information was needed which could only be achieved by an in-depth study embracing the whole water catchment area, using data collected over a longer period of time and calling on the expertise of specialists and expensive specialised equipment. This was clearly beyond the direct resources of Project S'Albufera. However, it was within the capabilities of the Mallorcan hydrological service, who we identify as the obvious body to obtain these data which are vital not only to the Project but to the Park authorities and, indirectly, to other local interests such as the agriculturalists and hoteliers. We understand from Joan Mayol that an in-depth hydrogeological study is now planned, supported and funded by the Balearic Islands Government.

3.1.2.2 Water quality and pollutants

This is an area for which we have very little data, other than

for salinity. However, observations indicate that the water chemistry is a key factor affecting the flora, fauna and ecosystems throughout the Park. Clearly aspects such as geohydrology, water chemistry, plant productivity and decomposition and habitats for birds and other animals are related to each other functionally. Apart from salinity, the ecosystem may be subject to a whole range of water and air borne pollutants. We know nothing of the effects on S'Albufera of emissions from the local power station; run-off from adjacent farmland may be bringing a range of agrochemicals from pesticides to nutrient-rich nitrates and nitrites; and speculation has been made about sewage infiltration into the Park. From 1993 we intend to study water quality, aimed at detecting these chemicals, initially by collecting water samples from selected locations. Drs Martinez and Medrano have indicated that facilities are available to analyse water samples within their departments at UIB. Eventually, the study should be developed, perhaps at postgraduate level, by the UIB where it would tie in with current and recent work by Martinez on the aquatic macrophytes and Medrano on reedbed plant photosynthesis and productivity.

This study is also of direct relevance to a number of other aspects of Project and Park work. For instance it may demonstrate the importance of reedbed plants such as Phragmites in absorbing, and thus acting as a natural cleansing agent for pollutants, reveal the impact of pollutants on biodiversity or the survival of threatened biota and, consequently, influence future management practices.

3.1.2.3 Nutrient exchange

In May 1992 Drs Moya, Ramon and Martinez of the UIB's Department of Biology, and two scientists from the University of Barcelona were awarded a three-year research grant (amounting to ca 5.5 million pesetas) to work on vertical nutrient exchange between water and sediment, and horizontal exchange between S'Albufera and the Bay of Alcudia. Though this constitutes independent research not initiated or suggested by Project S'Albufera, both topics are of interest and direct relevance to our work.

3.1.2.4 Freshwater macrophytes and water quality

Some of the most detailed scientific work done at S'Albufera, involving the distribution of aquatic macrophytes in relation to the physico-chemical dynamics of the water systems, was undertaken by Dr Antoni Martinez for his doctoral thesis in the 1980s. He has maintained a great interest in this subject and in 1990-91 attempted, unsuccessfully, to obtain funding for a study to extend this research. This was to be a joint undertaking with Dr Sven Jonasson, Director of the University of Copenhagen's Institute of Plant Ecology. Both retain a commitment to develop this topic if funding becomes available.

3.1.2.5 Freshwater invertebrates and water quality

Richard Fox, a postgraduate student from University College London (supervised by Dr Roderick Fisher of UCL's Ecology and Conservation Unit) made a study this summer (1992) of freshwater

invertebrate species as indicators of water quality. His intended methodology for the study included implementing the RIVPACS computer program, developed for UK freshwater systems but already tested in amended form in mainland Spain. Eventually he was not able to use this program. However, adaptation of such a system for S'Albufera would be very welcome and of direct relevance to our long-term monitoring objectives and Park management planning as well as providing additional information for studies such as those outlined in 3.1.2.2, 3.1.2.4 and 3.1.2.6.

3.1.2.6 Mollusc studies

Dr Chris Paul of the University of Liverpool's Department of Earth Sciences participated in the Project in October 1991 and May 1992. His task was to set up a baseline for molluscs, to investigate their role as key indicator species and to recommend further research relevant to the Project's objectives. One of the major findings from Dr Paul's survey was that, though shells were present in abundance, live snails were in much lower numbers than anticipated or normal in similar habitats elsewhere. This was particularly the case for aquatic snails. As a result he recommends monitoring of water quality, including salinity, in relation to the abundance of living aquatic molluscs. Apart from its relevance to our interest in water quality and its effects on the fauna and flora of the Park, this study also has an innovative aspect. Dr Paul knows of only one general study of the salinity tolerances of fresh and brackish water molluscs and that was done nearly 40 years ago. Dr Paul writes: "Jaeckel's (1955) classic study of the molluscs of the Schlei, which drains into

the Baltic where maximum salinities are only 16%, is the only general study of which I know. His fauna did not include six of the 15 aquatic species recorded from S'Albufera, including the four commonest species seen alive. Documenting salinity tolerances of the aquatic molluscs in S'Albufera would not only add to knowledge concerning molluscs, but reveal both changes in the hydrology of the marsh and their effects on aquatic molluscs. Such a study might also help explain some distributions, e.g. why live specimens of both Hydrobia and Amnicola are almost confined to the northern part of the Park".

Dr Paul felt that he, in conjunction with his department at Liverpool, could be involved in future researches into molluscs at S'Albufera but probably in partnership with Dr Cristian Altaba. Dr Altaba is an acknowledged expert on Balearic molluscs and is based in Palma with the CSIC. Dr Altaba has expressed an interest in becoming involved in mollusc studies at S'Albufera but stresses that, though the CSIC has offices at UIB, the CSIC comprises government scientists independent of the University and thus not working with students. Access to student participation can be achieved by Dr Paul retaining an involvement; the advantage of Dr Altaba's participation is not just his expertise but the year-round coverage he would be able to offer and which is necessary to further elucidate this and other mollusc problems. Dr Paul makes other very relevant recommendations for future mollusc research which appear under other headings in this document (see 3.1.3.5, 3.5.1.1 and 3.6.7).

3.1.2.7 Frog studies

Frogs *Rana ridibunda* are a visible and very audible component of the wetland fauna at S'Albufera and undoubtedly play an important role both as predators of invertebrates and small fish, and as prey to larger fauna (including birds and mammals). Attempts have been made to come to terms with the frog population, particularly in assessing numbers and distribution, but the results have been poor and are thought to severely underestimate the total population. Even basic facts such as the timing of the annual cycle are poorly known. A much better knowledge of frog populations is urgently needed and best achieved through a postgraduate study. I have not yet approached anyone, but the base for herpetological studies in Britain is at the Sir David Attenborough Laboratories, School of Life Sciences, De Montfort University, Leicester. I was until recently a postgraduate member of these laboratories and am in a position to make further enquiries about the feasibility of such a study. The Mallorca frog is also of interest because it is *R. r. perezii*, a distinctive race (sometimes given full species rank) which is thought to have originated in North Africa.

3.1.2.8 Fish population studies

Professor Newbould identified knowledge of the fish population as high priority from the start and a study using electro-fishing techniques, led by a Spanish scientist, was part of the programme in the first year. Unfortunately, he withdrew at the last moment and we have not been able to obtain the services of a fish scientist since. It still remains an area we should consider as

we strive towards a fuller understanding of the aquatic systems, and it has been suggested that we seek the expertise of the Tour du Valat Biological Station in this area.

3.1.3 The dune systems

3.1.3.1 Orchid population dynamics

Terry Wells has been studying the Park's orchid populations since 1991, using methodology and techniques designed by himself as part of his research into British orchid population dynamics for the Institute of Terrestrial Ecology (ITE). The study, which looks into recruitment and mortality of orchids within fixed quadrats, is currently mainly focussed on the fossil dune area, though he is also monitoring the *Orchis (laxiflora) palustris* populations of the reedbeds. This is a long-term monitoring study of a key group of species.

3.1.3.2 Studies of dune plant hierarchies

The coastal dunes show a succession to climax pine forest. This succession has frequently been arrested by fires. The most recent evidence is in the southern part of the coastal dunes where the vegetation is recovering from fires approximately eight years and fifteen years ago respectively. There are also differences in vegetation composition in relation to aspect, drainage and proximity to the sea. Three permanent transects have been set up and recorded by Dr Franklyn Perring. Dr Perring has indicated a willingness to return and initiate the continuation of this work in collaboration with other scientists committed to re-recording

the vegetation along these transects at regular time intervals.

3.1.3.3 Sand-dune evolution past and present

Dr van der Meulen, member of the scientists' review group present in April 1992, is vice-president of the European Union for Coastal Conservation (EUCC) and a member of the conservation organisation ECODUNE so was, not unnaturally, very interested in the evolution of the sand-dunes, particularly the coastal set. He suggested that the Project should study past, present and future changes in the foreshore (accretion and erosion) using photographic material and techniques. The study should also take into account sea level changes and the role of the sea-grass *Posidonia* in promoting accretion. This study would be of particular relevance to 3.1.3.2 above and, because the rare juniper *Juniperus oxycedrus macrocarpus* is virtually restricted to the coastal zone immediately abutting the beach where it is at risk from erosion, is also of importance for future management planning. It would also, hopefully, give impetus to our request to the Balearic government, through the good offices of Joan Mayol, to install an automatic sea level recorder at S'Albufera.

Dr van der Meulen indicated that he and his department of Physical Geography and Soil Science at the University of Amsterdam would be interested in becoming more closely involved in the Project and this is one area where we may wish to avail ourselves of his expertise. His participation may also be seen as a step towards integrating our monitoring work into international

networks, in this case the EUCC and ECODUNE.

3.1.3.4 Gra zing influence of mammals on fossil dune vegetation

Horses and cattle are grazed on the fossil dunes and the flora may be changing because these avoid *Euphorbia terracina* , which seems to be increasing. To monitor this Jo Newbould set up, in April 1992, a grid designed to determine the current and future distribution of the *Euphorbia* . In addition she has taken photographs of the area from fixed points, as a further means of assessing distribution and change. We do not know whether the impact of *Euphorbia terracina* is of a permanent or merely temporal nature. However, photography has given us the opportunity to follow the plant's annual cycle, thanks to the participation of Mallorcan volunteer, Tomeu Tomas, who has volunteered to repeat the photography on a monthly basis. This study also has relevance to section 3.2 below.

3.1.3.5 Mol lusc studies

Dr Paul (University of Liverpool's Department of Earth Sciences) recognised several questions which need to be answered regarding mollusc distribution in the sand dunes. He writes: "there is a general question as to what characteristics of the dune habitats are essential for the various [mollusc] species of the dune fauna. If it is just drainage, species should be equally at home on the fossil dunes of Ses Puntes and the area NW of Ca'n

Picafort as they are on the modern dunes. If proximity to the sea is important, some may survive on the modern dunes but not the fossil ones inland. Another point concerns the vegetation. Are the well wooded parts of the dunes significant? If so, some species may be absent on the bare ridge of Ses Puntes, but present in the wooded parts of both the Fossil and Recent dunes".

He recommends that, in conjunction with the dune vegetation transect studies already underway, comparisons should be made between populations of "dune snails" on recent and fossil dunes to assess how stabilization of dunes by vegetation, and the transition from grassland through scrubland to woodland, affects such species. Assessment of the influence of the sea by comparing similar microhabitats between recent and fossil dunes could be undertaken at the same time.

3.1.3.6 Insect studies

A north-south transect has been set up through the centre of the coastal (Es Comu) dunes to record butterflies and dragonflies. The transect has been divided into six sections, each reflecting a different habitat type and/or age after burning. The information gathered will demonstrate use of these habitats by butterflies, and possibly dragonflies, and the effects of vegetation change on their abundance and species' composition.

3.1.3.7 Bird population studies

Part of a longer transect, sampling major Park habitats, has been

set up through the centre of the coastal (Es Comu) dunes to record birds. The information gathered will demonstrate use of this habitats by birds and the effects of vegetation change on their abundance and species' composition.

3.1.4 The whole catchment of the Park and adjoining coastal waters

3.1.4.1 Remote Sensing

Work was begun in 1992 to incorporate remote sensing as part of our research. In the spring, Earthwatch volunteers did some "ground-truth" fieldwork in preparation for two studies undertaken in the summer by postgraduate students from the University of Aberdeen's Centre for Remote Sensing and Mapping Science. They undertook field work at S'Albufera based on two Landsat images shared by the Centre and Earthwatch Europe. One student looked at the current and recent distribution of Cladium and Phragmites and the other current and recent soils and land-use on agricultural land abutting the Park. Both studies were successful. Dr Loder of the Centre has indicated that there are many further studies which could be done by his department, in these and allied areas of research. I am very keen to maintain this link. The Centre for Remote Sensing and Mapping Science has an international reputation for remote sensing work, they are keen to participate and, most important of all, they already have a link with Spanish Universities including the UIB's Department of Geography. One of the 1992 studies was undertaken by a Mallorcan and the other by a Peninsular Spaniard. One of our

Mallorcan volunteers, who was instrumental this spring in advising us on "ground truthing" and digitising data in GIS (Geographic Information System) form, has just joined the department at Aberdeen.

One of the essential elements of the remote sensing studies is comparative information in order to monitor long term change on an objective basis. Studies which lend themselves to remote sensing methodology and which The Aberdeen Centre is keen to study include: the input of sediment plus suspended solids to the wetland and release via outflows to the Bay under normal and flood conditions; movement of sediment within the offshore, beach and dune systems; and changes in abundance and distribution of the important *Posidonia* (sea-grass) beds offshore in the Bay of Alcludia.

3.2 The impact of management and related studies

The Project needs to gather data on management events because these may impinge on the ecological and other processes being studied. In addition, some of the research undertaken by Project S'Albufera will have a direct bearing on planning of management and may serve to guide that management in the future.

3.2.1 Current management practices

Sara Hawkswell from the Royal Society for Nature Conservation has initiated work to adapt the British Countryside Management System (CMS) to the S'Albufera situation. This will be of help to the Park staff and to Project S'Albufera because the system records

management of the Park, both past and present. She is aiming to incorporate all types of work being done in the Park including practical management, monitoring, educational visits and research projects. This would ensure access by all interested bodies to relevant data and should begin to bring the different aspects together. Teething problems in setting up this system include time available by Sara and the Park staff to work on it.

3.2.2 Impact of Park habitats on the bird fauna

During fieldwork periods daily counts have been maintained of the maximum number of each bird species during a ten minute period from hides overlooking defined areas of grazed and ungrazed marsh. This study has been designed to compare the use by migrant and resident birds of open areas of marsh managed by grazing with those managed by other means or unmanaged.

3.2.3 Bat studies

Jean-Francois Noblet, a bat expert with specialist knowledge of the Mediterranean island bat fauna of Corsica, joined the Project in May 1992 to compile an inventory of bats present in the Park, to assess their importance as components of Park fauna and to propose future management planning of benefit to bats.

Jean-Francois recorded ten species, including several which are scarce or of restricted European range. His most notable discovery was that S'Albufera supported a population of

Barbastellus barbastellus, an extremely rare species in Spain and not previously recorded from the Balearic Islands. He concluded from his studies that S'Albufera was a very favourable site for bats, abundant water and invertebrate food associated with the

wetland situation being of particular benefit to this group. He found, however, that there was a shortage of roost and breeding sites, compounded by the lack of suitable old buildings within the Park and disturbance at roost caves in the foothills adjacent to the Park. He made a whole series of practical proposals designed to overcome this problem, including better protection of cave sites through well maintained entrance grills and the introduction of purpose built roost/nest boxes under Park bridges, on Park buildings etc.

Jean-Francois considered that there was considerable scope for more extensive work on S'Albufera bats. He pointed out that bats are under pressure from environmental change, loss of breeding and roost sites and the effects of pollution on their insect prey etc. throughout their European range and it was one of the roles of the Parc Natural to afford them protection. He recommended therefore that further studies be conducted. He has offered to extend his work in establishing the composition and role of the bat fauna by visiting during the period of reproduction (June to September) when he would continue to sample the population by mist-netting at night in a wide range of Park habitats. He also recommended that the study would benefit from the employment of a bat ultra-sound detector accompanied by a specialist in its use. He indicated that he could find such a person. In addition, he felt that careful dissection of owl pellets could also throw light on the bat population of S'Albufera but lamented that the removal of the old mill buildings had deprived the bats' major predator, Barn Owl *Tyto alba*, of a breeding site within the Park. He therefore made a practical proposal (including drawings) for

the Park authorities to create an artificial nest site in the old farm building at Ses Puntetes.

3.2.4 Grazing influence of mammals on fossil dune vegetation

This study, described under 3.1.3.4 above, is also relevant to the study of the impact of management.

3.3 Environmental and socio-economic studies

There is some overlap between this category and category 3.1.4 (studies of the whole catchment and immediate marine environment offshore), particularly regarding remote sensing and associated aerial photographic survey work.

3.3.1 Environmental functions and values

At the scientists' review meeting Dr Rudolf de Groot presented a novel way of studying the "value" of natural sites which has immediate appeal both from an environmental and socio-economic viewpoint. His method comprises an analytical approach for assessing the sustainable use of the wetlands by identifying the key environmental functions which it performs and assigning values to these functions. His functions, which he has applied in a number of natural areas in widely scattered parts of the world, are grouped into regulation, carrier, production, and information. Each of these is sub-divided and all the functions can be assessed and evaluated in relation to ecological, social and economic criteria. The management implications can then be deduced.

S'Albufera lends itself to this new analytical approach and such an assessment would be of benefit to the Project and to the Park authorities. We should explore the possibility of developing this line of study by asking Dr de Groot, through his and other Departments at the Agricultural University of Wageningen, to become more actively involved with the Project - perhaps through a series of studentships designed to collect and analyse the data required.

3.3.2 Land- use and vegetation

Both Dr de Groot and Dr van der Meulen stressed the importance of taking into account the entire catchment area, coastline and immediate offshore in any study of the processes at work in the Park. Dr van der Meulen concluded: "it is clear that events outside the Parc may exert considerable influences within it - and vice versa - so that any attempt at analysis must include the whole catchment and the coastline. For example, the Parc is probably important in regulating the flow of water from the hinterland to the sea; it serves as a recharge area and there may be recycling of nutrients and thus a positive influence on the quality of water leaving the area. In turn, the Parc is affected by the amount and quality of water entering it and activities in the watershed such as horticulture and water abstraction."

Dr van der Meulen indicated that he and his Department of Physical Geography and Soil Science at the University of Amsterdam would be interested in becoming more closely involved in the Project. A number of the studies proposed in this document are aimed to elucidate aspects of the impact of events described above (e.g. the remote sensing work begun and planned by the

University of Aberdeen's Centre for Remote Sensing and Mapping Science). However, Dr van der Meulen has particular knowledge and experience in areas of direct relevance to the Project (e.g. coastal studies) and we should not miss the opportunity to avail ourselves of his expertise. Currently, Dr van der Meulen has proposed that a team of students from his University undertake a mapping study of the vegetation and land-use in and around S'Albufera.

3.3.3 Past History & Land Use

This is a subject which was studied by UCL Ecology and Conservation Unit students. Their findings have been summarised but there is a considerable need for the study to be extended and information collected and collated in much greater detail. This may also be a study suitable for a UCL postgraduate student, but would perhaps be better tackled by a Mallorcan, perhaps a postgraduate of the Department of Geography but specialising in aspects of social geography/demography. This study also has relevance to studies of the evolution of S'Albufera described in 3.6.1 and 3.6.2.

3.3.4 Soils /sediments

Soil studies were undertaken in spring 1991 but the researcher failed to produce any documentation of her results. However, the Project needs detail of soils and sediments. This is best accomplished by bodies such as the University of Aberdeen, University of Amsterdam and University of Liverpool as an integral part of their studies of land use, remote sensing and

the geological past. This study also has relevance to studies of the evolution of S'Albufera described in 3.6.1 and 3.6.2.

3.3.5 Tourism related studies

In 1989 the UCL Ecology and Conservation Unit undertook preliminary studies of visitor impact on the Park, but there is ample scope for this work to be continued and expanded. Indeed, Joan Mayol is very keen to obtain more and better data. To achieve this we would need to seek expertise in the field. This may be an area of research that could be incorporated by Dr de Groot in his integrated socio-economic studies. Alternatively it might be achieved through UCL postgraduate research. Such a study would also be of benefit to the Tourist industry and funds should perhaps be sought from that avenue. Dr Perring has offered to advise.

3.4 Furtherance of data-processing and the data-base potential and methodology, including development of compatible systems for comparative work and integration into international networks and schemes

3.4.1 Storage and organisation of data, use of GIS

Research data should be incorporated in a site database, used also for data collected by Park staff, including meteorological and hydrological data. The importance of historic data and the necessity of making them available in readily accessible electronic form should be given more attention. A student from the UIB's Department of Geography was instrumental in setting up

a GIS recording system for the ground-truthing work done by Bernie Young. The adoption of GIS is a particularly important step towards ensuring wider applicability of Project S'Albufera data. Knowledge and expertise in GIS is clearly available at UIB and this is an area where we should encourage their involvement. We have received strong indications, via Joan Mayol, that UIB's geography department, through their Head and vice-rector of the University Dr Climent Picorell, is interested in becoming more involved with the Project. This department also has close links with the University of Aberdeen's geography department which, through its Centre for Remote Sensing and Mapping Science, is already participating in the Project.

The scientists review meeting recommended that integration through a GIS as a database should be made through the European Environmental Agency (EEA).

3.4.2 Development of ecological data bases

The problems involved in setting up a computer-based package to record management is described in 3.2.1 above. Even more problems beset us with development of a computerised system of storing and processing biological records. Sara Hawkswell indicates that the RECORDER database used in Britain is not suitable for immediate conversion to a system for wide use in Mallorca or Spain. Particular difficulties would arise from changing the species dictionary, codings, language and system maintenance. She recommends that a system should be devised to store all the data and make them readily available to all users in a variety of

formats. In order to accommodate future uses of these data (for example incorporation into a GIS or a network of biological databases), potential data standards should be considered.

This is specialist work, requiring time and commitment. Sara Hawkswell has a full-time job and inevitably does not have the time to commit to develop such a system in the time-scale we would need. I identify this as suitable for a postgraduate studentship, probably by someone in Computer Science with a specific interest in the natural world.

3.4.3 Gridding the Park

The Park Directorate has divided the Park area, for descriptive and mapping purposes, into 30 sectors/compartments. Sara Hawkswell feels that, though a computerised database can deal with records by compartment, this may be insufficient detail for the purposes of Project S'Albufera. There is general agreement among Project scientists that we should seek a more accurate recording system, relating records to UTM (international grid system as used by Ordnance Survey style maps). To do this our options are 1) to grid the Park, 2) to use a global position retriever (satellite-generated location retriever system).

There are a number of problems afflicting the first option. Joan Mayol does not want visible location points (i.e. he does not want visitors to see a series of posts scattered through the Park). We have solved this problem for quadrats and transects by sinking markers to or below surface level which if not visible at a later date may be located using a metal detector. This may be less appropriate or straightforward for more wide-ranging

studies. In addition, very few UTM intersection points occur in suitable locations - the setting up of reference points, visible or otherwise, in the middle of reedbeds is of little use to the Project (as well as a practical impossibility). Even if a grid system was set up, using tracks and other firm ground, this would require a lot of time and the involvement of someone with surveying expertise. The only such person at the Park, Biel Perello, has given indications that he might be able to help, but always his time has been fully usurped by his Park responsibilities. The second option may be more favourable, at least initially, and would prove a useful tool if we progressed to gridding at a future date.

3.4.4 Interpretive and educational

Practical application of data collected by the Project has begun through a collaboration between the Park's Technical Assistant Biel Perello and Project scientists Dinah McLennan and Jo Newbould. They are currently working together to produce display material and hope to follow that with a brochure or more detailed publications based on Jo's studies of the Park's botany, Dinah's artistic skills and Biel's knowledge of the Park and relevant languages. These materials would be directed to interpreting S'Albufera plantlife for visitors to the Park.

3.5 Studies aimed at assessing environmental change

One inevitable by-product of the studies described above will be information which may be used to assess environmental change.

Other studies currently in place or recommended have been specifically designed to achieve that objective. They fit into two sub-categories: 1) in-depth ecological studies; 2) constant or regular long-term monitoring.

3.5.1 Ecological studies

Studies in this category are ones which cannot be achieved by the Project in its present form of "snap-shot" field visits of short duration but which nevertheless are necessary if we are to understand the ecosystems and change. They do, however, make ideal subjects for postgraduate students to tackle.

3.5.1.1 Mollusc studies

Dr Paul (University of Liverpool's Department of Earth Sciences) recommends research topics which would seek more information about the ecological preferences of certain species. He has outlined the following.

1. Establishing basic ecological requirements and life cycles for endemic snails, particularly the operculate snail *Tudorella*, which would involve monitoring selected populations. Since its range has been reduced over the geologically recent past, understanding its ecological requirements may be the key to its continued survival, although it is not a threatened species at present. It is widespread and common in Mallorca and Menorca, but unknown elsewhere in the world. It is recorded as a Pleistocene fossil from Ibiza, Sardinia and possibly southern France. This study, therefore, has an element of change based on past changes. What ecological conditions exist for the survival of the species in S'Albufera which no longer exist in other

areas?

2. The precise ecological preferences of the three species of *Cochlicella* is recommended as an interesting study. Both Dr Paul and a previous observer noted that *C. barbara* was commonest alive within the marsh (though still on dry canal banks), while *C. conoidea* seems to be confined to the dune areas, both fossil and recent. *C. acuta*, the most widespread of the three, may be the most ecologically tolerant though even it was rarely seen by Dr Paul alive away from dunes and well drained paths. How, or even if, *C. acuta* and *C. conoidea* partition the dune habitats would be well worth studying. Such a study could easily be undertaken as a wider part of the dune transect studies already underway. There is probably, for instance, no information about the dominant plant species found at sites where *Cochlicella* is recorded let alone their food preferences or which species of plant they climb up in summer to aestivate.

3. Similar studies could be made of other congeneric species, e.g. why is *Trochidea* (*T.*) *elegans*, the more widespread species, so restricted in its occurrence in S'Albufera, whereas *T.* (*T.*) *trochoides* is more common in the dunes? Equally, what are the precise requirements/ preferences of the three species of *Vallonia* ?

3.5.2 Long-term monitoring

3.5.2.1 Entomological: moth studies

Once a comprehensive inventory of lepidoptera has been established (see 3.6.8), Barry Goater plans to outline a

monitoring programme based on light trap captures of moth species which are easy to recognise and likely to be key indicator species (e.g. for their impact at larval stage on major plant species such as *Phragmites*). Barry has already discovered that S'Albufera supports a healthy population of the moth *Pelusia plumosa* , an obscure but extremely interesting species known only from a few localities in southern Spain, north Africa and southern Italy and not recorded before from the Balearic Islands. Regular moth trapping will confirm the importance of S'Albufera for this species and provide information of its future status. Park staff assistance may be required in maintaining a regular trapping regime under guidance from Barry.

3.5.2.2 Entomological: butterfly monitoring

Two transects, one based in the coastal sand dunes and a longer one sampling all major Park habitats, have been established. Both transects are divided into sections, each reflecting a different habitat type. All species are counted within each section. The information gathered will demonstrate variations in the numbers and composition of butterflies and their use of Park habitats.

This study has been set up and is carried out by Nick Riddiford with Earthwatch volunteers. The period of study was extended through the summer in 1991 by a Mallorcan volunteer.

3.5.2.3 Bird population dynamics

Two transects, each of approximately 7 km and sampling all major Park habitats, have been established. Both transects are divided into sections, each reflecting a different habitat type. All

species are counted within each section. The information gathered will demonstrate variations in the numbers and composition of breeding and migrant birds and their use of Park habitats.

This study has been set up by Nick Riddiford but has been extended beyond the periods of Earthwatch field presence by Jon King, ornithological researcher from the Edward Grey Institute, University of Oxford, who is currently based there.

3.5.2.4 Fitness of migrant birds

Passage migrants are counted in April/May and a sample trapped as part of a study of body condition in passage birds. The main "target" species is the Swallow *Hirundo rustica*. This is primarily the work of Jon King and is continued through the year by JK and the Park ornithologist, Pere Vicens. The study aims to elucidate the importance of S'Albufera for migrant birds, particularly in times of poor weather. Like many of the studies carried out as part of Project S'Albufera, this research seeks good, comprehensive meteorological data to assist in the elucidation of processes.

3.5.2.5 Meteorological recording

The Park operates a simple weather station but the data it collects are insufficient for the needs of the Project. The nearest site which collects the quality of data which many of the Project's studies require is several kilometres away near Sa Pobla. Ideally a more sophisticated weather station, in line with the Environmental Change Network (ECN) sites in the UK, should be

installed at S'Albufera.

Dr Toni Martinez has offered to approach Dr Climent Ramis, of the UIB's Department of Meteorology about becoming actively involved in meteorological aspects of the Project. The head of this Department, Dr Sergio Alonso, has an active interest in Climatic Change and has urged the Spanish government to sign the IGBP protocol - which he sees as integrating climatic change studies to produce a vehicle for shaping government environmental policy. He and his Department are active in an ICSU-led initiative to establish a Regional Climate Investigation Centre which will study climatic variations in the Mediterranean and sub-tropical Africa region.

The involvement of this Department would be extremely useful for it may advance our request for the establishment of a sophisticated weather station at S'Albufera. If this is established we may also be able to seek the participation of Dr Rudolf de Groot in his capacity as co-ordinator of the Climate Change Research Centre at the Agricultural University of Wageningen.

3.5.2.6 Other studies

Several studies described elsewhere, for example Orchid population dynamics (3.1.3.1) and Studies of dune plant hierarchies (3.1.3.2), also have a long-term monitoring element.

3.6 Extension of baseline information

3.6.1 Evolution of S'Albufera: coring study for pollen

This study is being conducted by scientists from the Geography departments of the University of Barcelona and UIB. Though this constitutes independent research not initiated or suggested by Project S'Albufera , it is of direct relevance to our work; it will, by relating the pollens found to species and date, give a much clearer understanding of the past evolution of S'Albufera. I have spoken to one of the scientists involved who indicated that the results would be published and thus become available to us. He also indicated that the geological cores from which the pollen analysis would be taken could be made available to Project S'Albufera for parallel studies (see 3.6.2 below).

3.6.2 Evolution of S'Albufera: Diatoms in geological cores

If we do get access to the cores outlined in 3.6.1 above, geological research could be extended by the involvement of the University of Liverpool's Department of Earth Sciences under the leadership of Dr Andy Plater. Dr Plater has indicated that he would be in a position to investigate the Holocene/Pleistocene sediments and, hopefully, return with some material for pollen and diatom analysis. He writes "my primary interest is coastal evolution in relation to Holocene sea-level trends, so this opportunity is very appealing". This study could make an important contribution to our understanding of the past evolution of S'Albufera and its environs.

3.6.3 Flowering Plant distribution by management compartments

This work was begun by Dr Franklyn Perring in 1992 and he has indicated his willingness to continue with the study and produce a plant recording card. The study interrelates with the herbarium work described in 3.6.4 below.

3.6.4 Herbarium

Jo Newbould, assisted by other botanists and Earthwatch volunteers, has continued to build up the herbarium, augmented by a series of photographs, slides and line drawings. She has also drawn up a comprehensive list of known S'Albufera flowering plants which demonstrates that the herbarium is far from complete. The herbarium now has its own dedicated herbarium cupboard which is extensively used by Project workers and Park staff alike. There is also a comprehensive card index for all S'Albufera flowering plants. Jo will continue her responsibility for the herbarium and flowering plant inventory with the aim of making it as comprehensive as possible. Dinah McLennan continues to play an important role in supplementing the reference collection with accurate line drawings. They are planning to use this work as a basis for preparing material which may be used to interpret plantlife for visitors to the Park (see 3.4.4).

3.6.5 Extension of herbarium material to include lichens and mosses

A small collection of lichens has been established at the Park, based on identifications made by Tom Chester of specimens taken to England. It is far from complete, and no work has been done on the bryophytes. Lichens in particular are known to be sensitive

to air quality and may be a key group for this line of study. Work should initially comprise establishing a species inventory with reference material, but eventually there is scope for research, probably at postgraduate level, into lichen distribution and air quality within the Park. Dr P.D. Crittenden of the British Lichen Society and Department of Life Science of the University of Nottingham could be approached.

3.6.6 Fungi

Sheila Wells, wife of Principal Investigator Terry Wells, collected and identified fungi in April 1991 and April and November in 1992. Sheila plans to extend her fungal database on subsequent visits with her husband, including in April and October 1993.

3.6.7 Mollusc studies

Dr Paul (University of Liverpool's Department of Earth Sciences) points out in his report of 1991 work that basic data about life cycle (e.g. are they annual or perennial, when do they mate and lay eggs? etc.) are unknown for the endemic snails and slugs such as *Tudorella* , *Trochoidea* (*Xeroplexa*) *nyeli* , *Limax majoricensis* and probably for several other species (e.g. *Trichia lanuginosa* , *Otala* spp., *Pseudotachea*). Observations on these basic details would be very useful but would require a person with specialist knowledge and year-round access to the site (i.e. a student based at the Park or resident Mallorcan).

3.6.8 Invertebrate baseline studies including collection of reference material

Work to establish an on-site reference collection was given a boost, for lepidoptera, by the participation in May 1992 of British lepidopteran expert, Barry Goater. It is the aim of the Project to achieve a level of reference, including inventories, for invertebrates of a similar quality to that established for flowering plants. The Balearic Invertebrate Group have indicated their willingness to help with this task, e.g. for beetles, and Barry Goater has indicated his willingness to continue his participation - which includes studies and advice on other lepidopteran aspects of the Project (e.g. 3.1.1.4).

Barry has suggested that we expand our lepidopteran studies to include the "micros", the smaller species sometimes thought of as "insignificant" but nevertheless making a considerable impact on vegetation in their larval stages - hence the tag which many carry as "species of economic importance". He has recommended that we invite the Rev David Agassiz to undertake this part of the research.

3.6.9 Entomological: Odonata

Adult dragonflies are a very obvious part of the invertebrate fauna but difficult to study. To overcome this, in 1992 Ed Cross began to develop methodology to monitor the larval stages. Early results are extremely promising and Ed plans to refine his methodology further. His work demonstrates that the total number of dragonflies supported by the marsh at larval stage is very large, therefore the group will play an important role as predators of other small aquatic fauna and as prey to fishes,

frogs, some birds and other fauna. The adults are an important food source for the globally rare Eleonora's Falcon which gathers at S'Albufera to hunt dragonflies prior to its breeding season. The Cross methodology has great potential for monitoring Odonata population dynamics and their role in and interactions with the wetland ecosystem. Future work will also be needed outside the main Earthwatch field seasons, particularly in summer.

3.6.10 Hoverfly studies

This study aims to extend our knowledge of the composition and seasonality of hoverfly (Diptera; Syrphidae) species using the Park and to monitor variations in the abundance of one easily recognisable migrant species, *Episyrphus balteatus*. This is achieved by counting the number of individuals of *Episyrphus balteatus* and recording all other Syrphid species seen within an establish transect route. This study was set up by Simon McKelvey but is currently carried out by Nick Riddiford with advice and identification assistance provided by Simon from his home base.

Hoverflies are often considered in Britain to be key indicator species of the health of wildlife habitats, based on diversity of species.

3.6.11 Invertebrates

A Balearic Invertebrate Group, under the leadership of Josep Antoni Alcover of CSIC and based at UIB in Palma, has been set up to further research into invertebrates in the Balearic Islands. Sr Alcover has indicated that specialist help would be available

to increase our baseline knowledge for a number of groups. This was demonstrated in 1992 by visits from members of this group specialising in beetles and spiders. They set a series of pitfall traps in a number of habitats, which they visited on a regular basis during the spring. All these specialists have research commitments elsewhere and, though their expertise and assistance would be welcome, their involvement with the Project is likely to remain low-key.

3.6.12 Small mammal studies

A pilot small mammal study was done by Keith Bowey in October 1992 and a fuller study is planned by the University of Durham's Department of Biology in spring 1993. In addition to gaining a greater knowledge of small mammal populations and distribution, these studies may obtain comparable data to the small mammal work of Dr Alcover in the early 1980s, and published by Barcelo and Mayol.

Part 4 . Tier structure

4.1 First Tier. Earthwatch funded monitoring

Project S'Albufera is very different from what would be considered the norm for Earthwatch funded research projects. Other projects tend to concentrate on one particular item of research requiring scientific staff levels far below that demanded by Project S'Albufera lines of research. Project

S'Albufera has been much more expensive in a number of areas, but especially in the travel costs of bringing scientific specialists to the Project, providing for their extra equipment needs and their accommodation. Ancillary additional costs include extra for provisions and transport within Mallorca.

To bring this into perspective I have included in Tier 1 a list of those areas of research which can be achieved by strict adherence to the funding possibilities offered by Earthwatch. They are set out below. The numbers in parentheses cross-reference to the summary paragraphs above describing the studies. I have included the scientist/body responsible for each study.

4.1.1 List of studies

1. TITLE: Orchid population dynamics (3.1.3.1)
RESPONSIBILITY: Terry Wells
2. TITLE: Bird population dynamics (3.1.1.6; 3.1.3.7; 3.5.2.3)
RESPONSIBILITY: Nick Riddiford
3. TITLE: Hoverfly studies (3.6.10)
RESPONSIBILITY: Nick Riddiford & Simon McKelvey
4. TITLE: Butterfly monitoring (3.1.3.6 and 3.5.2.2)
RESPONSIBILITY Nick Riddiford
5. TITLE: Impact of Park habitats on the bird fauna (3.2.2)

RESPONSIBILITY: Nick Riddiford

4.2 Second Tier. Studies which need to be tackled but depend on extra funding.

Over the first four years the Project has benefited enormously from the involvement of a series of scientists who have developed their own methodologies for tackling the many problems the Project has met. Many of these scientists remain involved with the Project and have studies in progress and/or which require further work. These studies are set out in Tier 2. The numbers in parentheses cross-reference to the summary paragraphs above describing the studies. As in Tier 1, I have included the scientist/body responsible for each study.

4.2.1 List of studies

1. TITLE: Autecology of Phragmites and Cladium (3.1.1.1)
RESPONSIBILITY: Palmer Newbould (with UIB back-up).
2. TITLE: Studies of dune plant hierarchies (3.1.3.2)
RESPONSIBILITY: Dr Franklyn Perring.
3. TITLE: Grazing influence of mammals on fossil dune vegetation
(3.1.3.4)
RESPONSIBILITY: Jo Newbould (3.1.3.4).
4. TITLE: Current management practices (3.2.1)
RESPONSIBILITY: Sara Hawkswell, RSNC; S'Albufera Park staff.

5. TITLE: Bat studies (3.2.3)
RESPONSIBILITY: Jean-Francois Noblet.
6. TITLE: Interpretive and educational (3.4.4)
RESPONSIBILITY: Biel Perello, Technical Assistant, Parc
Natural de S'Albufera ; Dinah McLennan and Jo Newbould,
Project scientists.
7. TITLE: Entomological: Moth studies (3.5.2.1)
RESPONSIBILITY: Barry Goater, Project scientist; Andreu
Muntaner, Warden, Parc Natural de S'Albufera .
8. TITLE: Plant distribution by management compartments (3.6.3)
RESPONSIBILITY: Jo Newbould; Dr Franklyn Perring.
9. TITLE: Herbarium (3.6.4)
RESPONSIBILITY: Jo Newbould.
10. TITLE: Fungi (3.6.6)
RESPONSIBILITY: Sheila Wells.
11. TITLE: Invertebrate baseline studies including collection of
reference material (3.6.8)
RESPONSIBILITY: Barry Goater; Rev David Agassiz.
12. TITLE: Entomological: Odonata (3.6.9)
RESPONSIBILITY: Ed Cross.
13. TITLE: Small mammal studies (3.6.12)
RESPONSIBILITY: Keith Bowey.

14. TITLE: Remote Sensing (3.1.4.1)

RESPONSIBILITY: John Loder, Centre for Remote Sensing and Mapping Science, University of Aberdeen; Bernie Young.

4.3 Third Tier. Parallel studies planned for 1993-94 by Universities and other bodies.

We have always recognised that much of the more innovative, detailed and temporally extended work should be undertaken by Universities and other bodies in partnership with the Project (and thus in partnership with Earthwatch Europe). Steps towards achieving this were already in place by the time the review group met (e.g. co-operation agreement signed between Earthwatch Europe and the University of the Balearic Islands, Earthwatch Europe sponsored or part-sponsored studies by post-graduate students from University College London and the University of Aberdeen's Centre for Remote Sensing and Mapping Science). However, the review group meeting stimulated an increased interest and commitment from Universities, not least several scientific departments of the UIB - seen by us as an essential development for the future of the Project as the University "on the spot" and with most to gain from involvement in this international venture. The list which follows includes a number of studies suggested or encouraged by scientific members of Project S'Albufera but offered as a direct result of the review group meeting (and in particular the enthusiasm and insistence of the two Dutch scientists in the group who urged UIB scientists to grab what they saw as a great opportunity to participate in an

international project of great potential). As in Tiers 1 & 2, I have included the person/body responsible for each study. The numbers in parentheses cross-reference to the summary paragraphs above describing the studies.

4.3.1 List of studies

1. TITLE: Photosynthesis and productivity of marshland plants

(3.1.1.2)

RESPONSIBILITY: Hipolito Medrano, Dept of Vegetal Physiology, UIB; Roger Austen, University of Cambridge.

2. TITLE: Decomposition of reedbed plants (3.1.1.4)

RESPONSIBILITY: Dr Enrique Descals, Department of Environmental Biology & Dr Antoni Martinez, Department of Limnology, UIB.

3. TITLE: Study of relationships between *Archanara geminipuncta* biology, Reed Bunting feeding and breeding biology and their impact on *Phragmites* reed (3.1.1.5)

RESPONSIBILITY: Anna Traveset, CSIC, Palma.

4. TITLE: Ornithological studies: Moustached Warblers (3.1.1.7)

RESPONSIBILITY: Dr Chris Perrins, Edward Grey Institute for Field Ornithology, Oxford University; Dr Bernd Leisler Max-Planck-Institut fur Verhaltensphysiologie, Germany.

5. TITLE: Hydrogeological study (3.1.2.1)

RESPONSIBILITY: Dr Alfredo Baron, Balearic Hydrological Service.

6. TITLE: Water quality and pollutants (3.1.2.2)

RESPONSIBILITY: Drs Martinez and Medrano, Department of
Biology, UIB.

7. TITLE: Vertical nutrient exchange between water and sediment
(3.1.2.3)

RESPONSIBILITY: Drs Moya, Ramon & Martinez, Department of
Biology, UIB; two collaborators from the University of
Barcelona.

NOTE: Independently funded research study begun in 1992.

8. TITLE: Freshwater macrophytes and water quality (3.1.2.4)

RESPONSIBILITY: Dr Martinez, Department of Biology (Limnology
Section), UIB; Dr Enrique Descals, Department of
Environmental Biology, UIB; Dr Sven Jonasson, Institute
of Plant Ecology, University of Copenhagen.

9. TITLE: Freshwater invertebrates & water quality (3.1.2.5)

RESPONSIBILITY: Dr Roderick Fisher, Ecology and Conservation
Unit, University College London.

10. TITLE: Mollusc studies (3.1.2.6; 3.1.3.5; 3.5.1.1; and
3.6.7)

RESPONSIBILITY: Dr Chris Paul, Department of Earth Sciences,
University of Liverpool; Dr Cristian Altaba, CSIC,
Palma.

11. TITLE: Sand-dune evolution past and present (3.1.3.3)

RESPONSIBILITY: Dr van der Meulen, Department of Physical
Geography and Soil Science, University of Amsterdam.

12. TITLE: Remote Sensing (3.1.4.1)

RESPONSIBILITY: John Loder, Centre for Remote Sensing and

Mapping Science, University of Aberdeen.

13. TITLE: Environmental functions and values (3.3.1)

RESPONSIBILITY: Dr Rudolf de Groot, Climate Change Research
Center, Agricultural University of Wageningen.

14. TITLE: Land-use and vegetation (3.3.2)

RESPONSIBILITY: Dr Frank van der Meulen, Department of
Physical Geography and Soil Science, University of
Amsterdam.

15. TITLE: Storage & organisation of data, use of GIS (3.4.1)

RESPONSIBILITY: Sara Hawkswell; Dr Climent Picorell,
Department of Geography, UIB; Dr John Loder, Centre
for Remote Sensing and Mapping Science, University of
Aberdeen.

16. TITLE: Fitness of migrant birds (3.5.2.4)

RESPONSIBILITY: Jon King, EGI, University of Oxford; Pere
Vicens, Ornithologist, Parc Natural de S'Albufera .

17. TITLE: Evolution of S'Albufera: coring study for pollen
(3.6.1)

RESPONSIBILITY: Dr Ramon Julia, Institut Jaume Almera,
University of Barcelona

NOTE: Independently funded research study begun in 1992.

18. TITLE: Evolution of S'Albufera: Diatoms in geological cores
(3.6.2)

RESPONSIBILITY: Dr Andy Plater, Department of Earth Sciences,
University of Liverpool).

4.4 Fourth Tier. Studies which are needed but for which no scientists/means are available.

This tier is included for completeness. Although the funding to meet these extra studies is not currently available we cannot afford to omit items of research which are key to our full understanding of the processes and ecosystems. If funding remains difficult, these studies are at least on paper for consideration at a later date. In the list which follows, the numbers in parentheses cross-reference to the summary paragraphs above describing the studies. Areas of responsibility have been given but these are proposed rather than indicating acceptance or commitment by the scientists/organisations involved.

4.4.1 List of studies

1. TITLE: Heavy metals in marsh plants (3.1.1.3)
RESPONSIBILITY: Maria Pou Bordoy, Catalina Cabot and John Sibole, Department of Vegetal Physiology, UIB.
2. TITLE: Bird predator studies (3.1.1.8)
RESPONSIBILITY: Heinz Hafner, Tour du Valat Biological Station, Camargue, France.
3. TITLE: Frog studies (3.1.2.7).
RESPONSIBILITY: Herpetological department, Sir David Attenborough Laboratories, De Montfort University, Leicester.
4. TITLE: Fish population studies (3.1.2.8)

RESPONSIBILITY: Alain Crivelli, Tour du Valat Biological
Station, Camargue, France.

5. TITLE: Past History & Land Use (3.3.3)

RESPONSIBILITY: Dr Climent Picorell, Department of Geography,
UIB; or Ecology and Conservation Unit, University
College London.

6. TITLE: Soils/sediments (3.3.4)

RESPONSIBILITY: Geography/Earth Science Departments of the
University of Aberdeen, University of Amsterdam or
University of Liverpool.

7. TITLE: Tourism related studies (3.3.5)

RESPONSIBILITY: Dr de Groot, Agricultural University of
Wageningen; or Ecology and Conservation Unit, UCL.

ADVISOR: Dr Franklyn Perring.

8. TITLE: Development of ecological data bases (3.4.2)

RESPONSIBILITY: Sara Hawkswell, RSNC; postgraduate in Computer
Science.

9. TITLE: Gridding the Park (3.4.3)

RESPONSIBILITY: ?Park Directorate; specialist surveyor.

10. TITLE: Meteorological recording (3.5.2.5)

RESPONSIBILITY: Dr Climent Ramis, Department of Meteorology,
UIB; Dr Rudolf de Groot, Climate Change Research
Centre, Agricultural University of Wageningen.

11. TITLE: Extension of herbarium material to include lichens &

mosses (3.6.5)

RESPONSIBILITY: Dr P.D. Crittenden, School of Life Science,
University of Nottingham.

12. TITLE: Invertebrates (3.6.11)

RESPONSIBILITY: members of Balearic Invertebrate Group,
CSIC-UIB, Palma.

APPENDIX 5 - 1993 programme details

Project Title

Monitoring for environmental change at S'Albufera, Mallorca.

Research Site

Parc Natural de S'Albufera , Mallorca, Spain.

Principal Investigators

Nick Riddiford (Teams I-IV)

Dr Terry Wells (Team II)

Team Dates in Field

TEAM I March 28-April 11, 1993

TEAM II April 14-April 28, 1993

TEAM III May 1-May 15, 1993

TEAM IV October 23-November 6, 1993

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

Fields of Research

Botanical

1. Orchid population studies (Terry Wells)
2. Dune transects (Franklyn Perring)
3. Herbarium (Jo Newbould; Perring; Dinah McLennan)
4. Plant Illustrations/Preparation of display material (Dinah
 McLennan)
5. Distribution of *Euphorbia terracina* in areas of grazing (Dinah
 McLennan)
6. Fungi (Sheila Wells)

Vertebrates

1. Bird population studies (Nick Riddiford; Jon King; Mike Wood)
 - transects, point counts, Moustached Warbler distribution,

constant effort site ringing, body condition of migrants

2. Bird foraging studies (Mike Wood)
3. Mammal population studies (University of Durham)

Remote Sensing

1. Ground-truthing census work (Bernie Young as preparation for further work by students of Centre for Remote Sensing and Mapping Science, Department of Geography, University of Aberdeen, Scotland)

Hydrology

1. Preliminary studies of water quality (Alexandra Torn in partnership with UIB's Departments of Vegetal Physiology and Limnology)

Invertebrates

1. Entomology
 - a) insect reference collection (Riddiford; Goater)
 - b) studies of Diptera, Syrphidae (Riddiford)
 - c) butterfly and dragonfly transects (Riddiford)
 - d) odonata population studies (Ed Cross)
 - e) monitoring methods for night lepidoptera

Ecology of Phragmites

1. The ecological relationships of Phragmites, moth larvae and birds (Alan Radermacher)

Computerisation of Data

1. Program development for standardised data processing and storage (Sarah Hawkswell)

Project S'Albufera scientists, 1993

Team I 28 March-April 11

PI - Nick Riddiford

Jon King - ornithology

Alan Radermacher - ecology of Phragmites

Sarah Hawkswell - data programming

Team II 14-28 April

PI - Terry Wells

PI - Nick Riddiford

Sheila Wells - fungi

Jon King - ornithology

Alex andra Torn - water quality studies

Team III 1-15 May

PI - Nick Riddiford

Jon King - ornithology

Dinah McLennan - botany

Ed Cross - odonata studies

Bernie Young - remote sensing

Team IV 23 October-6 November

PI - Nick Riddiford

Barry Goater - lepidoptera

Franklyn Perring - dune transects

APPENDIX 6 - List of publications

Results from the first four seasons' work have contributed to the following publications. An asterisk draws attention to those which have appeared since the last Project S'Albufera report.

- *FOX, R. J. P. 1992. Monitoring Environmental Change at S'Albufera Parc Natural: the role of aquatic invertebrates. University College London M.Sc. in Conservation dissertation.
- 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.
- 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.
- HOWE, C. 1989. Albufera: Aspects of Hydrology, Vegetation, History and Management. University College London M.Sc. in Conservation dissertation.
- *JURADO ESTEVEZ, J. 1992. The usefulness of Landsat TM data for vegetation discrimination in S'Albufera de Mallorca - a marsh. MSc dissertation, Centre for Remote Sensing and Mapping Science, University of Aberdeen.
- *MARCUS, A. 1992. Estimation of soil's surface physical properties using Landsat TM Data in "Es Pla de Sa Pobla-Muro" (Mallorca). MSc dissertation, Centre for Remote Sensing and Mapping Science, University of Aberdeen.
- MAJOL, J. 1991. Plan d'ús i gestió del Parc Natural de S'Albufera de Mallorca. Documents tècnics de Conservació 3. SECONA, Palma de Mallorca.
- MAJOL, J. 1991. Parc Natural de S'Albufera de Mallorca: Ornithological overview, August 1989-July 1990. Associació

Balear d'Amics dels Parcs, Ca'n Picafort.

- *M AYOL, J. 1992. Plan for the use and management of the Natural Park of S'Albufera, Mallorca, 1990-94. Documents tecnicos de Conservacio 3. SECONA, Palma de Mallorca [English version].
- NE WBOULD, P. 1989. The Albufera as a Global Monitoring Station . Earthwatch Europe cyclostyled report.
- NE WBOULD, P. 1990. The Albufera, Mallorca, as a Global Observatory. Jornades del Medi Ambient de les Balears 2: 173-174.
- NE WBOULD, P. 1991. Phragmites and Cladium on Albufera . Manuscript.
- NE WBOULD, P. J., RIDDIFORD, N. J. and GRACE, E. 1989. Consumption of Phragmites australis at S'Albufera, Mallorca. In The Albufera as a Global Monitoring Station (Newbould 1989).
- NE WBOULD, P. J. and RIDDIFORD, N. J. 1990. Monitoring for Global Change: The Earthwatch Europe S'Albufera Project . Earthwatch Europe, Oxford.
- *N OBLET, J. F. 1992. Les chauves-souris du Parc Natural d'Albufera, Majorque, Iles des Balears - Espagne . Report to Earthwatch Europe.
- PE RELLO, G. 1991. Seguiment de l'avifauna del Parc, agost 1990-juliol 1991 . Associacio Balear d'Amics dels Parcs, Can Picafort.
- *P ERELLO COLL, G. 1992. Geografia y educacion ambiental: el parque natural de S'Albufera de Mallorca. Boletin de la Asociacion de Geografos Espanoles 14: 111-120.
- *P ERELLO, G., MAYOL, J. & VICENS, P. 1992. Seguiment de l'avifauna del Parc, agost 1991-juliol 1992 . Associacio Balear

d'Amics dels Parcs, Can Picafort.

- RI DDIFORD, N. 1991a. Project S'Albufera: A new model for environmental research . Earthwatch Europe, Oxford.
- RI DDIFORD, N. 1991b. A small influx of the Long-tailed Blue Lampides boeticus at S'Albufera Natural Park, Mallorca. Bull. Amat. Ent. Soc . 50: 164.
- *R IDDIFORD, N. 1992a. Project S'Albufera: Planning for 1993-94 and beyond: a discussion paper . Earthwatch Europe cyclostyled report, Oxford.
- *R IDDIFORD, N. 1992b. Dragonflies attracted to light. Bull. Amat. Ent. Soc . 51: 139-140.
- *R IDDIFORD, N. & AMENGUAL RAMIS, J. F. 1992. El Projecte S'Albufera a carrec d'Earthwatch Europe: un nou model de recerca medioambiental . Earthwatch Europe, Oxford.
- RI DDIFORD, N. & NEWBOULD, P. 1991. Monitoring for Environmental Change : The Earthwatch Europe S'Albufera Project - a summary report of the second season's work 1990 . Earthwatch Europe, Oxford.
- *R IDDIFORD, N. & PERRING, F. 1992. Monitoring for Environmental Change : The Earthwatch Europe S'Albufera Project - a summary report of the third season's work at S'Albufera Natural Park, Mallorca . Earthwatch Europe, Oxford.
- *V ARLEY, M. E. (ed.). 1992. Project S'Albufera: Report of Field Scientists' Review Meeting, 28-30 April 1992 . Earthwatch Europe cyclostyled report, Oxford.
- WO OD, B. (ed.). 1989. A monitoring programme for S'Albufera,

Mallorca. Discussion Papers in Conservation No. 52. Ecology & Conservation Unit, University College London.

WO OD, B. (ed.). 1991. Further studies towards a monitoring programme for S'Albufera de Mallorca. Discussion Papers in Conservation No. 55. Ecology & Conservation Unit, University College London.

□
ANNEX 8

Sampling of Odonata larvae and other aquatic fauna at S'Albufera, Mallorca, April 1992 by Edward Cross

Introduction

S'Albufera is a 1700 ha reserve in the north-east of Mallorca in which wetlands are the most widespread habitats. Most of the reserve is made up of beds of *Phragmites* or *Cladium*, but there are also more open habitats such as canals, dykes, old salt pans and grazed areas of marsh. During the summer and early autumn dragonflies (odonata) can occur in large numbers and are known to be part of the diet of Eleonora's Falcons *Falco eleonora* and Fan-tailed Warblers *Cisticola juncidis*.

Originally we intended to investigate dragonfly populations by counting exuviae (the skins left after a flying adult has emerged from a larva) as they can be identified down to individual species and are a good indication that a site can support a species from egg through to adult (unlike the adults which can fly in from other areas).

On arriving at S'Albufera in mid April it was clear that only a

few adult dragonflies had emerged. Exuviae would therefore have been hard to find, so it was decided to look at larvae instead. This was done by sampling a variety of sites to see where larvae occurred. In addition to this the density of larvae was measured at one site.

Odonata larvae go through a series of moults and most can only reliably be identified to individual species when they near maturity. (Askew 1988) records 18 species for Mallorca and at least ten of these may breed at S'Albufera. However, for our April 1992 sampling, it was only possible to divide larvae into three broad groups each consisting of several species. These groups were:

- Zygoptera : larvae with long bodies and three gills on the end of the abdomen. Heads wider than the abdomen.
- Libellulidae : short, squat larvae with hind leg reaching beyond the end of the abdomen. Labium (or lower lip/jaw) spoon-shaped.
- Aeshnidae : larvae with long bodies but head similar width to widest part of the abdomen. Hind leg not reaching beyond the end of the abdomen. Labium flat.

Examples of these are shown in Figure 1. The dragonflies represented by these groups are roughly as follows:

- Zygoptera : all the damselflies.
- Libellulidae : mainly Darters (*Sympetrum*), Chasers

(*Libellula*), and *Orthetrum* .

Aeshnidae : mainly Emperors (*Anax*) and Hawkers (*Aeshna*).

In addition to the sampling, some larvae were killed for identification later. Some records of flying adults were also obtained.

Methods

10-sweep sampling: Sites representing several habitats were chosen in the reserve. Within an area of roughly 10 m x 10 m at each site ten randomly located, 1 m long sweeps were made using a 33 cm wide, fine-mesh water net. Most sweeps were taken on the floor of the water body, but as little mud as possible was allowed into the net. For each sweep the Odonata larvae were counted, the presence or absence of *Gammarus* and Isopoda recorded and other fauna counted. Vegetation was recorded (either for each sweep or the site in general), as were water depth, water flow and whether the bottom was soft or solid. The daily temperature range was taken from Park meteorological records.

1m² counts: A frame made of wooden stakes, plastic sheeting and wire mesh (see plate 1) was used to isolate a 1m² area of marsh. Once the four corner stakes were knocked in, loose flaps of sheet at the bottom of the frame were pressed into the mud to prevent animals moving into or out of the 1m² area. Sweeps were then taken with a water net until ten consecutive sweeps failed to catch anything. For each 1m² area this took between 80 and 120 sweeps. All fauna caught was counted.

Results

10-sweep sampling: 10-sweep samples were taken from twelve sites and a total of 23 sets of sweeps were made. Table 1 shows the total results for each set of sweeps. In this table the figures given for Gammarus and Isopoda are the number of sweeps in which they occurred, not the total number caught. Detailed results are given in Appendix 2; abbreviations and translations are given in Appendix 1. Photographs of selected sites are shown in Appendix 3. Locations of the sampling sites are shown in Figure 2.

1m² counts: three 1m² counts were done in the south-east quarter of Tancat de Sa Roca. The total number of the different types of fauna are given in Table 2.

Discussion of results

10-sweep sampling: the number of Odonata larvae found in ten sweeps varied from 1 to 62. Zygoptera larvae were the most widespread as they were absent from only 3 sets of sweeps and were the commonest larvae in 16 sets. Libellulidae were commonest in two sets and Aeshnidae in five. Gammarus and Isopoda were the most frequent of the other fauna. Isopoda were absent from Las Salinas and Tancat de Sa Roca, whereas Gammarus were found in all sites. Gammarus outnumbered Isopoda in all sets of sweeps. In Las Salinas, Hemiptera were the most common of the other fauna, while an unidentified Crustacean (called 'otra Isop .' in Table 1) was the most frequent in S'Illot. The capture of eight fish ('Pisc .') in Tancat de Sa Roca was next to the wall of an old aqueduct, so

was something of a freak result.

This preliminary study produced a number of results suggesting relationships:

a) Depth: Table 3 shows a selection of results from ten sites (other sites are excluded as they have flowing water etc.). From this data Libellulidae appeared to prefer sites with a water depth of less than 400 mm. Isopoda seemed more frequent at deeper sites and Gammarus were consistently frequent in sites 400 mm or more deep. Zygoptera larvae occurred frequently throughout the depth range.

b) Bottom type: Table 4 presents the results from sites divided into three groups based on bottom stratum - comprising mud which was soft, firm or between the two. They suggest that both Zygoptera and Libellulidae preferred firm-bottomed sites, whereas these were less favoured by Isopoda. In soft sites it was not easy to get close to the mud surface without getting a net full of silt. This could mean some fauna were missed in soft-bottomed sites.

c) Temperature and date: the results from the first four sites in Table 1 seem to show that more larvae and other fauna were caught on hotter days and on later dates. However, the significance of this result is not known because comparative data were few and other factors, such as water temperature, were not recorded. More information is needed.

d) Aeshnidae larvae of this group seem to have a preference for

sites with tall, mature *Phragmites* . Examples of this are Es Ras and alongside the Cami de Ses Punes. In Las Salinas Aeshnidae were caught in *Carex* or *Juncus* , while in S'Illot they were found in tall and dense *Carex* .

e) Ses Punes: this site contained fewer larvae than the nearby sites Tancat de Sa Roca and Cami de Ses Punes, but at Ses Punes there were the highest numbers of both fish and tadpoles (Pisces and larvae of *Rana* respectively).

1m² counts: the three 1m² counts were taken in similar locations to the three 10-sweep samples at Tancat de Sa Roca. A comparison of the results for the two methods show some inconsistencies.

Table 5 shows the proportions of the three Odonata groups caught by the two sampling methods. The results indicate that Libellulidae and Aeshnidae are under-represented in the 10-sweep sampling. This could be due to a difference in the habits of larvae of these two groups compared to Zygoptera larvae, leading to a higher proportion being missed by the less intensive 10-sweep sampling. The 10-sweep sampling also failed to find the Isopoda type 'otra Isop .' and the Chironomidae larvae. Neither Ephemeroptera nor Isopoda were encountered in the 10-sweep samples and both were very scarce in the 1m² counts.

The average number of Odonata larvae found in the 1m² counts was 199, while the average for the 10-sweep samples in Tancat de Sa Roca was 47. Therefore, in this habitat the 10-sweep samples were catching less than 25% of the Odonata larvae present per 1m² .

In the 1m² counts only *Gammarus* were more common than Odonata larvae. In sample C and possibly also E, Odonata are probably the

group with the greatest biomass. Table 6 shows the percentage of the catch that Odonata and Gammarus represented in each 1m² count. The figure of 43% Odonata in Sample C is slightly high as small numbers of Gammarus were left uncaught. Therefore, according to these results Odonata larvae make up about 25% of the fauna living in the open water of Tancat de Sa Roca. This result suggests that, for this marsh, Odonata larvae are important members of the food-chain, both as predators and prey.

Records of flying adults and identifications of Odonata larvae are given in appendices 4 and 5 respectively. Appendix 6 gives a summary of the information about Mallorca's dragonflies given by Askew (1988). These show that, at S'Albufera, some adults appear unusually early. The provisional identifications of larvae of *Sympetrum meridionale* or *Sympetrum sainguineum* and a *Coenagrion* species, not recorded by Askew (1988), suggest that Mallorca's Odonata fauna is under-recorded.

Conclusions

Odonata larvae were found in all habitats sampled at S'Albufera. These included shallow grazed marshes, deep canals, old salt pans, the Grand Canal and beds of both *Cladium* and *Phragmites*. At sites where Odonata larvae are most common they are likely to be important members of the food chain. An example of this is Tancat de Sa Roca where Odonata larvae were found to represent about 25% of the fauna caught in the open water. At this site the larvae occurred at an average density of about 200/m² and only Gammarus were more numerous. Elsewhere sampling results suggest Gammarus,

Isopoda and Hemiptera are the most common invertebrates. Some geographically adjacent sites with apparently similar characteristics (e.g. matching depths of water and presence of grazing, in the case of Ses Puntes and Tancat de Sa Roca) had very different populations of Odonata and other aquatic invertebrates.

Little information about the occurrence of individual species of Odonata was gathered, and sites were only described in general terms regarding vegetation, water depth and mud-type. However, the few species identifications made indicated that Odonata are under-recorded in Mallorca and that the adults of some species are appearing unusually early.

Future work

The methodology employed in April 1992 appeared appropriate for studies of Odonata larvae at S'Albufera, but the following points could be considered:

- i) 10-sweep samples should select just one habitat type in any one site (e.g. in Las Salinas make one set of sweeps in the Carex beds and another set in the open mud).
- ii) for vegetation and fauna more identifications to species level should be made. Odonata larvae preserved for identification should have wing cases extending beyond the third abdominal segment as this indicates they are nearing maturity.
- iii) making 1m² counts in other habitats would provide interesting and relatively detailed information.

iv) Park records could be checked for information about the role of Odonata in the diets of the Park fauna.

v) information may be available about the habitat requirements of some types of fauna caught at the Park. This may help explain some of the differences between sites. A literature search may be required to access this information.

vi) Records of salinity, pH and nutrient levels should be applied to the sampling results.

vii) the presence of fine, silty mud greatly slowed the rate of sampling as it made sorting through the contents of a water net more difficult. If 1m² counts are to be made in soft-bottomed habitats, a quicker method must be found. Nets with a larger mesh could help (the smallest invertebrates counted were young Gammarus and Isopoda).

viii) visits to S'Albufera later in the year may increase the chances of finding exuviae and confirm breeding records to species level at individual sites.

Acknowledgements

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Reference

Askew, R.R. 1988. The Dragonflies of Europe . Harley Books, Colchester, U.K.

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Table 5: Percentage of the Odonata catch that each larval type represented for the two sampling methods in Tancat de Sa Roca

	Total no. larvae	%Zygop.	% Libell.	%Aeshni.
10-sweep sampling	149	64.3	35.0	0.7
1m 2 sampling	597	44.4	52.4	3.2

Table 6: Percentage of total catch represented by Odonata and Gammarus in each 1m 2 count

Sample	Total number of fauna caught	% Odonata	% Gammarus
A	988	14	81
B	759	35	51
C	444	43	40

A+B+C

2191

27

62

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Appendix 1: Translations of terms used in Tables 1 & 2, and
Appendix 2

agua	- water
al lado de	- beside
blando	- soft
cami	- road, track
circa de	- near to
denso	- dense
disp., disperso	- sparse
E (este)	- east
fecha	- date
flujo	- flow
fondo	- bottom
mues., muestra	- sample
N (norte)	- north
nada	- nothing, none
nivel	- depth
numero en mapa	- number on map
o	- or
O (oeste)	- west
otra	- other
peq., pequeno	- small
plantas aquaticas	- water weeds
rapido	- rapid
S (sur)	- south
siguia	- ditch, canal
situacion	- site
solido	- solid
suave	- gentle

torre (la) - tower (the)

Abbreviations used in Tables 1 and 2, and in Appendix 2

Aeshni.	- Aeshnidae
Anne	- Annelida
Anur	- Anura
Arach	- Arachnida
Ber	- Berosus
Chir	- Chironomidae
Clad	- Cladium
Cole adult	- adult Coleoptera
Cole larva	- Coleoptera larva
Crus	- Crustacea
Culic	- Culicidae
Dytis	- Dytiscidae
Ephe	- Ephemeroptera
Gamm	- Gammarus
Hemi	- Hemiptera
Isop	- Isopoda
Junc	- Juncus
Libell	- Libellulidae
Moll	- Mollusca
Ner	- Nereis
otra Isop	- Isopoda (another type, as yet unidentified)
Phrag	- Phragmites
Pisc	- Pisces
Zygopt	- Zygoptera

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ANNEX 9

Second report on the molluscs of S'Albufera by C. R. C. Paul

Introduction

During my first visit (October 1991) I was unable to survey the

Park as widely as I would have liked, and I discovered a diverse aquatic mollusc fauna represented by shells only but very few live specimens. The main aims of my second visit (May 1992) were, therefore, to complete the initial survey and to see if aquatic molluscs were more easy to find alive in late spring. As a result of the second visit I increased the number of sites sampled from 44 to 62 (Figure 1) and added slightly to the faunal list for the Park. Live Aquatic molluscs were much more common, but no more diverse. The current aquatic snail fauna consists essentially of five species only, with three more found living in the small pond at Ca'n Picafort. As undisturbed sediment from dredgings in the Grand Canal was available, I investigated the history of the aquatic mollusc fauna by taking sediment samples. These were supplemented by two more, from the Canal des Sol (locality 44) and from a ditch at the SW corner of the Park connected directly to the Font de Son Sant Joan (locality 20). The sediment samples from the Grand Canal suggest the Park was initially brackish lagoon which developed into a marsh. The sample from locality 20 also improved understanding of the fauna by providing abundant examples of some of the rarer forms from my first visit (e.g.

Pisidium spp.). Finally, between them these sediment samples yielded fresh, translucent shells of all the aquatic species known from the Park, suggesting that the apparent extinction of this fauna is a very recent event.

Sediment samples

Dredgings from the western end of the Grand Canal provided some large (up to 50 cm thick) continuous sections through the Recent sediments of the Park. These showed a clear section from a marl 10 cm thick with obvious common shells of the brackish water

bivalve *Cerastoderma* , often in pairs, up through identical marls (20 cm thick) without obvious *Cerastoderma* but with *Hydrobia* , overlain by organic-rich sediments with the roots of modern *Phragmites* (which confirm way up). The succession agrees with the suggested evolution of S'Albufera based on macrophytes (Martinez Taberner et al ., 1990). To investigate the molluscan succession I took two small samples (100-150 g) of sediment from (a) the brackish marl with obvious *Cerastoderma* at the base and (b) the upper marl without *Cerastoderma* . An additional sample (c) of approximately the same weight was taken from clays with freshwater shells a little further east along the canal, between the two electricity pylons. Two other sediment samples of subfossil material were also collected. One (d) from locality 44, on the Canal des Sol where recent dredgings revealed a good freshwater fauna, and another (e) from just outside the Park at the SW corner (locality 20) where a recently dredged ditch revealed a similarly rich mollusc fauna. These effectively sample water entering the Park via the three principal river channels.

Sediment samples were thoroughly dried, weighed and dissociated by soaking in water. Samples (a) and (b) from the Grand Canal did not dissociate on wetting and so were frozen and thawed twice to break them up. Dissociated samples were washed through a 63 μ m sieve, dried and residues separated into size fractions using a nest of sieves at 1 phi intervals from 4 mm to 63 μ m. All gastropod apices and bivalve prodissoconchs found in the fractions >1 mm were identified and counted. Counts were corrected to a standard sample weight of 100 g and results are presented in Table 1.

The counts show that the sediment samples fall into two groups. Samples (a) and (b) have a meagre, brackish-water fauna dominated by *Hydrobia* ; samples (c)-(e) have more diverse freshwater faunas dominated by '*Amnicola*'. Samples (a) and (b) came from the same large lump of marl dredged out of the edge of the Grand Canal. I believe they represent the underlying sediment of much of the marshland in the Park. If so, they reflect a transition from an open, brackish lagoon probably with a direct connection to the sea, up into marshland. The fauna of both is virtually identical, but sample (a) is very much richer in specimens. The freshwater samples (c)-(e) represent dredgings from the canals and ditches themselves and almost certainly post-date the construction of the drainage system through the marsh. Samples (c) and (d) have very similar faunas, typical of the marshland, while sample (e) includes a number of additional species and is very much richer in specimens than the other two. This increase in diversity is real. In particular, *Pisidium* spp., *Ovatella myosotis* and land snail *Cochlicella barbara* are present in too large numbers for their preservation to be an artifact of the larger sample size.

Seriation (Brower & Burroughs, 1982; Brower & Kyle, 1988; Paul, 1989) is a simple technique which will detect a dominant trend in the distribution of data and order both samples and species along the trend. I seriated the data for all taxa present as 1% or more of any sample (Table 2). From the known ecology of the taxa this trend is controlled by salinity, with *Cerastoderma* , *Abra* and *Hydrobia* brackish water species, while *Pisidium milium* and *P. personatum* are pure freshwater taxa and *C. barbara* is the

commonest land snail within the marshland at present. It definitely extends into the marsh and is not confined to the pathways and canal banks as are most land snails in the Park. The only surprise is that *O. myosotis* comes out at the freshwater end of the spectrum. It lives in the marsh, but crawling on mud or up banks of channels not in the water. In Britain it is a snail of salt marshes, never found inland nor in truly freshwater habitats. Nevertheless, there is little doubt that the seriation reveals a salinity trend and, with the odd exception, the order of species in Table 2 reflects their likely salinity tolerances. This being the case, there are effectively four groups of species.

1) *Cerastoderma*, *Abra* and *Hydrobia* are brackish-water molluscs, the last tolerant of more reduced salinities than the former pair.

2) *Physa acuta* and *Ancylus fluviatilis* are freshwater species tolerant of some brackish influence. [*Lymnaea trunculata* and *Trochoidea elegans* are only in the seriation because sample (c) was so poor in specimens. Their occurrences are based on just three shells each, but with a total of just 160 specimens, this constitutes more than 1% of the sample. Similarly, *L.* cf. *auricularia* and *Cerata virgata* are based on just eight shells each in sample (d). Furthermore, *T. elegans* and *C. virgata* are land snails with no known maritime association in the Mediterranean region. These last four species do not really belong in this association.]

3) Species from *Lymnaea peregra* to *Planorbis planorbis* inclusive are freshwater snails forming the bulk of the fauna

of the marsh and they have some slight tolerance of brackish incursions. This group is dominated by ` *Amnicola* '. *Oxyloma* is a land snail typical of marshes, living on emergent vegetation just above the water level. It is not known to be salinity tolerant, but again its presence in sample (c) is due to small sample size and is based on just two shells.

4) *Pisidium* spp., *Bithynia leachii* , *Ovatella myosotis* and *Cochlicella barbara* . The former pair are truly stenohaline freshwater taxa, intolerant of any brackish-water influence. As mentioned previously, *Ovatella* is the only unexpected species in this group, while *C. barbara* is a land snail typical of the present day marsh.

The present day aquatic snail fauna consists of *Hydrobia* , *Physa* , *Ancylus* , ` *Amnicola* ', all species of groups 1 and 2, and *Ovatella* . The first three live in the water, *Hydrobia* predominantly on bottom sediments (usually mud); *Physa* and *Ancylus* predominantly on aquatic vegetation. ` *Amnicola* ' and *Ovatella* live on mud, but generally out of the water and this may explain their survival. Nevertheless, all five species apparently have considerable tolerance to brackish water (or possibly the ability to avoid it by crawling out of the water). The remaining freshwater fauna (species of groups 3 and 4) is now apparently extinct in the Park. Since these sediment samples provided fresh, translucent shells of all species, their extinction was probably a very recent event, only 10-15 years ago at most.

One other sample of dead shells was taken from flood debris on

the south side of the Grand Canal immediately downstream (on the seaward side) of the barrage at Sa Roca. A concentration of shells was sampled just to see what species were present. This yielded most of the fauna known from the Park, included three marine bivalve species, and added *Euconulus fulvus* to the list of molluscs. *E. fulvus* is a woodland snail occurring in damp habitats. *E. alderi* is more typical of marshes, but more local in occurrence and, I suspect, more common in northern Europe. I doubt if *E. fulvus* lives in the Park, but it might survive in the damper patches of scrubland.

Additions and corrections to the faunal list of molluscs from
S'Albufera Natural Park

Land snails

Family Succineidae

Oxyloma pfeifferi (Rossmassler, 1835) Closer examination of shells collected on both visits suggests there are two forms consistently present. One has a smaller, more pointed apex, a more elongate shell and approaches shells of *O. sarsi* (Esmark, 1886). The other is probably *O. pfeifferi*, although the possibility that *Succinea putris* (Linne, 1758) occurs cannot be excluded. Succineids are exceedingly difficult to identify on shells alone. The only adult snail I saw in 1991 died before I could preserve it, while in 1992 I saw one live juvenile that had only just hatched out. Until some adults are dissected the identity and number of succineid species present will remain uncertain.

Family Euconulidae

Euconulus (*Euconulus*) *fulvus* (Muller, 1774) A single fresh shell found in flood debris at Sa Roca (locality 17).

Freshwater molluscs

Family Hydrobiidae

Amnicola similis (Draparnaud, 1805) This is probably not the best available name for this species. *Amnicola* s.s. is a North American genus (Altaba, personal communication).

Hydrobia acuta (Draparnaud, 1801) Again this is probably not the best name for this species.

Family Physidae

Isidora contorta (Michaud, 1889) Probably a species of *Bulinus* , but no live specimens have been seen. If it is a *Bulinus* it belongs in the family Planorbidae.

Family Lymnaeidae

Lymnaea (*Radix*) *peregra* (Muller, 1774) Examination of extensive collections of shells, especially from sample (e), demonstrates that there are consistently two shell shapes present (Figure 2). One is much smaller and more squat, has a flattened upper part to the outer lip and corresponds to *L. ovata* which is usually regarded as a synonym of *L. peregra* . The other is initially more

high spired, but later flares out more rapidly and grows larger. In shell shape it is somewhere between typical *L. stagnalis* and typical *L. auricularia*, but smaller than both. The two forms are commonly present together, suggesting that they are two species not ecological variants. It is particularly regrettable that both now seem to be extinct.

Family Sphaeriidae

Sphaerium corneum (Linne, 1758) Recorded in error in my last report based on a pair of valves, damaged in life and therefore somewhat distorted, which appeared to be symmetrical and are smooth and considerably larger than any other sphaeriids seen. The valves have since separated, revealing a hinge typical of *Pisidium*. The specimen is either an extremely large *P. personatum* lacking the typical callus on the hinge (see below), or an unusually smooth and dull form of *P. casertanum*.

Pisidium casertanum (Poli, 1791) With a very large set of specimens available from sample (e), I am now convinced that specimens previously recorded under this name are *P. personatum* without the typical callus on the hinge. All variations from specimens with an obvious callus, through those with very weak callus, to those with no trace of callus occur, but their general shell shape and surface ornament (dull and relatively smooth) are the same for forms with and without callus in the hinge. Unless the specimen referred to above is *P. casertanum*, I know of no undoubted specimens from S'Albufera. However, *P. casertanum* was recorded by Casull (1980).

Pisidium personatum Malm, 1855 Recorded by Gasull (1980, p. 198) from the Font de Son Sant Joan and now confirmed within the Park, at least as fresh shells.

Pisidium milium Held, 1836 Not previously recorded from any of the Spanish Mediterranean islands. Some 42 valves, many of them fresh and translucent and occasionally double, recovered from the >1mm fraction of sample (e) at the SW corner of the Park.

References

Brower, J.C. & Burrows, W.A. 1982. A simple method for quantitative biostratigraphy. In Cubitt, J.M. & Reyment, R.A. (eds). *Quantitative stratigraphic correlation*, pp. 61-83, Wileys, Chichester.

Brower, J.C. & Kile, K.M. 1988. Seriation of an original data matrix applied to palaeoecology. *Lethaia* 21: 79-93.

Gasull, L. 1980. Moluscos. In Barcelo, B. & Mayol, J. *Estudio Ecologico de la Albufera de Mallorca*, pp. 195-198, Universitat de les Illes Balears.

Martinez Taberner, A., Moya, G., Ramon, G., & Forteza, V. 1990. Limnological criteria for the rehabilitation of a coastal marsh. The Albufera of Majorca, Balearic Islands. *Ambio* 19: 21-27.

Paul, C.R.C. 1989. The molluscan faunal succession in the Hatherwood Limestone Member (Upper Eocene), Isle of Wight, England. *Tertiary Research* 10: 147-162.

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ANNEX 10

Mammal Studies at the Parc Natural de S'Albufera , October 1992 by
Keith Bowey

Introduction

Mammal studies in the Parc Natural S'Albufera in autumn 1992 were intended to follow two broad paths:

- 1) An extensive study which would draw together all "ad hoc" mammal sightings made by observers during the two week study period 17th-31st October 1992: and,
- 2) An intensive study of the small mammals of the Park using standard Longworth Small Mammal traps. The principal aim of this study was to identify all animals caught and to begin to identify the different habitats within the Park utilised by the different species.

Study 1 proceeded as planned and the collated data are given below. There were however a number of logistical problems associated with Study 2, the trapping programme. The principal problem was the non-availability of Longworth traps. Eventually through the good offices of Dr Antoni Alcover of the CSIC (Consejo Superior de Investigaciones Cientificas) a number of traps were made available for use. After some careful modification, to increase their trapping potential and efficiency, the traps were only available for three full trapping nights. This resulted in a severely restricted trapping programme and a

consequent limitation on the usefulness of the results obtained.

Methods

The traps consisted of a small rectangular wire cage, of mesh size approximately 0.8 cm by 0.8 cm, approximately 20 cm in length by 8 cm broad and with a flat wooden floor. The metal door, at one end of the narrow cage, was closed by the action of a spring and the closing action of the trap was governed by the movement of a small wire trigger (upon which bait was skewered) which hooked on to a metal loop extending out from the trap door. The bait employed during all trapping was a single large sunflower seed, with three or four of the same being deposited at the back of the trap as over-night provisioning. The traps, 35 of them, were placed (over a three night period) in four different trapping sites, representing four broadly different habitats. Traps were provisioned, positioned and armed just before dusk (approximately 1700-1730 hrs) on the three trap nights, then left overnight to be inspected soon after first light the following morning. The first night's trapping effort was split between two sites, with 24 traps at one site and 11 at another. This meant that over the period there was a total of 105 trap-nights (i.e. each trap-night comprising one trap at one site for one night). Details of trapping sites and trap configurations, including habitat descriptions, are given below. The location of trapping sites within the Park is presented in Map 1.

Trap Site 1: along the boardwalk leading to the Xisco Lillo hide.

Date: 27/10/92

Weather: warm overnight, some cloud, light north-west wind. Some dew present in morning on examining traps.

Habitat Description: the traps were set adjacent to the boardwalk which heads north towards the Xisco Lillo hide through Tamarisk scrub (average height 2.5 m, though rising to 3.5 m in places). The Tamarisk was underlain by low, dense, *Arthrocnemum* / *Salicornia* scrub and *Aster tripolium*. Ground vegetation was rather sparse with some grass in the drier eastern side of the boardwalk. On the western side of the boardwalk *Phragmites* became dominant as the ground became wetter 2-3 m from the boardwalk.

Trap configuration details: 24 traps placed at 2 m spacings, three either side of the boardwalk at marked intervals (see trap plan). Location three on the boardwalk had only two traps on the west side and four on the east due to the wet nature of that spot. All traps were set at ground level with the entrances orientated in a random fashion.

Trap Site 2: in Es Cibollar, approximately 800 m along the track towards the power station from Sa Roca.

Date: 27/10/92

Weather: warm overnight, some cloud, light north-west wind. Some dew present in morning on examining traps.

Habitat description: low *Arthrocnemum* / *Salicornia* scrub, average height approximately 30-45 cm over damp ground. Standing water of a few centimetres deep showed beneath the two easternmost traps. A dense *Pistacia* thicket was present some 4 m to the west of the trap site. The trap site was entered by passing through a gap in the old aqueduct wall and squeezing between the strands of a barbed wire fence.

Trap configuration details: 11 traps were positioned, nine on the ground, in three groups of three, set at 60 degrees from each other, with a further two, 5 m due east of the central grouping, at a height of 25 cm in the *Arthrocnemum* / *Salicornia* scrub (see trap plan).

Trap Site 3: in the dry scrub of Ca'n Picafort Woods.

Date: 28/10/92

Weather: warm, strong overnight wind force 5/6 from west. Some cloud but dry.

Habitat description: very low scrub, average height 45-60 cm, with some small interspersed *Pinus halepensis*, average height 1.25 m. Species present included *Asparagus acutifolius*, *Rosmarinus officinalis*, *Cistus* species, *Erica multiflora*, *Pistacia lentiscus* and rather sparse *Brachypodium retusum* on very dry sandy soil. All of this was surrounded by higher canopy pine woodland.

Trap configuration details: the traps were set in three parallel transects at 2 m spacings, with 10 m between each line of traps. The first traps was set some 3 m from the edge of the track which ran north-south on the edge of the area of scrub. For location of the traps see plan below.

Trap Site 4: in Phragmites reeds along mist-net ride close to Ses Puntas dunes.

Date: 29/10/92

Weather: warm, strong north-west wind during the night, very slight dew.

Habitat description: the central portion of the trap transect consisted of trampled Phragmites reed on a relatively dry bank of spoil formed from previous excavations of ditchlines. On either side of this raised bank there was, effectively, a monoculture of Phragmites in approximately 25 to 40 cm of standing water. A small amount of Juncus acutus was scattered sparsely around the trap site.

Trap configuration details: the traps were set in three parallel lines, one line along the centre of the dry "bund", at 3m intervals, and on either side of this were placed two traps, one 2 m to the left and another 3 m to the right (with the exception of the first trap on the right which had to be placed at 2 m due to the standing water). All traps were placed on the substrate with the trap doors orientated randomly. See trap plan below.

Results

Study 1

The following animal species were documented as being present in and around the Parc Natural S'Albufera during the 17/10/92 to 31/10/92 study period. This list was compiled from observations by Earthwatch scientists, volunteers and Park staff.

Kuhl's Pipstrelle *Pipistrellus kuhli*

Two of these, a male and a female, were found dead on the main Puerto Alcudia to Ca'n Picafort road, on 29/10/92. Bats which were thought to belong to this species were observed regularly hunting in the Park workshops at night. During this period the animals were observed feeding, presumably on small insects, in the usual manner but also on a number of occasions they were seen "gleaning" insects, and perhaps other invertebrates, from the whitewashed walls of the building. This is a feeding method quite often employed by *Myotis* bat species.

Ship or Black Rat *Rattus rattus*

Seen daily around the Park especially in and around the duck trap close to the warden's house and Park buildings. A number of *Pinus halepensis* cones, from this year and one year old, apparently

processed by this species were collected from Ses Puntas dunes on 24/10/92.

Brown Rat *Rattus norvegicus*

Frequently seen around the buildings. A dead female was found on the main track into the Park on 20/10/92 and a dying individual was found in the Park buildings on 27/10/92.

Rabbit *Oryctogalus cuniculus*

Seen almost daily, principally along the main Park tracks. A number were noted to be suffering from the effects of Myxomatosis.

Weasel *Mustela nivalis*

There was one sighting of this carnivore during the study period, alongside the approach road to the reception centre on 27/10/92.

Domestic Cat *Felis*

Two cats were noted dead on the main Puerto Alcudia to Ca/n Picafort road on 29/10/92; and a feral cat was present around the Park buildings on the evening of 20/10/92.

Study 2

The 105 trap/nights resulted in the capture of 19 small mammals, an 18.1% capture rate.

Table 1 Summary of species caught

House Mouse	Mus musculus	.....	11	(57.9% of total capture)
Algerian Mouse	Mus spretus	.....	7	(36.8% of total capture)
Wood Mouse	Apodemus sylvaticus	....	1	(5.3% of total capture)

Table 2 Summary according to capture site/habitat (showing number of animals caught and capture coefficients of each species in the different habitats)

	M. musculus	M. spretus	A. sylvaticus	No. of Trap/nights
Site 1 (wet/dry)	2 (0.083)	4 (0.167)	0	24
Site 2 (wet)	3 (0.273)	1 (0.091)	0	11
Site 3 (dry)	0	2 (0.057)	1 (0.029)	35
Site 4 (wet)	5 (0.143)	0	0	35

The figures in parentheses in Table 2 represent the capture coefficients for each species at the different sites. This is calculated, rather simply, by dividing the number of captures of each species, in a given habitat, by the number of trap nights in that habitat. The higher the capture coefficient the greater the likelihood of capturing that species in that habitat under the prevailing trapping conditions. Comparison of capture coefficients, rather than numbers caught, should give a more reliable indication of the true numbers of each species present at each site (i.e. any biases in capture rates resulting from differential trapping effort are, theoretically, removed). However since trapping was undertaken on consecutive nights,

differing weather conditions may also have affected the capture efficiency. This potential variation could be eliminated by comparing results from sites trapped on the same night under the same conditions.

Discussion

From examining the above, rather limited, results it would appear that there may be a link between the presence of *Mus musculus* and the degree of wetness of the habitat. The capture coefficients for that species were highest in the reedbed trapping site and the highest for *Mus spretus* were in the mixed wet/dry Site 1. This however is somewhat misleading, for within Site 1 three quarters of the *Mus spretus* captures were in the drier part of the site. By contrast the *Mus musculus* at Site 1 were all caught in the wetter areas, the two left-hand most traps on the first row to the left of the boardwalk where *Phragmites* began to encroach upon the *Arthrocnemum* / *Salicornia* and Tamarisk scrub. In the totally dry dune/woodland habitat of Site 3 no *Mus musculus* were caught, although it should be stressed that capture rates at that site were very low. These initial results suggest that the House Mouse *Mus musculus* is more likely to be caught in the wet habitats of the Park than either of the other two species caught. Indeed it is possible that there may be a degree of isolation by habitat, within the Park, of the two closely related *Mus* species. However a more wide ranging trapping programme and larger sample sizes are needed to test this hypothesis (see recommendations for further study).

Recommendations for further study

- 1) Repeat the work detailed above in Study 2 using fixed numbers of Longworth mammal traps, to construct a more detailed picture of habitat use and species distribution within the Park. Small mammals may vary their use of the Park's habitats according to water levels and season. Therefore, there should be a long-term plan to obtain a series of comparable trapping data sets from different times of the year for each habitat.
- 2) A future trapping programme should include Longworth mammal traps taped, at different heights, to vegetation within Cladium and Phragmites beds, in both wet and dry situations. This would investigate the three-dimensional aspect of small mammal activity within the Park's reedbeds.
- 3) Baited Longworth traps should be placed or taped into low scrub and higher trees to discover if Garden Dormouse *Eliomys quercinus* is a constituent of the Park fauna. Ca'n Picafort Woods may be particularly worth investigating.
- 4) Trapping could be done at a variety of heights within the Tamarisk scrub, close to the Xisco Lillo hide, to investigate any vertical stratification in habitat utilisation between the two *Mus* species in that area.
- 5) The mark and re-capture of *Mus musculus*, in wet areas, and *Mus spretus* in dry areas should be considered as a means of estimating population size for the two species in relation to habitat.

6) The carrying capacity of different habitats could be examined by establishing two trap sites, with similar trap configurations and trap effort i.e. number of trap nights as defined above, and running them in tandem on the same nights. The object of this method would be to remove any variation in capture efficiency due to weather conditions or difference in employment of the traps. A series of results from such a programme would allow comparison of species ratios in each habitat. Such a series should also allow the difference in carrying capacity of the habitats to be examined, by comparing the capture coefficients for each species in each habitat. Potential sites for comparative study include Sites 3 and 4, described above.

7) Better data for some mammal species could be obtained by systematic night-time transects, along fixed and repeatable routes, using powerful "lamping" beams. This technique is suitable for largely nocturnal species, such as Rabbit, which are otherwise difficult to monitor. Some sample "lamping" might also be undertaken in the coastal dunes and other habitats. Such a programme might also obtain further information about the status of the Pine Marten *Martes martes* in and around the Park.

ANNEX 11

The Bats of the Albufera Natural Park, Mallorca, Balearic Islands
- Spain by Jean-Francois Noblet

The following is a partial translation of the report *Les chauves-souris du Parc Natural d'Albufera, Majorque, Iles des Balears - Espagne* by J.F. Noblet. The translation has concentrated on the results of his fieldwork from 19th-25th May 1992. Copies of his full report (Noblet 1992), which includes detailed practical management proposals aimed at increasing roost and breeding sites for bats within the Park, have been lodged with the Parc Natural de S'Albufera and at the Earthwatch Europe office at Oxford, England. A translation of the report's contents page, demonstrating the depth and breadth of the study, is given in Appendix 1 below.

Introduction

Mr Nick Riddiford of Earthwatch Europe asked me to draw up an inventory of the bats of the Albufera Natural Park on the island of Mallorca in the Balearics (Spain) and to propose measures for managing these mammals, which are protected by law.

Created in 1988, the Natural Park comprises 1,708 hectares of marshland drained by canals, grazing land, plantations predominantly of white poplar bordering the canals and pine woods.

The majority of the site comprises reed-beds (of *Phragmites australis* and *Cladium mariscus*).

I - Methods used

A) BIBLIOGRAPHY

We were fortunate to have a good quality library at our disposal. We were particularly aided by the work of ALCOVER 1986 (1) and BENZAL Y. DE PAZ 1991 (3), who had already researched existing references and produced excellent synopses of the bats of the Balearics.

The most recent publication (3) gives 14 species as present on Mallorca: Greater Horseshoe Bat *Rhinolophus ferrumequinum*, Lesser Horseshoe Bat *Rhinolophus hipposideros*, Mehely's Horseshoe Bat *Rhinolophus mehelyi*, Large Mouse-eared Bat *Myotis myotis*, Long-fingered Bat *Myotis capaccinii*, Natterer's Bat *Myotis nattereri*, Serotine *Eptesicus serotinus*, Noctule *Nyctalus noctula*, Pipistrelle *Pipistrellus pipistrellus*, Kuhl's Pipistrelle *Pipistrellus kuhli*, Savi's Pipistrelle *Hypsugo savii*, Grey Long-eared Bat *Plecotus austriacus*, Schreiber's Bat *Miniopterus schreibersi*, European Free-tailed Bat *Tadarida teniotis*. Note that ALCOVER (pers. comm.) doubts the presence of *Nyctalus noctula*, the observation of which does not appear to be sufficiently well documented.

B) SEARCH FOR ROOSTS

We systematically searched for potential roosts within the perimeter of the Park:

- Under bridges . Only the English Bridge on the main road had cracks which were irregularly occupied by bats (presence of guano) .

- Buildings (behind shutters, holes in walls, ruins, caves, dark unoccupied rooms, under tiles). A single roost was discovered (*Pipistrellus pipistrellus* in a crack in the toilet building opposite the Park information centre) .

- Holes in hollow trees . These are very rare. Trees are not very abundant as it is and the area has no breeding woodpeckers Picidae. Therefore hole-dwelling species are absent or in very low densities. None of the tree-holes was found to be occupied by bats.

- Cave . We visited the nearby cave of St. Marti (Alcudia) on the 21st May 1992. We found large quantities of guano, 1 male *Myotis capaccinii* and 3 male *Myotis myotis* .

C) CAPTURES BY MIST NET

This is the most original part of our work.

This technique works well and it proved itself again here. We trapped on 4 nights.

- 19th May 1992 : Under the bridge on the side canal upstream from

the Casa Sa Roca: 7 *Pipistrellus pipistrellus* (4 males and 3 females) captured using two 12 metre nets one above the other, between 21hrs and 03hrs.

- 20th May 1992 : Across the Grand Canal upstream from the sluice gates level with the information centre, using two 12 metre nets one above the other: 1 male *Pipistrellus pipistrellus* and 2 *Myotis capaccinii* (1 male and 1 pregnant female) captured between 22hrs and 00.30hrs.

Across a woodland track on a dyke between two White Poplar plantations at the same site as above. Capture of 3 *Pipistrellus pipistrellus* (2 males and 1 female) and 3 *Barbastella barbastellus* (3 females) between 22.30hrs and 00.30hrs.

- 21st May 1992 : Across a woodland track in a pine wood using two 12 metre nets one above the other. Capture of a female *Myotis myotis* , 1 *Pipistrellus kuhli* , 1 *Myotis nattereri* and, very early in the morning, (01hrs, 02hrs, 03hrs) 3 female *Barbastella barbastellus* .

- 23rd May 1992 : At the exit of St Marti's cave using one 6 metre net from 21hrs to midnight. Saw 2 *Rhinolophus hipposideros* , one *Miniopterus schreibersi* . Capture of 7 *Myotis capaccinii* (4 males and 3 pregnant females). The females were returning to the cave towards midnight. Also captured 4 *Myotis myotis* (3 males and 1 pregnant female).

D) DIRECT OBSERVATION

By direct observation at dusk, at dawn and at night with the aid

of a light we were able to establish:

- the abundance of bats over the whole area.
- the presence of *Tadarida teniotis* whose audible calls were identified every evening high in the sky above the Park.
- the probable presence of *Nyctalus leisleri* whose audible calls we appeared to recognise without being able to confirm with 100% certainty.
- the occupation of St Marti's cave at Alcudia by isolated *Myotis myotis* individuals, a male *Myotis capaccinii* , 2 *Rhinolophus hipposideros* and one *Miniopterus schreibersi* .

E) FOOD PELLETS

We found a Barn Owl *Tyto alba* nest close to the Park. Dissection of the pellets did not turn up any bat remains amongst the 150 determined prey items (comprising birds, insects, the small mammals *Mus* , *Apodemus* and *Rattus* , the gecko *Tarentola*). Taking into account the percentage of bats found in *Tyto alba* pellets in equivalent circumstances, 1,000 prey specimens would be needed before bat remains were likely to be encountered.

II - Results, list and status of Bats at S'Albufera Natural Park,
Balearic Islands, Spain

A) RHINOLOPHIDAE

1 - RHINOLOPHUS HIPPOSIDEROS : 2 individuals seen in flight at St Marti cave, Alcudia, 23rd May. Summering.

B) VESPERTILIONIDAE

2 - MYOTIS CAPACCINII : very abundant. Hunts over the canals. An important breeding colony is cited in the bibliography[1] for the cave of St Marti, Alcudia.

A lactating, pregnant female was trapped on 20th May 1992. It would be interesting to investigate this species which has a "threatened" status in the north of its range (FRANCE). A portion of skull was found in the cave of St Marti, Alcudia.

Parasites collected : Penicillidia d. dufouri , 3 males and 3 females; Nycteribia pedicularia , 11 males and 7 females; Spinturnix sp.

3 - MYOTIS NATTERERI : A lactating, pregnant female was captured in the pine wood at midnight on 21st May 1992.

Parasite collected : Spinturnix sp.

4 - MYOTIS MYOTIS : although we only found 3 isolated individuals along a woodland track on 21st May 1992, we caught a lactating, pregnant female at 22.45hrs on 21st. On 23rd May we trapped 4 Myotis myotis (3 males and a pregnant female) at the exit to the St Marti cave.

The measurements of those captured are given (in mm) below.

SEX	FORE-WING	THIRD FINGER	FIFTH FINGER	CM3
F	65.7	105.6	83.3	10
F	63	100	76.5	
M	60.5	100.2	78	10
M	61.1	103	79	10.8
M	60.7	97	76	10.7

Parasites collected : *Penicillidia d. dufouri* (Nyct.), 1 male; *Spinturnix myoti* .

5 - *PIPISTRELLUS PIPISTRELLUS* : this is probably the commonest species at S'Albufera. We saw it flying round the buildings, over water and woodland and along the woodland paths.

We also observed *Pipistrellus* bats (not identified to species) hunting at dusk among the stems of the *Phragmites* reed. They probably breed on site, but we were not able to demonstrate this because the breeding season had not yet started.

Note that in 1991 one was found, the victim of a road accident, on a road bordering the Park (Earthwatch data, 1991).

6 - *PIPISTRELLUS KUHLI* : we trapped a female of this species on 21st May 1992 at 23.15hrs. She showed no sign of reproduction.

Parasite collected : *Argas vespertilionis* (1 larva).

7 - *BARBASTELLA BARBASTELLUS* : this was the major discovery of our work.

We caught 6 individual females, all late in the night, at two separate sites: along a woodland track composed of poplars along a raised embankment on 20th May 1992 and a woodland track in a pine wood on sand on 21st May 1992.

Two of the six females were pregnant. These comprise the first record of the species for the Balearic Islands. Clearly the species is not rare at S'Albufera and uses specific habitats (woodland tracks).

To this list we add two species

- *Nyctalus leisleri*
- *Tadarida teniotis* (family: Molossidae)

based on audible calls which were heard every night at the site. The presence of *Tadarida teniotis* is without doubt. The record of *Nyctalus leisleri* is less certain.

Conclusion

As might be expected, S'Albufera Natural Park is a very favorable site for bats.

Water is abundant, as is a food source for insectivorous mammals. Only roost/breeding sites are lacking. It is probable that more detailed searches will reveal the presence of *Hypsugo savii* , *Plecotus austriacus* and *Eptesicus serotinus* .

III - Future recommendations

A) FOLLOW-UP WORK

One of the roles of the Natural Park is to protect bats. It is therefore necessary to continue collecting information in order to establish status. I advise continuing with mist-net captures throughout the Park in a range of habitats (dunes, reed-beds, areas of open water, etc.) in summer, during the breeding season (June to September).

It would be useful to complement this technique by using ultrasound equipment operated by a specialist in this field. I could find this person.

Finally it would be useful to put up nest boxes for Barn Owls in order to obtain food pellets regularly. It would be possible to construct one in the building which serves as a workshop, in the ruins at Ses Puntes, and in the signal towers by the sea.

Nest boxes for this species could also be installed in large trees.

V - References

- [1] Alcover, J. A., & Muntaner, J. 1986. Els quiropters de les Balears i Pitiuses: una revisio. Endins , No. 12, 1986. Ciutat de Mallorca.
- [2] Barcelo & Combis. 1875. Apuntes para la fauna balear,

- catalogo metodico de los mamiferos observados en las islas Baleares. Anales de la Sociedad Espanola de Historia Natural 4: 53. Madrid.
- [3] Benzal, J. & de Paz, O. 1991. Los Murcielagos de Espana y Portugal . Coleccion Tecnica, ICONA.
- [4] Earthwatch. 1991. Project S'Albufera. A new model for environmental research . Earthwatch Europe, Oxford.
- [5] Fernandez, R & Ibanez, D. 1987. Patterns of distribution of bats in the Iberian peninsula. In: European bat research (eds. Hanak, V., Horacek, I. & Gaisler, J. 1989): 357-361. Charles Univ. Press, Praha.
- [6] Anon. 1990. Tadarida teniotis in Magalluf. Papers de la Nature 7, November 1990. Conselleria d'agricultura i pesca.
- [7] Stebbings, R. E. 1986. Distribution and status of bats in Europe . Institute of Terrestrial Ecology/Natural Environmental Research Council.
- [8] Tupinier, Y. 1975. Chiropteres d'Espagne. Systematique, Biogeographie . Doctoral Thesis, Univ. Cl. Bernard (Lyon).

Appendix 1 Translation of the full report's contents page

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ANNEX 12

The use of Remote Sensing for monitoring environmental change in
the Parc Natural de S'Albufera , Mallorca by Bernice Young

Aims

To utilise remotely sensed data (both Satellite Imagery and
Aerial photography) to monitor changes in vegetation, land-use,
soil moisture and water levels for the whole catchment area of
the Park.

Objectives

a) to establish a method by which Ground Truth data can be
collected regularly and systematically by Earthwatch volunteers
and any other interested parties.

b) To establish a method of storing the data in such a way that

they can be easily disseminated to all interested parties.

c) To establish links with Colleges, Universities and other organisations with the facilities to match and process the Remotely sensed data and the ground-truth data as a means of achieving the aims of the project.

Discussion

Objective (a). The utilisation of satellite imagery is still very much in its infancy in England and much of Europe. However, the number of Academic Institutions which have the equipment and expertise to process this imagery is growing rapidly and it may not be too long before Earthwatch sees a need for such equipment. Meanwhile, satellites are collecting data on a regular basis for those who have the facilities (and the finances) to exploit this means of monitoring the earth's surface. The resolution of this imagery requires that ground-truth data must be available if accurate interpretation of the data is to be achieved. At some time in the future Earthwatch and other organisations interested in the Parc Natural de S'Albufera may find themselves in a position of having historic images of the Park (i.e. those that are being recorded now) but have no ground-truth data for accurate interpretation of the images. Objective (a) will ensure that such data are available. Volunteers on TEAM II in 1992 have made good progress with objective (a); for more details see Annex 13.

Objective (b). Methods of storing and disseminating collected data are still to be established, something which could be

undertaken during forthcoming fieldwork periods.

Objective (c). Links have already been established with Aberdeen University which is sending two students to the Park in June-July to undertake projects in connection with their current studies, the results of which will be available to Earthwatch Europe.

Aberdeen University already has one image of the area and Earthwatch is providing a second image which will be utilised by the students. More recently links have been established with the University of the Balearic Islands (UIB) which is showing an interest in the project; indeed one of the volunteers on the pilot study (TEAM II) was a recent graduate of UIB's Department of Geography and provided valuable local knowledge and a great deal of enthusiasm to enable some of the objectives to be achieved. In addition to this, Dr van der Meulen has indicated that students from the University of Amsterdam would be prepared to produce historical vegetation maps from the aerial photography already available at UIB.

Summary of progress

The pilot study undertaken in May 1992 (TEAM II) indicated that the project is feasible. A methodology for the collection of data has been set up and utilised by Earthwatch volunteers and some ground-truth data have already been collected. These data have already been offered to the students from Aberdeen should they wish to make use of them.

Editor's Footnote

The University of Aberdeen students referred to above were Antoni Marcus and Jesus Jurado Estevez from the University's Centre for Remote Sensing and Mapping Science. Using two LANDSAT images shared by the Centre and Earthwatch Europe, they undertook ground-truthing fieldwork in June-July 1992. Their studies comprised an assessment of the usefulness of Landsat TM data for vegetation discrimination in the Park (Jurado Estevez 1992); and an estimate of soil surface physical properties of the land adjacent to the Park, using the Landsat TM data (Marcus 1992). Both studies culminated in Master's dissertations (Jurado Estevez 1992; Marcus 1992), copies of which have been deposited at the Parc Natural de S'Albufera and at Earthwatch Europe's office in Oxford, England.

ANNEX 13

Parc Natural de S'Albufera - Remote Sensing pilot study by Bernice Young

Aim

To determine the feasibility of using Earthwatch volunteers to collect the ground-truth data for Remote sensing studies on a regular and systematic basis.

Objectives

(a) To establish a working methodology for collecting data both within the Park and beyond its boundaries but within its catchment area.

(b) To test the methodology in the field and adjust where

necessary.

(c) To identify the areas to be surveyed.

(d) To use Earthwatch volunteers to employ the method devised to collect data from the areas identified.

Discussion

Objective (a).

As there were a number of particular avenues of study possible using remote sensing, it was necessary to select the most relevant type of data to collect in relation to the immediate needs of Project S'Albufera . Outside the Park it seemed most feasible to collect land-use/vegetation data as this would provide valuable background information for any type of specialised study (e.g. the soils study planned by the University of Aberdeen). Within the Park the land-use/vegetation is fairly uniform, i.e. open water and reed beds. It was decided that greater detail of vegetation type might be required here, in particular the distribution of the two most dominant species in the Park, *Phragmites australis* and *Cladium mariscus* .

In order to collect data systematically, it was necessary to construct a key to the main land-use/vegetation categories. Taking into account the fact that many volunteers collecting the data would not be Geographers, Botanists or Agriculturalists, it was important for the key to be as simple as possible and self explanatory. Consequently the volunteers themselves were asked to produce the key, with the valuable assistance of the Mallorcan

volunteer who knew the area well. The decision was also made to produce the Mallorcan and Spanish versions of the key so that it was available for use by English-speaking and local people.

Once a provisional key was in place, it was necessary to select the size of area to be surveyed given the method of transport available and access to the area (though car and bicycles were available to transport surveyors to the site, most of the surveying on site needed to be undertaken on foot). In England it is usual to survey 1 km² units in relation to the UTM grid. In Mallorca, where the field sizes are much smaller and the time available for the survey limited to between two and six weeks, it was decided that 0.5 km squares would be most appropriate.

Establishing a methodology for data collection required different approaches to survey inside and outside the Park.

Outside the Park full consideration was needed of the fact that much of the land was private and that local people might be concerned to see strangers making notes with regard to the crops they were growing, etc. Usually survey squares are chosen at random but in this case it was necessary to choose squares that had sufficient public right-of-way for data to be collected without trespassing. A letter was also written in Mallorcan explaining the nature of the survey, which could be shown to anyone who might challenge the survey team or show concern at their presence. The content of the letter was approved by Biel Perello and printed on Parc Natural de S'Albufera letter headed paper.

Inside the Park consideration had to be given to the difficulties and dangers of working in a marsh. The reeds were tall enough to obscure landmarks and it was easy to lose one's sense of direction. The reedbeds were criss-crossed by deep canals and Park workers reported that on occasions they had slipped into deep holes beneath the reeds. It was theoretically possible to access most of the Park by boat. In practice a number of the canals were choked with vegetation and progress by boat was painfully slow, and often impossible. Squares had to be chosen which were accessible by land or boat without too much difficulty and full consideration of safety had to be incorporated in the methodology devised to record the distribution of vegetation.

Objective (b).

The volunteers were shown how to read grid-references on a map, how to use a compass and once in the field they were shown how to record their observations on the data recording sheets provided. In the land surrounding the Park recording proved fairly straight forward and only a few changes were required to the provisional land-use/vegetation key. Within the Park, working in the marsh proved more problematical until a 100 m rope was purchased and whistles adopted for communication.

Objective (c).

Once working methods had been established and tested, survey squares had to be identified and pro-formas created (without the use of a photo-copier this required a lot of tracing from the map

which in itself was time consuming and should not be necessary in future). For the pilot project, squares within cycling distance of Sa Roca were identified from the map (see plan attached). Four squares were chosen within the Park, one square on the Park boundary and four squares outside the Park. The grid references of the chosen squares (South West Corner) were:

Sa Pobla sheet 671 - 11 1:25.000

1. 0511.5 4403.5 Sand dune/Caseta de ses Salines
 2. 0510.5 4402.5 Urban/agricultural area
 3. 0509.5 4405.0 Reed beds
 4. 0509.5 4402.5 Reed beds (Park boundary)
 5. 0509.0 4404.0 Reed beds
 6. 0508.5 4406.5 Reed beds
 7. 0507.0 4402.5 Residential/marsh Son Monget
 8. 0506.0 4406.5 Agricultural
 9. 0506.0 4404.0 Residential/agricultural
- Objective (d).

Of nine squares chosen, two proved unworkable due to access problems. They were:

Square 6. The canal adjacent to the track was too deep to cross with waders. Access to the square by boat was not possible due to vegetation in the canal. In future this square could only be worked if a small boat were transported by land.

Square 9. Hard to get to by bicycle (Torrent de Muro gets in the way). Access is possible by car if approached from the south.

Squares 2, 7 and 8 outside the Park were successfully surveyed, each one taking approximately one day and requiring two

volunteers.

Squares 4 and 5 within the marsh were completed once a few logistical problems had been overcome. Marsh squares take on average 1.5 days to complete using a minimum of 3 volunteers.

There was not sufficient time to survey squares 1 and 3.

Conclusion

Considering that Team II only had four volunteers and that other work such as bird and butterfly studies was also undertaken, a tremendous amount was accomplished. Three of the volunteers had never undertaken work of this nature before but were very successful in completing squares 2, 7 and 8 without any supervision from the Scientific Team once initial guidance had been given. A lot of the hard work in the marshland was undertaken, with great enthusiasm, by the Mallorcan volunteer (Macia) gallantly assisted by at least one other volunteer and with myself making up the third member of the team on most occasions. The work is hard, wet and dusty, especially in hot weather and a certain amount of stamina is required. (Macia advocates that we should advertise for at least one BIG volunteer for this job). Nevertheless, the work was enjoyed by all and there was never any shortage of volunteers. Many thanks to Patricia, Zita, Alexandra and Macia - and to Sara who got 'roped in' (literally) on occasions. For further details of methodology and data collected, see Annex 12.

ANNEX 13 MAP HERE
(page 220)

ANNEX 14
Monitoring orchids at S'Albufera, Mallorca, 1992 by Terry Wells

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(page 221 to page)
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ANNEX 15
Fungi at S'Albufera by Sheila Wells

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ANNEX 16
Ornithological Research based on ringing, S'Albufera 1991-92 by
Jon King

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APPENDIX 6 - List of publications

Results from the first four seasons' work have contributed to the following publications. An asterisk draws attention to those which have appeared since the last Project S'Albufera report.

*FOX, R. J. P. 1992. Monitoring Environmental Change at S'Albufera Parc Natural: the role of aquatic invertebrates. University College London M.Sc. in Conservation dissertation.

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 tecnicos de Conservacio 4. SECONA, Palma de Mallorca.
- HA FNER, 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.
- HO WE, C. 1989. Albufera: Aspects of Hydrology, Vegetation, History and Management . University College London M.Sc. in Conservation dissertation.
- *J URADO ESTEVEZ, J. 1992. The usefulness of Landsat TM data for vegetation discrimination in S'Albufera de Mallorca - a marsh . MSc dissertation, Centre for Remote Sensing and Mapping Science, University of Aberdeen.
- *M ARCUS, A. 1992. Estimation of soil's surface physical properties using Landsat TM Data in "Es Pla de Sa Pobla-Muro" (Mallorca) . MSc dissertation, Centre for Remote Sensing and Mapping Science, University of Aberdeen.
- MA YOL, J. 1991. Plan d'us i gestio del Parc Natural de S'Albufera de Mallorca. Documents tecnicos de Conservacio 3. SECONA, Palma de Mallorca.
- MA YOL, J. 1991. Parc Natural de S'Albufera de Mallorca: Ornithological overview, August 1989-July 1990 . Associacio Balear d'Amics dels Parcs, Ca'n Picafort.
- *M AYOL, J. 1992. Plan for the use and management of the Natural Park of S'Albufera, Mallorca, 1990-94. Documents tecnicos de Conservacio 3. SECONA, Palma de Mallorca [English version].
- NE WBOULD, P. 1989. The Albufera as a Global Monitoring Station .

Earthwatch Europe cyclostyled report.

- NE WBOULD, P. 1990. The Albufera, Mallorca, as a Global Observatory. *Jornades del Medi Ambient de les Balears* 2: 173-174.
- NE WBOULD, P. 1991. Phragmites and Cladium on Albufera . Manuscript.
- NE WBOULD, P. J., RIDDIFORD, N. J. and GRACE, E. 1989. Consumption of Phragmites australis at S'Albufera, Mallorca. In *The Albufera as a Global Monitoring Station* (Newbould 1989).
- NE WBOULD, P. J. and RIDDIFORD, N. J. 1990. Monitoring for Global Change: The Earthwatch Europe S'Albufera Project . Earthwatch Europe, Oxford.
- *N OBLET, J. F. 1992. Les chauves-souris du Parc Natural d'Albufera, Majorque, Iles des Balears - Espagne . Report to Earthwatch Europe.
- PE RELLO, G. 1991. Seguiment de l'avifauna del Parc, agost 1990-juliol 1991 . Associacio Balear d'Amics dels Parcs, Can Picafort.
- *P ERELLO COLL, G. 1992. Geografia y educacion ambiental: el parque natural de S'Albufera de Mallorca. *Boletin de la Asociacion de Geografos Espanoles* 14: 111-120.
- *P ERELLO, G., MAYOL, J. & VICENS, P. 1992. Seguiment de l'avifauna del Parc, agost 1991-juliol 1992 . Associacio Balear d'Amics dels Parcs, Can Picafort.
- RI DDIFORD, N. 1991a. Project S'Albufera: A new model for environmental research . Earthwatch Europe, Oxford.
- RI DDIFORD, N. 1991b. A small influx of the Long-tailed Blue

- Lampides boeticus at S'Albufera Natural Park, Mallorca. Bull. Amat. Ent. Soc . 50: 164.
- *R IDDIFORD, N. 1992a. Project S'Albufera: Planning for 1993-94 and beyond: a discussion paper . Earthwatch Europe cyclostyled report, Oxford.
- *R IDDIFORD, N. 1992b. Dragonflies attracted to light. Bull. Amat. Ent. Soc . 51: 139-140.
- *R IDDIFORD, N. & AMENGUAL RAMIS, J. F. 1992. El Projecte S'Albufera a carrec d'Earthwatch Europe: un nou model de recerca medioambiental . Earthwatch Europe, Oxford.
- RI DDIFORD, N. & NEWBOULD, P. 1991. Monitoring for Environmental Change : The Earthwatch Europe S'Albufera Project - a summary report of the second season's work 1990 . Earthwatch Europe, Oxford.
- *R IDDIFORD, N. & PERRING, F. 1992. Monitoring for Environmental Change : The Earthwatch Europe S'Albufera Project - a summary report of the third season's work at S'Albufera Natural Park, Mallorca . Earthwatch Europe, Oxford.
- *V ARLEY, M. E. (ed.). 1992. Project S'Albufera: Report of Field Scientists' Review Meeting, 28-30 April 1992 . Earthwatch Europe cyclostyled report, Oxford.
- WO OD, B. (ed.). 1989. A monitoring programme for S'Albufera, Mallorca. Discussion Papers in Conservation No. 52. Ecology & Conservation Unit, University College London.
- WO OD, B. (ed.). 1991. Further studies towards a monitoring programme for S'Albufera de Mallorca. Discussion Papers in Conservation No. 55. Ecology & Conservation Unit, University

College London.

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