Darwin Initiative for the Survival of Species

Final Report

1. Darwin Project Information

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Project title	Establish Penguin Monitoring Programme
Country	Chile
UK Contractor	Environmental Research Unit
Partner Organisation (s)	CONAF
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Project website	
Author(s), date	Mike Bingham

2. Project Background/Rationale

The project took 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 Mike Bingham have revealed an 80% decline in Magellanic penguins between 1990/91 and 2002/03. 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 2002).

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 had previously 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 was vital to determine whether penguin populations in Chile were under threat, and the project sought to provide this information.

3. Project Summary

Chile is a country rich in biodiversity, but with limited financial resources or expertise in environmental protection. The project aimed 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 suggested that Magellanic penguins are not declining on Magdalena Island, despite its close proximity to the Falklands, but a long-term monitoring programme needed to be established in order to accurately determine population trends. Magdalena Island holds a population of around 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 5.

The original objectives and operating plan remained constant throughout the project and were successfully completed (see Section 5).

4. Scientific, Training, and Technical Assessment

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.

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 occurring in the region, including those which are not found on Magdalena itself (Appendices 1 & 2).

A survey of Magdalena Island was then 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 (Appendix 3). 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.

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 (Appendix 4). 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 generally 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. If 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 a margin of error of plus or minus 10% is usually allowed 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 (Appendix 5 and 6).

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 internationally 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 (Appendix 5) and cormorants (Appendix 6) were the only colonial birds recorded (excluding Magellanic penguins which are semi-colonial and covered separately). No pinipeds were recorded breeding on Magdalena Island.

NON-COLONIAL BIRDS

SHOREBIRDS

Shorebirds, such as oystercatchers, marine ducks and marine 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 territorial and 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.

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 and should be counted. Lone females, or males that leave the area when approached, are probably non-breeders and should not be counted. A repeat census two or three weeks later will 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. Shorebird populations can usually 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 determining territorial 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, but can usually be estimated from the clarity of the clusters observed.

INLAND BIRDS NOT HOLDING TERRITORY

For inland birds which do not nest in colonies, 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 that 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.

3C. 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 under section 3A. 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).

Burrows containing eggs but no adult are still counted as occupied nests. Because Magellanic penguins live in burrows egg losses are low, and abandoned eggs usually remain in the burrow for many days. Under-estimation due to breeding failure is therefore usually low, and 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.

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 sectors of high and low density (Appendix 8) (or high, medium and low density if the level of variation warrants it - Appendices 7 & 9). The total area covered by each density is calculated from the map using a dot matrix overlay. A number of study plots in each sector determine the mean nesting density for each sector, and this nesting density is multiplied by the appropriate area 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 for 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 under Sections 2 and 3 above provide 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 carried out under Section 3C, 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 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 under Section 3, 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.

The same permanent study plots must be used each year for determining changes in penguin population. If permanent study plots reveal annual increases or decreases in all sectors of the colony, then these observed changes can be assumed to be fairly reliable, since they are not subject to the 20% margin of error associated with turning study plot counts into population totals. Changing study plots is not recommended, since it reintroduces the 20% margin of error for each season's data, making small population changes impossible to detect.

Annual changes in area must also be considered when determining overall population change.

ANNUAL BREEDING SUCCESS

Annual 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 ready to take to sea.

For penguins which breed on the surface in colonies, the number of breeding pairs within the colony is counted using methodology described in section 3A. The colony is then revisited later in the season, just prior to the chicks fledging and leaving the colony. The total number of chicks within the colony is counted, with the mean of three counts being taken as the result.

The number of chicks surviving to the point of fledging is divided by the number of breeding pairs (nests) recorded in the colony at the beginning of the breeding season. 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). Provided that chicks have not already begun leaving the colony at the time of the count, productivity will be slightly over-estimated as a result of some chicks which are not at the point of fledging, and which may still die prior to fledging. However surface-breeding species are fairly uniform in development, and chick losses reduce as chicks mature, so the margin of error should be within plus or minus 10%.

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, there are two possible ways of recording breeding success. The number of chicks surviving to fledge can be estimated from a second visit as for surface-breeding species, with the total number of chicks in any given colony or plot being divided by the number of occupied nests. However penguins living in burrows are much less uniform in development, especially when food is short, and this method can greatly over-estimate breeding success for Magellanic penguins.

Studies in the Falkland Islands have shown that chicks which receive less food take much longer to develop, causing chicks to become abandoned by the adult whilst still dependent on the adults for food, leading to high chick mortality just prior to fledging. These late developing chicks, most of which die, would be counted as successfully fledging according to the above methodology, greatly over-estimating breeding success. A much better methodology is therefore to make regular observations of egg and chick development throughout the season, right up until the point that each chick either leaves the nest to fledge or dies.

When the study plots are counted at the beginning of the breeding season, twenty occupied burrows in each plot are marked with small sticks bearing names or numbers to identify individual nests. These nests are visited on a regular basis until the chicks change their mesoptile plumage into water-proof plumage and leave the nest. Chicks disappearing prior to shedding their mesoptile plumage are presumed to have died. Chicks disappearing afterwards are presumed to have fledged (see Appendix 10).

The number of chicks fledging is divided by the number of marked burrows being observed in each study plot. This figure is the breeding success or productivity, expressed as chicks per breeding pair.

This method not only allows for accurate measurement of breeding success, but also the timing and causes of breeding failure. Abandoned eggs are opened to determine the stage of development, after it is certain that the eggs have been completely abandoned for at least two weeks. Dead chicks are removed for weighing and examination to determine causes of death. Hatching dates, development duration, and the proportion of breeding failures that result from egg losses and chick mortality can be determined.

DIET AND FORAGING OBSERVATIONS

Diet and foraging behaviour are important aspects of seabird monitoring, especially when commercial fishing activities operate in the region. However many aspects of foraging behaviour are difficult to observe, except as part of a separate research programme. For a site-specific monitoring programme, observations of foraging behaviour and diet will inevitably be limited. One such limitation is the time of year during which foraging behaviour and diet can be observed.

When adults are not breeding they are not restricted to the locality of their breeding site, and are therefore difficult to observe as part of a site-specific monitoring programme. However this freedom to forage wherever food resources are most abundant means that adults find it comparatively easy to locate sufficient food, even when prey is scarce, and starvation during the winter migration is not usually a major mortality factor for adult Magellanic penguins.

During the breeding phase adults are not free to forage wherever food resources are most abundant, because their foraging range is restricted by the need to return regularly to their nest. In addition, each adult is only able to spend half the time foraging for food when brooding eggs or small chicks, as nesting duties are shared between the two parents. Chicks are totally dependent on food caught over and above what the

adults require for their own metabolic needs. If adults only catch sufficient food to meet their own metabolic needs, the chicks will starve.

The usual method of determining prey composition is by stomach flushing adults returning from foraging trips. The best place to catch adults is between the beach and their nest site. Catching adults too close to the water will allow them to escape back into the sea, whilst catching within the confines of the colony leads to excessive disturbance. It is important to ensure that only birds returning from foraging trips are caught.

Once the adult is caught, a small plastic tube (such as used in hospital for stomach-flushing infants) is passed carefully into the penguin's stomach through the open beak, taking care not to enter the wind-pipe by mistake. It is important not to apply too much pressure in order to avoid injury. Sea water is then poured into the stomach using a funnel attached to the other end of the tube. (Pump mechanisms are not recommended since it is important not to create excess pressure in the stomach). The tube is then removed, and the penguin is inverted over a bucket, so that the water in the stomach flushes out into the bucket with the stomach contents. This is repeated two or three times, until little food remains.

During the chick rearing stage it is possible to record not only prey composition, but also the quantity of food being brought back to chicks. It is therefore important to ensure that the stomach is flushed until the water is mostly free of remaining food. This may require 4 or 5 flushes. Outside of the chick-rearing phase measurements of food quantity have little significance, and it is not necessary to flush out all the stomach contents in order to determine prey composition. It is therefore better to release the bird after the majority of food appears to have been flushed.

Prior to release, the bird should be weighed, and marked with an animal-marking crayon to ensure that the same bird is not caught a second time. The stomach samples are drained and stored in jars with formaline solution or alcohol, ready for later examination. The jars should be carefully marked with date, species and location.

In the laboratory the stomach samples should be rinsed with water, and then drained and padded with cloth to remove any excess liquid. They are then weighed to determine the quantity of food retrieved (wet weight). Each sample is then divided up into its appropriate components, which are weighed individually to determine proportional dietary composition by wet weight. Fish otoliths, cephalopod beaks and crustacean carapaces (which are not easily digested) can be used to aid species identification, and to estimate proportional composition.

The number of diet samples taken, and the period of time over which samples are taken, is a balance between the need for new data and the well-being of the birds. Whilst stomach-flushing does not cause long-term harm when carried out carefully, it is very stressful, and has the potential to be fatal if the procedure goes wrong. It is therefore important to limit such an invasive and risky procedure to the minimum.

Diet composition can also be evaluated from food dropped when adults feed chicks, and from analysis of faeces, which may contain fish otoliths, cephalopod beaks and crustacean carapaces.

For Magdalena Island, diet composition is well known from previous studies, and from ongoing collection of faeces and food scraps spilt when adults feed chicks. Stomach-flushing is therefore not considered necessary under the present monitoring regime.

Foraging duration during chick-rearing can also be recorded by marking adults in burrows that are incubating or feeding chicks. Adults in burrows can be easily marked using animal-marking crayons attached to the end of a stick which is passed down into the burrow. Each penguin should be marked around the neck and throat area where it cannot preen. Although animal-marking crayon can last several days at sea, it is important to re-apply the marking whenever it begins to fade. By marking each member of the breeding pair with a different colour, and observing the times that each penguin leaves and returns on foraging trips, it is possible to record foraging duration.

These observations are particularly important during the chick-rearing phase, when the time taken collecting food for chicks has a significant impact on chick survival. Such observations can be combined with observations of chick mortality described under section 4B.

Where financial resources permit, satellite transmitters, time-log recorders and dive-depth recorders can provide useful information on where birds forage on a daily basis, how deep they dive, how long they spend during each dive, and where they forage during the non-breeding season.

ADULT & JUVENILE MORTALITY

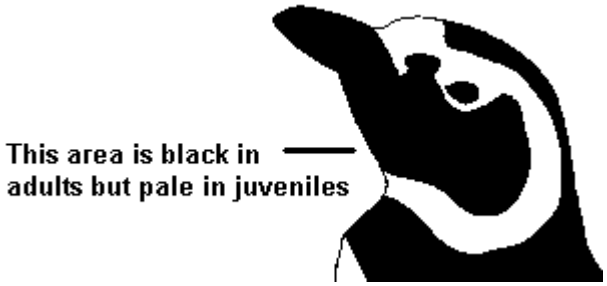
Assuming that a colony or population is not subject to significant emigration or immigration, then population trends are a function of adult mortality, breeding success and juvenile survival. The previous sections deal with monitoring population trends and breeding success, which leaves two unknown factors 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 for 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 from January through to March. 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. Juveniles differ from chicks in the facial plumage, which when huddled together is often all an observer can see.

It is worth spending time familiarising oneself with the difference in plumage between juveniles and adults / chicks before commencing the juvenile count. (NOTE: Newly moulted chicks, which have slightly different plumage, are not counted as juveniles. Juveniles must be 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 around the coast is counted each week from end of January to end of February. These timings may differ for other locations, or for acceptional years, but the correct timing can be established from the spread of results. 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. The 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 do not comprise solely of chicks from the previous year. The results can 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 can also be used to identify colonies with low juvenile survival, or to 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 above 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 areas that are subjected to tourism, and in control sites which are 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 occurring 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 or 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 effect chick survival.

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PARTICIPANTS

Environmental Research Unit
Corporación Nacional Forestal
The rangers of Magdalena Island (Louis, Roberto, Domingo and Floridor)
The crews of "Melinka", "Hundy", "Don Jorge" and “Mandamiento”
Trainees Nidia Mendez, Elena Mejias, Cici Legoe, Christopher Burney, Jennifer Rock and Jon Philipsborne.
Funding by the Darwin Initiative

5. Project Impacts

Results confirm that Magdalena Island has an increasing population, and that at the current level tourism and other human activities are not having any major detrimental affect on penguin populations. High breeding success compared to the Falkland Islands supports the argument that the Falkland Islands population is in decline due the Falkland Islands Government’s refusal to introduce no-fishing zones. These conclusions have been published in the Chilean Journal of Natural History (BINGHAM 2002 - The decline of Falkland Islands penguins in the presence of a commercial fishing industry. **Error! Reference source not found.**)

Local members of CONAF have been instructed in seabird monitoring techniques,

and a comprehensive Seabird Monitoring Training Manual has been written and circulated. The monitoring programme established by the project is not only continuing on a permanent basis in Chile, but has also been extended to Cabo Virgenes in Argentina, with the support of the Argentine government. These programmes are to be run by the Darwin Project Leader, Mike Bingham, under the auspices of La Organización para la Conservación de los Pingüinos, operating in Chile and Argentina.

The project did have unexpected results in so far as the Falkland Islands Government tried to prevent the project from drawing comparisons with penguins in the Falkland Islands, following the mass starvation of 100,000 penguins in the Falklands during May 2002. This resulted in the Project Leader, Mike Bingham, taking the Falkland Islands Government to the Supreme Court for human rights abuse in October 2003. Mr Bingham won his case, with the Supreme Court ruling that the Governor, Chief Executive, Attorney General, and members of the Falkland Islands Government's Executive Council had committed acts of human rights abuse which were described by the Supreme Court judge as "morally and constitutionally indefensible."

The establishment of a long-term monitoring programme will greatly assist Chile in meeting its obligations under the Biodiversity Convention, since it is now generating data with which to protect and monitor penguin populations. In addition, the local partner CONAF have been enabled in Seabird Monitoring on the island through the training of staff and the production of training material. This is an ongoing process, since the Project Leader is continuing the work which the project began. Local tourism has benefited from the monitoring and safeguarding of the penguins which are the foundation of local tourism.

6. Project Outputs

See appendix II and III. Dissemination has been through internal reports and training material for local partner and other researchers, local newspaper reports for local community and scientific publications for the international scientific community. Further dissemination will continue funded by La Organización para la Conservación de los Pingüinos.

7. Project Expenditure

Table A Salary costs

Table B Other costs

8. Project Operation and Partnerships

The project was 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 was made up of a British project leader and Chilean, American and Australian field assistants, working with Chilean staff who were trained in penguin monitoring techniques. There have been no difficulties but many benefits.

CONAF, who are the owners of the reserve, were very pleased not only with the work achieved, but also the opportunity to have staff trained in penguin monitoring techniques. The project has generated 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.

9. Monitoring and Evaluation, Lesson learning

Initial scientific outputs were evaluated by the Chilean Journal of Natural History through the normal peer-review process, and by the Organización para la Conservación de los Pingüinos. Baseline surveys were completed for all wildlife, and habitat maps and GPS grid maps were created. Annual changes in population, breeding success, and chick mortality are being monitored, and will be for the foreseeable future. This enables the local partners to now make informed decisions about the islands management.

The main problems to overcome were the administrative problems resulting from the Darwin office losing and failing to reply to correspondence. This situation was compounded by the lack of continuity, with Darwin administration staff changing without notification, resulting in email addresses being left unattended. This resulted in a 7 month delay in payment being made, during the summer season when funds were desperately needed. This resulted in some final details being run over until November 2004.

10. Actions taken in response to annual report reviews (if applicable)

Recommendations relating to the statistical conversion of study plot data into population estimates has not been adopted, since this falls outside the remit of the project, which was to establish a monitoring programme and determine annual trends. The recommendations will be considered at a later date, when more data relating to annual trends has been gathered, but will not necessarily be adopted because they are contradictory to the advice given by most other experts in penguin census work. All other recommendations made in annual report reviews have been adopted.

11. Darwin Identity

All published material bears the Darwin logo and acknowledges the funding made available by the Darwin Initiative. Material on the Internet also promotes the Darwin Initiative through the use of logo and acknowledgements.

12. Leverage

The project is now funded by the Organización para la Conservación de los Pingüinos, and is not only continuing in Chile, but has been extended to Argentina.

13. Sustainability and Legacy

The Project Leader is continuing to run the project under new funding (see above). CONAF staff remain working on the island under internal funding generated from tourists visiting the island who pay an entrance fee.

14. Post-Project Follow up Activities *(max. 300 words)*

This section should be completed ONLY if you wish to be considered for invitation to apply for Post Project Funding*. Each year, a small number of Darwin projects will be invited to apply for funding. Selection of these projects will be based on promising project work, reviews, and your comments within this section. Further information on this funding scheme is available from the Darwin website.*

15. Value for money

I consider the project to have been excellent value for money, in terms of the scientific data obtained, international goodwill, the training of local staff, and the raising of awareness of conservation issues in the region.

Appendix I: Project Contribution to Articles under the Convention on Biological Diversity (CBD)

Please complete the table below to show the extent of project contribution to the different measures for biodiversity conservation defined in the CBD Articles. This will enable us to tie Darwin projects more directly into CBD areas and to see if the underlying objective of the Darwin Initiative has been met. We have focused on CBD Articles that are most relevant to biodiversity conservation initiatives by small projects in developing countries. However, certain Articles have been omitted where they apply across the board. Where there is overlap between measures described by two different Articles, allocate the % to the most appropriate one.

Project Contribution to Articles under the Convention on Biological Diversity		
Article No./Title	**Project %**	**Article Description**
6. General Measures for Conservation & Sustainable Use	2	Develop national strategies that integrate conservation and sustainable use.
7. Identification and Monitoring	30	Identify and monitor components of biological diversity, particularly those requiring urgent conservation; identify processes and activities that have adverse effects; maintain and organise relevant data.
8. In-situ Conservation	30	Establish systems of protected areas with guidelines for selection and management; regulate biological resources, promote protection of habitats; manage areas adjacent to protected areas; restore degraded ecosystems and recovery of threatened species; control risks associated with organisms modified by biotechnology; control spread of alien species; ensure compatibility between sustainable use of resources and their conservation; protect traditional lifestyles and knowledge on biological resources.
9. Ex-situ Conservation	5	Adopt ex-situ measures to conserve and research components of biological diversity, preferably in country of origin; facilitate recovery of threatened species; regulate and manage collection of biological resources.
10. Sustainable Use of Components of Biological Diversity	10	Integrate conservation and sustainable use in national decisions; protect sustainable customary uses; support local populations to implement remedial actions; encourage co-operation between governments and the private sector.
11. Incentive Measures	1	Establish economically and socially sound incentives to conserve and promote sustainable use of biological diversity.

12. Research and Training	5	Establish programmes for scientific and technical education in identification, conservation and sustainable use of biodiversity components; promote research contributing to the conservation and sustainable use of biological diversity, particularly in developing countries (in accordance with SBSTTA recommendations).
13. Public Education and Awareness	5	Promote understanding of the importance of measures to conserve biological diversity and propagate these measures through the media; cooperate with other states and organisations in developing awareness programmes.
14. Impact Assessment and Minimizing Adverse Impacts	5	Introduce EIAs of appropriate projects and allow public participation; take into account environmental consequences of policies; exchange information on impacts beyond State boundaries and work to reduce hazards; promote emergency responses to hazards; examine mechanisms for re-dress of international damage.
15. Access to Genetic Resources	3	Whilst governments control access to their genetic resources they should also facilitate access of environmentally sound uses on mutually agreed terms; scientific research based on a country's genetic resources should ensure sharing in a fair and equitable way of results and benefits.
16. Access to and Transfer of Technology	0	Countries shall ensure access to technologies relevant to conservation and sustainable use of biodiversity under fair and most favourable terms to the source countries (subject to patents and intellectual property rights) and ensure the private sector facilitates such assess and joint development of technologies.
17. Exchange of Information	1	Countries shall facilitate information exchange and repatriation including technical scientific and socio-economic research, information on training and surveying programmes and local knowledge
19. Bio-safety Protocol	3	Countries shall take legislative, administrative or policy measures to provide for the effective participation in biotechnological research activities and to ensure all practicable measures to promote and advance priority access on a fair and equitable basis, especially where they provide the genetic resources for such research.
Total %	**100%**	**Check % = total 100**

Appendix II Outputs

Please quantify and briefly describe all project outputs using the coding and format of the Darwin Initiative Standard Output Measures.

Code	Total to date (reduce box)	Detail (←expand box)
Training Outputs		
1a	Number of people to submit PhD thesis	0
1b	Number of PhD qualifications obtained	0
2	Number of Masters qualifications obtained	0
3	Number of other qualifications obtained	0
4a	Number of undergraduate students receiving training	2
4b	Number of training weeks provided to undergraduate students	14
4c	Number of postgraduate students receiving training (not 1-3 above)	2
4d	Number of training weeks for postgraduate students	14
5	Number of people receiving other forms of **long-term** (>1yr) training not leading to formal qualification(i.e not categories 1-4 above)	2
6a	Number of people receiving other forms of **short-term** education/training (i.e not categories 1-5 above)	1
6b	Number of training weeks not leading to formal qualification	28
7	Number of types of training materials produced for use by host country(s)	2
Research Outputs		
8	Number of weeks spent by UK project staff on project work in host country(s)	54
9	Number of species/habitat management plans (or action plans) produced for Governments, public authorities or other implementing agencies in the host country (s)	1
10	Number of formal documents produced to assist work related to species identification, classification and recording.	1
11a	Number of papers published or accepted for publication in peer reviewed journals	1
11b	Number of papers published or accepted for publication elsewhere	2
12a	Number of computer-based databases established (containing species/generic information) and handed over to host country	4
12b	Number of computer-based databases enhanced (containing species/genetic information) and handed over to host country	0
13a	Number of species reference collections established and handed over to host country(s)	0
13b	Number of species reference collections enhanced and handed over to host country(s)	0

Dissemination Outputs		
14a	Number of conferences/seminars/workshops organised to present/disseminate findings from Darwin project work	1
14b	Number of conferences/seminars/ workshops **attended** at which findings from Darwin project work will be presented/ disseminated.	1
15a	Number of national press releases or publicity articles in host country(s)	1
15b	Number of local press releases or publicity articles in host country(s)	3
15c	Number of national press releases or publicity articles in UK	0
15d	Number of local press releases or publicity articles in UK	0
16a	Number of issues of newsletters produced in the host country(s)	0
16b	Estimated circulation of each newsletter in the host country(s)	0
16c	Estimated circulation of each newsletter in the UK	0
17a	Number of dissemination networks established	0
17b	Number of dissemination networks enhanced or extended	0
18a	Number of national TV programmes/features in host country(s)	0
18b	Number of national TV programme/features in the UK	0
18c	Number of local TV programme/features in host country	0
18d	Number of local TV programme features in the UK	0
19a	Number of national radio interviews/features in host country(s)	0
19b	Number of national radio interviews/features in the UK	0
19c	Number of local radio interviews/features in host country (s)	0
19d	Number of local radio interviews/features in the UK	0
Physical Outputs		
20	Estimated value (£s) of physical assets handed over to host country(s)	£300
21	Number of permanent educational/training/research facilities or organisation established	0
22	Number of permanent field plots established	8
23	Value of additional resources raised for project	?

Appendix III: Publications

Provide full details of all publications and material that can be publicly accessed, e.g. title, name of publisher, contact details, cost. Details will be recorded on the Darwin Monitoring Website Publications Database that is currently being compiled.

Mark (*) all publications and other material that you have included with this report

Type * (e.g. journals, manual, CDs)	**Detail** (title, author, year)	**Publishers** (name, city)	**Available from** (e.g. contact address, website)	**Cost £**
Journal	**Decline of Falkland Islands penguins in the presence of a commercial fishing industry Bingham 2002**	**Chilean Journal of Natural History - Revista Chilena de Historia Natural**	**Revista Chilena de Historia Natural**	**?**
Manual*	**Manual de Instrucción para Monitoreo de Aves Marinas en Isla Magdalena Bingham 2004**	**Organización para la Conservación de los Pingüinos**	**Organización para la Conservación de los Pingüinos Casilla 263, Punta Arenas, Chile**	**$15**

Appendix IV: Darwin Contacts

To assist us with future evaluation work and feedback on your report, please provide contact details below.

Project Title	**Establishment of Penguin Monitoring Programme**
Ref. No.	**162/10/007**
UK Leader Details	
Name	**Mike Bingham**
Role within Darwin Project	**Project Leader**
Address	**Alvear 235, Rio Gallegos, Provincia de Santa Cruz, Argentina**
Phone	
Fax	
Email	
Other UK Contact (if relevant)	
Name	
Role within Darwin Project	
Address	
Phone	
Fax	
Email	
Partner 1	
Name	**CONAF**
Organisation	**Corporacion Nacional Forestal**
Role within Darwin Project	**Local partners**
Address	**Punta Arenas, Chile**
Fax	
Email	
Partner 2 (if relevant)	
Name	**Organización para la Conservación de los Pingüinos**
Organisation	
Role within Darwin Project	
Address	**Casilla 263, Punta Arenas, Chile**
Fax	
Email	

APPENDIX 5: 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