# Chapter 46

# Recommendations for a regional monitoring programme for Cape Fur Seals in the BCLME

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## Background

In marine ecosystems, the distribution and abundance of living resources may be directly affected by changes in physical and oceanographic features (Beauplet *et al.* 2004). This is especially true in mid- and high-latitudes, where the annual seasonal cycle accounts for much of the total temporal variability in marine organisms (Bertram *et al.* 2001). While the general seasonal patterns repeat each year, climatic variability of the atmosphere and the ocean produce detectable changes in the timing and intensity of events (Bertram *et al.* 2001). Such variability can pose major challenges to the management of living marine resources, particularly since changes in marine ecosystems can be manifested in many different ways, on different temporal and spatial scales (Diamond and Devlin 2003). Moreover, in the last 150 years, increasing fishing activity and global climate change have been superimposed upon these natural environmental fluctuations (Hindell *et al.* 2003).

The Benguela Current Large Marine Ecosystem (BCLME), which adjoins southern and western South Africa, Namibia and southern Angola, is an example of an ecosystem that experiences high levels of variability at different temporal and spatial scales (Shannon and Jarre-Teichmann 1999). It is characterized by high biological productivity, but experiences major fluctuations in the production of forage fish species, which has consequences for trophic functioning, fisheries, and socio-economic considerations (Shannon and Jarre-Teichmann 1999, Roux 2003), both within and across national boundaries. To ensure the sustainability of the ecosystem, management needs to take into account such variability, particularly considering the increasing threats of fishing and climate change. Thus, in order to sustain the health of the BCLME and guarantee the responsible use of its marine resources for current and future generations, all three countries in the region have adopted, or are in the process of adopting, an Ecosystem Approach to Fisheries (EAF) (Cochrane *et al.* 2004, Roux and Shannon 2004).

As they are sensitive to changes in the abundance and distribution of their prey species (Crawford *et al.* 1983, Weimerskirch *et al.* 2003), marine top predators tend to be good indicators of alteration in trophic functioning and other ecosystem changes (Diamond and Devlin 2003, Reid *et al.* 2005). Therefore, these predators are increasingly being used to monitor variability in marine ecosystems (Montevecchi and Myers 1995, Boyd and Murray 2001). Terrestrial breeding marine top predators are potentially most useful in this regard; their relative accessibility when on land facilitates the monitoring of their reproductive performance, their population trends and aspects of their foraging ecology, all of which may be affected by the distribution and abundance of prey species.

The most prominent mammalian land breeding marine top predator in the BCLME is the Cape Fur Seal *Arctocephalus pusillus pusillus*. Historically, the breeding distribution of this species ranged from the south-east coast of South Africa to central Namibia. At least since 1993, there has been a northwards shift in the distribution of the population (Kirkman *et al*. 2007a). A small breeding colony was recently established at Baia dos Tigres, southern Angola (Meÿer 2007). Management priorities for Cape Fur Seals vary regionally in the BCLME. In South Africa, National Policy (Policy on the Management of Seals, Seabirds and Shorebirds: 2007) prohibits the killing of seals for profit, its objective being rather their sustainable, non-consumptive use for ecotourism. In Namibia, however, harvesting/culling of seals is ongoing; seals "…are considered to be exploitable resources and will be utilized through culling, but conserved at safe sustainable levels" (Namibia Ministry of Fisheries and Marine Resources White Paper "Towards Responsible Development of the Fisheries Sector", 1991). However, notwithstanding different management objectives within the region regarding the seal population, the implementation of a regional monitoring effort for land-breeding top predators, including seals, is integral to an ecosystem-based management approach to the living marine resources of the region.

## Discussion

Based on the management objectives within the region and on relevant international declarations, some priorities for an ecosystem monitoring programme in the BCLME using land-breeding top predators have been proposed (BCLME Top Predators Project Steering Committee 2007). These are listed below (*a*–*f*) and discussed with regard to the Cape Fur Seal, with the aim of recommending monitoring tools for achieving these objectives.

***(a) Monitoring the conservation status of top predator species of conservation concern, and assessing and updating their conservation status***

Although the conservations status of the Cape Fur Seal is regarded as 'least concern', several potential threats to the population have been identified (Kemper *et al.* 2007). These include prey shortages due to environmental fluctuations or over-fishing, ongoing harvesting/culling in Namibia, and mortality related to fishing operations (incidental and intentional). Because counts of pups may be used as an indication of population size (Wickens and Shelton 1992), continuation of the frequent censuses of breeding colonies, which occurred between 1972 and the present (Kirkman 2007a), will allow for any changes in abundance to be monitored. In addition, incidence of seal mortality in fishing operations (e.g. drowning in trawl nets) should be monitored.

***(b) Managing interactions between species of top predators, where one or more species are of conservation concern***

***(c) Assessing the outcomes of conservation interventions***

Continuation of the census time series is also applicable to these objectives, specifically with regard to any management interventions that may occur regarding interactions between Cape Fur Seals and seabird species of conservation concern (e.g. Makhado *et al.* 2006). It is also applicable to the detection of possible deleterious side-effects of management, such as effects of the harvesting/culling of bulls on the social structure of the seal breeding population.

***(d) Providing indices of the state of health of marine ecosystems using top predators***

Parameters to measure for providing indices should be responsive to environmental variation. Hindell *et al.* (2003) broadly classified possible monitoring parameters into the following three groups: (i) Demographic attributes (e.g. changes in abundance and distribution of population); (ii) Performance attributes (e.g. reproductive output or success); (iii) Behavioral attributes (e.g. diet, foraging patterns). A key to using predators as indicators of the state of ecosystems is understanding the relationships between predators and appropriate biological (e.g. prey abundance estimates from surveys) or physical (e.g. upwelling indices) parameters (Croxall *et al.* 1999). Long term monitoring of such parameters therefore needs to be in place for meaningful indices to be created from time series of information on predators.

Censuses of pups permit detection of medium to long term trends in the abundance and distribution of the breeding population (demographic attributes), which may be related to ecosystem changes (including prey shifts), density dependence, or anthropogenic effects. Considering the changes documented in the distribution and abundance of prey species (e.g. Crawford *et al.* 2007), emphasis should be placed on searches for new haulout colonies in remote areas, and confirming the formation of new breeding colonies where suspected (e.g. Meÿer 2007). Apart from an index of population trends, pup counts can be seen as a measure of reproductive output (performance attribute) interpretable at a finer time scale, since they may fluctuate between years due the effects of environmental variability on birth rates (Wickens and Shelton 1992, Kirkman *et al*. 2007a). For logistical reasons, obtaining comprehensive coverage of the entire population on an annual basis may not be practicable. Furthermore, excepting for extreme events, it is generally difficult to establish a causal link between changes in numbers and a specific environmental change (Hindell *et al.* 2003). Therefore, censuses as indicators of ecosystem effects on the seal population are not sufficient on their own, and other attributes should be monitored in conjunction with abundance.

Other performance attributes which are amenable to monitoring include the annual average growth rate (or some index thereof) or indices of pup condition (e.g. mass) at any specific period, such as at the time of weaning. These parameters, which could have direct consequences for pup survival, and consequently reproductive success of mothers, reflect the rate of energy transfer from mothers to pups and therefore provide a good indication of prey availability (Reid 2002, Beauplet *et al.* 2004). Indeed, strong correlations have been found between coastal upwelling indices at Lüderitz, the main upwelling centre in the BCLME, and the average growth rate/weaning mass of pups in the region (Roux 2002). Thus, pup growth parameters may serve as an index of environmental variability and prey availability. Because fur seal mothers are central place foragers during the lactation period, these parameters can be expected to reflect conditions whose spatial and temporal boundaries can be readily determined or estimated (Reid 2002).

However, unlike some other local top predators such as the African Penguin *Spheniscus demersu*s, Cape Fur Seals are generalist feeders and are able to switch prey and possibly maintain their overall energy intake when the abundance of a prey resource declines (Kirkman *et al.* 2007b). Therefore, neither their performance or their demographic attributes are likely to be reliable indicators of any particular prey species, and these parameters should ideally be supplemented with other information, such as diet (behavioural attribute). The diet of seals can be monitoring using a cheap and practical method such as analysis of scats collected in colonies, which can provide important information on spatial and temporal changes in diet (Tollit and Thompson 1996). A more recent innovation that also gives insight into trophic interactions,with minimal impacts to the animals and with low analysis costs, is the stable isotopic analysis of tissue removed from animals (Montevecchi 1993, Zhao *et al*. 2004).

With regard both to the monitoring of diet and of performance attributes such as pup growth/weaning mass, it is important that studies be designed with adequate replication to address the high levels of spatial and temporal variability that occurs throughout the seals' range in the BCLME. Furthermore, considering the substantial individual variation that may occur within both performance and behavioural parameters, large sample sizes should be aimed at (Hindell *et al.* 2003). In practice, these ideals may not always be achievable, considering the inaccessibility and difficult working conditions that characterise many seal colonies. Indeed, the need for large sample sizes and spatio-temporal replication tend to compromise the feasibility of monitoring certain parameters for providing indices of ecosystem health. This may include the monitoring of annual pup survival rates (performance attribute), which requires intensive effort.

The development of modern instruments (e.g. satellite transmitters, time–depth recorders) which can be deployed on seals during shore visits, allow for investigation of geographical and vertical variation in foraging effort or behaviour (behavioural attribute), and may provide clues regarding changes in prey availability (e.g. Guinet *et al*. 2001). Such instruments are expensive and considering the desirability of replication and representative sample sizes may not be practicable as routine monitoring tools. However, information obtained from such studies may serve to facilitate understanding of relationships between monitored parameters of the predators and prey availability or environmental variability.

***(e) Accounting for the requirements of top predators dependent on species targeted by fisheries***

Censuses of pup numbers, together with information on relevant life history parameters (e.g. standing age distribution, survival, fecundity, age at first breeding and longevity) can be used to model population size and trends (e.g. Wickens *et al*. 1992). This, with information on diet (e.g. from scats), energy requirements, calorific content and digestibility of prey, can be used to estimate the prey requirements of the seal population or components thereof (e.g. Mecenero *et al*. 2006). Information on prey consumption of the seal population can be included in ecosystem models to investigate trophic relationships between seals and other top predators, as well as commercial fisheries (e.g. Roux and Shannon 2004).

***(f) Providing information useful in the management of prey resources, based on top predators***

Diet data derived from seals may complement conventional fisheries science in providing quantitative information relevant to management considerations for commercial fisheries, e.g. age estimation, forecasting recruitment. Sampling and analysis of seal scats from key colonies has been shown to be an appropriate technique for providing such information (Roux 2007, Mecenero *et al*. 2007).

**Recommendations**

In summary, the following recommendations are made for the monitoring of seals in the BCLME:

- An integrated approach should be followed, incorporating demographic, performance and behavioural attributes of the seals. As a minimum the programme should aim to monitor at least one parameter relevant to each of these attributes.
- Based on their applicability to the various management objectives and their practicability, the following three parameters are suggested as minimum requirements: pup production, an index of pup growth rate/weaning mass, and diet.
- The monitoring studies should be carefully designed with the various scales of spatial and temporal variability in mind. Emphasis should be placed on the need for suitable sample sizes considering the substantial individual variation that may occur within performance and behavioural parameters.
- Assessments of historical information, where available, should be conducted to facilitate the estimation of desirable levels of spatial and temporal coverage and sample sizes.
- Wherever possible, monitoring studies should be coordinated between regions, i.e. with regard to which parameters are monitored and the timing of sampling, to facilitate comparison.
- Sampling/data collection techniques should be standardized between regions and over time. Detailed explanations of various basic monitoring techniques, including those applicable to the studies of diet, pup growth and abundance, are given in Kirkman (2007b).
- Standardizing data management software and procedures will facilitate the sharing of information between regions.
- In order to assess the usefulness of parameters as indicators of ecosystem health and to allow meaningful interpretation of variability in results, the time series of information collected need to be linked to other physical or biological parameters relevant to prey availability.
- Research using sophisticated technological devices such as satellite transmitters or time–depth recorders to investigate foraging effort/behaviour of seals should be encouraged; such studies can facilitate understanding of relationships between measured parameters of the predators and prey availability or environmental variability.
- New and innovative techniques of monitoring, such as the stable isotopic analysis of tissue removed from animals to investigate diet, should be tested. However, although it is desirable to keep up with technological and scientific advances, the introduction of new techniques should not jeopardize existing monitoring programmes; the development of reliable long term time series of information depends upon continuity. Where it is desirable to overhaul a monitoring technique (e.g. replacement of black-and-white film with digital photography for aerial censuses), emphasis should be placed on calibrating the results of the old and the new techniques, before the old is discarded.

Based on the above and the methods described in Kirkman (2007b), suggestions for a seal monitoring programme in the BCLME are presented in Tables 1 to 3. Three different levels of monitoring intensity are considered, based on a hypotheti-

**Table 1**: Basic monitoring programme

| Parameter | Technique | Spatial resolution | Temporal resolution |
|---|---|---|---|
| Pup numbers | Aerial census | Entire range | 1 in 3 years |
| Index of pup condition at 6 weeks after birth | X-samples of pup mass | Representative colonies in SA and Na. (e.g. 3 each) | 1 sample per year at a specified date |
| Index of pup condition at weaning | X-samples of pup mass | Representative colonies in SA and Na. (e.g. 3 each) | 1 sample per year at a specified date |
| Diet | Scat sampling | Representative colonies in SA and Na. (e.g. 4 each), Baia dos Tigres (An.) | Monthly for SA and Na., seasonally in An. |
| | Scat sampling | Selected colonies | More frequent scat sampling (e.g. bi-monthly) if necessary for fish monitoring studies (e.g. aging) |

(SA = South Africa, Na. = Namibia, An. = Angola, X-sample = cross sample)

**Table 2:** Desired monitoring programme (in addition to Table 1)

| Parameter | Technique | Spatial resolution | Temporal resolution |
|---|---|---|---|
| Pup numbers | Aerial census | Selected colonies/regions (e.g. harvested colonies, local populations declining or growing rapidly) | More frequent censuses, e.g. annually |
| | Aerial census | Entire range | Additional censuses in the case of major environmental events, mass mortality event or mass abortion events. |
| Index of pup growth | X-samples of pup mass | Representative colonies in SA and Na. | Monthly sampling, Jan–Sep |
| Diet | Stable isotope measures | Colonies representative of regional diet (based on scats) | Seasonal |

(SA = South Africa, Na. = Namibia, An. = Angola, X-sample = cross sample)

**Table 3:** Optimal monitoring programme (in addition to Tables 1 and 2)

| Parameter | Technique | Spatial resolution | Temporal resolution |
|---|---|---|---|
| Pup numbers | Aerial census | Entire range | More frequent censuses, e.g. annually |
| Pup size at birth | Weighing of pups at birth | Representative colonies in SA and Na. | Annual |
| Measures of pup growth | Longitudinal sampling | Selected colonies | Annually for specified period (e.g. from birth to 60 days of age) |
| Trip duration | VHF monitoring | Selected colonies | Annually for specified period |
| Foraging range, at-sea movements | Satellite telemetry | Selected colonies | Annually for specified period |
| 1st year survival estimates | Tagging of pups and subsequent monitoring | Selected colonies | Annually |

cal scale of increasing financial support and regional co-operation. (i) 'Basic' refers to the minimum monitoring requirements to provide essential data for long term management, and involves routine monitoring; (ii) 'Desired' is the suggested goal for a regional monitoring initiative to attain in the short to medium term in terms of monitoring effort; (iii) 'Optimal' assumes the existence of a substantially funded, dedicated regional team.

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