REPORT

WORKSHOP ON RESEARCHER-SEABIRD INTERACTIONS

JULY 15-17, 1993
MONTICELLO, MINNESOTA, USA

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Conveners

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WORKSHOP REPORT

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Photo courtesy of Donna L. Patterson

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TABLE OF CONTENTS

INTRODUCTION

During the last two decades, researchers have developed new instrumentation and sampling techniques for studying seabirds that have provided valuable information on their biology, ecology, physiology and behavior. Coincident with these developments has been the growing concern that some of these methods and technologies may be detrimental to the individuals and populations under study, and could represent a potential source of bias in data collection. Seabirds play critical roles in marine ecosystems and, because they are accessible, diverse and abundant, have increasingly become the chosen subjects for a variety of research. This includes, most recently, studies with an ecosystem perspective that seek to use seabirds as indicators of change in marine environments that may result from human activity. How researchers and their methodologies might affect seabirds, and the quality and interpretation of the resulting data, thus become important scientific questions with coupled ethical, social and economic concerns.

To address this issue, a unique workshop was held at the Riverwood Conference Center, Monticello, Minnesota, USA, on 15-17 July, 1993. The workshop's objective was to bring together some of the leading authorities in basic and applied seabird research world-wide to discuss their views and data on a theme previously unaddressed. As such, the workshop was designed to represent a first step in a process expected to need further development; its focus, therefore, had less to do with formulating solutions than with identifying problems, stimulating targeted research and providing a vehicle to discuss and share scientific and philosophical approaches to seabird research.

WORKSHOP SCOPE

The workshop had a three-day working agenda (15-17 July). In attendance were 28 invited participants from the United States and 8 other countries representing a variety of specializations with interests in seabird behavior, physiology, population biology and ecology. The question of seabird-researcher interactions was addressed by examining six general areas of concern:

1. Banding and Marking Techniques.

2. Diet Sampling and Stomach Lavage.

3. Instrument Attachment, External Technologies.

4. Instrument Implantation, Internal Technologies.

5. Physiological Studies.

6. General Disturbance.

For each area of concern, one or more of the following related questions were addressed:

1. What are the current methods and technologies?

2. What are the objectives in using particular methods and technologies?

3. How might the methods and technologies in question affect individuals and populations?

4. What potential biases do the methods and technologies in question introduce in the data and how might data interpretation be affected?

5. Are the methods and technologies in question satisfactory or does the evidence indicate that change is warranted?

The 28 participants presented 20 papers addressing the six areas of concern. An additional 10 papers, some of which included data provided by researchers unable to attend the workshop, were presented during open sessions in the agenda. The majority of the papers dealt specifically with seabirds of the Antarctic and Sub-Antarctic, although the subjects covered had clear, global applications. Areas of concerns 1-5 were addressed during the first day of the workshop; area of concern 6, General Disturbance, was addressed during the morning of the workshop's second day. The final day was devoted to a workshop synthesis, which included the development of consensus statements and recommendations. The following statements, which were drafted by a subset of workshop participants charged with the task, reflect the general outcome of the workshop. Note that references given in parentheses pertain only to the author of the workshop abstract where the subject was addressed. More references, and, in many cases, the key references on the subject, are listed numerically at the end of each abstract. Readers desiring more information on any workshop topic are advised to consult the "Workshop Topics: Cited and Related Literature" section of this report. References used in this report are listed alphabetically and numerically in the "Literature Cited" section.

CONSENSUS STATEMENTS

Banding and Marking Techniques

Marking techniques for seabirds have, until recently, been limited primarily to tarsal bands on flighted species and flipper bands on penguins. The use of implanted transponders to identify individuals in studies with objectives similar to those in which bands are normally used is a new and developing technology. There is little evidence that tarsal bands have an adverse effect on flying seabirds. In certain situations bands may show rapid wear, leading to illegibility and/or band loss and the need for frequent replacement. If these species are also sensitive to being handled (Cooper), then undesirable levels of disturbance may occur. In general, it was emphasized that the use of bands, including color bands, of the correct size and materials is crucial to the success of studies requiring individually identified birds.

Penguins initially were banded with tarsal bands but difficulty in reading such bands and concerns over injuries caused by their use led to the development of flipper bands (Trivelpiece, Culik). These have been an invaluable aid in the development of many fields of penguin research. Nevertheless, there are two areas of concern regarding their use. The first involves band application, which is a highly skilled task; incorrect application can easily result in injury or even death, especially at the time of molt (Valencia).

The second area of concern involves band-induced effects. Concern over band loss and band-induced mortality in penguins has led to periodic improvement in band design (Trivelpiece, Valencia, Culik, Clarke). Nevertheless, even with the current band design, recent studies of King (Aptenodytes patagonicus), Adélie (Pygoscelis adeliae), Gentoo (P. papua) and Macaroni (Eudyptes chrysolophus) Penguins have all documented significant levels of band loss (Trivelpiece, Clarke). Several of these studies have also inferred or demonstrated that significant levels of band-induced mortality may exist, particularly of birds in the first year after banding, and especially of fledglings (Trivelpiece, Clarke). How the materials involved in band construction may add to band loss is not known. Also, the particular ecology of the species being banded should not be discounted as a possible contributing factor, as the response of different species and individuals can be expected to vary (Fowler). The first evidence that the energy costs of swimming are significantly elevated in flipperbanded penguins (Culik) due to disruption of the water flow patterns so crucial to efficient propulsion is now also available (Bannasch). Further studies of the biological significance of these effects are desirable, however, because the question of compensation due to habituation remains to be addressed.

Taken together, these findings suggest that flipper bands may create undesirable effects, particularly in studies involving foraging performance and estimation of survival rates. In other studies where permanent individual identification is required flipper bands may still be the most effective, least disruptive, and/or economic technique currently available for marking penguins. Nevertheless, it would seem prudent and essential to rapidly develop alternative methods for permanent identification of penguins that do not have the drawbacks inherent in the use of flipper bands. Currently there is only one such potential method in use, namely, implanted transponders.

Implanted transponders have been used with captive penguins for nearly 10 years. The tags are similar to those in widespread use in the fields of animal husbandry (live stock and pets) and in captive breeding programs. Implanted transponders are also currently being used in six field studies involving wild penguins. These are:

1. Y. Le Maho, King Penguin, Iles Crozet.
2. C. O. Olsson, King Penguin, South Georgia.
3. K. R. Kerry and J. Clarke, Adélie Penguin, Mawson.

4. W. Z. Trivelpiece, Adélie and Gentoo Penguins, King George Island.
5. Taronga Zoo, Little Penguin (Eudyptula minor), New South Wales, Australia.
6. Phillip Island, Little Penguin, Victoria, Australia.

Initial field reports from these penguin studies have been very favorable, with excellent results being reported for tag retention, lack of transponder malfunction and the general reduction of researcher disturbance. These tags also offer significant opportunities for linking to automatic identification recorders to produce data on body mass changes, and incubation shift and foraging trip duration, which includes reduced disturbance compared to field methods now currently in use. There are, however, quite a number of issues to be addressed and problems to be solved before these transponders can easily be used widely, routinely and in large numbers.

In contrast to bands, there are no regulations guiding the use of transponders. For example, there are no restrictions on who can purchase transponders or qualify for their use. Existing users (who currently differ in the implant sites they use) stress that correct injection technique is important in eliminating injury to the subject and maximizing the distance at which the implant can be detected (Clarke, Olsson). This indicates the need for appropriate training of researchers new to the technique. There are also no requirements for documenting the use of transponders. Researchers currently using transponders do not need to notify anyone regarding the nature and extent of their use, which is in marked contrast to the records required from banders. This needs rapid attention to minimize potential confusion between researchers and the risk of repeat injections of the same bird.

Finally, there is the problem of long-term marking of birds to identify individuals carrying transponders. Not only would these be required for assessment of the effect and performance of implants, but they would be invaluable in all population studies, enabling researchers to identify easily the presence of implanted birds from a distance without disturbance. Six possibilities offer viable avenues for further research:

1. Leg Bands. Previous band designs have apparently caused unacceptable injuries; however, these bands were large (in order to carry numbers) and a small, flexible ring might not necessarily have injurious effects.

2. Freeze Branding. The feasibility of using this technique on birds has never been evaluated. A pilot study using experimental laboratory birds may be desirable before any experimentation on wild penguins took place. The latter would require extreme care.

3. Tattoos. Current experience suggests that web tattoos and marks are very difficult to see from a distance and would not be compatible with the idea of minimizing researcher disturbance.

4. Bar Codes. At present, it appears that these would have to be attached to plumage (rather than to permanent hard parts) and would therefore only be suitable for within-season

research. The possibility that miniaturized bar codes could be attached to the bill, however, might be a highly effective alternative.

5. Fin Tags. The use of fin tags with streamers used to mark fish might be worth investigating, provided a suitable attachment site could be located.

6. Improved Flipper Bands. Significant design improvements may still be possible, provided recommendations are subjected to thorough testing for drag and other effects.

The key to successful implementation of transponders is clearly tied to research and development. Reduction in transponder size, enhancement of detection range, reduction in costs, and assessment of short- and long-term effects of implants are all important factors for further consideration. In several of these areas, the best progress is likely to be made by taking advantage of the considerable research and development already conducted by manufacturers, coupled with the experience of long-term users (especially in zoos). As technologies develop, the assessment of the short-term (within season) effects of implants initially should be conducted using control birds individually identified with something other than attachable marks, such as plumage stains. Assessment of longer term (across years) effects will require the development of marks which will not be lost at molt (see above). Appropriate data from studies of captive penguins could provide valuable information on long-term effects.

Diet Sampling and Stomach Lavage

Methods used in diet studies of seabirds were extensively reviewed by Duffy and Jackson (1986). To avoid killing birds, various methods have been tried. For seabirds that regurgitate naturally (many petrels and albatrosses) when caught or handled, techniques for intercepting the regurgitates have been developed. These methods have several drawbacks, however, the most important ones being that usually some unknown portion of the sample remains in the stomach and that they are not effective with many groups of seabirds, including penguins. For species that do not readily regurgitate, emetics and lavage methods have been used. Emetics have in general proven difficult to administer in appropriate doses, thus consistent success in obtaining adequate samples has rarely been achieved. Lavage techniques, however, have proven highly reliable and successful, and are the methods recommended for general use in seabirds (Robertson).

In penguins, stomach lavage, which is also known as stomach pumping or flushing and water off-loading, was first implemented in 1968, with subsequent refinements in the technique occurring quite recently (Robertson). The technique is also part of the standard method for obtaining diet samples from Antarctic penguins of the genera **Pygoscelis** and **Eudyptes** as recommended by Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) (1991). Done with care and good technique, few problems have been encountered when using lavage. Very rarely, perforation of the stomach wall may occur when the tube is inserted into birds with full stomachs. It has also been noted that, particularly at cold temperatures, the choice of tubing material is important, with some of the softer latex tubes presenting a better alternative. Carefully controlled autoclaving can also be used to soften tubing permanently and/or make it more pliable. Lavage has been shown to have little or no effect in controlled experiments (Clarke, Robertson) using behavior, chick growth and reproductive success as the measured variables. Because of the success with this technique, other researchers (e.g. Prince) have now used modifications of lavage with Procellariformes, but no details have yet been published.

Instrument Attachment, External Technologies

During the past 10 years, advances in miniaturization have led to the manufacture and use of a wide assortment of externally mounted instruments for seabirds. These advancements started with the development of simple radio transmitters that provided nothing more than presence-absence data, and have progressed to sophisticated time-depth recorders, satellite-linked transmitters and a variety of externally-mounted physiological monitors. Virtually all these instruments are designed to collect data that are otherwise impossible to obtain by conventional means, in particular data related to the pelagic ecology of seabirds. This includes, but is not limited to, data related to foraging ecology, movements and distribution, and diving physiology.

Instrument attachment techniques generally have been similar for flying and non-flying species. In the past, harnesses were used to attach many types of instruments. More recently, however, harnesses have been shown to create significant drag and to adversely affect bird behavior and reproduction (Pietz). Research on Mallard Ducks (Anas platyrhynckos), for example, suggests that harnesses probably disrupt the waterproof layer formed by contour feathers, thus allowing birds to become wet (Pietz). For seabirds in high latitudes, this may have adverse thermoregulatory consequences. In recent years, alternative attachment methods have been developed that appear to avoid most of the problems related to harnesses. Some of these have been tested for use on seabirds and are in common use.

The least invasive of these methods use tape, plastic cable ties or glue to attach instruments directly to the feathers. Tape appears to have the least impact on birds (Wilson), but there are concerns about its usefulness if instrument attachment is required for more than two months. Currently, the only tape that has been used for these purposes is Tesa Tape, which is manufactured in Germany (Wilson). Typically, the tape is wrapped around the feathers and the instrument (or attachment tabs) simultaneously. In using this tape, the main concerns relate to duration of instrument deployment, the environment in which it is used, instrument mass and the species on which it is used. This tape has been used to attach 200 g instruments to Adélie Penguins for up to 70 days. To be used successfully, the feathers have to be dry and the tape must be warm (with pocket-warming, the tape can be used in temperatures as low as -5° C). In species other than Adélie Penguins, experimentation with model instruments is recommended. King Penguins, for example, have been observed loosening the tape if the ends are not covered with epoxy glue. The major advantage of using tape is that it leaves no residue on the feathers when the instruments are removed. Application and removal are also quick, and because no drying time is required, disturbance when handling birds is minimized.

For longer-term instrument deployment, or for species for which the tape has not been tested, the use of plastic cable ties and/or glue (epoxy or cyanoacrylic) has been used very successfully (Emslie). This is the method currently recommended by CCAMLR in its monitoring program. In this technique, the cable ties are wrapped around the feathers and the instrument simultaneously; epoxy may then be applied to prevent slippage and streamline the instrument's profile. The number of cable ties needed is dependent on the size of the instrument, but one to three is often sufficient. Alternatively, smaller instruments may be glued directly to the feathers without cable ties, although this may require handling the birds for a longer period of time while the glue dries to insure against instrument loss. With both these techniques, instrument recovery can only be accomplished by cutting the feathers, or, provided the species remains accessible, by waiting for the molt. Hoods are highly recommended to reduce stress to the birds during handling. If feathers are cut, extreme care has to be given to preserving locomotory and/or thermoregulatory capabilities. The use of glue, unlike the use of tape, leaves a residue on the feathers when the instruments are removed, but it eventually falls off during the molt. Although molting ultimately determines the maximum duration of instrument attachment, cable ties have held instruments on Emperor Penguins (Aptenodytes fosteri) for up to 150 days. Cable ties have also been used to attach instruments to the tail feathers of albatross (Diomedea spp.).

In some situations, as when data are needed beyond the period of feather molt, it may be necessary to attach devices directly to the skin. In some bird species, sutures and/or glues have been used to attach devices to the skin, although results have been highly variable, with retention times ranging from days to months. Some researchers have used sutures in combination with a subcutaneous anchor to improve retention time of devices on ducks (Pietz). Radio transmitters (4-5 g) attached in this way, for example, stay on ducks for at least several months, often longer. Researchers should note that this attachment method has not been tested on seabirds, meaning that some procedural/design modifications may have to be made to prevent potential thermoregulatory problems for birds in high latitudes.

The effects that externally attached instruments have on seabirds vary between flying and non-flying species, with the former, in general, exhibiting fewer effects than the latter given similar instrumentation and methods of attachment. In penguins, instrumented birds compared with controls exhibited higher predation rates (Emslie), longer foraging times and lower reproductive success (Clarke, Trivelpiece). Problems with a variety of instrument-specific and/or instrument attachment characteristics were implicated as possible causal factors in experiments (Bannasch). These experiments led to a number of suggestions on ways to minimize the negative effects of externally attached instruments on seabird, as summarized below.

Instruments should be as small and light-weight as possible, particularly in flying birds where mass will have a greater effect. In devices being used in water, weight and buoyancy need to be balanced. For most applications, however, mass and volume are not necessarily the most critical factors to consider. Of equal or more importance, is instrument shape and its placement on the bird. Indeed, the observation was made that a light, badly shaped, improperly positioned instrument will have more negative impacts than a heavier, well-shaped, well-positioned device

(Bannasch, Culik). To reduce drag and the energetic costs of carrying an externally mounted device, therefore, it should be hydrodynamically or aerodynamically contoured. This means that its components should be arranged in as flat and elongated a shape as possible to minimize frontal area. Thus, ideally, the device's physical profile (height) should be minimized while striving for a length:width ratio of about 4.5:1. Moreover, externally mounted instruments should be placed as far caudally as possible without interfering with the tail or uropygial gland in penguins, but more towards the center of gravity in flying birds. It should also be noted that if the antenna on an instrument extends into the flow stream around the bird's body, and in particular into the tail area, it can increase drag, interfere with steering and cause serious behavioral disturbances. Consequently, the antenna should not interfere with the tail feathers, which appear to be important in reducing drag and increasing mobility. This may require using instruments with coiled or enclosed antennas, or antennas that are flexible enough to lay down during under water swimming or flight.

Instrument Implantation, Internal Technologies

Instrument implantation techniques have evolved more or less coincident with the topic and technologies discussed above, and, in general, for the same purposes and with the same objectives. Some forms of implantation, however, involve a surgical procedure, meaning there have been fewer practitioners, and, consequently, less of an opportunity to apply broadly the methods and technologies in most field studies. As a result, data of the type sought by the workshop are comparatively scarce and very much in the formative stages when compared to what is known currently about external instrument attachment.

Implanting instruments (see also earlier discussion on the use of transponders) involves one of two procedures, surgical implantation, or placing instruments in the stomach by inserting them down the esophagus. Surgically implanted instruments have, in general, been placed in the abdominal cavity, and have included locational transmitters, heart rate monitors and temperature censors. Although an immediate effect of this procedure may involve a lack of normalization of the transduced variable (e.g. heart rate) for 36-48 hours, longer term, adverse effects have not been noted, at least not in penguins and albatrosses, two species where these techniques have been commonly applied (Butler). In most instances, incisions also heal rapidly, even in the absence of antibiotic use, and birds quickly resume prior activities (Hector). The advantage in surgical implantation is that the instruments do not increase hydrodynamic or aerodynamic drag. They also offer no external visual stimulus that may alter the recipient's behavior or provide cues to predators. The disadvantage is that, unless it is surgically removed, the instrument is carried by the bird for the remainder of its life. The long-term (years) health effects, if any, are unknown, although some species have borne implanted data loggers for four years, involving several long-distance migrations, without apparent ill effects (Butler).

Instrument insertion (e.g. temperature and other sensors) down the esophagus and into the stomach is comparatively less invasive, and is accomplished by enticing the bird to swallow the instrument, or by restraining the bird and manually inserting it (Wilson). Instrument size and shape appears to influence whether or not it is retained or immediately regurgitated. As yet, there has been little research on optimal instrument size and shape relative to the question of maximizing retention and minimizing adverse effects. Retention time also appears to be species-specific. Gentoo Penguins will regurgitate the instruments in several days, for example, whereas Adélie Penguins will retain the same instruments longer. In general, however, instrument retention time appears to be low for most species. Research on the acute and chronic health and other effects (if any) of this technique are critically needed, as is research on alternate methods of instrument delivery to see if retention time can be improved. Feeding birds with instrumented prey, such as fish or squid, for example, may yield better retention times.

Physiological Studies

Workshop participants recognized that many physiological studies are wholly or in part dependent on instrumentation procedures of the type discussed in the two preceding sections. However, at least two additional methodologies were rather specifically defined for- and associated with- physiological studies. These were blood sampling and injections.

Blood samples are obtained from seabirds for a variety of purposes, including hormonal, genetic, energetic, parasite, disease and stress studies. These often require obtaining blood in different amounts and under different conditions that sometimes necessitate extremely specialized sampling procedures. Different levels of experience and training are thus needed to apply these techniques. At one end of the sampling complexity gradient are studies that require only a few drops of blood (e.g., genetic studies), in which case a capillary prick is sufficient, and its use requires little training or particular skill. At the other end of the gradient, however, are studies typical of those related to stress hormones, which require obtaining blood very quickly. In such cases, jugular puncture is recommended, but it carries with it a potentially high risk of mortality, and thus should only be used by trained, highly experienced researchers (Fowler). In between these extremes in sampling complexity, are endocrine and doubly-labeled water (DLW) studies. These may require serial sampling, in which case the insertion of a cannula to minimize disturbance and discomfort to the bird (Hector) is recommended. DLW studies in particular often draw blood samples from the brachial or tarsal veins and problems of vasoconstriction are often experienced. These problems tend to be acute in incubating birds and in penguins just returned from foraging trips. Inducing vasodilation without undue stress requires extreme care and patience, and can be aided by warming the feet with hand warmers or warm water.

Discussion on the subject of injections was brief. Participants recognized that injections are used primarily in research where anesthesia was needed or in research related to the use of labeled isotopes. In most cases, intravenous injections are adequate, and should follow standard procedures. In other cases, however, as in DLW studies, intraperitoneal injections are recommended. In this regard, the very pertinent point was made that little is known about the impacts of injection (and blood sampling) procedures on seabirds, and that only rarely have researchers looked at the issue using experimental controls due to the assumption that impacts are either minimal or non-existent. However, we now have evidence that a single, large intramuscular injection can cause enough aberrant behavior in some seabirds to seriously compromise the acquisition and interpretation of data (Wilson). The suggestion was thus made that if intramuscular injections are contemplated, they should be given slowly in small amounts at several different localities.

General Disturbance

In addressing the topic of general disturbance, workshop participants recognized that the issue is remarkably complex. The definition of acceptable and unacceptable levels of disturbance ultimately represent value judgments based on an individual or organization's experience, perceptions and ethical beliefs. The proximate factors that underpin the rationale for those value judgments, however, have many imponderables to consider. These include, but are not limited to, variability to the effects of disturbance between species and between populations within a species. And superimposed over these factors, are the critical questions related to detecting, interpreting and mitigating the impacts of disturbance against the background of natural ecosystem variability, but within the spatial and temporal scales defined by different levels of seabird social organization (individuals, colonies, populations).

It was generally agreed that investigator disturbance has the potential to operate at three levels: the individual, the colony and the (meta) population, which is the sum of the colonies (Duffy). Of these, however, only at the level of the individual have the most clear relationships between investigator activities and potential disturbance been demonstrated. Indeed, when assessed at this level, virtually every methodology discussed at the workshop carried with it an associated, potentially negative effect. No objective evidence was presented to suggest that investigator disturbance affects populations, and only limited evidence was offered to indicate that colonies may be affected (Cooper, Davis).

This apparent lack of correspondence between measured effects at the individual level, and subsequent effects at the colony and population levels, suggests that the individuals that define colonies and populations have inherent capabilities to accommodate a range of environmental stressors. An individual penguin carrying an instrument, for example, may indeed exhibit increased foraging times, but what does that mean? It may actually mean nothing if the increase falls within the adaptive range of responses defined by evolution for individuals to deal with, for instance, periods of low prey availability. Measuring a correspondence between human activity and an increase in heart rate or corticosterone secretions in individual seabirds (Giese, Fowler), or a decrease in swimming speed and increased foraging times (Culik, Bannasch, Clarke, Trivelpiece), or even a decrease in within-season reproductive success (Boersma, Miller), may be similarly viewed. Unless these and related responses exceed the limits of natural variation, become pathological and lead to eventual death or long-term reproductive failure, the effects at the individual level will have no direct consequences to colonies and populations.

With the exception of possible band and predation-induced mortality due to external instrumentation (Trivelpiece, Valencia, Emslie), chronic pathological effects on individuals could not be demonstrated for any of the methods discussed at the workshop. Although this might suggest that researcher-induced disturbance may not impact seabirds at the colony level, workshop participants indicated that such a conclusion may be premature due to the general paucity of data on long-term patterns of recruitment at colonies subjected to disturbance each year (Davis, Miller). Nevertheless, the general consensus was that the effects of researcher-induced disturbance are likely to become progressively less significant at the colony and especially at the population levels. Indeed, the few long-term studies that have examined the potentially adverse effects of research and other human activities on seabird populations suggest these effects may in fact be negligible relative to the effects imposed by long-term changes in other environmental variables (Fraser).

In concluding this topic, it was agreed that although it would be desirable to produce clear guidelines to address the issues raised during the session, the number of variables to consider would likely frustrate the development and application of these guidelines. What seems clear enough, based on the data presented, is that researcher-induced effects seem to lie within the region of environmental "noise". As such, these effects may not only be difficult to detect, but their impacts, if any, are probably swamped by environmental change. What this suggests, therefore, is that our efforts as researchers may be better spent not in the creation of guidelines, but rather in improving our ability to obtain data that are representative of the systems we are studying. This necessarily implies that we have to tackle the ethical questions that surround us, as these questions are linked directly to the issue of data quality (Giese, Cassady-St. Clair). The assumption that our impacts get masked by environmental noise does not negate the fact that we base all our research and conclusions on work with individual seabirds. If we are aware of an effect, or of a potential effect, that results from our actions, mitigation for both ethical and scientific reasons should be our primary responsibilities.

RECOMMENDATIONS

Banding and Marking Techniques

Banding procedures require skill, and, if impacts and disturbance are to be minimized, a basic knowledge about the ecology of the species involved. To the maximum extent possible, therefore, research groups using banding as a marking technique should ensure that all practitioners have full appropriate training from experienced banders and/or appropriate qualifications from national banding organizations. Moreover, it is absolutely essential, in view of the data presented, that all researchers banding penguins receive full training from experienced banders.

The use of implanted transponders is a new and promising technology for marking seabirds. A workshop should be convened to facilitate an exchange of information and to identify the desired technological developments that would aid the widespread use of this technology by researchers, especially in the area of demographic studies. This workshop should in particular bring in the experience of current practitioners from manufacturing companies, zoos and animal husbandry.

The use of implanted transponders carries no current registration or experience requirements. Scientific Committee for Antarctic Research (SCAR) in particular should address this as a matter of urgency before the use of the technique proliferates, especially in the Antarctic Peninsula region.

Research on penguins involving alternative, long-term individual identification marks should be undertaken and encouraged.

Diet Sampling and Stomach Lavage

Although the methodologies discussed are safe and without any apparent negative consequences, experienced practitioners emphasized that successful implementation of stomach lavage often relies on subtle differences in technique, including, for example, the rate and method of water delivery, water temperature, tubing softness and the selection and handling of birds. It was agreed, therefore, that a new version of the best lavage methods for use with penguins should be made available, and that the CCAMLR ecosystem monitoring program should, perhaps, be the first party invited to compile this document.

Because of the success experienced with lavage methods in general, it was agreed that it would be very useful to obtain details on the use of lavage in species other than penguins. Dr. Richard Veit should be invited to consider providing a first draft due to his extensive experience with ship-board research on other species.

As with banding, lavage requires skill and experience. It was thus emphasized that practical training from experienced practitioners is essential in developing diet sampling programs using lavage.

Instrument Attachment, External Technologies

Instrument attachment techniques using tapes, glues and cable ties are well developed, and currently evolved to the point that their impacts on seabirds are probably minimal relative to the effects imposed by poor instrument shape and suboptimal mounting location. Although some workshop recommendations can be implemented immediately (e.g. making sure that devices are positioned towards the rear in swimming birds), the more difficult issues related to instrument shape and mounting position can only be resolved by hydrodynamic or aerodynamic testing of instruments. Such testing requires specialized facilities not available to most researchers. Research that seeks to understand the physical forces acting on both instruments and birds should thus receive high priority, and should be solicited and encouraged by public-funding agencies and private- manufacturing enterprises that provide instruments to researchers.

Researchers should be encouraged to conduct field tests with appropriate controls to assess the biological consequences apparent in the use of externally attached instruments. In particular, the possibility that seabirds may compensate for instrument effects needs to be investigated.

Instrument Implantation, Internal Technologies

These technologies appear to offer all the advantages and none of the disadvantages inherent in externally mounted devices, and were thus viewed by workshop participants as an area where more research should be directed. In this regard, two priority areas were identified:

> Emphasis should be placed on non-surgical procedures, such as instruments that may be inserted into the stomach, to make the technologies available to a wider group of researchers.
>
> Where surgical procedures seem inevitable, methods of downloading data without subjecting birds to further surgery need to be encouraged.

Because of the potential health consequences of surgical procedures, it is clear that the techniques should only be attempted by trained and experienced researchers.

There is a paucity of data on the long- and short-term effects of some of these instruments and procedures on the biology of implanted seabirds. Because of the potential held by these technologies, coincident studies to assess biological impacts should be conducted by the currently active practitioners.

Physiological Studies

The current AOU (American Ornithologists Union) guidelines on blood sampling and injection procedures are not comprehensive enough due to their emphasis on passerines. It was agreed that a review of blood sampling and injection techniques pertinent to seabird research would be very useful. This review should in particular indicate the techniques for which special levels and types of training were desirable or essential. In addition, it was agreed that more information is needed on the physiological responses (e.g., energy flux, hormone secretion) of seabirds to human disturbance and to research techniques, and, in particular, on how individual-level responses might influence populationlevel parameters.

General Disturbance

Human impacts on seabirds must necessarily be assessed against the background of natural variability inherent in the system. National and international concerns should consider the need to identify formally and designate control sites where long-term colony and population level monitoring can take place unencumbered by other levels of research.

Ideally, researcher-induced disturbance should not exceed levels of perturbation experienced by seabirds in natural undisturbed situations. Although these levels of perturbation are, in most cases, difficult to define, funding agencies should seek peer reviewers with the experience to carefully evaluate research proposals in terms of their potential consequences to colonies and individuals. Peer reviewers should place a high priority on this task.

The guidelines established and maintained by national and international animal use and ethics committees were deemed adequate for addressing issues related to disturbance. The development of guidelines to deal with specific geographic areas of research (e.g. Scientific Committee on Antarctic Research Code of Ethics for Animal Research in Antarctica) are encouraged.

Researchers should be encouraged, through the appropriate funding agencies, to investigate the short- and long-term effects of their activities within the scope of work outlined by their proposals.

Most of the issues related to researcher-induced disturbance will require long-term research to be understood and must necessarily be approached from an ecosystem-level perspective. Ecosystem-level studies are expensive and logistically complex, and not likely to be justified under the singular need to examine impacts related to human activities. However, national programs that already have ecosystem-level studies funded and in place, should seriously consider including human impact studies within the scope of objectives to capitalize on the efficient use of funds and logistics, and provide a viable vehicle for addressing human disturbance issues.

WORKSHOP AGENDA

WORKSHOP ON RESEARCHER-SEABIRD INTERACTIONS

15-17 July 1993, Riverwood Conference Center

Monticello, Minnesota, USA

JULY 14 - WEDNESDAY

Arrivals and Welcome.

JULY 15 - THURSDAY (Chair, Dr. Wayne Z. Trivelpiece)

7:45-8:00	Welcome. Dr. Polly Penhale, Program Manager, Biology and Medicine, NSF—Office of Polar Programs.
8:00-8:25	Ms. Susan Trivelpiece, Banding and Implant Studies of Pygoscelis Penguins.
8:25-8:50	Dr. Judy Clarke, Monitoring of Adélie Penguin Breeding and Feeding ecology at Bechervaise Is. Mac. Robertson Land, Antarctica.
8:50-9:15	Dr. Jose Valencia, Undesirable Effects of Fastened Flipper Bands on Small Breeding Populations of Pygoscelis antarctica, Ardley Is., Antarctica.
9:15-9:40	Dr. Boris Culik, Rings on Penguins: What is the Cost of a Life-long Commitment?
9:40-10:05	Dr. Graham Robertson, Effects of the Water Off-Loading Method on Adélie Penguins.
10:30-10:55	Dr. Pamela Pietz, Evaluations of Three Transmitter Attachments Used on Wild Ducks.
10:55-11:20	Dr. Rudolf Bannasch, Hydrodynamic Aspects of Design and Attachment of Back-mounted Devices in Penguins.
11:20-13:00	OPEN SESSION Short Presentations and Topic Discussions: Banding, Implants, Stomach Sampling and Instrument Attachment.
14:00-14:25	Dr. Jan Taylor, Noninvasive Methods of Determining Body Composition and Digestive Physiology in Seabirds.

14:25-14:50	Dr. Rory Wilson, Energy Studies of Free-living Seabirds: Why Penguins Don't Always Like Water.
14:50-15:15	Ms. Melissa Giese, Measuring the Impacts of Human Visitation to Adélie Penguins Breeding in Antarctica.
15:45-16:10	Mr. John Cooper, Demography and Doubts: Effects of Human Disturbance on Wandering Albatrosses and Giant Petrels at Marion Island.
16:10-16:35	Dr. Gary Miller, The Effects of Daily Nest Checks on South Polar Skuas and Helicopter Traffic on Adélie Penguins at Cape Bird, Ross Island.
16:35-17:00	Ms. Colleen Cassady St. Clair, Optimizing Researcher Disturbance in Bird Colonies.
17:00-18:30	OPEN SESSION Short Presentations and Topic Discussions: Physiological Measurement Effects and Researcher Impacts.

JULY 16 - FRIDAY (Chair, Dr. William R. Fraser)

08:30-08:45	Announcements
08:45-09:10	Dr. Lloyd Davis, Effect of Different Levels of Disturbance/Handling on Recruitment in Adélie Penguins.
09:10-09:35	Lic. Claudio Aguirre, Penguin Rookeries and Antarctic Stations: Do Adélie Penguins Habituate to People?
09:35-10:05	Lic. Jose M. Acero. Adélie Penguin Breeding Site Selection and its Relation to Human Presence.
10:30-10:55	Dr. P. Dee Boersma, Visits to Murre Breeding Plots Reduce Reproductive Success.
10:55-11:20	Dr. Gene Fowler, Field Studies, Tourism and Stress Responses in Magellanic Penguins.
11:20-11:45	Dr. William Fraser, Human Disturbance and Long-term Changes in Adélie Penguin Populations: A Natural Experiment at Palmer Station, Antarctic Peninsula.

11:45-13:00	OPEN SESSION Short Presentations and Topic Discussions: General Disturbance.
14:00-15:00	Group leaders and rapporteurs planning meeting. Dr. William Fraser, Dr. Wayne Trivelpiece, Mr. John Cooper, Dr. John Croxall, Dr. Lloyd Davis, Dr. Randall Davis, Dr. Gerald Kooyman.

JULY 17 - SATURDAY (Chair, Dr. William R. Fraser)

09:00-09:15	Announcements
09:15-12:00	Group meetings.
12:00-13:00	Group leaders/rapporteurs report in plenary session. Dr. William Fraser, Dr. Wayne Trivelpiece, Mr. John Cooper, Dr. John Croxall, Dr. Lloyd Davis, Dr. Randall Davis, Dr. Gerald Kooyman.
14:00-17:00	Draft Workshop Report.
17:00-18:00	Group leaders/rapporteurs report in plenary session. Dr. William Fraser, Dr. Wayne Trivelpiece, Mr. John Cooper, Dr. John Croxall, Dr. Lloyd Davis, Dr. Randall Davis, Dr. Gerald Kooyman.

JULY 18 - SUNDAY

08:00-10:00	AM and PM Departures.

ABSTRACTS

Banding and Implant Studies of Pygoscelis Penguins

Susan G. Trivelpiece and Wayne Z. Trivelpiece

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Although bands have been used on penguins since the early 1900s, it was not until demographic studies were undertaken in the 1960s and 1970s that the problems of band loss and mortality due to bands were addressed. Ainley et *al.* (1983) calculated a 28% band induced mortality rate among the Cape Crozier Adélie Penguin (Pygoscelis adeliae) population. These findings resulted in a new, enlarged band design to accommodate the swelling of the flippers during molt. We subsequently attempted to determine the extent of band loss and mortality due to these new bands.

Our double-banding study from 1984/85 to 1985/86 resulted in the discovery that double-banded birds (i.e., with one band on each flipper) had higher mortality rates than those with only single bands. 31% of the double-banded Adélie and Gentoo Penguins (P. papua), and 32% of the Chinstrap Penguins (P. antarctica) returned versus 39%, 56%, and 44% of the single-banded Adélie, Gentoo, and Chinstrap Penguins, respectively. In addition, Gentoo Penguin chicks were double- and single-banded at the same time. Differences in survival between these two groups showed dramatic differences; only one of the 200 double-banded birds returned as a one-year-old, versus 84 of the 800 single-banded birds.

We hypothesized that silver flipper bands might be acting as "flashers", thereby putting double-banded birds at greater risk to predation by Leopard Seals (Hydrurga leptonyx). To test this hypothesis, Adélie Penguins were double-banded with black bands, silver bands, and black and silver bands in 1987/88. The following season (1988/89), no differences were found in survival among these groups (20%, 21%, and 26%, respectively). However, single-banded black and single-banded silver birds had significantly higher survival rates than double-banded birds (39% and 44%, respectively).

These results suggest that flipper bands affect survival in penguins. To test this hypothesis, we have initiated a study of Adélie Penguin male survival using implanted transponders. Results of this experiment will help us to determine the extent of band loss and band induced mortality in penguins.

Cited and Related References: 4, 5, 16, 21, 34, 77, 82, 88, 94

Measuring the Impacts of Human Visitation to Adélie Penguins Breeding in Antarctica

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Adélie penguins (Pygoscelis adeliae) in the Prydz Bay region of East Antarctica, were exposed to controlled, human approach experiments over the 1992-93 summer. Behaviors and heart rate were measured as birds nesting at the periphery of larger colonies were subjected to various human approach treatments. An experiment was designed to determine the nature and extent of habituation to human disturbance. Behavior was recorded on video and heart rate was simultaneously measured using externally fitted ECG devices. The behavior, and, in some cases, heart rate of control birds which were not subjected to experimental approaches was also monitored.

Birds that were approached displayed agonistic behaviors more frequently than control birds that were not approached in the incubation phase. In the hatch phase, birds were more vigilant (as indicated by frequencies of head turning) than control birds. In both cases, results were significant to a 95% confidence level.

The heart rate response of birds at a human/penguin distance of 1m was significantly ($p > 0.05$) higher than that at a 50m human/penguin distance in both the incubation and hatch phases.

Experimental birds showed no evidence of a reduced behavioral or heart rate response after being exposed to five consecutive human approaches to 1m.

Further statistical analysis of results from this pilot study, emphasized the need to select appropriate sample sizes so that statistical power is maximized. Power analysis revealed that in order to detect subtle changes in behavior and heart rate (such as might be expected during the gradual desensitization of birds to human approach), large sample sizes may often be required.

Cited and Related References: 8, 20, 31, 32, 38, 100, 102

Monitoring of Adélie Penguin Breeding and Feeding Ecology at Bechervaise Island, MacRobertson Land, Antarctica

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Three years ago a long-term monitoring program was established at Bechervaise Island to study the breeding and feeding ecology of a colony of Adélie Penguins (Pygoscelis adeliae) and to provide data to CEMP (CCAMLR Ecosystem Monitoring Program). An automated weighing and identification system has been set up on the island, utilizing implanted transponders (Texas Instruments) for identification of individual penguins with minimal interference. Conventional flipper bands have also been used and the return rates of birds with each method of identification compared. Although there is no indication from over 100 birds of band or tag loss over one year, there is an increase in the non-return rate of banded birds after two years of wear. Future years' return rates of tagged banded birds should indicate whether this effect is due to band loss or to increased mortality of banded birds.

Foraging ecology has been studied with the aid of externally attached satellite trackers and time/depth recorders, along with stomach lavage. The effects of stomach lavage on breeding success have been investigated, as have the effects of package attachment on foraging trip duration and water turnover. Nests of 52 stomach-lavaged birds have fledged equal or greater numbers of chicks than control nests, indicating that the lavaging procedure does not affect breeding success when carried out only once per bird during chick rearing. Satellite tracker attachment during incubation results in significant increases in foraging trip durations (especially of females) and in increased nest failure rates. Attachment of satellite trackers and time/depth recorders for single foraging trips during chick rearing has no measurable significant effects on breeding success, foraging duration or water turnover rate for the sample sizes used, but effect may be masked by the large natural variation in foraging strategies within our colony. Package attachment for more than two successive foraging trips does result in decreased breeding success.

Cited and Related References: 4, 5, 16, 18, 19, 24, 25, 27, 29, 34, 36, 39, 43, 52, 53, 72, 73, 86, 87, 88, 91, 92, 93, 94, 98, 101, 106

Investigator Disturbance or Disturbed Investigators?

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Investigator disturbance operates at three levels: the individual, the colony, and the (meta) population which is the sum of the colonies. We are frequently able to demonstrate investigator disturbance at the individual and colony levels, but there is no objective evidence that investigators affect populations. Scientists probably lack the resources and opportunity to affect any but the smallest of populations. Such effects are also likely to be trivial compared to other major factors such as oil spills, feral mammals, and fisheries.

Damage by seabird biologists tends to be self-limiting, as biologists can't be productive if their study animals die, desert, or act strangely, or if their study colonies are abandoned. In addition, through hostile referees and grant-reviewers, the scientific community would tend, over time, to limit the publications and funding of scientists whose damaging effects outweighed their science.

At times, seabird investigators may even play a positive role, by protecting colonies from egging or disturbance, popularizing seabirds, and detecting problems and threats. For example, biologists studying seabirds were instrumental in detecting problems with PCB's, DDT, long-lining, overfishing, and feral mammals, and in generating world attention for Galapagos and the Antarctic.

Despite such contributions, there is a growing trend to regard research on seabirds as negative and to impose increasingly onerous restrictions, even in the absence of demonstrated negative effects. We clearly need to investigate scientific disturbance in an objective manner. Such research should be double-blind so that the disturber does not measure his or her own effect. Research should examine effects at the colony and population level, as well as for individuals, possibly through the use of models. Referees and editors should encourage publication of statistically supported studies of disturbance, even when these show a lack of effect.

Cited and Related References: 38, 41, 55, 65

Techniques for Laparoscopy and for Obtaining Blood Samples from Albatrosses

J. A. L. Hector

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(Presented by J. P. Croxall)

In studies of albatross reproductive endocrinology in the early 1980s (Hector et al. 1986a, b, 1988) we pioneered field laparoscopy of seabirds, developing appropriate methods for anesthesia and for laparoscopy (using a modified otoscope). Details of ketamine (IM) and Saffan (IV) doses and of the laparoscopic technique were given in Hector (1984). Of 160 birds subjected to laparoscopy, only 5-7% failed immediately to resume prior activities (incubation, brooding, foraging). Over 80% of these birds were seen alive subsequently in the same season after the operation and no adverse effects on their survival have been detected over the last decade. Modern laparoscopic instruments and techniques would result in more efficient and quicker internal examination and avoid the need for sutures.

As part of the same study, over 800 plasma samples were obtained. Techniques for single-operator sampling of albatrosses, for obtaining blood from incubating birds and for obtaining serial samples of blood via cannulation are described in full Hector (1984).

Cited and Related References: 23, 35, 46, 47, 48, 49, 89, 90

Use and Effect of Automated Weighing Systems and Radio Transmitters on Albatrosses at South Georgia

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Platform systems located within artificial albatross nests have been used to weight albatross chicks since the early 1980s (Prince and Walton 1984, Ricketts and Prince 1984). The current version, which is entirely electronic, runs at up to 10 nests for up to 180 days, recording chick mass every 10 minutes. The main advantage of this system, apart from the rapid acquisition of high quality data on provisioning rate and growth of chicks, is the reduction in disturbance compared with manual weighings. In comparison with data on peak and fledging mass for albatross chicks weighed manually only on these occasions, the masses of chicks on the artificial nest are not significantly different.

In conjunction with the above system we use a ring-mounted radio transmitter (and fixed location scanning receiver system) to record the identity of one of the parents provisioning chicks at each study nest. For a large sample of data on the mass of delivered meals and the duration of foraging trips, we can detect no significant difference between birds with or without radio transmitters.

Cited and Related References: 53, 72, 74, 86, 101

Use of Implanted Data Recording Units With Seabirds

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(Presented by J. P. Croxall)

Devices recording ECG (heart rate) and body temperature have been implanted into the abdominal cavities of birds since the mid-1970s (Butler and Woakes 1979). This work was started with birds (including ducks and penguins) kept under laboratory conditions (see Butler and Woakes 1982, Woakes and Butler 1983, 1986 for details of experimental techniques) but soon involved free-flying birds (Butler and Woakes 1980). Some of the latter have borne data loggers for over 4 years, involving several longdistance migrations, without ill effect. The current data logging system for recording heart rate and body temperature described in Woakes (1992) has been used extensively on penguins and albatrosses at South Georgia. A more advanced logger, incorporating a micro-computer and pressure (depth) sensor is undergoing field trials. Further development, including the possibility of data down-loading without the need to remove the logger, is planned.

Cited and Related References: 8, 13, 14, 15, 31, 32, 99, 100, 101, 102, 103, 104, 105

Use of Passive Induction Transponders in Demographic and Behavioral Studies of King Penguins at South Georgia

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(Presented by J. P. Croxall)

Transponders have been used in this study since December 1991. The TIRIS (Texas Instruments) transponder (which measures 32.0 x 3.8mm) has been injected into 214 adult and 106 chick King Penguins (Aptenodytes patagonicus) at Husvik, South Georgia. By March 1993 (i.e. after 16 months) no losses or failures had been reported. Recording distance, using a stationary (gate) unit is nominally 1.0 m but effectively 0.7-0.8 m. Using the hand-held reader, the effective distance is 0.5 m. Reading distances are significantly affected by orientation of the transponder (optimal when pointing towards antenna) and the tuning of the antenna. Transponders are injected between the tail and the leg on the dorsal side, where there is adequate loose skin; the whole operation takes about 1 minute and probably causes less disturbance than banding.

Cited and Related References: 53

Hydrodynamic Aspects of Design and Attachment of a Back-mounted Device in Penguins

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In 1992 a new multi-channel data logger equipped with five different sensors was built and tested in order to obtain complete data sets on penguin foraging trips in the Southern Ocean. A special speed-sensor was developed and significant effort was made to minimize device-induced impacts on the birds. Wind tunnel and water tank experiments were carried out in order to optimize shape and attachment of the back-mounted data logger in conjunction with a penguin model and to calibrate the sensors. Device-induced turbulence became reduced when the unit was placed in the most caudal position, considering, however, the functional-anatomical peculiarities of the bird. Drag minimization was further achieved by fitting the shape of the device to the body contour. The device induced drag increment was measured in a large circulating water tank by using a penguin model with and without the device. Compared to a device shaped as suggested by Obrecht et al. 1988, the incremental drag could be reduced by 2/3 (CD=0.12). The results presented here clearly indicate that at the present stage of development streamlining is much more important than more miniaturization. The results are discussed against the background of a new propulsion theory and the hydrodynamic investigations of Bannasch (in press), and with consideration of preliminary results from new studies on kinematics and energetics of under-water swimming of live penguins equipped with devices in a swim canal. The use of data loggers is discussed in comparison with other techniques in biotelemetry. Finally, some ideas are developed on how data loggers may also be adapted for use in flying birds and for other purposes.

Cited and Related References: 9, 11, 16, 19, 24, 25, 33, 43, 64, 70, 86, 87, 92, 93, 95, 101

How Flipper Bands Impede Penguin Swimming

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In birds, penguins are the best adapted for wing-propelled diving and swimming. Penguins do not paddle. As in flying birds, thrust (lift) is generated by using profile action; wing structure and wing geometry are thus highly optimized.

A flipper band is likely to impede penguin swimming in four ways:

1. The band blocks a part of the wing profile. Because that part can no longer contribute to thrust generation and propulsion, it becomes less efficient.

2. As a result, water circulation and distribution changes over the whole wing, creating a surplus trailing vortex at the proximal end of the wing. This consumes energy.

3. Apart from disturbing the normal wing body interference, the turbulence generated by the flipper band also disturbs the flow pattern over the body surface behind the wing. This causes an increase in body drag.

4. Finally, a flipper band causes asymmetry in the load of the wings and consequently in the kinematics of the wing action. Over longer periods, chronic changes on the muscle skeleton system are liable to occur.

Cited and Related References: 11, 34

The Effect of Human Disturbance on the Breeding Success of South Polar Skuas

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During the 1992-93 austral season, two research teams were collaborating on a study of the relationship between diets and reproductive success in South Polar Skuas (Catharacta maccormicki). The two groups were working on separate breeding populations of South Polar Skuas in the vicinity of Palmer Station, Anvers Island, Antarctic Peninsula. Our group was monitoring 123 South Polar Skua pairs breeding on four islands; our colleagues were following 24 pairs on Bonaparte Point. The skua populations on the four islands we were following were subjected to different visitation frequencies. Shortcut Island, with 53 pairs, was visited every three days, weather permitting, and all of our diet sampling (fecal samples from which fish otolithes were later extracted for species identification and size) was confined to these pairs. Humble Island, with 11 pairs was visited weekly. Limitrophe and Cormorant Islands, with 46 and 11 skua pairs, respectively, were visited once in December after egg laying, and again in February to census the number of surviving chicks. Our colleagues worked on the skua population at Bonaparte Point, performing weekly nest checks and fecal sample collections.

We compared the breeding success of the four island skua populations on 9 February 1993 and found no differences among them. Forty-three percent of all pairs had at least one surviving chick (range among the populations, 40-46 percent). However, the skua population at Bonaparte Point had a breeding success of only 4 percent, an order of magnitude below the island pairs. The only difference between the methodologies used by us on the islands and those used by our colleagues on Bonaparte Point was the duration of time spent in each skua territory to collect the fecal samples. We spent only enough time (1-5 minutes) to check the nest and gather a fecal sample at each territory. In contrast, our colleagues, wanting to collect the freshest fecal samples possible, waited in the territories until an adult defecated. The longer periods of disturbance had a highly significant impact on chick mortality, which is probably related to the fact that chicks often flee out of their territories during prolonged disturbance and fall prey to neighboring skuas.

Cited and Related References: 41, 42, 44, 56, 59, 65, 67, 75, 108

The Effects of Instrument Attachment on the Food Load and Foraging Time in Adélie and Gentoo Penguins

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Adélie (*Pygoscelis adeliae*) and Gentoo (*P. papua*) Penguins were fitted with transmitters (TXs) and time depth recorders (TDRs) as part of a study of the foraging ecology of these species conducted during the 1990-91 austral summer at King George Island, Antarctica. The TXs (Advanced Telemetry Systems, Isanti, MN, USA) weighed 14g and had a 15 cm long, horizontal antenna; the TDRs (Mark 4 models, Wildlife Computers, Seattle, WA, USA) weighed 45 g. We captured 16 Adélie and 24 Gentoo Penguins during their respective chick rearing stages and glued (Devcon 5-minute Epoxy) the TXs to the back feathers between the shoulder blades. The penguins were then released and their foraging trip patterns recorded using an automatic data logger (Advanced Telemetry Systems, Isanti, MN. USA). After four to six foraging trips had been recorded seven to ten days later, individual birds were recaptured and a TDR was glued to their backs, just posterior to the TX. The penguins were again released and observed as they returned to their nests to feed chicks.

The data logger was equipped with a buzzer that was programmed to alert personnel when the instrumented birds returned to the colony beach following their next foraging trip, thus making it possible to capture these birds before they returned to their nest sites. Coincident with capturing the experimental bird, control birds (carrying no instruments) of the same sex were also captured from among the penguins that had just returned with the experimental bird. Both penguins were then stomach lavaged using the water off-loading technique (see abstract by Robertson). Stomach contents were weighed, sorted and measured. The TX and TDR were removed and both birds released.

There were no differences in the amount of food carried by experimental and control birds. Adélie Penguins returned with a mean 620 g and 656 g; Gentoo Penguins with 535 g and 553 g for experimental and control birds, respectively. Gentoo Penguins also showed no significant differences between the mean duration of the foraging trips with TX only (11.0 h) when compared to the mean duration of the foraging trip with both TX and TDR (11.8 h). However, Adélie Penguins with both TX and TDR had significantly longer foraging trips than the mean trip durations of these same birds equipped with TXs only; these were 28.2 h and 22.0 h, respectively.

Cited and Related References: 16, 19, 24-27, 43, 52, 54, 71, 86, 87, 92, 93, 101

Undesirable Effects of Fastened Flipper Bands on Small Breeding Populations of Pygoscelis antarctica, Ardley Island, So. Shetlands

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During two consecutive seasons, 1979-1980 and 1980-1981, a population of Chinstrap Penguins (Pygoscelis antarctica) breeding at Ardley Island, King George Island, was banded. The bands used had a protruding fastener that produced severe wounds on the breast of the banded birds. The total number of bands applied were 349 and 57 each season, respectively. The total number of nests in 1979-1980 and 1980-1981 was 180 and 210, respectively. Data on the sex and age of the banded birds is lacking. Because several banded birds were found dead, many bands were removed at our request by the original banders.

During the first two years after the banding operation, the following reductions in nest numbers occurred: 1981-1982, a decrease to 141; 1982-1983, a decrease to 91 nests. After a slight recovery in 1984-1985 to 116 nests, the total count of nests decreased to 40 in 1991-92. Although the banding operation has not been the only disturbance for this penguin population, it is probable that the nest decrease was the main consequence of this manipulation.

We discuss several factors that may have enhanced the undesirable effects of using bands not specifically designed for penguin flippers.

Cited and Related References: 4, 5, 10, 16, 19, 21, 34, 76, 77, 82, 88, 94

Flipper Bands on Penguins: What is the Cost of a Life-long Commitment?

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The individual marking of flying and flightless birds has a long history in ornithology. It is the only technique, which, besides labor costs, is cheap, relatively simple and effective, and promises results on bird migration, age-specific annual survival and recruitment. Consequently, thousands of birds are annually banded worldwide. Unfortunately, researchers all too often tend to neglect problems associated with bands. These range from changes in behavior as birds attempt to remove the band, to infections, loss of the limb and even death, which can occur when excrement accumulates under the band or when the ring becomes too small due to growth or molt. In Antarctic penguins, flipper bands have been used extensively by a variety of nations, and banding is an intricate part of the CCAMLR Ecosystem Monitoring Program (Standard method A4). It is suggested that mortality in penguins wearing bands can be either attributed to a) prey species availability, b) predation, c) weather conditions or d) other reasons.

In this paper, I have attempted for the first time to quantify the costs associated with wearing a flipper band. For that purpose, seven freshly caught Adélie Penguins (*Pygoscelis adeliae*) were introduced, in Antarctica, into a 21 m-long swim canal, where their behavior and energy consumption were determined via observation and gas respirometry. Birds were either immediately marked with a flipper band and tested in the canal for approximately two hours, and then taken out and tested again after removal of the band, or vice-versa. In total, I obtained 154 measurements in penguins swimming with a flipper band and 194 measurements of the same birds without the band. Flipper bands significantly (t-test, $p=0.002$) increased the power input of Adélie Penguins during swimming by 24% (from 17 W/kg to 21.1 W/kg) over the speed range of 1.4-2.2 m/s, ($n=115$ and 157, respectively). The implications of banding on foraging performance and survival of penguins are discussed. Implantable passive transponders could help us overcome such problems.

Cited and Related References: 4, 5, 16, 19, 21, 34, 57, 77, 82

Effects of the Water-Offloading Method on Adélie Penguins

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Manipulative experiments were conducted on Adélie Penguins (Pygoscelis adeliae) to examine the effect of the water-offloading method to collect stomach samples on adult foraging cycle length and mass gain of chicks deprived of a meal. Control and treated adults on their second foraging trip, post-stomach flushing, spent the same length of time away from colonies. Meal deprivation had no effect on mass gain of fledging two-week-old chicks in two colonies. Differences in survival rate of chicks between control and treated groups in two colonies was negligible. The findings support the acceptance of the water-offloading method as the most humane way of procuring stomach samples from Adélie Penguins.

Cited and Related References: 19, 36, 39, 53, 68, 69, 91, 95, 98

Evaluations of Three Transmitter Attachments Used on Wild Ducks

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Harness transmitters with head and body loops (Dwyer 1972) have been used in studies of waterfowl for more than two decades. In a study of Mallard Duck (Anas platyrhynchos) ecology in the prairies of North Dakota and Minnesota, we observed that female Mallards Ducks with harness transmitters spent less time feeding and more time resting than unmarked females (Pietz *et al.* 1993). We also observed an aversion to water among females with harness transmitters (i.e., they spent less time swimming, feeding in water >10 cm, and feeding with neck and upper body submerged than unmarked females), suggesting that harnesses may have disrupted the birds' waterproof layer of contour feathers. This may explain why females with harness transmitters spent less time feeding. Reduced feeding time, in turn, probably explains why these females nested later and produced smaller clutches and eggs than did unmarked females (Pietz *et al.* 1993).

As a result of these findings, we and other researchers tested 3- to 9-g transmitters attached mid-dorsally by sutures and glue in 1991. Mallard Ducks wearing this transmitter did not delay nesting; however, most of them shed their transmitters within a few weeks. In 1992, we added a subcutaneous anchor (modified from Mauser and Jarvis 1991) to this transmitter (4-g) in an attempt to improve retention time. Only 1 of 35 transmitters attached with sutures and an anchor (20 on Gadwall Anas strepera and 15 on Mallard Ducks) was known to be shed during the time the birds were monitored. This attachment method is currently being tested for 8-g transmitters. It may have potential for use on a variety of bird species, especially in studies that extend through the molt period.

Cited and Related References: 24, 25, 27-29, 37, 54, 58, 64, 66, 73, 86, 87, 92, 93

New Techniques for Lipid Metabolism Studies on Seabirds

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Many seabirds ingest most of the energy contained in food in the form of lipids. The accumulation and depletion of lipid stores in tissues is a very characteristic feature of all aspects of seabirds biology, especially breeding and chick development. On the other hand, the significance of often huge fat reserves is not always clear, and few hypotheses have been proposed. New techniques to measure lipid assimilation and accumulation have been developed in recent years:

1. A new method of gross body composition analysis to determine total body fat is based on total body electrical conductivity (TOBEC) measurement, which is non-invasive, fast, and simple. It does not require sacrificing individual birds, and can be conducted on the same individuals repeatedly. The applicability of the method for measurements on seabirds and its accuracy is discussed. The accuracy of tissue fat measurement may be much improved in procellariiforms by parallel measurement of stomach oil volume in proventriculus by the method of radio isotope marker dilution.

2. Techniques for monitoring lipid metabolism (lipid transit rate through the gastrointestinal tract, lipid assimilation efficiency) are based on feeding birds assimilable and non-assimilable radio-labeled lipid phase markers and collecting excreta. The markers are nontoxic and do not influence the normal absorption of nutrients.

The methods discussed above circumvent many technical problems encountered using older techniques, and both of them avoid destructive sampling.

Cited and Related References: 6, 35, 74

Energy Studies of Free-living Seabirds: Why Penguins Don't Always Like Water

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The effect of intramuscular injection of doubly labeled water on foraging behavior of 14 Gentoo Penguins (Pygoscelis papua) breeding at Ardley Island, Antarctica was studied by comparing presence/absence of birds at the colony as well as swim speed, dive depth and foraging location as determined by dead reckoning loggers fitted to birds that were (a) injected with 5 ml water in one site in the pectoralis muscle (b) injected with 1.25 ml water in four sites in the pectoralis (total 5 ml) and (c) uninjected birds. All groups were absent from the colony for extended periods which suggested normal foraging behavior. However, birds injected once spent little time in the water and had lower swim speeds, shallower dives and shorter foraging ranges than either birds injected four times or uninjected birds. Thus, visual assessment of penguin foraging rhythms at the colony is not enough to assess the extent of aberrant behavior induced by intramuscular injection of doubly-labeled water. We suggest that the volume of water in single intramuscular injections causes unacceptable muscle fibre stress and possibly tissue necrosis. In future studies, water should be injected intraperitoneally or intramuscularly in small amounts in many different localities.

Cited and Related References: 23, 35, 63

Demography and Doubts: Effects of Human Disturbance on Wandering Albatrosses and Giant Petrels at Marion Island

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Population sizes and breeding success of Wandering Albatrosses Diomedea exulans and Southern and Northern Giant Petrels Macronectes giganteus and M. halli at Marion Island, southern Indian Ocean, are assessed annually by complete-island counts during mid-incubation and shortly before fledging commences. In intensive study sites nests are also individually marked at the time of laying and breeding birds metal- and colour-banded. Thereafter, nest contents are checked at regular intervals until fledging.

Wandering Albatrosses are decreasing at a mean annual rate of -0.7%, Southern Giant Petrels decreasing at -2.2%, and Northern Giant Petrels are increasing at a rate of +4.1%. Breeding success in Wandering Albatross and Northern Giant Petrel study sites was not significantly different to elsewhere on the island. However, Southern Giant Petrels bred less successfully in study colonies than elsewhere in all years of study. Southern Giant Petrel breeding success was not correlated with colony size, geographical position, distance from the meteorological station or distance from the nearest field hut, suggesting, specifically that researcher rather than general human disturbance was the main reason for relatively low breeding success in study colonies.

The colonial, exposed-nesting habits of Southern Giant Petrels seem to make them relatively prone to being adversely effected by intensive study. Furthermore, giant petrels at Marion Island lose bands to wear, sometimes within a year, necessitating regular recapture for replacements and thereby adding to disturbance levels.

Southern Giant Petrels could be marked by implantable electronic tags to avoid problems of band loss and visits to colonies should be reduced to the minimum necessary to gather required data. Careful choice of study species is warranted when setting up long-term demographic or monitoring studies. Breeding success should be monitored in less intensively studied populations as a partial control.

Cited and Related References: 16, 30, 41, 42, 44, 45, 56, 57, 73

The Effects of Daily Nest Checks on South Polar Skuas and Helicopter Traffic on Adélie Penguins at Cape Bird, Ross Island

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South Polar Skuas (Catharacts maccormicki) exhibit a variety of interesting life history characteristics (siblicide, brood reduction, cannibalism, and adoptions) that are difficult to investigate without frequent knowledge of the status of eggs and chicks. In order to determine chick growth and the timing and causes of egg and chick losses at Cape Bird, Ross Island, nests are visited every day. Such frequent visits disturb the animals in their territories and potentially cause problems for the skuas. The purpose of this study was to determine the effects that daily nest checks have on the reproductive success of skuas. For three seasons reproductive success was determined for all of the study nests (n=81 to 118) and a set of control nests (n=66 to 70). The control nests were visited two times in the entire season. In 1988 the control nests fledged more chicks than disturbed nests but there was no difference in either 1990 or 1991. It is clear that there can be effects on individuals and populations, but, with care, these effects can be controlled. Ways to minimize those effects are discussed.

In addition to the effects on skuas, information will be presented on how the arrival and departure of helicopters from Cape Bird can affect nesting Adélie Penguins (Pygoscelis adeliae). The helicopter landing pad is 150 m from the nearest penguin colony at the northern rookery on Cape Bird. In the 1991 season, three adjacent penguin colonies were video-taped during the arrival and/or departure of 13 helicopters to Cape Bird. In general, birds with eggs or chicks would not leave their nest, but others left the site temporarily. Those penguins that left a colony nearly always returned to their site after the helicopter noise subsided. Net change in the number of birds in the colonies was 0.8 and 1.40 for arriving and departing helicopters, respectively. Despite the agitation exhibited by the penguins, these relatively small, isolated colonies have persisted during more than 30 years of similar disturbance. Although the colonies declined in size rapidly between 1961-1975, declines after 1975 have been slow. I conclude that other factors have an equal or greater controlling effect on the success of these colonies.

Cited and Related References: 3, 8, 31, 32, 50, 51, 56, 59, 61, 85, 97, 99, 100, 108

Optimizing Researcher Disturbance in Bird Colonies

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Whereas colonies offer obvious research advantages (e.g., abundance and concentration of subjects), they also magnify unwanted side-effects from human intrusion, such as elevated predation and desertion. Finding an optimal balance between these cost-benefit features depends critically on careful, a priori research designs that consider both the nature (quality) and amount (quantity) of researcher disturbance. We suggest ways in which the value of collected data can be enhanced, stressing the need for specific research questions and explicit hypotheses, and evaluating the merits of observational, census, and instrumental techniques. Design adjustments can also minimize quantitative disturbance effects. In particular, we recommend that statistical power analyses be conducted prior to data acquisition to reduce the number of subjects used and to avoid wasted research effort. Repeated measures and sequential designs can further increase efficiency of subject use. Some published and unpublished examples demonstrate these approaches.

Cited and Related References: 8, 20, 38, 41, 42, 44, 55, 56, 57, 60, 65, 75, 100, 107, 108

Effect of Different Levels of Disturbance/Handling on Recruitment in Adélie Penguins

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Over the last 15 years at Cape Bird, Ross Island, Antarctica, there have been a number of different studies of Adélie Penguins (Pygoscelis adeliae) by various researchers. These have employed techniques that vary in terms of their level of interference and degree of handling of the birds. At the same time the entire rookery has been censused by ground and/or aerial photography. This has enabled us to measure retrospectively the effects of research on breeding group (colony) size in seasons subsequent to the studies. From our preliminary analysis of studies carried out between 1977-1992, it seems that research did affect the behavior of Adélie penguins, even though measures of reproductive success in the year of a study were typically not different from controls. It seems that recruitment to breeding groups was reduced in the season following a study. Although this effect was most noticeable when birds had been handled during the course of research, even the presence of a "passive" observer could affect recruitment if the observer was frequently present. Small colonies (< 80 pairs) tended to be more affected than larger colonies.

Cited and Related References: 3, 4, 5, 19, 38, 45, 61, 83-85, 96, 97, 100, 108

Penguin Rookeries and Antarctic Stations: Do Adélie Penguins Habituate to People?

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We report here on Adélie Penguin (Pygoscelis adeliae) habituation and responses to visitors in areas frequently visited by Esperanza Station (Hope Bay, Antarctic Peninsula) personnel and areas of no disturbance. We randomly sampled 100 breeding groups during the creche stage at the Three Lakes (no disturbance) and Peninsula (disturbed) zones. To evaluate the behavioral response of Adélie Penguins to a man walking to the breeding group, the following procedure was developed: An observer, dressed in the same clothes as station personnel, walked to the breeding group in three stages, and, at each stop (10, 5 and 1 meters from the breeding group edge), evaluated the behavior of adult birds as, a) the bird does not modify its behavior; b) the bird modified its behavior and increased head and flipper movements, paid attention to the observer and exhibited restlessness, but remained at the same site and; c) the bird modified its behavior and abandoned the site.

At all distances, penguins at the Three Lakes zone showed higher proportions of responses B and C. The differences between the Peninsula and Three Lakes zones were very significant when compared for ten (X2: 336.20, d.f.=2, $p<0.001$), five (X^2:102.11, d.f.=2, $p<0.0001$) and one meter (X^2:231.47, d.f.=2, $p<0.0001$).

Our data shows that at Hope Bay, Adélie Penguins may have developed habituation to humans. This behavior could be explained in at least two different ways. First, the observed habituation is an adaptive response of Adélie Penguins due to long-term disturbance. The stronger reaction to humans in nondisturbed areas (Three Lakes zone) is explained by the low level, or absence of experience with humans of the birds breeding there. Second, the observed behavior results from variation in penguin age class distribution between the study areas. Carlini *et al.* (1992) and Acero and Aguirre (In preparation) suggested that recruitment rate at the Peninsula zone is lower due to human disturbance. The lower recruitment rate could produce a different age structure, with a prevalence of experienced breeders rather than young breeders. Non-breeding birds, or breeders with insufficient experience, may be more sensitive to disturbance, and, consequently, are predisposed to abandon the area more easily than experienced breeders. The lower proportion of non-experienced breeders at the Peninsula zone explains the differences found in the behavioral response between this and more distant zones.

Cited and Related References: 1, 2, 3, 17, 45, 50, 51, 61, 83-85, 96, 97, 99, 100, 106, 108

Adélie Penguin Breeding Site Selection and its Relation to Human Presence

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(Presented by Claudio Aguirre)

Population changes of an Adélie Penguin (*Pygoscelis adeliae*) rookery at Esperanza Station (Hope Bay, Antarctic Peninsula) during the last fifty years is analyzed relative to human activities. The rookery increased in size from about 50,000 pairs in 1945 to 123,000 in 1985. An assessment of the population increase between 1963 and 1992 (Carlini *et al.* 1992) showed that the increase was lower in the Peninsula zone (+11%), close to the station, than in the Eagle Cove zone (+40%) and Three Lakes zone (+50%), which are farther away from the station. This assessment was performed using the methodology described in Acero and Agraz (1991). During the same period, the rookery suffered a reduction of its occupied area of 16.8 ha (21%).

Population changes of the Adélie Penguin rookery relative to human activities carried out at Esperanza Station during the period 1945-1991 is summarized as follows:

1. Before the construction of Esperanza Station, the Adélie Penguin rookery covered the entire Peninsula zone up to Trinity House. Occupation of land by the station and subsequent human activities led to the abandonment of breeding sites, and to a decrease of 16.8 ha. (-21%) in surface area at the east border of the rookery.

2. The rookery increased from about 50,000 pairs in 1945 to 123,000 in 1985. The increase, estimated by area between 1963 and 1991, was lower in the Peninsula zone (+11%) than in the Eagle Cove (+40%) or Three Lakes zone (+50%). Breeding groups far away from the station, or protected by topography, showed a significant expansion in their occupied areas between 1945 and 1991.

3. The Peninsula zone increase was due to birds selecting breeding sites protected from the station by topography. This caused a fusion of breeding groups in the west and northeast sides of the Peninsula zone and a disappearance of breeding groups in the southeast side. Many former breeding sites exposed to the station along the east and southeast borders are still available but penguins have not reoccupied them.

Cited and Related References: 1, 2, 3, 17, 45, 50, 51, 61, 83-85, 96, 97, 99, 100, 106, 108

Visits to Murre Breeding Plots Reduce Reproductive Success

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A 25-m plot where Common Murres (Uria aalge) were breeding on the top of East Amatuli Rock in the Barren Islands, Alaska was visited two or three times to count the number of eggs and chicks produced in 1990 - 1992. The first visit to mark eggs was on 13 July 1990, on 26 July 1991 and on 11 August 1992. Loss from the first to the second visit, which was 20 to 30 days later in each year, was 74% (range 62% to 82%). Glaucous-winged Gulls (Larus glaucescens) waited nearby until researchers left the colony and then preyed upon eggs and chicks before the murres returned. Researcher disturbance caused murres to leave and neglect their eggs or chicks, making them easy prey. By comparison, murres lost no eggs or chicks from July through late August in 1991 on two plots that were photographed every six minutes from sunrise to sunset by time-lapse cameras. Estimates of reproductive success by visiting nest sites of murres where there are predators drastically underestimates reproductive success.

Cited and Related References: 38, 41, 42, 44, 56, 59, 75

Field Studies, Tourism and Stress Responses in Magellanic Penguins

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Vertebrates respond to a wide variety of stressors in their environment by secreting glucocorticosteroid hormones (corticosterone in the case of birds) from the adrenal glands. I studied the adrenocortical responses of Magellanic Penguins (Sphenisus magellanicus) to stress in two contexts. First, I studied seasonal and sex-based variation in response to a generalized stressor (capture and handling). I found that the degree of response depends greatly on the body condition (stored fat) of the individuals. Condition varies seasonally in response to fasting, and responses to stress therefore also vary. Thus, responses of penguins to field studies, and invasive procedures in particular, may depend on the seasonal stage in which studies are conducted, and may also differ by the sex of the anima. Second, I also studied behavioral and adrenocortical responses to nest visits in three areas with different histories of visitation. One area (TOURIST) received many visits daily, the other two (STUDY and CONTROL) received a single daily visit or none at all, respectively, prior to the study. STUDY and CONTROL area birds did not differ behaviorally or hormonally, but both groups differed strongly from TOURIST area birds, which showed much lower rates of alarm behaviors and lower corticosterone titers. Magellanic Penguins that are not themselves subject to study appear to habituate to constant high levels of visitation, but not to the less constant (even though regular) level typical of biological field studies. I also compared corticosterone levels in TOURIST and CONTROL area birds with individuals whose nests had been studied for 4-5 years, after those individuals had watched their mate be captured and handled. Long-term study birds appeared to have a lesser response to this form of disturbance than CONTROL birds did to a nest visit, although the average time of disturbance was lower in long-term study birds. It appears that study animals may habituate to some degree to the presence of humans, though probably not to capture and handling.

Cited and Related References: 7, 23, 35, 40, 47, 50, 51, 61, 62, 78, 80, 81, 89, 90

Human Disturbance and Long-term Changes in Adélie Penguin Populations: A Natural Experiment at Palmer Station, Antarctic Peninsula

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Human activity related to tourism and research in the vicinity of seabird colonies near Palmer Station, Anvers Island, Antarctic Peninsula, shows a significant increase since 1974. Although much of this activity originally focused on the large, easily accessible populations of Adélie Penguins (Pygoscelis adeliae) on Litchfield and Torgersen islands, Litchfield Island was designated a Specially Protected Area (SPA No. 17) in 1978. This ended tourism on the island and reduced research-related activities to negligible levels. Despite SPA status, breeding populations of Adélie Penguins on Litchfield Island decreased by 56% between 1975 and 1992. In contrast, on Torgersen Island, where tourism and research-related activities continued, the decrease in these populations amounted to only 13% over the same time period. There is increasing concern that tourism and other human-related activities may negatively impact Antarctic wildlife populations. Although this concern may be justified for some types of human activity, our data suggest that the potentially adverse effects of tourism and research may be negligible relative to the effects imposed by long-term changes in other environmental variables.

Cited and Related References: 4, 5, 16, 17, 32, 40, 44, 45, 51, 61, 83-85, 88, 94, 96, 97, 99, 100, 106, 108

The Effect of Instrument-Attachment on Predation of Adélie Penguins by Leopard Seals at King George Island, Antarctica

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We placed radio transmitters on 20 Adélie Penguins (Pygoscelis adeliae) between 15 December 1992 and 5 January 1993 at King George Island, Antarctica. The 14 g cylindrical transmitters (Advanced Telemetry Systems, Isanti, MN, USA) were mounted with epoxy glue (Devcon 5-minute epoxy) and a plastic cable tie on the upper back of the bird, between the shoulder blades, with the 15-cm flexible antenna directed posteriorly. The birds were monitored remotely for presence/absence at the colony using a data logger and receiver (Advanced Telemetry Systems, Isanti, MN, USA). Nests were checked for attending birds every two to three days during the first week, then daily thereafter. Twenty breeding birds marked with flipper bands only from the same colonies were monitored daily during chick-guarding and creche phases and acted as a control. Since birds forage at sea once every other day during the chick phase, and daily during creche, we were able to estimate the total number of trips to sea for all birds in the control group to compare with known trips in the sample population. We found a slight but insignificant increase in trip frequency by birds with transmitters versus those in the control sample.

We calculated percent predation by dividing the number of disappearances and confirmed predation events by the number of birds in the control and sample population. Predation by Leopard Seals (Hydrurga leptonyx) was confirmed when penguin carcasses with transmitters and bands still attached were washed to shore or retrieved by scavenging Brown Skuas (Catharacta lonnbergi). These carcasses had characteristics typical of seal predation, namely, skins that were often turned inside out, visible tear marks or punctures and meat stripped off the breast and legs of the bird. In addition, we observed at least 34 seal attacks on penguins from these colonies within 500 m of shore during the study period. Of the 20 birds with transmitters, three were killed by Leopard Seals and two disappeared during this period. Of the control sample in the same period, one bird was killed and one wounded by a seal; the wounded bird survived but failed at breeding. Survivorship in the control sample was significantly higher (X2 with Yate's correction, $p < 0.05$) than in birds with transmitters.

Increased predation as an effect of instrument-attachment is rarely documented in birds (Calvo and Furness 1992) as carcasses are usually not recovered after the subject disappears. Our results are the first we know of to document increased predation in diving birds due to instrument-attachment. Wilson *et al.* (1989) and Croll *et al.* (1991) found a significant increase in the duration and decrease in the number of foraging trips by Adélie and Chinstrap Penguins (P. antarctica) with instruments attached. Contrary to their results, we observed no decrease in the number of foraging trips in our sample population. This difference may be due to the heavier devices (25 g and above) used in these other studies. We also did not observe a chronic or cumulative effect of instrument-attachment as suggested by Croll *et al.* (1991) for their population; our birds disappeared or suffered predation on day 1 up to day 20 (mean=12 days, N=5) after the devices were attached. We assume that the increase in predation for birds with transmitters was due to increased drag caused by the instrument. New instruments need to be designed and tested to minimize drag and its effect on predation in diving seabirds.

Cited and Related References: 9, 11, 16, 19 24, 25, 26, 29, 54, 86, 87, 92, 93, 99, 101

WORKSHOP TOPICS: CITED AND RELATED LITERATURE

Banding and Marking Techniques.

4, 5, 9, 16, 18, 19, 21, 34, 53, 76, 77, 82, 88, 91, 94

Diet Sampling and Stomach Lavage.

18, 19, 28, 36, 39, 53, 68, 69, 72, 74, 91, 98

Instrument Attachment, External Technologies.

9, 11, 13, 18, 19, 24, 25, 26, 27, 29, 37, 43, 52, 54, 58, 64, 66, 69, 70, 71, 73, 86, 87, 92, 93, 95, 99, 101

Instrument Implantation, Internal Technologies.

6, 13, 14, 15, 22, 31, 101, 102, 103, 104, 105

Physiological Studies.

6, 7, 23, 35, 46, 47, 48, 49, 62, 63, 78, 80, 81, 89, 90

General Disturbance.

1, 2, 3, 8, 12, 17, 18, 19, 20, 30, 32, 40, 41, 42, 44, 45, 51, 55, 56, 57, 59, 60, 61, 65, 67, 75, 79, 83, 84, 85, 96, 97, 100, 106, 107, 108

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