Summary of responses to MARAM/IWS/DEC14/Peng/B2-11

Christina Hagen[1], Astrid Jarre[2,3,4], Richard B. Sherley[5,6], Antje Steinfurth[7]

[1] Seabird Conservation Programme, BirdLife South Africa, PO Box 7119, Rogge Bay, 8012, South Africa
[2] Marine Research (MA-RE) Institute University of Cape Town, Private Bag X3, Rondebosch 7701, South Africa
[3] Department of Biological Sciences, University of Cape Town, Private Bag X3, Rondebosch 7701, South Africa
[4] Centre for Statistics in Ecology, Environment and Conservation, University of Cape Town, Private Bag X3, Rondebosch 7701, South Africa
[5] Animal Demography Unit, Department of Biological Sciences, University of Cape Town, Private Bag X3, Rondebosch 7701, South Africa
[6] Environment and Sustainability Institute, University of Exeter, Penryn, Cornwall, TR10 9FE, United Kingdom
[7] Percy FitzPatrick Institute, DST/NRF Centre of Excellence, University of Cape Town, Rondebosch 7701, South Africa

The B series of documents present various arguments to suggest that the island closures study should be discontinued and three of the four islands under consideration be opened to fishing. The view of the authors of the A series of papers remains unchanged, that such a strategy would be inadequate in view of the aims of the African Penguin Biodiversity Management Plan (BMP-AP) and no management recommendation can be made without consideration of management objectives and the trade-offs between them (as outlined in Hagen *et al.* 2014: MARAM/IWS/DEC14/Peng/A1).

This document presents a summary of the responses to papers B2-11, some of which are presented in separate documents. B1 was not considered as this is an overview of the documents B2-11. We have not been able to provide comments on all B documents within the time-frame permitted, but this does not necessarily imply agreement with their contents.

MARAM/IWS/DEC14/Peng/B2

This document was not commented on specifically, as rebuttals to the points it contains are dealt with in other documents. It may however more suited to being put before the Pelagics Scientific Working Group again after the Panel workshop, as it is not the primary document detailing the analyses but contains management recommendations.

MARAM/IWS/DEC14/Peng/B3a and b

First and foremost, it is important to note that this document and the model it describes do not deal with the effects of prey biomass or fishing on the spatial scale relevant to the Island Closures study. This model deals with prey biomass between Hondeklip Bay and Cape Agulhas for the 1+ biomass (November) and between the Orange River mouth and Cape Infanta for the recruit biomass (May survey) and catches over a similar spatial scale. The biomass away from the immediate vicinity of the islands is not available to the birds when they are breeding. Thus, this model is of little help in assessing whether fishing pressure in the immediate vicinity of the breeding colonies of Robben and Dassen Islands might be negatively affecting penguin population dynamics. In fact, the model does not deal with island closures in any sense at all.

One of the important findings of the analyses described in this document is that there is no relationship between an anchovy recruit index and penguin reproductive success (Figure 8 in MARAM/IWS/DEC14/Peng/B3a and b)). The concerns with this result are explained in more depth in MARAM/IWS/DEC14/Peng/A9). The lack of relationship between reproductive success and anchovy abundance is problematic, as is the fact that *Hy* (the annual reproductive success) incorporates survival from hatching to age 8 months. In reality, chicks at Robben Island fledge approximately 4 months after hatching (Sherley et al. 2013b) and then leave the colony. They are subject to no further parental care and do not forage in the vicinity of the breeding colonies (Sherley et al. 2013a). Survival from fledging to 8 months of age is therefore not influenced by the same process as survival from hatching to fledging. For the latter, chicks are dependent on the food that can be found by their parents within about 20 km of the breeding colony. For the former, fledglings must feed themselves and may travel as far as central Namibia to do so (Sherley et al. 2013a). Thus, *Hy* is severely confounded in this model, a point which has been made previously.

That a relationship does in fact exist between reproductive success and anchovy abundance has also been pointed out previously, is pointed out again in response to these documents (MARAM/IWS/DEC14/Peng/A9) and is published in the peer-reviewed literature (Crawford et al. 2006). In addition, we would draw the panel's attention to the fact that the authors of MARAM/IWS/DEC14/Peng/B3a were asked to "consider simulations in which there is an impact of sardine and anchovy on the dynamics of the penguin population via, for example, impacts on fledging success, participation in, and age-at-first breeding, juvenile survival and adult survival even if the current model suggests that there is no impact on some of these demographic parameters" by previous panels in 2010 and 2011 (see BA.6 (H) and BE.8 (H) in MARAM/IWS/DEC14/Peng/B11) and to "Estimate a linear (constrained not to decrease) relationship between reproductive success and anchovy abundance rather than assuming there is no dependence of reproductive success on anchovy abundance" in 2011 (BE.6 (H) in in MARAM/IWS/DEC14/Peng/B11). The responses in MARAM/IWS/DEC14/Peng/B11 indicate that these requests have not been met. This is troubling given the observed relationship between anchovy recruit biomass and the number of chicks fledged per pair at Robben Island from 1989 to 2012 shown MARAM/IWS/DEC14/Peng/A9.

As a result of the above, the only variable which can then respond to a release in fishing in this model is adult survival. Therefore the potential for population growth in response to a cessation of fishing is almost certainly underestimated because a) adult survival is generally high in penguins in the absence of anthropogenic pressures (Sidhu et al. 2007); b) it realistically needs to be over 0.81 just to keep the population in equilibrium (Crawford et al. 2006; Weller et al. 2014: MARAM/IWS/DEC14/Peng/A8); but c) the lowest adult survival estimated in recent years is 0.46 while the highest has been 0.95 (Sherley et al. 2014b, note that an estimate of 0.99 was recorded, but the upper 95% CI was 1). Thus, if juvenile survival and reproductive success are not able to respond to changes in food availability in the model, then there is more capacity for the population to decrease in the model when prey availability is scarce than there is for the population to increase in response to a) increased prey availability and b) a release of fishing pressure. This is almost certainly why the future scenarios with the 1984-1998 sardine distribution shown in Table 2 (of MARAM/IWS/DEC14/Peng/B3a) led to a decrease in the modelled population in 2032 with fishing, when in reality (during 1984-1998) the penguin populations at Robben Island and the colonies on the west coast in general increased (Underhill et al. 2006).

Furthermore, the model results show that the population at Robben Island was not sustainable without immigration from other colonies which the authors interpret to mean that Robben Island is a sink population and is not a suitable breeding location. The reasons suggested for the suboptimal breeding conditions are the lingering effects of the past oil spills and the removal of guano resulting in penguins nesting on the surface or under vegetation. While oiling certainly has had an important effect on the population at Robben Island, as an explanation for the model results in MARAM/IWS/DEC14/Peng/B3a it is somewhat problematic because the oil spills occurred in 1994 and 2000. Figure 9 of MARAM/IWS/DEC14/Peng/B3a suggests that very little recruitment was needed after 1994 and none at all after 2000 to fit the population trajectory observed at the island.

The second point about the removal of guano is backed up by the statement "Evidence that breeding success at surface nests is lower than that for artificial nest boxes or nests in buildings suggests that vegetation does not provide optimal nesting habitat for penguins (Sherley 2010). Surface nests may be more susceptible to predators such as feral cats and kelp gulls (Underhill et al., 2006), especially if guarding adults vacate their nests for some reason (e.g. to alleviate heat stress)." at lines 511 to 515 in MARAM/IWS/DEC14/Peng/B3a. However, there is a distinction made in Sherley (2010) between open surface nests (those with no cover at all) and nests under vegetation which has been missed by the authors of MARAM/IWS/DEC14/Peng/B3a. In fact, the conclusion in Sherley (2010) was "This suggests that nests under vegetation may be, at the very least, adequate breeding habitat and Crawford et al. (1995b) has suggested that the availability of nesting space under shade may have been one of the factors leading to Robben Island being recolonised in 1983". The peer-reviewed paper stemming from that earlier work (Sherley et al. 2012) also stated "Robben Island has at times supported a population in excess of 7000 pairs of Penguins (see Table 1 in Underhill et al. 2006), birds have bred successfully since 1983 (e.g. Crawford et al. 1999; 2006) and the reproductive output in this study (0.7 chicks per pair) was on par with or surpassed that previously recorded at other breeding colonies (see Table 6 in Kemper et al. 2007b). This suggests that nests under vegetation may be, at the very least, adequate breeding habitat".

Simulations in which reproductive success and juvenile survival are linked to food availability are likely to yield model fits to the observed data that require less reliance on immigration. In any event, the individuals oiled after the *Apollo Sea* and *Treasure* oil spills are effectively no longer in the breeding population and much has been done to improve the breeding habitat at Robben Island in recent years, with many more nest boxes put out (but not yet occupied) in 2013 and 2014. So if these were impairments to the growth of the colony, this should not be the case in the future as they have mostly been nullified.

Finally, the authors of B3 acknowledge that "disproportionately higher fishing pressure on the west coast" may have exacerbated the effects of natural variability in fish abundance. In addition to disproportionately high fishing pressure on the west coast as a whole, in some years there is disproportionately high fishing pressure in the vicinity of the penguin breeding colonies. For example between 2011 and 2013, the anchovy catch within 30 nm of Robben Island ranged from 37 to 69% of the catch taken in stratum B and 14 to 31% of the total anchovy catch (catch data compared between MARAM/IWS/DEC14/Peng/C1 and van der Westhuizen 2011, 2012, 2013). This high fishing pressure may indeed cause environmental anomalies to have more severe effect than they would have otherwise, suggesting that a fishing exclusion zone may help to buffer against natural variability. However, this model can make no statement to that effect, unless it were to be modified to deal with prey availability and catches on an appropriate spatial scale.

MARAM/IWS/DEC14/Peng/B4

The comments made in Bergh *et al.* (2014: MARAM/IWS/DEC14/Peng/A2) and Hagen *et al.* (2014: MARAM/IWS/DEC14/Peng/A3) regarding the use of annual means and the way in which catch is incorporated still apply. In addition, further comments and simulations addressing the use of catch and biomass in the models and the conclusions that can be drawn from positive catch effects in MARAM/IWS/DEC14/Peng/B4 have been addressed in Bergh (2014: MARAM/IWS/DEC14/Peng/A10).

MARAM/IWS/DEC14/Peng/B5

The "River model" presented in de Moor and Butterworth (2014: MARAM/IWS/Peng/B5) builds on assumptions relating to time and space that are not explicitly tested. Hutchings *et al.* (2014: MARAM/IWS/DEC14/Peng/A7) argues that, in order for the river model approach to be useful in adequately estimating escapement of anchovy for seabirds feeding on them at the west coast, the temporal resolution has to be finer, spatial dynamics need to be modelled explicitly, and consequences of "bad years" need to receive particular attention. Furthermore, the consequences of the assumption that all anchovy in the water are available to breeding penguins needs testing, as do any remaining assumptions on shoal variability in view of the birds' feeding dynamics once an appropriate temporal and spatial resolution has been chosen.

MARAM/IWS/DEC14/Peng/B7

Weller *et al*. (2014: MARAM/IWS/DEC14/Peng/A8) outlines changes made to the Robben Island Penguin Pressure Model in response to suggestions for improvements made by members of MARAM in document B7 and participants of a recent modelling workshop. The selection of biomass drivers and critical biomass thresholds for different penguin age classes was updated based on recent analyses, and the resulting models used as a basis for survival response curves to replace previous linear approximations. Following these changes, the pressure model shows improved responsiveness and realism of outcomes, and continues to indicate a positive effect of fishing closures around Robben Island on the penguin population.

MARAM/IWS/DEC14/Peng/B8 and MARAM/IWS/DEC14/Peng/B9

Document B9 analyses catch (and various catch rate measures) against total anchovy recruit biomass to conclude that anchovy catch does not provide a meaningful index of anchovy abundance. However, the document consistently mischaracterises statements made in Sherley et al. (2013b) and the way in which catches in the 30 nautical miles (nm) around Robben Island were used. The authors of that paper have not attempted to use anchovy catches in the 30 nm around Robben Island to predict anchovy abundance at a stock level and would agree from first principles that this would not appear to be a useful approach for managing a fishery. What was found in Sherley et al. (2013b) was a positive correlation between catches within 30 nm of the island and penguin breeding success. The same paper also noted that chick fledging probabilities appeared to be influenced by the percentage of anchovy in the diet of breeding birds in two-chick broods. In other words, more chicks apparently survived when breeding birds were able to find more anchovy. However, the previously noted relationship between penguin breeding success and overall anchovy spawner biomass (Crawford et al. 2006) were not reproduced and overall anchovy recruitment biomass was not well correlated with breeding success either (in contrast to the long-term relationship noted in Sherley *et al.* (2014: MARAM/IWS/DEC14/Peng/A9). The suggestion in Sherley et al. (2013b) for what might explain these results was that the broad-scale changes in the distribution of anchovy and sardine spawners may have resulted in a de-coupling of local and broad-scale prey biomass and that annual catches may be providing some indication of the availability of anchovy to birds breeding at Robben Island that the overall anchovy recruitment biomass was not. In other words, the local catch data may provide a relative indication of the local availability of anchovy.

We understand the argument put forward that for this to be the case; catches at a local level should be proportional to biomass at a local level. While we appreciate the work put in by the authors of MARAM/IWS/DEC14/Peng/B9, we would contend that it is quite difficult to test the relationship between catches within 30 nm of Robben Island and the local availability of anchovy when the latter is unknown. Using the overall recruitment biomass (or model estimated recruitment) for the whole west coast makes the unproven assumption that the former indexes local biomass (around Robben Island) without error. Or at least the two are directly proportional, which is also not proven.

Although small scale surveys have been undertaken for only 5 years, a linear regression between the maximum biomass recorded from the small-scale survey estimates each year (from Table 13 of MARAM/IWS/DEC14/Peng/C1) and the overall recruitment biomass (measured in the May survey from Table 12 of MARAM/IWS/DEC14/Peng/C1) in that same year suggests no obvious relationship (Figure 1, $r_3 = -0.0001$, $p = 0.96$). The same is true if the annual mean value of the small-scale surveys is used instead ($r_3 = 0.006$, $p = 0.90$), noting that only one survey was conducted in 2013. In contrast, the relationship shown in Figure 2 (below) suggests that the annual catch made within 30 nm of Robben Island may well be broadly proportional to the anchovy available to the penguins breeding at Robben Island. The linear relationship is not significant ($r_3 = 0.81$, $p = 0.097$), though this is not surprising given the degrees of freedom available, but the adjusted R^2 value = 0.54. Thus, with additional small-scale surveys, this relationship might well reach significance.

Clearly, this analysis is basic and further investigations into this relationship are warranted. However, it would appear from the below that the line of argument followed in Sherley et al. (2013b) is not entirely unfounded. Ultimately, if we wish to fully understand how fishing affects the availability of prey to penguins at a local scale, it seems likely that additional small-scale surveys would be needed to understand how local recruitment biomass is related to overall recruitment biomass and catches.

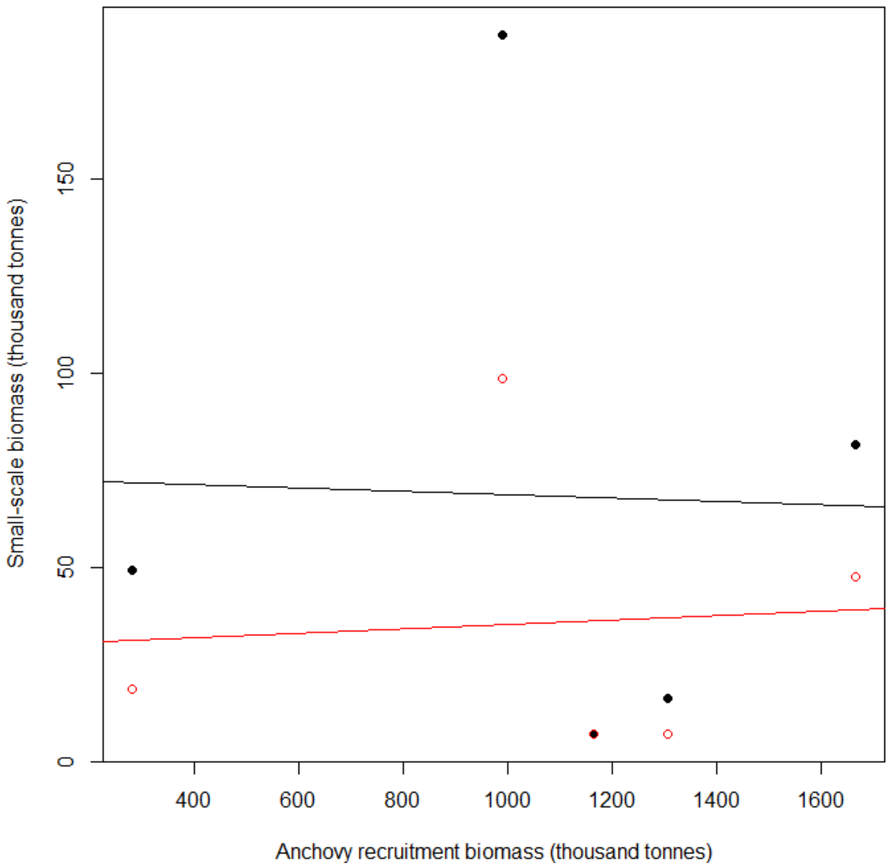

Figure 1: The linear relationship between the May recruitment biomass survey estimate for anchovy and the mean (red) and the maximum (black) small-scale biomass estimate around Robben Island from 2009 to 2013. Data are from MARAM/IWS/DEC14/Peng/C1. Only one small-scale survey estimate was made in 2013, so the value is the same for both analyses.

Of course, if catches are proportional to local biomass, then it is possible for a negative impact of fishing to occur when the underlying relationship between catches and the penguin response is positive. Hypothetically, this could occur if fishing reduces the availability of prey to penguins to some degree, but does so approximately in proportion to the local availability (i.e. a consistent reduction of 10%). In other words, the underlying relationship is actually between the penguin response and the local biomass available after fishing and the latter maybe reduced (making it harder for penguins to find prey), but not to the extent that a negative relationship between catches and the penguin response prevails. Alternatively, if the exploitation rate becomes sufficiently high that very little biomass is left after fishing has occurred, then one might expect a negative relationship between catches and a penguin response. The problem, as has been noted before, is to understand how fishing actually affects the prey that remains available to the breeding birds. Since local biomass is likely modified by fishing and since catches may, in some cases, be proportional to local biomass and in others spatially disproportionate, the relationship between penguin responses and catches is difficult to interpret unless local biomass can be measured without error. These problems may be exacerbated when trying to compare different penguin responses to catch levels of different fish (e.g. anchovy and sardine) and in area of vastly different prey availability (the west coast and Algoa Bay) as is done in MARAM/IWS/DEC14/Peng/B8. The problem of understanding exactly what a high catch or a low catch means in the absence of an accurate measure of local prey availability is exactly why we have advocated using closure status in the analysis in MARAM/IWS/DEC14/Peng/A3. It is perhaps worth noting that when closure status is used, we detect a significant benefit of closure on the foraging path length of birds breeding at St. Croix (Table 2, MARAM/IWS/DEC14/Peng/A3) and a positive benefit of closure was determined for chick survival at Robben Island (Sherley et al. submitted) and chick condition at Robben Island (Table 2, MARAM/IWS/DEC14/Peng/A3). Despite the apparently different relationships between catches and penguin responses at these two islands shown in MARAM/IWS/DEC14/Peng/B8.

These issues relating to the confounding of catch and biomass are discussed further in Bergh (2014: MARAM/IWS/DEC14/Peng/A10.

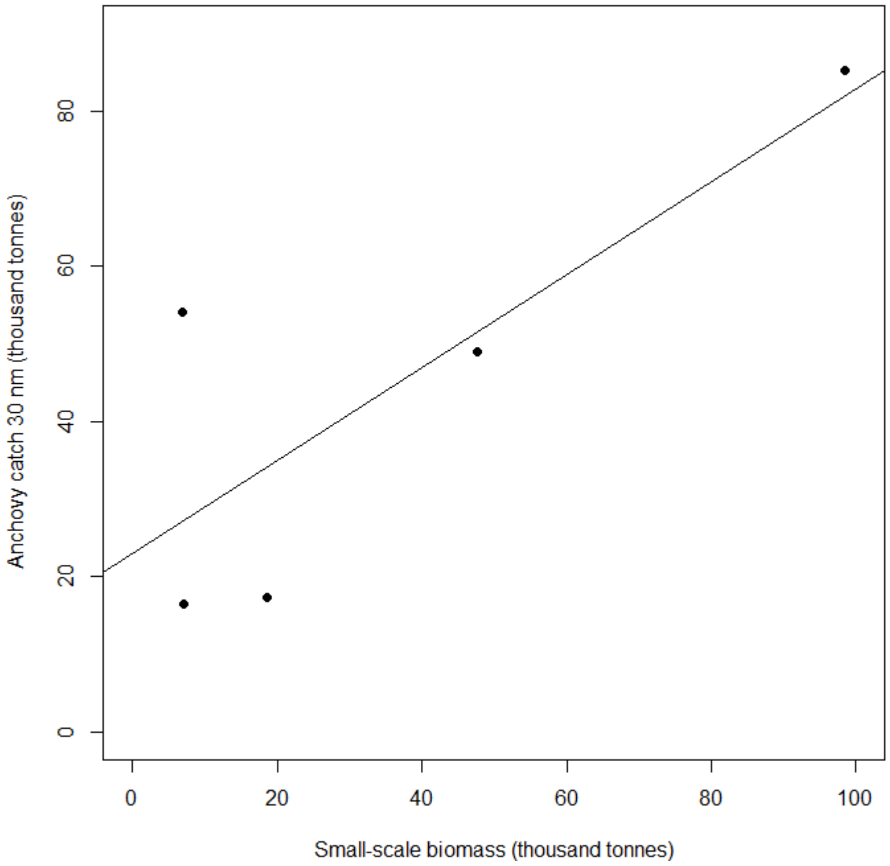

Figure 2: The linear relationship between the maximum value recorded during the small biomass surveys around Robben Island for 2009 to 2013 and the annual anchovy catch made within 30 nm of the island. Data are from MARAM/IWS/DEC14/Peng/C1.

MARAM/IWS/DEC14/Peng/B10

Responses are provided in Sherley *et al.* (2014: MARAM/IWS/DEC14/Peng/A9) and Bergh (2014: MARAM/IWS/DEC14/Peng/A10) to the contents of in document B10.

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