Establishment of Penguin Monitoring Programme in Chile

Annual Report: April 2002

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Darwin Initiative for the Survival of Species

Annual Report

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1. Project Background

The project takes place on Magdalena Island, near the city of Punta Arenas in southern Chile. Magdalena Island is one of Chile's most important breeding sites for Magellanic penguins, a species whose global distribution is restricted to southern South America. Best guess estimates put the current world population of Magellanic penguins at around 1.5 million breeding pairs, with approximately 700,000 pairs in Chile, 650,000 pairs in Argentina and 150,000 pairs in the Falkland Islands (Bingham 1998, Bingham & Mejias 1999, Gandini et al. 1998).

Population studies in the Falkland Islands conducted by Dr Mike Bingham have revealed a 75% decline in Magellanic penguins between 1990/91 and 2001/02. A reduction of fish and squid resulting from large-scale commercial fishing appears to be the cause of the penguin decline, through reduction of foraging rates, breeding success and juvenile survival (Bingham & Mejias 1999).

Population studies conducted in Argentina show evidence of decline at some colonies, but not all (Boersma 1997). Declines in Argentina appear to be largely the result of high adult and juvenile mortality caused by oil pollution. An estimated 40,000 Magellanic penguins are killed by oil pollution every year along the coast of Argentina, representing the main cause of adult mortality (Gandini et al. 1994).

No population studies have yet been carried out on Magellanic penguins in Chile, even though Chile holds around half the world's population. The reason for this is a lack of financial resources, which has not only prevented the establishment of a long-term monitoring programme, but also inhibited training of local personnel in seabird monitoring techniques. With large scale population declines occurring elsewhere, it is vital to determine whether penguin populations in Chile are under threat, and the project seeks to provide this information.

2. Project Objectives

Chile is a country rich in biodiversity, but with limited financial resources or expertise in environmental protection. The project aims to set up a long-term penguin monitoring programme, and to train Chile's existing manpower resources to run the programme on a long-term basis, thereby helping them to honour their commitments under the Biodiversity Convention.

One of Chile's largest and most important Magellanic penguin breeding sites is situated on Magdalena Island in the Straits of Magellan. Provisional examination suggests that Magellanic penguins are not declining on Magdalena Island, despite its close proximity to the Falklands, but a long-term monitoring programme needs to be established in order to accurately determine population trends. Magdalena Island holds a population of over 60,000 breeding pairs of Magellanic penguin, making it an ideal site at which to establish Chile's first long-term penguin monitoring programme.

The island has been designated a national nature reserve because of its importance as a Magellanic penguin breeding site, and it is managed by the Corporación Nacional Forestal (CONAF), but the island is also a popular tourist destination. It is therefore important to monitor the effects of tourism on penguin survival and breeding success. The programme will eventually enable Chile to monitor its globally important penguin populations, and to ensure the sustainable use of Magdalena Island as a tourist resource.

A logistical framework for the aims and objectives of the project are attached as Appendix 1. No changes to the objectives or operational plan have been required, and the programme is progressing as predicted.

3. Progress

Between April and October 2001 a general study was made of the area in order to establish the vegetation and habitat types typical of the area. This enabled baseline survey techniques and classification categories to be adapted for local conditions. During November and December 2001 a comprehensive baseline survey of Magdalena Island was conducted, mapping out littoral and terrestrial habitat types, and recording the location and population size of all birds and mammals present on the island.

During November 2001, 50m x 50m field plots were established at various locations around the island, and the number of breeding pairs in each plot was recorded. From November through February the plots were monitored daily to record nesting activity, and to determine hatching dates, fledging dates, chick growth rates, causes of egg/chick mortality, and the nesting/foraging patterns of adults. During January and February juveniles returning to moult were counted every few days to determine juvenile survival.

All monitoring work on Magdalena Island was undertaken with the assistance of park wardens who live on the island. A training manual has also been prepared which will teach the wardens about the ecological principals behind the work being done. The project aims to have the wardens fully trained in all penguin monitoring techniques employed on the island, so that they will be able to take over the long-term running of the penguin monitoring programme after completion of the Darwin Project in 2004. Full details of the methodology used during the project are provided in Appendix 2.

On 19th November 2001, a press article appeared in the Chile national newspaper “La Prensa Austral” reporting on the project - led by a British marine biologist and funded by the Darwin Initiative. In addition the detailed observations resulting from the project have already resulted in a new scientific discovery about Magellanic penguin behaviour.

The majority of penguins make burrows in which to lay their eggs, but about 5% of breeding pairs lay their eggs on the surface, where they are more exposed to predation by gulls and skuas. It was assumed that they did this due to a lack of suitable ground for making burrows. This theory seemed to be confirmed by the fact that shortly after the eggs hatch, most of the open nests become abandoned, leading to the assumption that predators had killed the exposed chicks.

This year’s daily observations have shown that most chicks in open nests are not being killed, but are leaving the open nests to take refuge in burrows abandoned by other pairs that lost eggs during the incubation phase. Now that the movement of these chicks has been realised, it means that previous assumptions about open nests being a poor option need to be re-evaluated. It also means that chick survival and breeding success have been previously misrepresented. These results will be written up in a major scientific journal, since it is of great importance to other penguin biologists.

The work has progressed in complete accordance with the baseline timetables set out for the period, and there has been no need to alter the programme techniques or timetable for the coming year.

TIMETABLE FOR FORTHCOMING REPORTING PERIOD

April to October 2002: The results of the first season's data will be written up and presented to the host country, accompanied by further press releases. CONAF staff will discuss the first season of research, and training material will be translated and updated. Comparisons of breeding success and chick survival will be made for areas with tourists and those without. An end of year report will be drawn up, along with a web site to promote the project.

October 2002 to March 2004: Repeat of monitoring and training on Magdalena Island. Assessment of progress and amendments to management plan and training material as required. Final handing over of the monitoring programme to Chilean hosts.

4. Partnerships

The project has been a truly multi-national affair. Funds and expertise have been provided by Britain, backed by a Falkland Islands research organisation, working to support an impoverished host country, Chile. The project team itself has been made up of a British project leader and a Chilean field assistant, working with Chilean staff who are being trained to take over the penguin monitoring programme, when the Darwin Project ends in 2004.

CONAF, who are the owners of the reserve, are very pleased not only with the work so far achieved, but also because they welcome the opportunity to have staff trained in penguin monitoring techniques, so that they can eventually run the programme themselves, using existing resources. The project is also generating awareness amongst tourist operators, of the need for tourism to be managed in a sustainable manner, to safeguard not only the wildlife resources, but also the industry as a whole.

In addition to the projected outputs, a qualified veterinary surgeon from Australia worked on the project free of charge, in order to learn penguin monitoring techniques for use back in Australia (which also has penguins).

5. Impact and Sustainability

The project has been well received by the host country. The owners of the nature reserve not only welcome the scientific data being generated by the programme, but also the opportunity to have their own staff trained in monitoring techniques, so that they themselves will be left with the ability to take over the programme in the long-term.

The local tourist industry has also been made more aware of the need for protection of the wildlife resources essential to the continuation of their industry. Tour guides taking tourist to Magdalena Island have been given better information to pass on to tourists, in relation to both education and conservation.

The project has been reported in the Chilean national press, with the British contribution of funding from the Darwin Initiative, and British expertise being stressed. A web site is being prepared to raise awareness of penguins and penguin conservation in Chile, and for this purpose the address www.penguins.cl has been acquired. The web site will be an important aspect of the exit strategy, along with the handing over of the programme to the host nation, and publication of reports and scientific papers.

6. Outputs, Outcomes and Dissemination

Table 1. Project Outputs (According to Standard Output Measures)

Code No.	Quantity	Description
8	9	Field Plots established and monitored daily (Nov - Mar)
8	1	Annual Census of Juveniles
12A	4	Data Collection forms and Databases drawn up
5	2	Local staff trained in seabird monitoring techniques
15A	1	National Press articles about the project
7	1	First draft of Training Manual prepared
5	1	Australian veterinary surgeon trained in penguin monitoring techniques (additional to project objectives)

All the outputs scheduled for the first year of the project have been achieved. In addition a veterinary surgeon from Australia received training in penguin monitoring techniques in exchange for working as a volunteer on the project.

Table 2: Publications

Type * (e.g. journals, manual, CDs)	Detail (title, author, year)	Publishers (name, city)	Available from (e.g. contact address, website)	*Cost £*
National Newspaper	19th November 2001	La Prensa, Punta Arenas	La Prensa, Punta Arenas	600 pesos

In addition to the training programme, which will enable CONAF to continue monitoring penguin populations on their reserve after the project finishes, a number of other long-term benefits are resulting. Tour operators are now able to provide guidance to their passengers, in order to minimise the impact of tourism on penguin populations during visits. Visitors are also being given better educational material regarding penguins and penguin conservation during their visit.

Using data obtained during the first year of the project, CONAF are preparing a management plan for the island. The recommendations of the plan will continue after the project finishes, as will the penguin monitoring programme. This work will be funded from revenue generated by tourists visiting the island, who each pay a 3000 peso landing fee.

7. Project Expenditure

Table 3: Project expenditure during the reporting period

Item	Budget	Expenditure
Salaries (specify)		
Project Leader		
Field Assistant		
Travel and Subsistence		
Office administration costs		
Capital items/equipment		
Others: Auditing		
Total		

Because this was the first year, a greater amount of preparatory work was needed on the baseline survey work, which resulted in a rise in Travel and Subsistence costs. As project leader I therefore took a reduction in salary to balance the budget. The overall project costs for the first year are therefore in complete accordance with projected costs.

Since the baseline survey work is only performed during the first year, it is expected that next year costs will be as originally budgeted.

8. Monitoring, Evaluation and Lessons

The scientific outputs of the project are monitored by the quality of data obtained, and the successful completion of databases. The quality of this data is evaluated by comparison with standards developed during 10 years of penguin monitoring in the Falkland Islands by the Project Leader. The scientific outputs of the first year of the project are summarised in Appendix 3.

The training side of the project is evaluated by the ability of CONAF staff to undertake the work on their own. It was not expected that this would be achieved during the first year, hence the need for a three year project. The recruitment of a volunteer from Australia did allow the Training Manual to be tried out on somebody with no previous experience, and improvements will be made to the manual as a result of this trial.

Some minor modifications have been made to fieldwork techniques, in order to incorporate local conditions. These were re-scheduling of the juvenile penguin counts in order to avoid disturbance to nesting gulls present on the upper shore during January, and alterations to penguin markers which were being eroded by wind blown sand.

9. Author(s) / Date

Mike Bingham 12th April 2002

APPENDIX 1: Logical framework.

Project summary	Measurable indicators	Means of verification	Important assumptions
Goal To assist countries rich in biodiversity but poor in resources with the conservation of biological diversity and implementation of the Biodiversity Convention	An ongoing process which would show improvements in the ability of developing countries to protect their biodiversity	Reports, publications and site visits by international organisations.	Help from countries which hold the lacking resources
Purpose To assist Chile, a country poor in resources, with the conservation of globally important penguin populations.	Data on penguin status, threats and conservation. Management plans for protected breeding sites. Training for local staff.	Reports and publications, databases, management plans for reserves, ability of local agencies to continue with research and raise own funds	Funding to initiate process Available expertise Local support for the project
Outputs To gather information about Chilean penguin populations To help Chile to monitor and manage its own penguin populations in the long-term To identify potential threats from human activities To raise the profile of penguin research in Chile To give Chile access to other sources of funding through training.	Population estimates and data on breeding success The ability of local staff to continue with penguin monitoring after 3 years Information and data on potential human interactions Education and public awareness programmes Ability of local agencies to begin new areas of research using own staff after 3 yrs	Annual reports and scientific publications Annual training assessments and the production of a management plan Annual reports and scientific publications Press reports, tourist information, projects with Charles Darwin School Management plan after 3 years including future work	A research programme to gather data A training programme to teach local staff Availability of local staff Data on the impact of potential threats Information for education and public awareness An infrastructure that will nurture funding for new research
Activities To establish a penguin monitoring programme on Isla Magdalena. To provide local staff with the expertise to conduct the work in the long-term To produce baseline data and management plan for Isla Magdalena. To promote conservation work through education, press reports and publications	Annual data on population size, breeding success and foraging behaviour Annual training assessment and development of locally based research objectives Maps and databases of fauna and flora. Production of initial management plan after 1 year Educational initiatives run through the Charles Darwin School and local press	Annual reports, press releases and scientific publications Annual training reports and locally prepared management plan and research proposals Baseline survey report containing distribution maps, population estimates and databases after 1 year. Management plan each year. Visits to island by pupils. Darwin drawing competition. Press releases and reports.	Available funding (Darwin?) Overseas (British) expertise Co-operation of local agencies, staff and public Access to media and scientific publications Office facilities to analyse data and write reports and articles. A clear set of objectives

APPENDIX 2: Details of Methodology used during project

BASELINE SURVEY

In order to correctly interpret the findings of any long-term monitoring programme on Magdalena Island, it was essential to conduct an Environmental Baseline Survey of the island. An Environmental Baseline Survey aims to provide the best practicable assessment of the abundance and distribution of birds and mammals, and to map out the vegetation and habitat types which support them. This provides baseline data with which to assess future changes in any component of the island's ecosystem.

A. HABITAT

The first step of a conventional baseline survey is to identify and map out the key vegetation/habitat types found within the study area (Hiscock 1993). Initial studies undertaken by Dr Bingham identified the key vegetation/habitat types that occur in the region. These keys include vegetation/habitat types not found on Magdalena Island, but which are present in the region. It is important to include these in order to allow for future changes that may occur on the island.

A survey of Magdalena Island was conducted to map out the location and area of each vegetation/habitat type present on the island. This was performed by walking the entire coastline of the island, once along the littoral zone, and once along the adjacent terrestrial zone. The island was also repeatedly traversed in order to ensure that the interior was mapped out correctly according to the vegetation/habitat types present.

The littoral and terrestrial vegetation/habitat types were mapped out on field maps during the survey, and later copied onto the final survey map. This method is consistent with MNCR/NCC Phase 1 Survey methodology (Nature Conservancy Council CSD Report No.1072 / Marine Nature Conservation Review Occasional Report MNCR/OR/05). The results will allow future changes in vegetation and habitat to be recorded, in order to observe potential links between changes in fauna and their associated habitat.

B. FAUNA

A baseline survey of all birds and mammals present on the island was also recorded. Birds and mammals which breed in colonies can be accurately recorded by counting the number of breeding pairs in each colony, and mapping the colony locations. Species which breed individually require different techniques, depending on whether they are coastal birds or inland birds. Magellanic penguins are loosely colonial, breeding in burrows over a large area. Small Magellanic penguin colonies can be counted as per colonial birds, but larger colonies, such as found on Magdalena Island, require measurements of nesting density and area to determine total population size.

POPULATION CENSUS

COLONIAL BIRDS & MAMMALS

During an initial survey of the study area, all breeding colonies of birds and mammals were located and recorded on the map using a letter code. These colonies were then visited at the appropriate stage of the breeding cycle to record the number of breeding pairs within each colony.

Counts are always expressed in terms of breeding pairs, since this is the only meaningful figure for measuring population size. The number of individuals present within a colony will change during the course of the day, as individuals come and go in order to feed. The number of breeding pairs provides a constant measure of colony size regardless of daily changes.

For bird colonies, population counts are taken at the end of the egg-laying period, when incubation of the eggs has just begun. Counts are made of occupied nests only, which equates to the number of breeding pairs. Only incubating birds that are lying or sitting on nests are counted. Birds which are not on nests are ignored, since they are either non-breeders, or have partners nearby that are on nests. Where two birds occupy the same nest only one is counted.

By conducting counts at the end of the egg-laying period, under-estimates of population resulting from abandoned or failed nests are kept to a minimum. Counts are recorded using tally-counters, with three nest counts being taken at each colony. The result is the mean of the three counts, whilst the spread of results gives an indication of the margin of error. For small discrete colonies the margin of error can be well below plus or minus 5%, but figures are usually assigned a margin of error of plus or minus 10% for counts of this type.

The number of breeding pairs within each colony is entered on the map, along with the letter code indicating the species, and an arrow pointing to the exact location of the colony.

The only colonial mammals likely to be encountered are pinipeds (seals & sealions). Pinipeds do not have nests, and dominant males often mate with several females, so breeding females are the nearest equivalent to breeding pairs. Since it is not possible to be certain which females have mated, population counts rely on counting pups. This is not ideal, since it only records successful births, but it is the accepted method of determining population size for pinipeds.

Counts are made upon completion of pup births, although some under-estimation is inevitable due to pup loses prior to counting, or late births. Nevertheless with careful timing of the census the margin for error should be within plus or minus 10%. Counts are recorded on the map as per colonial birds.

On Magdalena Island, gulls and cormorants were the only colonial birds recorded (excluding Magellanic penguins which are covered later). No pinipeds were recorded breeding on Magdalena Island.

NON-COLONIAL BIRDS

SHOREBIRDS

Shorebirds, such as oystercatchers and marine ducks & geese, nest above the high water mark and patrol a territory that includes a section of beach. Because their breeding territories are restricted to the coastal strip, population size can be determined by walking the coastline. This is aided by the fact that such species are conspicuous, with the male usually holding a prominent position overlooking his territory.

During the incubation phase at least one bird from each pair (usually the female) will be sitting on eggs and well hidden from sight, increasing the likelihood of missing the pair if the male is resting. Once the chicks have hatched, they generally leave the nest and forage along the littoral and sub-littoral zones under the supervision of the adults, making the pair very visible and easy to count. Shorebird census work is therefore best conducted after the chicks have hatched, although the timing of the census is not as critical as for colonial birds.

Pairs that fail to breed will remain as a pair within their territory where they can still be visible for counting, so population size will not be underestimated as a result of failed breeders, as would be the case for colonial birds. Margins of error associated with shorebird counts are usually very low, although some error may arise when determining the breeding status of single birds encountered along the shore.

As for most bird census work, counts are made of breeding pairs rather than individuals, but when counting shorebirds it is common to see only one member of the pair. A male that is prominently positioned, or which calls and shows alarm when approached, will probably have a female close by. Lone females, or males that move further down the beach when approached, are probably non-breeders and should not be counted. A repeat census two or three weeks later can help to determine the status of lone birds, since breeding pairs will remain in the same section of coast, even if they fail to breed successfully. Generally shorebird populations can be recorded to within a margin of error of plus or minus 10%.

Breeding pairs of shorebirds are recorded on the map in the exact location at which they were recorded, using the appropriate letter code. Where more than one pair occurs too close together to mark individually on the map, they should be marked together, with the number of pairs written before the letter code, as per colonial birds.

INLAND BIRDS HOLDING TERRITORY

Conspicuous birds that hold large territories, such as raptors, can be assessed by recording their individual breeding territories. Breeding pairs patrol their own territories in search of food, making them easy to record, and with sufficient observation the actual nesting sites can usually be determined for each breeding pair. The location of each nest site should be recorded on the map using the appropriate letter code. The best time to record birds holding territory is during the chick rearing stage, when foraging activity is greatest. Accuracy is usually well within plus or minus 10%, unless specific problems in assessing territory status are encountered.

Where territories are smaller, and nest sites harder to find, numerous daily records may be necessary to determine territories. The study area should be walked twice a day, recording all bird sightings on a map, using a separate sheet for each visit. After three or four weeks the daily sightings are transferred onto one common map, with a separate map for each species. With three or four weeks of observations overlaid onto one map, territories will show up as clusters of sightings, allowing the size and number of territories to be determined, even if the actual nest sites cannot be found. The location of each territory (breeding pair) can then be marked on the survey map using the appropriate letter code. Accuracy is dependent on species type and number of recordings. Accuracy can usually be estimated from the clarity of the clusters observed.

INLAND BIRDS NOT HOLDING TERRITORY

For inland birds which do not nest colonially, and for which territories cannot be determined, census work must rely on rough estimates of density using transect counts.

The study area is crossed a number of times along set lines (transects) so that all areas and habitat types are represented. All birds observed within a set distance from the transect line are recorded in their appropriate position on the map. This distance from the transect line is called the Effective Transect Width (ETW) and is determined by species and habitat type. The ETW is the distance at which birds can be reliably sighted whilst walking the transect.

For dense habitat cover, such as woodland, a narrow ETW is required due to the difficulty of spotting birds. For open habitat, such as that found on Magdalena Island, a much wider ETW is possible because birds can be reliably sighted at a greater distance. For passerines in open habitat the ETW is set at 25 metres, so all birds observed within 25 metres each side of the line being walked (transect) are recorded. Birds observed outside the ETW are ignored. For larger birds, such as geese, the ETW can be set at 100 metres.

The total distance walked (transect length) is recorded, and multiplied by the ETW to give the total area surveyed for each species (this will vary according to the ETW used for each species). The density is the number of individuals or pairs recorded within the survey area.

Ideally only breeding pairs should be recorded, and for geese this should be possible if sufficient time is taken, because pairs generally remain together or close by during the chick rearing period. For passerines however, it is generally impossible to determine breeding status of individual birds, and pairs are often not seen together. For this reason all birds are recorded, and the number of individuals is divided by two to give a figure for breeding pairs. This can greatly over-estimate the breeding population due to non-breeders, or under-estimate the population due to birds hidden from sight, during incubation for example.

There is no preferred time for a census of passerines, provided that it is conducted during the main breeding season, because passerines begin nesting early and often have multiple broods. Because of the nature of the census, and the difficulty in determining breeding status, the margin of error for passerines is likely to exceed plus or minus 50%. It is generally only of use in determining relative abundance.

BURROWING PENGUINS

Penguins which live above ground, such as Rockhopper and Macaroni penguins, are treated in the same way as other colonial birds, as described above. Magellanic penguins also live in loose colonies, but their nests are hidden from sight below ground in burrows, making them impossible to count in the same manner. Because the nests are in burrows, it is not possible to see how many nests are in a given area. Many burrows are unoccupied, and to assume that all burrows contain nests would greatly over-estimate the population size.

Small Magellanic penguin colonies can be counted by looking into each burrow with the aid of a flashlight to determine which burrows contain incubating birds on nests. Counts should be made immediately after the completion of egg-laying, whilst adults are incubating the eggs. The total number of occupied burrows in the colony is recorded with the aid of a tally-counter, and a spot of bright spray paint is put in front of each burrow in order to prevent double-counting or missing burrows (the paint disappears within a few days).

Because Magellanic penguins live in burrows, egg losses are generally low, except during periods of heavy rain, when flooding of burrows may lead to high egg losses. If burrows are heavily flooded at the time of the count, then some under-estimation can be expected as a result of abandoned nests, but otherwise the margin of error should be well within plus or minus 10% for this type of census.

The only drawback to this methodology is that it is very time consuming, and therefore impractical for very large colonies. In such cases it is necessary to calculate the population size by mapping out the total area of the colony, and multiplying this area by the density of occupied burrows (nests/pairs) determined from study plots.

A number of study plots should be selected at random from areas within the main colony. Study plots should not cross the periphery of the colony since any area outside the colony would reduce the plot count and give a lower density reading. Plot size is determined by nesting density. For areas of moderate to high nesting density (0.05 to 0.1 nests per sq.m) the suggested plot size is 50m x 50m. For areas of nesting density below about 0.025 nests per sq.m. a plot size of 100m x 100m is recommended.

Once the study plots have been marked out, the number of occupied burrows (nests/pairs) within each study plot is counted using the methodology described above for small colonies. This gives the number of nests within a known area, allowing the mean nesting density to be calculated as nests per square metre.

The total area of ground occupied by the penguin colony is then mapped out, and the area of the colony calculated from the map using a dot matrix overlay. (A dot matrix overlay is a clear acetate sheet with squares and dots used to accurately determine area from a map). The area of the colony in square metres is multiplied by the mean nesting density (nests per square metre) to give the estimated population total, however this only applies if the nesting density is fairly constant throughout the colony.

If during the above procedure it is discovered that nesting density varies by more than 25% (eg. 0.10 nests per sq.m. to 0.075 nests per sq.m.), and that the areas that lie outside this range cover greater than 10% of the total colony area, then the colony must be mapped out in greater detail according to density variation.

The colony should be mapped out to show regions of high and low density (or high, medium and low density if the level of variation warrants). The total area of each density is then calculated from the map using a dot matrix overlay. A number of study plots should be established in each region to determine the mean nesting density within each region, and the mean nesting density for each region is multiplied by the area of that region, to give a separate population total for each.

EXAMPLE:

High Density: Area = 492,090 sq.m Mean Density = 0.098 nests/sq.m.

TOTAL = 48,225 breeding pairs (occupied nests)

Medium Density: Area = 115,223 sq.m Mean Density = 0.077 nests/sq.m.

TOTAL = 8,872 breeding pairs (occupied nests)

Low Density: Area = 39,054 sq.m Mean Density = 0.050 nests/sq.m.

TOTAL = 1,953 breeding pairs (occupied nests)

TOTAL FOR COLONY = 59,050 breeding pairs

Given the criteria above, and the inherent inaccuracies of using mean density instead of direct counts, population totals obtained using the above methodology should allow a margin of error of plus or minus 20%. Clearly direct counts as described for small colonies is preferable, but for very large colonies it is usually impractical.

PENGUIN MONITORING

The Baseline Survey and Population Census work described below provides the basis upon which a penguin monitoring programme can be built. Such ground work is essential for the correct interpretation of any changes observed during long-term monitoring. The population census work, when repeated annually, provides the first step of the monitoring programme.

POPULATION TRENDS

One of the most important parameters of any monitoring programme is the study of population trends. Population trends indicate the overall health of a colony or population. A declining population may well indicate problems which need to be identified and rectified in order to protect the population, whilst increasing populations may suggest a thriving population, even if some conflict with human activity is occurring.

In order to identify population trends it is necessary to record the population size at regular intervals, preferably every year if other factors such as breeding success or food abundance are to be recorded and related to population change. The method of recording population size each year is described above, and it is essential to ensure that the census is conducted in an identical manner each year if observed changes are to be valid. Any deviations from the stated methodology, which may be necessary because of local conditions, must be recorded in detail so that future census work can be conducted in a compatible manner.

ANNUAL BREEDING SUCCESS

Breeding success is the mean number of chicks reared to the point of fledging per breeding pair each year. For penguins, fledging is taken as the point at which chicks shed their mesoptile plumage and grow water-proof plumage.

For penguins which breed on the surface in dense colonies, the number of breeding pairs within the colony is counted using methodology described above. The colony is then revisited later in the season when chicks are fledging, and the total number of chicks within the colony is counted. Chicks are counted in a similar manner to that employed for nest counts.

The number of breeding pairs (nests) recorded in the colony at the beginning of the breeding season, is divided by the number of chicks surviving to the point of fledging. This figure is the breeding success or productivity, expressed as chicks per breeding pair. This figure may also be expressed as a percentage, where 100% is equal to 1 chick per breeding pair (nest). It is important not to mistake juveniles, (which return to their natal colony to moult at this time of year) with moulting chicks, or an artificially high breeding success will be recorded. Careful observation of plumage will differentiate between moulting chicks and juveniles from previous seasons.

For penguins that live in burrows, such as Magellanic penguins, the procedure is slightly different. The number of breeding pairs within the colony should have been recorded using the methodology described above. For small colonies, where it was possible to look into every burrow to record the actual number of occupied burrows within the colony, chicks are counted in the same manner to record the total number of chicks within the colony. Breeding success is again expressed as the number of chicks fledged divided by the number of breeding pairs (occupied burrows).

For large colonies, where the colony total was determined by calculations of area and density, it is necessary to record breeding success for selected study areas within the colony. During the early incubation phase, burrows are examined to determine whether they are occupied by a breeding pair. Occupied burrows are marked by a small stick. This is important, since later in the season it is not possible to determine which empty burrows were never occupied, and which had nests which later failed or were abandoned. Generally 25 to 50 occupied burrows are marked in each study area, to give an average that is representative of the area as a whole. Where several study areas are being recorded, a similar number of occupied burrows are marked in each area.

Later in the season, just before the chicks leave their burrows, each of the marked burrows are visited again to record the total number of surviving chicks. The total number of chicks recorded is divided by the number of marked burrows to give the mean number of chicks per breeding pair in each study area.

It is important to ensure that chick counts are performed at the correct time. As the chicks mature, they begin to sit outside their burrows during fine weather, but still return to their burrows when approached. Chicks will then begin to show signs of shedding their mesoptile plumage, and this is the best time to conduct chick counts. If counting is left any later, chicks begin to leave their burrows and gather on the beach, giving low chick counts within the marked burrows, and hence artificially low breeding success rates. Wherever possible chick counts should be conducted at regular intervals over a period of two or three weeks, in order to ensure that the timing of the count is correct for each burrow.

In addition to straight forward measurements of chicks per breeding pair, repeated observations throughout the breeding season are recommended to determine the timing and causes of breeding failure. In particular it is useful to re-examine colonies and marked nests at regular intervals during the egg-hatching phase, to record hatching dates, and to determine the proportion of breeding failures that result from egg losses and from chick mortality. Detailed observations of selected nests to observe the causes of egg losses and chick mortality are also recommended.

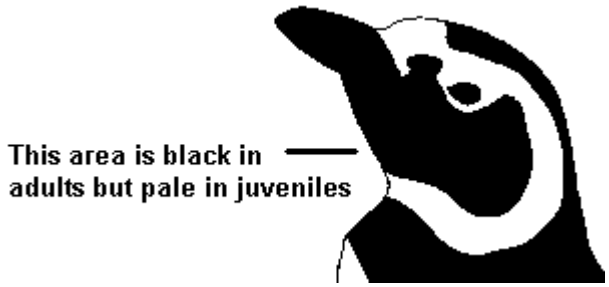
ADULT & JUVENILE MORTALITY

Assuming that a colony or population is not subject to significant emigration or immigration, then population trends are a function of adult mortality, breeding success and juvenile survival. The previous sections deal with monitoring population trends and breeding success, but that still leaves two unknown factors in the equation: adult mortality and juvenile survival.

In a fairly self-contained population, such as the penguin population on Magdalena Island, adult mortality can be estimated by tagging large numbers of adults to see how many fail to return each year. Unfortunately because penguins have short, stubby legs, and travel through the medium of water rather than air, they cannot be ringed around the leg as can most birds. Despite extensive development current penguin tags still cause considerable drag, reducing the penguin's ability to forage and escape predators. Existing tags also cause abrasions on the flipper, which can lead to infection. These side-effects not only cause stress to the birds, but increase mortality, which is the very factor which needs to be measured.

Juvenile survival can also be monitored through the use of tags, but the same problem exists as described above for adults. Fortunately tagging is not the only method available for estimating juvenile survival. After fledging and leaving the colony, most surviving juveniles return to their natal colony to moult each year until they are ready to breed. A rough estimate of juvenile survival can therefore be achieved by counting juveniles returning to moult each year.

Moulting juveniles are found along the beaches adjacent to the colony during late December and January. To a casual observer they can be mistaken for moulting chicks, but juveniles are easily distinguished from chicks and adults by their plumage, even during their moult. The plumage of juveniles is generally much paler than adults, but the most striking feature is the cheek area below the eye and bill, which is black in adults, but very pale in juveniles. Juveniles also lack the extensive area of pink skin above the eye and bill which is found on all adults. (NOTE: Moulted chicks, which have slightly different plumage, are not counted as juveniles. Juveniles are at least one year old. Care must be taken not to mistake moulted chicks for juveniles)



Counting juveniles along the beach can be difficult and unreliable where several colonies are scattered along a long length of coastline, but for a discreet island population such as the one found on Magdalena Island, it can provide valuable data.

The number of juveniles present along the beach is counted every few days throughout January. These counts will initially increase as a result of the daily arrival of new juveniles coming ashore to moult. Eventually a peak will be reached, and the counts will drop as juveniles begin to leave following completion of their moult. This peak figure is divided by the total number of surviving chicks estimated for the previous year, to give juveniles (year Y) per surviving chick (year Y-1).

The resulting figure is not a direct measure of the previous season's cohort, since juveniles counted will not only comprise chicks from the previous year. The results should initially be used only to estimate juvenile survival over the previous two or three year period, however after several years of data, statistical analysis can be employed to reveal annual changes in juvenile survival.

Despite the limitations, long-term counting of juveniles can provide invaluable data which can be used to identify years of high or low juvenile survival. Seasonal changes in juvenile survival may correspond with other observations, such as variations in breeding success, changes in prey composition, oil spills or El Niño years. Such observations may also show whether years of population decline correspond to periods of low juvenile survival, helping to identify or eliminate potential causes of concern.

COMPARING COLONIES

Penguin monitoring techniques described under the previous sections are used to monitor the health of a particular colony or population, but they can also be used to investigate or monitor external factors which may impact certain colonies or areas within a colony. On Magdalena Island tourism is a potential cause of concern, and it is important to monitor the effects of tourism in order to ensure sustainable use of the island as a tourist resource.

Human presence in the form of tourism has the potential to disturb breeding birds in a number of ways:

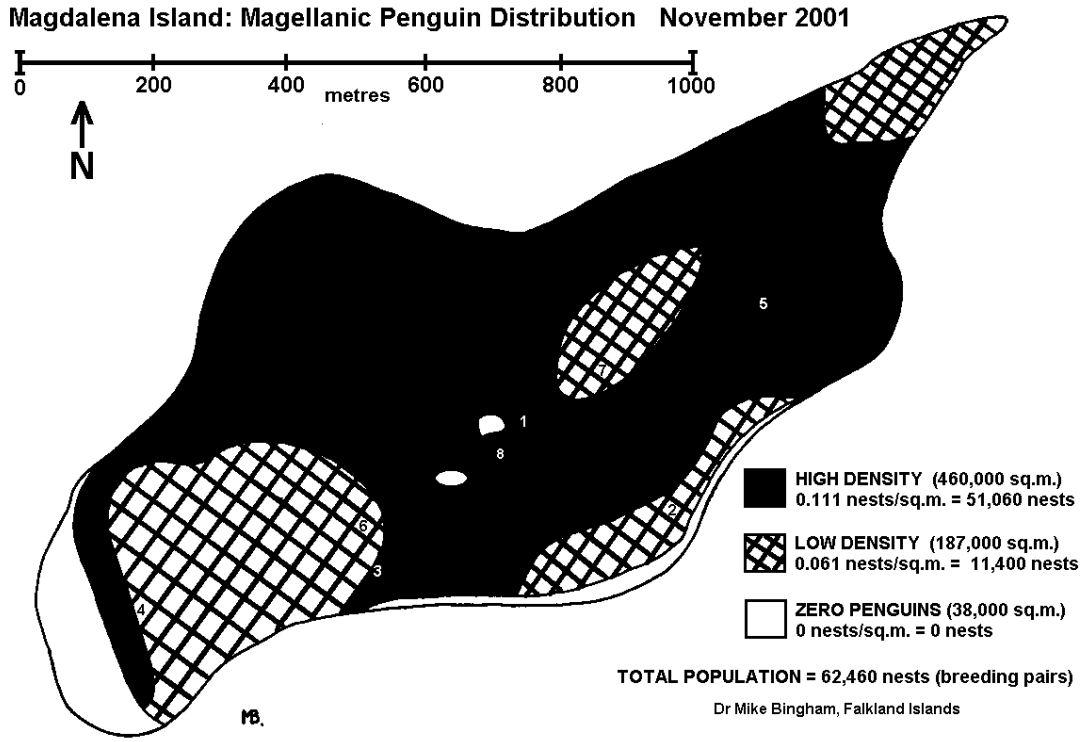
- Incubating birds may be frightened away allowing predators to take eggs or young.
- Raised metabolic rates brought on by stress may lead to greater food requirement.
- Natural behaviour, such as courtship or the feeding of young, may be disrupted.
- Adults could be scared away completely, causing them to abandon eggs or young.
- Severe disturbance could lead to adults or young being killed or injured.
- Birds living in burrows may be killed if the burrow collapses under human weight.

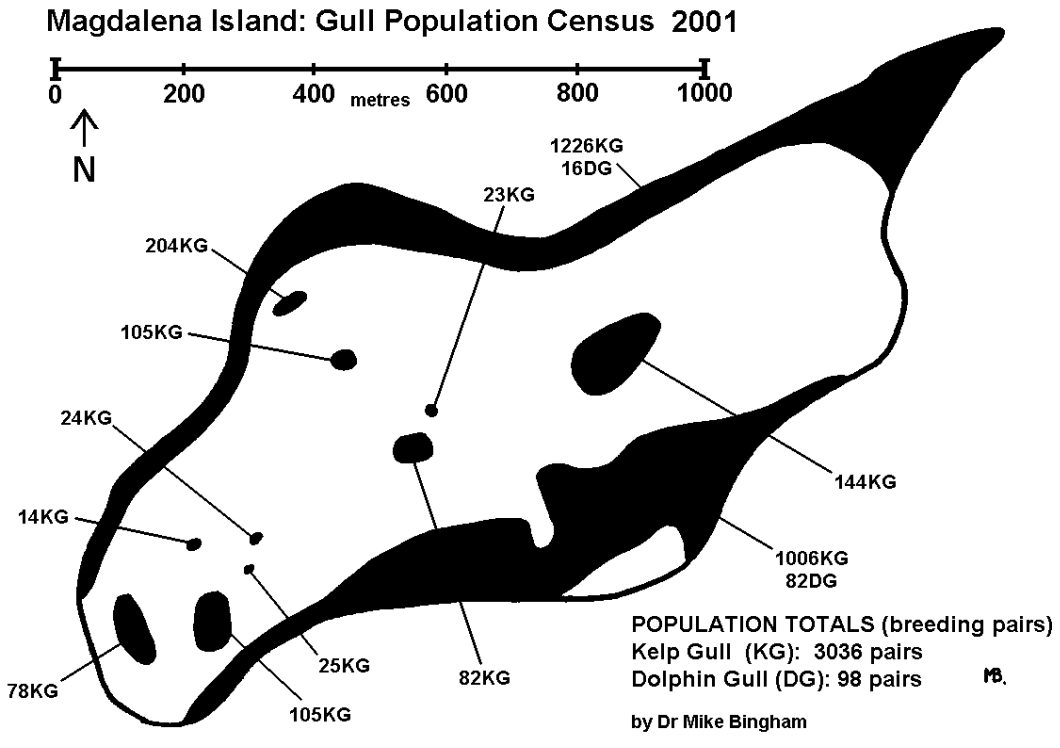
To identify the level of disturbance, monitoring is carried out in a study site that is subject to tourism, and in a control site which is well away from tourists. Significant levels of disturbance within the study site would be evident from reduced breeding success. There may also be observed changes in predation, or the causes of egg and chick mortality. Over a longer time-scale, continued disturbance may lead to a reduction in population size.

On Magdalena Island tourists are only permitted to walk within a controlled area. Penguin burrows adjacent to this area are monitored to determine nesting density, breeding success, egg loss rates, chick mortality rates, predation and the causes of egg and chick mortality. Similar studies are conducted in other parts of the island, well away from where tourists are permitted to walk, in order to monitor any changes that may result from tourism.

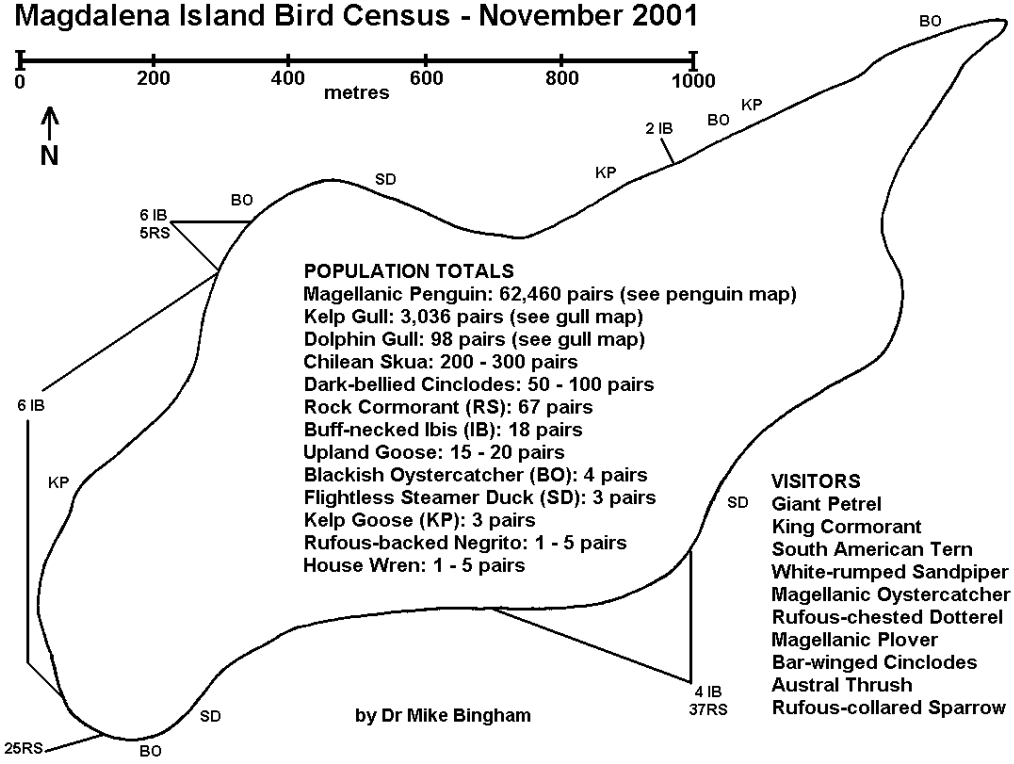
Where other human activities away from the breeding site are under examination, such as the impacts of commercial fishing or oil pollution, the principals are the same. Comparisons are made of study areas within the zone of human impact (eg. area that is fished or area of pollution), and control areas that are outside the zone of impact. Studies into the effects of commercial fishing and oil pollution should look for reductions in population size, breeding success, and juvenile and adult survival. Studies into the effects of commercial fishing should also look for increases in foraging range and duration, and changes in dietary composition, all of which will effect chick survival.

APPENDIX 3: Summary of results for Magdalena Island 2001/2002





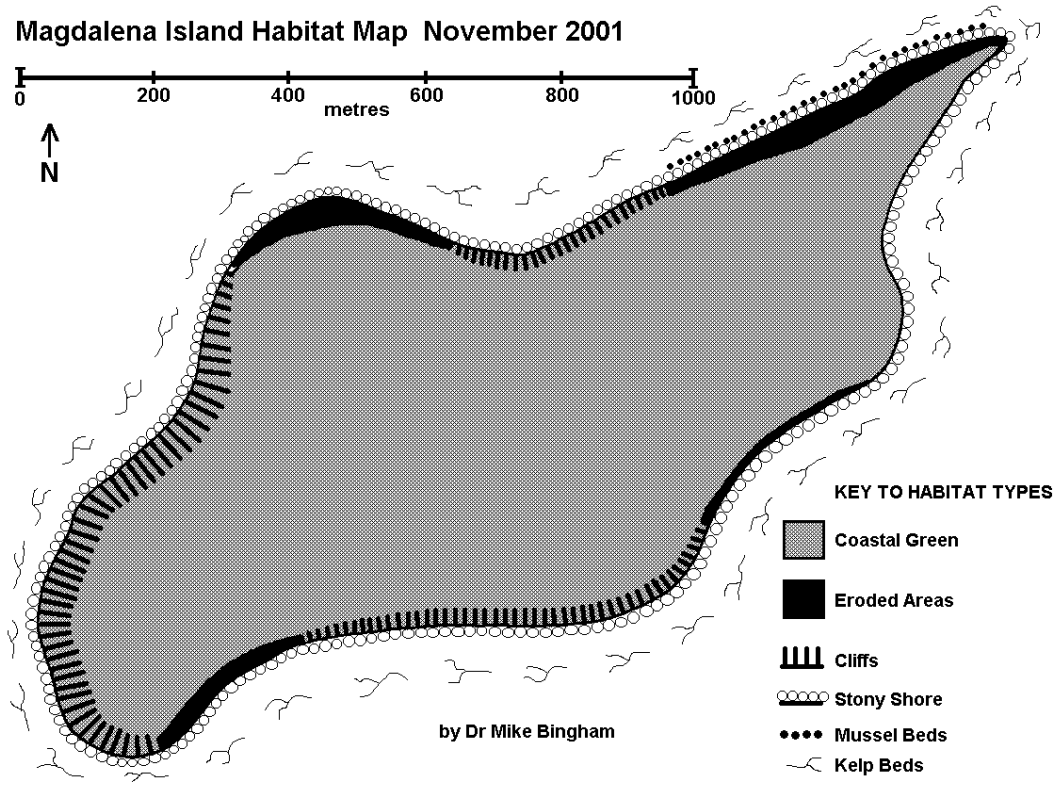
Magdalena Island Bird Census - November 2001



POPULATION TOTALS
Magellanic Penguin: 62,460 pairs (see penguin map)
Kelp Gull: 3,036 pairs (see gull map)
Dolphin Gull: 98 pairs (see gull map)
Chilean Skua: 200 - 300 pairs
Dark-bellied Cinclodes: 50 - 100 pairs
Rock Cormorant (RS): 67 pairs
Buff-necked Ibis (IB): 18 pairs
Upland Goose: 15 - 20 pairs
Blackish Oystercatcher (BO): 4 pairs
Flightless Steamer Duck (SD): 3 pairs
Kelp Goose (KP): 3 pairs
Rufous-backed Negrito: 1 - 5 pairs
House Wren: 1 - 5 pairs

VISITORS
Giant Petrel
King Cormorant
South American Tern
White-rumped Sandpiper
Magellanic Oystercatcher
Rufous-chested Dotterel
Magellanic Plover
Bar-winged Cinclodes
Austral Thrush
Rufous-collared Sparrow

Magdalena Island Habitat Map November 2001



Database of Nesting Success for Magdalena Island 2001/2002

	Nests	*Success*	*Lost as Eggs*	*Lost Hatching*	*Lost as chicks*	*Fledged*
Plot 1	*23*	*78%*	*22%*	*17%*	*30%*	*131%*
Plot 2	*9*	*88%*	*22%*	*0%*	*11%*	*167%*
Plot 3	*26*	*81%*	*15%*	*4%*	*27%*	*154%*
Plot 5	*25*	*60%*	*28%*	*24%*	*40%*	*108%*
Plot 6	*25*	*76%*	*16%*	*8%*	*44%*	*132%*
Plot 7	*24*	*83%*	*17%*	*17%*	*29%*	*137%*
TOTAL	*132*	*77%*	*19%*	*13%*	*33%*	*135%*
PATH	*19*	*84%*	*11%*	*5%*	*37%*	*147%*
OPEN	*15*	*73%*	*33%*	*20%*	*40%*	*107%*

Juvenile Counts on Magdalena Island

Date	**No of Juveniles**
05/02/2002	**4066**
10/02/2002	**4260**
15/02/2002	**2980**

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