The expanding population of fur seals coming onshore Antarctica's Signy Island: Ecological impacts and implications for environmental management

In the 19th and early 20th centuries commercial seal hunting in maritime Antarctica resulted in a huge decline in the populations of Antarctic fur seals. In some areas to near extinction. (1) However, since the end of sealing in the Southern Ocean the population has made a huge recovery. At Signy Island in the South Orkney Island's paleolimnological studies suggest that the population of fur seals coming onshore during the summer months has increased beyond any in the past 6500 years. (1) The increased activity is having a major impact on the unique terrestrial ecology of Signy Island and if some sort of strategy for managing the seal population is not established permanent ecological damage may be done. (3)

The ecological importance of Signy Island and damage being done by Fur Seals.

Signy Island is a small land mass (19.94 km2) south of Coronation Island in the South Orkney Islands, latitude 60°43' S, longitude 45°38'W (4). Signy has long been of interest to scientist due to its varied and diverse terrestrial ecology, the most diverse to be found within the Antarctic biosphere. There are many ice free areas over the summer months, seabird and penguin colonies ensure a rich nutrient supply and the maritime climate means there is plenty of water during summer. There can be found 2m deep peat beds beneath banks of moss which have formed over 5000 year time periods. Extensive carpets of wet moss around a number of freshwater lakes (4), the only two Antarctic vascular plants, hair-grass and pearlwort, and a diverse range if lichens can all be found on Signy Island. Within this varied flora is an extensive and diverse microbial and invertebrate fauna. (3)

Because of the short growing season due to Signy spending 9 out of 12 months covered in ice the lichens and moss banks take an extremely long time to form. They are therefore of great historic and scientific interest. And while these species may be quite hardy in that they live in one of the harshest environments in the world, they are also very susceptible to physical disruption and there is every chance that the local ecology, once disturbed, may not recover. (3)

The nature of the flora of Signy Island is such that the physical actions of the fur seals can cause extensive damage. The moss banks are loosely bound to the slow forming peat beds and the trampling of seals will quickly destroy a previously untouched, for 5000 years, moss and peat bed. There has been considerable loss of moss and lichen communities, and in some areas there is virtual eradication. The huge influx of seal excrement into the soil has resulted in blooms of the nitrogenous algae, Prasiola crispa, into areas previously dominated by Antarctic mosses and macrolichens (3). One of the worst hit regions is in the vicinity of the Sombre, Heywood and Knob lakes, this, unfortunately, coincides with one of the most ecologically diverse areas of the island, rich in moss carpet bogs. Now the moss has been heavily damaged and the water chemistry and microbiological environment of the lakes, profoundly changed. (4)

The fact that some of the peat beds being destroyed have been dated as old as 5000 years suggests that the seal population has not extended as far inland as these moss banks for at least the last 5000 years. This pattern of fur seal ecological impact is mirrored in other fur seal populations experiencing the rapid population growth such as on Bird Island at South Georgia where extensive areas of tussock grassland are being destroyed by the sheer number of seals now using them as resting places. This has ongoing ecological implications on, for example, the breeding sites of a number of seabirds (5).

Growth of the fur seal population

In the 1950's and early 60's the number of fur seals coming ashore Signy Island each year numbered in the 10's but by 1969 the population had increased to several hundred. Shortly thereafter began a rapid increase; in 1976 to around 3000 individuals and then to nearly 12,000 by 1983 (3). By 1994 the number was over 20,000. This population consists of mostly young, non-breeding males. (1) This, unfortunately for the ecology of Signy Island, represents the group most likely to travel in land and to higher latitudes. (5)

The Antarctic fur seal population growth has been the most rapid of any marine mammal ever recorded. At one of the main breeding sites, Bird Island at the northern tip of South Georgia, the population showed a growth rate of 15 – 17% per annum between 1958 and 1975 before beginning to level off. (3) Tagging of seals at the main breeding population at South Georgia and consequent satellite tracking suggest that the population of young male fur seals onshore at Signy are probably an overspill from this northerly population. (6) It is therefore relevant when considering the reasons for the burgeoning seal population to consider what is occurring at the South Georgia breeding sites that may be promoting this population bloom.

In the 1996/97 season Hodgson et al looked at the viability of looking for fur seal hairs within the sediment history and using this as an indication of past population size in comparison to present (1 and 2).They looked at sediment cores from the deepest part of Sombre Lake. The samples were dated at 5cm intervals and the number of hairs present counted. They also looked at the top10cm at 0.5cm intervals in order to see how this most recent core reflects recent history. This study revealed that there have been fur seals coming onshore for at least the last 6500 years however the abundance of seal hairs within sediment in the recent past is much greater then during any other time in this period years suggesting it is quite possible that the present population is much larger then it has been since at least the last glaciation period.

It is likely that the vegetation found in the outlying, coastal regions of the island has evolved amongst continuous seal impact and may very well have the capacity to recover from the most recent extent of the population.

However if the results from Sombre lake can be applied to Signy as a whole it may very well be that the plant communities are not well equipped for the kind of disruption being experienced and it may take centuries for them to reach their previous state of ecological equilibrium. (1)

Breeding population explosion particularly at Bird Island, South Georgia

Following the hunting of fur seals to near extinction a small breeding colony was discovered on Bird Island in the 1930's. In the early 1960's an estimated 10,000 pups were born each year and by 1975, 90,000 individuals could be found on Bird Island. (7) 90% of the world population of Antarctic fur seals can be found at South Georgia (8) and many of the smaller populations in Maritime Antarctica, breeding or otherwise, seem to derive from this large breeding population (7). The total population of Antarctic Fur seals is estimated in excess of 2.4million individuals (8).

In the case of the Antarctic fur seal, there does appear to be some dependence on krill availability for breeding success. Krill appears to be the principle food source at South Georgia, though squid and fish do play a role (7). Fur seals differ from other Antarctic seals in that they breed on land and their 4 months pupping and lactation period is proportionally longer than that of the pack ice seals. Because this lactation period is long, an adequate food supply in the female feeding range and long term availability of ice free regions is essential to reproductive success. (7)

Historical evidence indicates that the pre-exploitation breeding population at South Georgia did not occupy all available breeding sites. This suggests that there was something other then the availability of appropriate breeding sites limiting the population, possibly the availability of food within the lactating females feeding range. (7) This idea is further supported by studies at South Georgia of the breeding success of krill eating populations of seals, penguins and albatross, in which seasonal fluctuations in breeding populations have been associated with fluctuations in krill availability associated with climatic effects such as el-nino (9)

It may be that food, specifically the availability of krill, could once again becomes the limiting factor in the breeding seal population but the present extent of said population suggest that food availability may very well be in excess of that before the exploitation of the Southern Ocean seals and whales. In light of this it is interesting to note that prior to their exploitation, large numbers of the very large Baleen whales could be found in the waters around South Georgia. (7)

Is the present growth trend due to human influence in the Southern Ocean?

Relevant to this question is the Sombre lake sediment study (1 and 2). This group first looked for links in the sediment record between seal hair abundance and paleo-climate indicators and records. Climate change is one of the alternative hypotheses given for the exploding seal population. However, no correspondence was found, suggesting no link between climate change, including the recent warming trend, and fur seal populations. Secondly, the sediment record was examined for links between fur seal hair abundance and human activity in the southern ocean. This revealed a telling timeline. Prior to the start of commercial sealing there do seem to have been seals at Signy Island. From around 1820 there was a decline in the number of fur seal hairs corresponding to the onset of sealing. Whether this was because of direct exploitation of the Signy population or a reflection of the population decline at South Georgia is difficult to determine. There is negligible evidence that the South Orkney Islands were an important source of pelts for sealers, on the other hand sealing activities in the area may not have been recorded, even if they did occur. (10) Regardless, there is a telling link here between population decline due to human activities and an apparent decline in the sediment record of seal hairs.

The reduction of sealing in the 1870’s and an increase in the number of fur seal hairs shortly there after may reflect a post sealing recovery. However, from 1911 to the late 1970’s there were no seal hairs deposited in the

sediments of Lake Sombre implying that there was no seal population there at this time, possibly due to continued exploitation, particularly as there was a whaling station established there in 1911. Sealing ceased in the region from 1966 with the decline of the whaling industry but it was not until the late 1970's that the fur seals began to return in large numbers. The most recent sediment records reflect the most recent population boom. (1)

This sedimentary evidence suggests that the seal population has not only recovered but may now exceed the population pre human activity in the southern ocean. One popular theory for why this is occurring is the 'krill surplus theory' which speculates that the seal population is responding to an abundance of krill found in the absence of the large baleen whales. (3) While this theory does make a certain amount of sense it is at present, merely conjecture and further research is required on the krill and whale populations and exactly how they impact on the seals.

Understanding the krill surplus hypothesis.

While there is little detailed understanding of how top predator populations are regulated there is a suggestion that it is unlikely that limitation is due to the availability of breeding sites. Populations are generally thought to be ultimately regulated by food supply (11) though the complexities, such as the summer versus winter effects, are a matter of great debate. This supposition is central to the krill surplus hypothesis. Essentially, with the massive exploitation of both seals and whales in the Southern ocean the amount of krill available for predator consumption become extremely high, proportional to these top predator populations. Whale were hunted in the southern ocean in such a way that each species was targeted and over exploited to within 10% of the previous population, with the exception of the Minke whale which was only targeted at the end of the whaling era. (11). The generational time of the recovering fur seals is quite a lot less then that of the large baleen whales that previously were responsible for the majority of the krill consumption in the southern ocean. Seals within the recovering population are reaching sexual maturity as young as age 3 with most cows being fully recruited into the

breeding population by age 5 (7). Whales on the other hand have proportionally longer generational times. There is some debate as to what age the whales are reaching sexual maturity, but between 5 and 10 years for the humpback and blue whales seems to be a general consensus. This makes population analysis and detection difficult, but it does suggest that they are likely to take longer to recover to their pre exploitation numbers then the seals.

The suggestion in Payne that something other then breeding site availability was limiting the pre-exploitation seal population, most likely the availability of krill, fits well into the krill surplus hypothesis. Before the exploitation era the krill was being consumed mostly by the large baleen whales, therefore, in terms of food web dynamics, the seal population was being limited by the whale population. When the whales were hunted to within 10% of their previous population the seals, with their shorter generational time were able to recover quicker. As the population grew it did not experience a krill shortage that would have limited the reproductive success so they just continued to grow and spread, thus the growth of the breeding population at South Georgia and also the increase in juveniles coming ashore in places such as Signy. The krill surplus hypothesis is also supported in a way by the growing population of Minke whales. These small whales are also krill feeders and their numbers were not nearly so dramatically depleted as the other much larger (and therefore profitable) baleen whales in the region. Their current population size is estimated to be double what it was initially.

The question has got to be asked; if the krill surplus hypothesis is indeed a significant contributing factor to the seal population growth then what impact is the large seal population is having on the recovery of the large baleen whales? Pre-exploitation, these animals consumed vast numbers of krill limiting the seals ability to reproduce; now we may have the opposite. The whales exist in much reduced numbers and the seals, because of their rapid recovery are now the principle krill consumers in the area. Are the seals now consuming enough krill that it may become limiting to the breeding success of the whales? It is an area of research vastly under studied, possibly because

of the difficulty in studying the whale populations. There does appear to be some link between krill availability and fur seal breeding success (7) but observations of the recovery of the large baleen whales and the effect of krill availability on their breeding success often presents a logistical problem. Nonetheless, it is a possibility that ought to be considered and further research conducted.

Should controlled management of the fur seal population be considered?

The nearby ASPA's of Lynch and Litchfield islands are also suffering as the seal population increases and what needs to be acknowledged here is the reasons for making these areas specially protected. Protection was awarded these places specifically because of the scientific interest of the local flora, the flora which is now being profoundly affected by the increasing seal population. If the population at Signy and in other nearby areas is allowed to increase, perhaps even to include the establishment of a breeding population, it will be at the expensive of the terrestrial and freshwater environments. Would it be better to consider some sort of carefully executed control methods thus affording these amazing, diverse and very fragile ecosystems some level of protection from this natural destructive force? It is significant that this is the first time that an Antarctic Specially Protected Area has been threatened by a natural agent, (3) and it does make these questions of what is the best thing to do that much more difficult. Even if it is shown that the present population boom is a direct result of human influence, we must always be careful of causing further damage in the attempt to fix our mistakes. However there is significant damage being done here and now and not doing anything may be the worst possible option of all.

At present, direct control of seals is not really an option as fur seals are still a specially protected species and the Convention of the Conservation of Antarctic Seals (CCAS) prohibits killing any seals within the Antarctic treaty area below 60°S. (1) However if the present seal population is due to some

human influence such as that suggested by the ‘krill surplus theory’ and the seal population is consequently unnaturally large, then it may be that natural equilibrium cannot be reached without intervention of this sort. In addition, regional population control would be unlikely to provide any long term solution (1). Perhaps what needs to be considered is a lift on the protection of fur seals to allow some controlled management of not only local populations such as that at Signy but in particular, of the large breeding population found at South Georgia. The flip side of this is of course, it may not be necessary and could be potentially harmful. Regulations to manage stocks of whales, fish and krill may begin to exert some regulatory influence on the seal population. As, by the krill surplus theory, it is the levels of krill that ultimately determine the limitations of the seal population, the krill fishery and a, hopefully, growing whale population may do more to limit the fur seal population in the long term then any culling program. (2) Having said this there is a very real risk that even if this is the case, by the time its influence is exerted it may be too late for some of the terrestrial ecosystems currently being damaged to recover?

The principle and at present most practical method of control being used in light of CCAS involves the employment of physical barriers to prevent seals venturing into areas of special scientific and ecological interest. (2) On Signy there are five 5x5m areas and one 10x5m area enclosed by chain-link fences, there are also adjacent to these, unfenced control areas. These were chosen because they represented the principal plant communities in areas expected to experience damage by the seals. The plots are photographed annually and used to monitor deterioration caused by the seals and any recovery resulting from the enclosures. (3) This has proved to be a practical and reasonably successful method of control in the interim, however it has not been entirely so as excrement and fur are still being washed into the fenced off areas causing nutrient toxicity and resulting in plant deaths and algal blooms.

Ecosystem management is always a difficult and complex matter and all potential risks do need to be considered. Further research into understanding the complexities of the situation is a must but it is worth realising that the damage being done by the seals to the terrestrial and freshwater ecology is

occurring now and rapidly and it may very well be irreversible. The longer the damage is allowed to proceed, the more difficult the recovery process. Practical short term management is as important in this situation as establishing a viable, long term management plan for controlling the seal population.

1. Hodgson, D.A., Johnston, N.M., Caulkett, A.P., Jones, V.J. (1998). Paleolimnology of Antarctic Fur Seal, *Arctocephalus gazelle,* Populations and Implications for Antarctic Management. *Biological Conservation 83:2*,

2. Hodgson, D.A., Johnston, N.M. (1997). Inferring seal populations from lake sediments. *Nature 387*

3. Lewis Smith, R.I. (1988). Destruction of Antarctic Terrestrial Ecosystems by a Rapidly Increasing Fur Seal Population. *Biological Conservation 45.*

4. Heywood, R.B. (1967). The freshwater lakes of Signy Island and their fauna. *Philosophical Transactions of the Royal Society of London B-Biological Sciences 252.*

5. Bonner, W.N. (1985). Impact of Fur Seals on the Terrestrial Environment at South Georgia. *From Antarctic Nutrient Cycles and Food Webs* (ed. by WR Siegfried, PR Condy and RM Laws)

6. Laws, R.M. (1973). Population increase of fur seals at South Georgia. *Polar Record 16.*

7. Payne, M.R. (1977). Growth of a Fur Seal Population, *Philosophical Transactions of the Royal Society of London B-Biological Sciences, 279.*

8. Boyd, I.L. (1989). Spatial and Temporal distribution of Antarctic fur seals () on the breeding grounds at Bird Island, South Georgia. *Polar Biology 10.*

9. Croxall, J.P., McCann, T.S., Prince, P.P., Rothery, P. (1988). Reproductive performance of seabirds and seals at South Georgia and Signy Island, South Orkney Islands, 1976-87: implications for Southern Ocean monitoring studies. *In Antarctic ocean and resources variability* (ed. D. Sahrhage), Berlin: Springer-Verlag.

10. Smith, R.I.L. (1990). Signy Island as a paradigm of biological and environmental change in Antarctic terrestrial ecosystems. In *Antarctic Ecosystems. Ecological Change and Conservation* (ed. K.R. Kerry and G. Hempal), Berlin: Springer-Verlag.

11. Croxall, J.P. (1992). Southern ocean environmental changes: effects on seabirds, seal and whale populations. *Philosophical Transactions of the Royal Society of London B-Biological Sciences 338*.

12. Boyd, I.L. (1993). Pup production and distribution of breeding Antarctic fur seals (*Arctocephalus gazelle*) at South Georgia. *Antarctic Science 5:1.*