
The potential impacts of climate change on the Phillip Island Little Penguin colony - regional economic impacts

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Executive Summary

Introduction

The impacts of climate change on the Little Penguin population of Phillip Island could have repercussions for the Phillip Island economy, and that of the Bass Coast Shire more broadly.

While tangible data on the direct impacts of climate change on the Little Penguin population has not yet been gathered, it is possible to explore the economic impacts that might occur should climate change-induced population decline occur. For this, a number of hypothetical economic impact scenarios have been modelled.

Phillip Island and Bass Coast Shire tourism economy

The penguin population contributes to a strong and viable tourism industry on the island. Tourist visitation for the penguins underpins not just the activities of Phillip Island Nature Parks, but also flows on to the rest of the local economy, as the park employs local workers and visitors spend tourism dollars in the local area.

Of the more than 1000 businesses in the Shire, over half benefit directly from tourism. Tourism businesses¹ account for one quarter of total businesses, and a further third of businesses directly benefit from tourist visitation (on average, one quarter of their income is derived from tourists).

Tourism in the area is synonymous with Phillip Island, receiving over 2 million visitors in 2007.² A survey undertaken in 2004/05 found that 94 per cent of visitors to the shire visited the Island. Some 80 to 90 per cent of respondents considered Phillip Island their primary destination and 69 per cent considered it their only destination.³

Approach to assessing regional economic impacts

This study reports the findings of a regional economic impact assessment on the Bass Coast Shire economy. The study explores the potential economic impacts on the shire of a decline in tourist visitation to Phillip Island associated with climate change-induced impacts on the Little Penguin population.

Economic impact assessment, as distinct from an assessment of 'economic value', provides high level insight into the economic significance of an event, attraction or industry (in this case the penguin colony of Phillip Island Nature Park). The measure of economic impact focuses just on the Bass Coast Shire and estimates the net economic loss to the shire due to the loss of economic activity associated with the penguins. As such, it uses visitation from outside the shire and attributes an economic expenditure to that visitation.

¹ These are businesses that cater almost exclusively for tourists, including visitor accommodation, wineries, attractions, tours and activities, restaurants. Data from Urban Enterprise, 2005.

² Tourism Research Australia This data does not include international day visitors, numbering up to 300,000 per year.

³ Urban Enterprise, 2005.

In 2007/08, a total of 491,780 people visited the Nature Park to see the penguin parade. Of these, 308,465 were international tourists and 183,315 were Australian visitors. Of the Australian visitors, an estimated 178,796 were from outside the Bass Coast Shire.⁴

Relevant expenditure is assumed to be the average day visit to the Shire for domestic visitors and the average expenditure per night for international visitors.⁵ (Table ES.1)

Table ES.1 : Visitor expenditure related to the penguin population, 2007/08

Visitor type	Visitor numbers	Expenditure per visitor (\$)	Total expenditure (\$ m)
Domestic day visitors	178,796	86	\$15.4
International visitor (night)	308,465	64	\$19.7
Total	487,261		\$35.1

Source: Visitor numbers - Phillip Island Nature Park (visitors from outside Bass Coast Shire); expenditure - Tourism Research Australia⁶

Flowing this data through the non-linear input-output model⁷ provides the following result.

Table ES.2: Economic impact of visitors to the penguin parade

	Final demand	Flow-on (indirect) effects		Total flow-on	Total
		Industry	Consumption		
Gross output (\$ m)	35.2	14.7	17.0	31.7	66.9
Value added (\$ m)	24.9	7.2	8.1	15.3	40.2
Factor income (\$ m)	16.5	2.8	3.5	6.4	22.9
Employment (FTEs)	74	22	30	62	136

Source: MJA estimates.

The annual economic impact of penguin visitation therefore has:

- a total gross output effect of \$66.9 m - made up of a direct effect of \$35.2 m and a flow-on (indirect) effect of \$31.7 m. Gross output refers to the value of increased production from penguin related tourism;
- a total value-added effect of \$40.7 m - made up of a direct effect of \$24.9 m and a flow-on (indirect) effect of \$15.3 m. Value-added is the measure usually preferred when

⁴ Source: all data from Phillip Island Nature Parks. Estimation of local visitors: MJA analysis.

⁵ International visitation per night is the only estimate available (no data exists on day visits), and the difference between domestic day visits and visitation per night was \$2.

⁶ <http://www.tra.australia.com/content/documents/LGA%20Profiles/VIC/BassCoast%20LGA.pdf>

⁷ The non-linear input-output (NLIO) model is designed by Professor John Mangan from the University of Queensland's Economic Policy Modelling Centre.

measuring economic impact. It measures the added value placed on intermediate products from the productive process;

- a factor income effect of \$22.9 m - made up of a direct effect of \$16.5 m and a flow-on (indirect) effect of \$6.4 m. Factor income refers to the share of value-added which is directly paid to individuals or firms in the form of wages or profits; and
- an employment effect of 136 Full -Time Equivalents (FTEs) - made up of 74 FTEs directly employed and 62 FTEs indirectly employed.

Tourism scenarios under climate change

As noted, the impacts of climate change on the penguin population have not been detailed as yet. Nor has the impact on tourism of penguin population decline.⁸ Although reduced penguin numbers are likely to result in reduced visitation, this relationship is unlikely to be linear. Indeed, it is hypothesised in this study that a significant decline in visitation is unlikely to occur until such time as tourism operators are unable to guarantee penguin sightings on any given night.

Three scenarios have been developed to hypothesise tourism decline, and the resulting economic impacts modelled. Scenario 1 models a small penguin population decline, with no notable change in economic impact. Scenario 2 involves significant population decline with similar economic impacts while Scenario 3 models extreme population decline and associated visitation. These scenarios are summarised in Table ES.3.

Table ES.3 : Hypothetical scenarios for decreased visitation

Scenario	Features	Impact on visitation
Scenario 1 Small population decline	Climate change causes population decline, but penguin parade continues every night.	Negligible change. Domestic and international tourism continues.
Scenario 2 Large reduction in population	Population declines significantly, causing penguin sightings to become sporadic during winter months	Park closure to the public for winter months. International visitation suffers significant decline (50%) as tours remove penguins from itinerary. Domestic visitation declines during winter months only (30%).
Scenario 3 Extreme reduction in population	Population declines dramatically, causing sporadic penguin sightings year-round and rare sightings during winter months	International visitation collapses (90%) and domestic visitation dramatically reduced (80%). Viability of tourism threatened.

Source: MJA analysis

⁸ Information on the impact of climate change on the penguin population would require detailed scientific study. A detailed understanding of the impacts on penguin numbers on visitation numbers would require detailed survey work to establish consumer preferences. Both these areas are outside the scope of this study, but could be undertaken for future work.

Conclusions

The differing economic impacts of the three scenarios are summarised in Table ES.4. Differences in economic impacts compared with the status quo (Scenario 1) are shown in

Table ES.5.

As can be seen in Table ES.4 and

Table ES.5, Scenario 2 involves a sizeable decrease in economic activity once tourism is affected noticeably by penguin population decline. This involves a decline in direct economic output of \$14.5m per year, and with flow-on, a decrease in total gross output of \$28.6m per year. The decrease in direct value-added associated with Scenario 2 is \$11m per year, and with flow-on, \$18m per year. Total employment loss in the Bass Coast Shire (direct and indirect) is estimated at 66 full-time jobs.

Table ES.4: Economic impacts summary table, scenarios 1-3

	Direct Demand			Flow-on			Total Demand		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Gross output (\$ m)	35.2	20.7	5.1	31.7	17.6	4.6	66.9	38.3	9.7
Value added (\$ m)	24.9	13.9	3.5	15.3	8.5	2.1	40.2	22.4	5.6
Factor income (\$ m)	16.5	9.2	2.3	6.4	3.5	0.9	22.9	12.7	3.2
Employment (FTEs)	74	41	10	62	29	8	136	70	18

Source: MJA estimates.

Scenario 3, involving more extreme penguin population decline, is modelled to have more dramatic impacts on associated tourism. This involves a decline in direct economic output of \$30m per year, and with flow-on, a decrease in total gross output of \$57m per year. The decrease in direct value-added associated with Scenario 3 is \$21.4m per year, and with flow-on, \$34.6m per year. Total employment loss (direct and indirect) is estimated at 118 full-time jobs.

Table ES.5: Economic impacts difference table, scenarios 1-3

	Direct Demand			Flow-on			Total Demand		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Gross output (\$ m)	35.2	-14.5	-30.1	31.7	-14.1	-27.1	66.9	-28.6	-57.2
Value added (\$ m)	24.9	-11.0	-21.4	15.3	-6.8	-13.2	40.2	-17.8	-34.6
Factor income (\$ m)	16.5	-7.3	-14.2	6.4	-2.9	-5.5	22.9	-10.2	-19.7
Employment (FTEs)	74	-33	-64	62	-33	-54	136	-66	-118

Source: MJA estimates. Differences are relative to S1

MJA stresses that these scenarios are purely hypothetical. They have been compiled in the absence of detailed understanding of the likely impacts on penguin population of climate change and without survey analysis of visitor preferences relating to penguin tourism.

Further work in these areas could establish a more robust understanding of the regional economic impacts of climate change on the Phillip Island Little Penguin colony.

1. Introduction

1.1. Study purpose

The Phillip Island penguin population contributes to a strong and viable tourism industry on the island. Tourist visitation for the penguins underpins not just the activities of Phillip Island Nature Parks, but also flow-on effects to the rest of the local economy as the parks employ local workers and visitors spend tourism dollars in the local area.

Where climate change affects the future of the penguin population of Phillip Island, so too will it affect tourist visitation and the broader local economy. This report explores scenarios relating to a decrease in tourism visitation as a result of climate change affecting the penguin population.

1.2. Phillip Island and Bass Coast Shire tourism economy

The Bass Coast Shire has a large and active tourism sector, attracting holiday home visitors, other overnight visitors and day trippers. Visitors staying in holiday homes account for the vast majority of overnight visitors (82 per cent)⁹, and contribute around half of total visitor expenditure to the shire.¹⁰ Despite this, the majority of visitors to the shire visit for the day.

Of the more than 1000 businesses in the shire, over half benefit directly from tourism. Tourism businesses¹¹ account for one quarter of total businesses, and a further third of businesses directly benefit from tourist visitation (on average, one quarter of their income is derived from tourists).

Tourism in the area is synonymous with Phillip Island, receiving over 2 million visitors in 2007.¹² A survey undertaken in 2004/05 found that 94 per cent of visitors to the shire visited the island. Some 80 to 90 per cent of respondents considered Phillip Island their primary destination and 69 per cent considered it their only destination.¹³

Phillip Island is home to the key tourist attractions in the shire. Almost 500,000 visitors attended the Penguin Parade in 2007/08¹⁴, while the Australian Motor Cycle Grand Prix attracted approximately 93,531 in 2006.¹⁵

⁹ <http://www.tra.australia.com/content/documents/LGA%20Profiles/VIC/BassCoast%20LGA.pdf>

¹⁰ Urban Enterprise, 2005. Bass Coast Shire, Economic Impact of Tourism. P.6

¹¹ These are businesses that cater almost exclusively for tourists, including visitor accommodation, wineries, attractions, tours and activities, restaurants. Data from Urban Enterprise, 2005.

¹² Tourism Research Australia. This data does not include international day visitors, numbering up to 300,000 per year.

¹³ Urban Enterprise, 2005.

¹⁴ 491,780 visitors to the Penguin Parade were recorded in 2007/08, a further 140,878 to the Koala Conservation Centre and 75,215 to Churchill Island.

¹⁵ Bass Coast Shire Council, Phillip Island Community Profile
<http://www.basscoast.vic.gov.au/content/content.asp?cid=472&ctid=1&cnid=2471#> (accessed 25.06.2008)

As a proportion of Bass Coast tourism, Phillip Island has:

- almost 60 per cent of holiday homes;
- over half of all specialised tourism businesses;
- around 83 per cent of all guest rooms in accommodation establishments; and
- around 86 per cent of all camping sites.¹⁶

Tourism's share of total employment is on Phillip Island 8.2 per cent, whereas for the State of Victoria tourism represents 5.1 per cent of total employment.¹⁷ The Australia Victorian Tourism Employment Atlas 2005 states:

Phillip Island is the second highest tourism intensive campaign region in Victoria with one in twelve jobs attributable to tourism. Major developments which partly contributed to this growth were improved quality accommodation and Phillip Island Nature Park.

Of the 116 specialised tourism businesses (excluding accommodation) in the shire, 56 per cent are found on Phillip Island. They employ over 1000 people.

Phillip Island tourism is largely synonymous with its penguin population. In the survey noted above, 'Penguins and Australian fauna' was the most common characteristic associated with Phillip Island, and 67 per cent of respondents visited the penguin parade.

In terms of marketing, the natural wildlife within the Bass Coast Shire and the ocean beaches should continue to be a focus for marketing campaigns. Natural fauna is responsible for attracting the majority of visitors to the region.¹⁸

The penguin colony has become the centrepiece of a growing nature-based tourism sector in the region, as Phillip Island Nature Parks has added the Koala Conservation Centre and the Nobbies Centre featuring seals, sharks and dolphins.

Phillip Island Nature Parks now employs almost 200 people, with total operating revenue of almost \$14m in 2007/08.¹⁹

While not directly addressed in this analysis, it is worth noting that the growing nature-based tourism industry in the area, underpinned by the penguin colony, is a large contributor to the holiday home tourism market, in terms of demand for visits to the area and overall awareness of the area.

¹⁶ Urban Enterprise, 2005. P.19

¹⁷ Australia Victorian Tourism Employment Atlas 2005

¹⁸ Urban Enterprise, 2005. P.100

¹⁹ Phillip Island Nature Parks.

2. Approach

2.1. Regional economic impact assessment

This study reports the findings of a regional economic impact assessment on the Bass Coast Shire economy. The study explores the potential economic impacts on the shire of a decline in tourist visitation to Phillip Island associated with climate change-induced impacts on the little penguin population.

Economic impact assessment, as distinct from an assessment of 'economic value', provides high level insight into the economic significance of an event, attraction or industry (in this case the penguin colony of Phillip Island Nature Park). It provides a broad indication of the importance of ongoing operations to the regional economy by estimating the contribution of the penguin population in attracting visitors to the Bass Coast Shire.

The study does not estimate the 'economic value' of the penguin population to Victoria or Australia, which measures the net addition to the economy that is attributable to the penguin population. A study of this kind would measure the 'consumer surplus', reflecting the difference between actual expenditure and what consumers would be willing to pay.

A decline in tourism associated with changes to the penguin population does not mean that an equivalent expenditure is not made elsewhere in the Victorian economy. If the penguin population did not exist, a family might choose to visit a different nature-based tourism attraction elsewhere, or spend their money on home-based entertainment – something they would have preferred slightly less. A measure of net economic value would measure the change in consumer surplus associated with this loss.

The measure of economic impact focuses just on the Bass Coast Shire, and estimates the net economic loss to the shire if the economic activity associated with the penguins was lost. It uses visitation data from outside the shire and attributes an economic expenditure to that visitation.

Visitor numbers

In 2007/08, a total of 487,251 people visited the Nature Park to see the penguin parade. Of these, 308,465 were international tourists and 183,315 were Australian visitors. Of the Australian visitors, an estimated 178,796 were from outside the Bass Coast Shire.²⁰ As this study focuses on the impact of visitation to the region from outside the local area we exclude locals attending the penguin parade.

Expenditure estimates

For this assessment, Tourism Research Australia estimates for average expenditure have been applied to domestic and international visitor numbers to the Nature Park.

As such, this study assumes that for those who visit the Nature Park from outside the shire, the penguins are the primary incentive for their visit to the shire on that day. This will tend to overestimate the expenditure of those for whom the penguins were not the major reason for their visit and underestimate those who may have come for the penguins and stayed longer than one day.

²⁰ Source: all data from Phillip Island Nature Parks. Estimation of local visitors: MJA analysis.

Expenditure related to the penguins is assumed to be the average day visit expenditure to the shire for domestic visitors and the average expenditure per night for international visitors.²¹

Table 1 : Visitor expenditure related to the penguin population, 2007/08

Visitor type	Visitor numbers	Expenditure per visitor (\$)	Total expenditure (\$ m)
Domestic day visitors	178,796	86	\$15.4
International visitor (night)	308,465	64	\$19.7
Total	487,261		\$35.1

Source: Visitor numbers - Phillip Island Nature Park (visitors from outside Bass Coast Shire); expenditure - Tourism Research Australia²²

2.2. Tourism scenarios under climate change

The aim of this project is to assess the possible impacts on the local economy associated with a negative impact of climate change on the penguin population of Phillip Island. It may be that climate change or climate change responses affect visitation by other means, such as through increasing petrol prices (due to an emissions trading scheme, for example). However, impacts of this nature are beyond the scope of this study and we restrict ourselves to analysing the impact of climate change on the penguin population itself and, through this, to visitor numbers.

Visitation to the region associated with the penguins is dependent upon a healthy penguin population, sustainable interaction between visitors and penguins and appropriate infrastructure to facilitate viewing. Clearly, infrastructure should facilitate viewing without adversely affecting sustainability of the interaction. Indeed, visitors are informed that their presence helps to improve the penguins' health by assisting the research program.

Therefore, the only remaining influence on penguin visitation within the scope of this project is the health and viability of the penguin population itself.

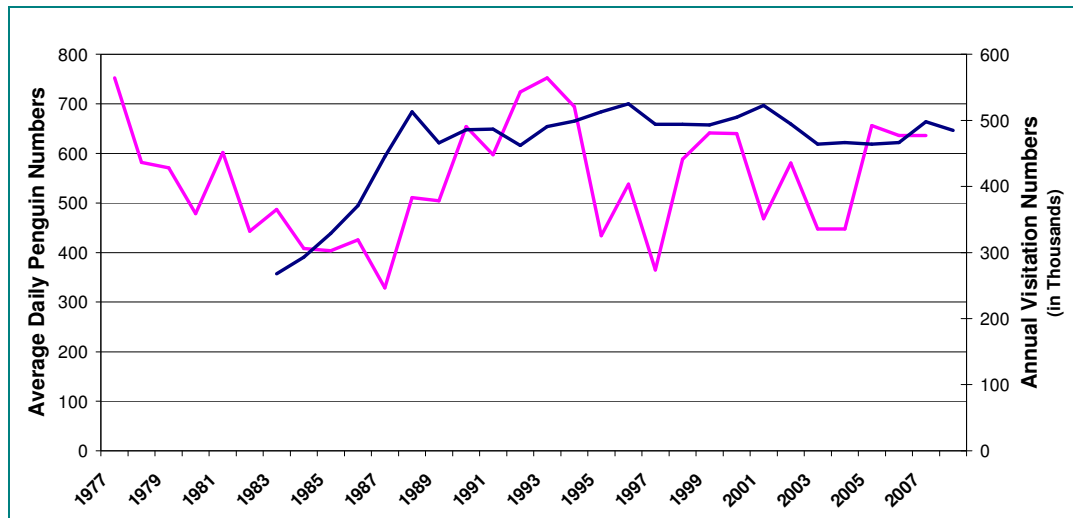
There is no clear relationship between healthy penguin numbers and visitor numbers over time.

Figure 1 shows the relationship between penguin numbers and visitor numbers since 1978, with the pink line representing average daily penguin sightings, and the blue line representing annual visitors (on the right hand axis). Clearly, visitor numbers have moved independently of average penguin numbers as the tourist attraction has matured into the professional project it is today. In recent years, as a mature industry, annual visitor numbers have been relatively stable.

²¹ International visitation per night is the only estimate available (no data exists on day visits), and the difference between domestic day visits and visitation per night was \$2.

²² <http://www.tra.australia.com/content/documents/LGA%20Profiles/VIC/BassCoast%20LGA.pdf>

Figure 1: Average daily penguin sightings and annual visitation numbers



MJA has developed plausible but hypothetical scenarios for visitation based on realistic assumptions about the penguin population of Phillip Island and its relationship with visitation. MJA stresses that these scenarios are based on assumptions, and providing statistical data would require detailed survey work beyond the scope of this study.

In general, sightings of penguins are more frequent during the summer months than the winter months, although in late summer (February/March) there is a short dip in penguin numbers at the parade.

It is reasonable to suggest that the continued viability of penguin visitation is dependent upon consistent penguin sightings year-round. Anecdotal evidence suggests that consistent viewing year-round is a prerequisite for the present scale of international visitation, as package tours will be reluctant to book visitors if they cannot guarantee penguin sightings.²³

This is expected to be less of a problem for domestic visitation. Living locally, if penguin sightings in February/March and the winter months became sporadic,²⁴ domestic visitors could plan their trip in the summer months without undue inconvenience.

MJA is unable to predict the scale of penguin population decline that would lead to sporadic sightings of penguins at the daily parade. This would require detailed biophysical modelling that is beyond the scope of this project, but could be considered for further work if possible.

However, MJA has devised scenarios in which penguin population declines so as to affect visitation, primarily due to population decline occurring to an extent that sightings of penguins cannot be guaranteed year-round. Where this occurs, seasonal park closures occur and international tourism is especially affected as tours begin to drop the Nature Park from their itinerary.

²³ The failure of a small penguin tourism operation in Western Australia was in large part attributed to the small size of the penguin population, resulting in the inability to guarantee daily viewing of penguins (Pers. Comm Peter Dann, Research Manager, Phillip Island Nature Parks).

²⁴ Penguin numbers are lower in February/March during 'pre-moult' foraging trips, and during winter due to long foraging trips (Pers. Comm Peter Dann, Research Manager, Phillip Island Nature Parks).

Three hypothetical scenarios are outlined in Table 2. The first scenario reflects impacts on the penguin population such that penguin numbers decline, but not to an extent that results in no penguins being sighted. In this scenario, tourism is unaffected, based on the assertion that visitation will continue until penguin sightings can no longer be guaranteed.

In the second hypothetical scenario, the penguin population declines to the point that sightings of penguins during the winter months can no longer be guaranteed. In this scenario, domestic visitation declines especially over these months, and international visitation declines significantly as tours begin to remove the penguin parade from their itineraries. This is likely to cause the closure of commercial activities during the winter months, and significantly reduce international visitation year-round. Tours targeting international visitors are considered unlikely to retain the penguin parade on their itineraries if they are unable to guarantee visitors penguin viewing, resulting in a significant decline in international visitation.

The third scenario is a more dire one in which penguin numbers decline to the extent that penguin viewing is uncertain year-round, causing a dramatic decrease in domestic visitation (80 per cent) and the even greater loss of international visitation (90 per cent). International visitation is considered more vulnerable than domestic, as local visitors have lower opportunity costs associated with ‘gambling’ on penguin sightings. Unlike most domestic visitors, international visitors have less time in Victoria and would be less willing to travel if they are not certain of seeing penguins.

Table 2 : Hypothetical scenarios for decreased visitation

Scenario	Features	Impact on visitation
Scenario 1 Small population decline	Climate change causes population decline, but penguin parade continues every night.	Negligible change. Domestic and international tourism continues.
Scenario 2 Large reduction in population	Population declines significantly, causing penguin sightings to become sporadic during winter months	Park closure to the public for winter months. International visitation suffers significant decline (50%) as tours remove penguins from itinerary. Domestic visitation declines during winter months only (30%).
Scenario 3 Extreme reduction in population	Population declines dramatically, causing sporadic penguin sightings year-round and rare sightings during winter months	International visitation collapses (90%) and domestic visitation dramatically reduced (80%). Viability of tourism threatened.

Source: MJA analysis

MJA stresses that this is a consequence analysis only, in which the likelihoods of scenarios are not assessed. A likelihood analysis of the scenarios described in Table 2 is beyond the scope of this project, but may be considered for further work. The consequences are themselves considered realistic as broad scenarios, but are not based on detailed analysis. Furthermore, these scenarios are hypothetical and are not projections. More rigorous scenario work involving consumer surveys could be considered for further work. Sensitivity analysis of these scenarios is found in the Attachment.

2.3. Economic flow-on

Visitor expenditure figures do not provide a measure of the total economic impact of tourism attributable to public open space; there are additional flow-on or multiplier effects. To calculate these we insert the figure of \$35 m from Table 1 derived above into the non-linear input-output (NLIO) model designed by Professor John Mangan from the University of Queensland's Economic Policy Modelling Centre.²⁵

Primarily the model estimates four economic impact measures (gross output, value-added, factor income and employment), the results of which are summarised in Table 3.

Table 3 : Economic impact of visitors to the penguin parade

	Final demand	Flow-on (indirect) effects		Total flow-on	Total
		Industry	Consumption		
Gross output (\$ m)	35.2	14.7	17.0	31.7	66.9
Value added (\$ m)	24.9	7.2	8.1	15.3	40.2
Factor income (\$ m)	16.5	2.8	3.5	6.4	22.9
Employment (FTEs)	74	22	30	62	136

Source: MJA estimates.

The annual economic impact of penguin visitation therefore has:

- a total gross output effect of \$66.9 m - made up of a direct effect of \$35.2 m and a flow-on (indirect) effect of \$31.7 m. Gross output refers to the value of increased production from penguin related tourism;
- a total value-added effect of \$40.7 m - made up of a direct effect of \$24.9 m and a flow-on (indirect) effect of \$15.3 . Value-added is the measure usually preferred when measuring economic impact. It measures the added value placed on intermediate products from the productive process;
- a factor income effect of \$22.9 m - made up of a direct effect of \$16.5 m and a flow-on (indirect) effect of \$6.4 m. Factor income refers to the share of value-added which is directly paid to individuals or firms in the form of wages or profits; and
- an employment effect of 136 Full -Time Equivalentents (FTEs) - made up of 74 FTEs directly employed and 62 FTEs indirectly employed.

²⁵ Further information on the NLIO model and the estimation undertaken in this study can be found in Attachment 1.

3. Results: Economic Impact of Reduced Tourism

The final task in this report is to quantify the economic impact on the Bass Coast Shire of a reduction in tourism associated with the penguin parade due to climate change. The change in economic activity is modelled on the three hypothetical scenarios outlined in Table 2.

3.1. Scenario 1

Scenario 1 describes a situation in which climate change has a negligible impact on penguin numbers at the parade, causing no notable change in tourism. This is consistent with the experience of the last 25 years as penguin numbers have fluctuate within that time period without discernable impact on visitation.

Table 4 outlines this scenario.

Table 4 : No change in economic impact (Scenario 1)

	Final demand	Flow-on (indirect) effects		Total flow-on	Total
		Industry	Consumption		
Gross output (\$ m)	35.2	14.7	17.0	31.7	66.9
Value added (\$ m)	24.9	7.2	8.1	15.3	40.2
Factor income (\$ m)	16.5	2.8	3.5	6.4	22.9
Employment (FTEs)	74	22	30	62	136

Source: MJA estimates.

3.2. Scenario 2

Table 5 shows the economic impact associated with Scenario 2, in which tourism to the Bass Coast Shire associated with penguin visitation declines significantly (domestic visitation decreases by 30 per cent, and international visitation by 50 per cent). When compared with the current economic impact, there is a decrease in total gross output of \$28m per year, total value-added is reduced by \$17m, and reduced total employment (direct and indirect) of 66 FTE. (These differences are summarised in Table 8.)

Table 5: Significant change in economic impact (Scenario 2)

	Final demand	Flow-on (indirect) effects		Total flow-on	Total
		Industry	Consumption		
Gross output (\$ m)	20.7	8.2	9.4	17.6	38.3
Value added (\$ m)	13.9	4.0	4.5	8.5	22.4
Factor income (\$ m)	9.2	1.6	1.9	3.5	12.7
Employment (FTEs)	41	12	17	29	70

Source: MJA estimates.

3.3. Scenario 3

Table 6 summarises the economic impact associated with Scenario 3, modelling a dramatic hypothetical decline in both domestic visitation (80 per cent) and international visitation (90 per cent). This reflects a decline in penguin sightings at the parade resulting in some nights of zero penguin sightings year-round. The viability of the parade would clearly be in question under this scenario.

When compared with the current economic impact (shown in Table 4), under Scenario 3 there would be a decrease in total gross output of \$58m per year, total value-added would decline by \$35m, and total employment (direct and indirect) would decline by an estimated 119 full-time equivalent employees. (These differences are summarised in Table 8.)

Table 6: Dramatic change in economic impact (Scenario 3)

	Final demand	Flow-on (indirect) effects		Total flow-on	Total
		Industry	Consumption		
Gross output (\$ m)	5.1	2.1	2.5	4.6	9.7
Value added (\$ m)	3.5	0.9	1.2	2.1	5.6
Factor income (\$ m)	2.3	0.4	0.5	0.9	3.2
Employment (FTEs)	10	3	5	8	18

Source: MJA estimates.

3.4 Conclusions

The differing economic impacts of the three scenarios are summarised in Table 7. Differences in economic impacts compared with the status quo (Scenario 1) are shown in Table 8.

Table 7: Economic impacts summary table, scenarios 1-3

	Direct Demand			Flow-on			Total Demand		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Gross output (\$ m)	35.2	20.7	5.1	31.7	17.6	4.6	66.9	38.3	9.7
Value added (\$ m)	24.9	13.9	3.5	15.3	8.5	2.1	40.2	22.4	5.6
Factor income (\$ m)	16.5	9.2	2.3	6.4	3.5	0.9	22.9	12.7	3.2
Employment (FTEs)	74	41	10	62	29	8	136	70	18

Source: MJA estimates.

As can be seen in Table 7 and Table 8, Scenario 2 involves a sizeable decrease in economic activity once tourism is notably affected by penguin population decline. This involves a decline in direct economic output of \$14.5m per year, and with flow-on, a decrease in total gross output of \$28.6m per year. The decrease in direct value-added associated with Scenario 2 is \$11m per year, and with flow-on, \$18m per year. Total employment loss (direct and indirect) is estimated at 66 full time jobs.

Scenario 3, involving more extreme penguin population decline, is modelled to have more dramatic impacts on associated tourism. This involves a decline in direct economic output of \$30m per year, and with flow-on, a decrease in total gross output of \$57m per year. The decrease in direct value-added associated with Scenario 3 is \$21.4m per year, and with flow-on, \$34.6m per year. Total employment loss (direct and indirect) is estimated at 118 full-time jobs.

Table 8: Economic impacts difference table, scenarios 1-3

	Direct Demand			Flow-on			Total Demand		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Gross output (\$ m)	35.2	-14.5	-30.1	31.7	-14.1	-27.1	66.9	-28.6	-57.2
Value added (\$ m)	24.9	-11.0	-21.4	15.3	-6.8	-13.2	40.2	-17.8	-34.6
Factor income (\$ m)	16.5	-7.3	-14.2	6.4	-2.9	-5.5	22.9	-10.2	-19.7
Employment (FTEs)	74	-33	-64	62	-33	-54	136	-66	-118

Source: MJA estimates. Differences are relative to S1

MJA stresses that these scenarios are purely hypothetical. They have been compiled in the absence of detailed understanding of the likely impacts of climate change on the penguin population and without survey analysis of visitor preferences relating to penguin tourism.

Further work in these areas could establish a more robust understanding of the regional economic impacts of climate change on the Phillip Island Little Penguin colony.

Attachment 1: Economic Impact Analysis – Technical Document

The Economic Significance of Penguin Related Tourism on the Victorian Economy and the Sensitivity to Biophysical Changes

Economic modelling

Economic modelling may proceed from a number of perspectives. One approach is to examine the value of a project or enterprise in terms of its alternative, ie an opportunity-cost approach. This view of modelling sees resources as effectively fixed, or at least slow-moving, and evaluates specific projects in a marginal way. For example, the real value of the decision to invest in additional tourist infrastructure would only be the additional gains from its operations over and above those gains that would flow from the alternative use of those funds on some other projects. Taken to extremes, this general equilibrium approach would only see a positive economic value from exogenous spending if it represented the most efficient use of these scarce resources in comparison to other potential uses.

At the other extreme, a partial equilibrium approach would attempt to value the economic contribution of spending on penguin-related tourism in isolation from other potential activities. That is, if a decision has been made to use funds in this way, what are its net economic benefits? Traditional Input Output (IO) analysis takes this standpoint. In other words it is not primarily interested in establishing efficient resource allocation but rather, the impact of each specific project in isolation and without the constraints of having to compete for scarce resources.

While this may seem a more direct way of attempting to provide economic measurement, the traditional IO method has a number of weaknesses. The main one is that, once a decision is made to consider a project in isolation, those factors that operate in the real world such as the competition among other economic agents for scarce materials, are not considered. For example, constraints on economic activity such as supply imbalances, lack of demand for the product or non-linearities in economic production are not assumed to exist. In other words, the output from a traditional IO analysis gives the best (or maximum) result from an economic activity on the assumption that there are no barriers in the rest of the economy that may constrain that maximum result from occurring. For small, localised projects that have no great impact on the economy this may be a reasonable assumption. For larger projects or projects that take place in a booming economy, these assumptions can be highly misleading.

Modifying traditional IO by the introduction of non-linear assumptions goes a long way to reducing a number of these constraints and for projects regarding such activities as penguin-related tourism, probably offers the best way of economic evaluation.

Non-linear input output models²⁶

The Non-linear input output model (NLIO) seeks to remove one of the major limitations of standard input-output analysis by removing the assumption of linear coefficients for the household sector and allowing marginal income coefficients adjustment. This is because, as is widely known, the household sector is the dominant component of multiplier effects in an

²⁶ The description of the non-linear model properties is taken from CEPM model descriptions (West 2003).

input-output table. As a result, using marginal income coefficients for the household sector will provide a more accurate, and empirically more valid, estimate of the multiplier effects, which in turn, provides results closer to those of a computable general equilibrium (CGE) model. The transactions flows in the input-output table can be expressed in matrix equation form as:

$$T(\hat{X}^{-1})X + Y = X$$

That is, for each industry, total industry sales equals intermediate sales to other industries for further processing plus sales to final users, where T is the matrix of intermediate transactions, X is the column vector of sector total outputs and Y is the column vector of aggregate final demands. This can be rewritten as:

$$AX + Y = X$$

Where A is the matrix of direct coefficients which represents the amounts of inputs requires from sector i per unit of output of sector j. Thus, for a given direct coefficient matrix, it is possible to solve the set of simultaneous equations to find the new sector production levels X which will be required to satisfy a potential or actual change in the levels of sector final demands Y. By rearranging and converting to differences, this equation can be rewritten as:

$$\Delta X = (I - A)^{-1} \Delta Y$$

where $(I - A)^{-1}$ is termed the total requirements table, Leontief inverse matrix or general solution, and represent the direct and indirect change in the output of each sector in response to a change in the final demand of each sector. ΔY can incorporate any element of final demand expenditure, including household expenditure, government expenditure and capital expenditure.

This model is a linear model in which the A matrix represents a (constant) matrix of average input propensities. Normally, the A matrix endogenises the household sector²⁷ so that household consumption-induced effects can be measured. This is referred to as the type II model; the alternative type I model is where households are treated as exogenous to local economic activity. Generally speaking, the consumption-induced effects are the largest component of the total multipliers. This is because consumer driven consumption (and income) to a large extent dominates local economic activity.

Total inputs are equal to intermediate inputs plus primary inputs (labour and capital). In the conventional input-output model, the inputs purchased by each sector are a function only of the level of output of that sector. The input function is assumed linear and homogeneous of degree one, which implies constant returns to scale and no substitution between inputs. A more reasonable assumption is to allow substitution between primary factors. If there is an expansion in economic activity, say due to a development project, employers will attempt to increase output without corresponding proportional increases in employment numbers, particularly in the short term, e.g. construction projects, where there are economies of scale in getting the existing workforce to work longer hours rather than employ additional persons. This occurs for two reasons.

First, there is evidence in Australia that labour productivity (output per employee) is increasing over time. Secondly, as companies strive to reduce costs and satisfy the micro-economic reform processes imposed on all states by the National Competition Policy, there is evidence

²⁷ That is, household income varies with the level of intersectoral activity.

of a shift in primary factor use from labour to capital. This implies that the conventional input-output model has a tendency to overestimate impacts, in particular the income and employment impacts. Therefore, a more realistic approach to modelling impacts is to replace the average expenditure propensities for labour income by employers with marginal input propensities. In other words, the household income row in the A matrix, which are average input coefficients, should be replaced by income elasticities of demand. Note that, as in the CGE model, the linear coefficients assumption between intermediate inputs, and also total primary inputs, and total inputs is retained.

One problem associated with this approach is that the solution procedure is now more complex. Now the income impacts will be a function of ΔX but the income coefficients are included in the A matrix which determines ΔX . Therefore the equation set becomes recursive; ΔX depends on A and A depends on ΔX . Solving the input-output equation therefore requires an iterative procedure, a common method being the Gauss-Seidel method.

The income and employment flow-ons from the initial impact also need to be modified. In the conventional input-output model, income and employment flow-ons are calculated as linear functions of the output flow-ons, but in the revised model the parameters relating income to output are no longer constant. The impact on household income needs to be calculated as the difference between the base (i.e. before impact) income levels and the post impact income levels. It can be shown that this is equivalent to using the matrix equation:

$$\Delta \text{Inc} = \hat{X}_0^{-1} (\Delta \hat{X}) \hat{L} U_0$$

where U is a vector of household income flows and L is a vector of sectoral household income elasticities of demand. The zero subscript denotes the base level values and the hat denotes a diagonal matrix formed from the elements of the corresponding vector. This equation simply states that, for each sector, the change in household income payments equals the proportional change in output times the base level income payments multiplied by the income elasticity of demand. These income elasticities of demand can be shown to be equal to:

$$I_j = \eta_{WX} + \eta_{EX}$$

where η_{WX} is the elasticity of wage rate with respect to output, and η_{EX} is the elasticity of labour demand with respect to output; that is, they are made up of two components, the wage price component and the labour productivity component.

Similarly, the change in sectoral employment can be calculated as the change in the sectoral wage bill times the wage rate:

$$\Delta \text{Emp} = \hat{H}_0^{-1} \hat{P}_0^{-1} \Delta \text{Inc}$$

where H is a vector of average household income coefficients and P is a vector of coefficients representing average output per employee.

There are several implications arising from the use of this model, compared to the conventional input-output model. Firstly, while the output multipliers and impacts should not be significantly different between the two models, we would expect the income and employment impacts to be smaller in the marginal coefficient model. This is because many industries, especially those which are more capital intensive and can implement further

productivity gains, can increase output, particularly in the short run²⁸, without corresponding proportional increases in employment and hence income payments.

Secondly, unlike the conventional input-output model in which the multiplier value is the same for all multiples of the initial shock, the multiplier values from the marginal coefficient model vary with the size of the initial impact. Thus larger changes in final demand will tend to be associated with smaller multipliers than small changes in final demand. Therefore, the differential impacts of the marginal coefficient model are not additive, unlike the conventional (linear) Leontief model and CGE model.

Overall, within the confines of a static model, the major improvements brought by the non-linear model are to improve the overall accuracy of the factor income and employment impact projections.

The Victorian non-linear model

An input-output table developed by using generation of regional input output models (GRIT) methods was modified to have non-linear properties by the use of the IO-8 software developed by Guy West from the Centre of Economic Policy Modelling at the University of Queensland.²⁹ The table was also updated to reflect latest Australian Bureau of Statistics Census (2006) employment data. In an essentially static model, the way in which non-linearities can be included is by the interaction of estimated elasticity coefficients upon the multipliers, particularly the employment and factor income multipliers.

Economic impact measures

The primary economic impact measures used in this section are as follows:

- Gross Output (regional turnover) - refers to the gross value of increased production from an additional economic activity. Within this gross value is included the value of raw materials that, in most cases, have already been counted as part of gross output from earlier production. Therefore there is a tendency for gross output figures to include some double counting. As a result, more concentration is placed upon incremental (additional output created) or value-added. Nevertheless, the concept of gross output should not be abandoned because it is a good indicator of the level of turnover in the economy and hence a good measure of the total level of economic activity.
- Value-Added - refers to added or net output. Value-added is equivalent to the gross state / regional product as used by the Australian Bureau of Statistics. It is the measure usually preferred when measuring economic impact. It measures the added value placed on intermediate products (raw materials) from the productive process. It is made up of margins, wages, profits and transfers
- Factor Income - relates to the share of value-added (and gross output) which is directly paid to individuals or firms in the form of wages and/or profits. By definition it is a percentage of value-added and cannot exceed value-added.
- Jobs - relates (usually) to the amount of labour required for the level of production. Depending upon the type of activity, job numbers measure either the use of existing labour

²⁸ The term 'short run' here does not refer to any specific time period; rather it will vary from industry to industry. It is used here in the conventional economic sense to mean that the full adjustment from any shock has not had time to occur, i.e. the system has not yet returned to full, long run, equilibrium.

²⁹ Some assumptions had to be made concerning elasticity coefficients for some industries. Where exact data was not known, the Rest of Australia (minus NSW) estimates were used.

(continuing jobs) or hiring new staff. Full Time Equivalent (FTEs) employment refers to the number of full time person-years of employment generated by a particular project or event. This alleviates the overstating of the level of job growth due to the stimulus.

Economic impact modelling

To determine the economic benefits that may accrue to the economy of Victoria as a result of tourism on Phillip Island, data supplied was applied to a non-linear input output model of Victoria. The impacting sectors chosen are shown in Table 1 and international tourism is modelled as additions to exports.

Table A1 Tourism - Allocation of Impacting Sector

Impacting Sector	Percentage Contribution
Retail and Wholesale Trade	35%
Transport	12%
Personnel Services	20%
Restaurants and Cafes	12%
Finance	10
Miscellaneous	11

Percentage weights estimated from Bureau of Tourism Research and CEPM (2003).

On the basis of this assumption and the arguments used above the results obtained were:

Table A2(a) Annual Impacts of Phillip Island Tourism Domestic Lower Scenario (\$m)

	Final Demand	Industry Effects	Consumption Effects	Total	Flow-on
Gross Output	11.5	4.9	5.3	21.6	10.2
Value added	8.3	2.4	2.7	13.3	5.1
Factor Income	5.5	1.0	1.2	7.6	2.2
Employment supported**	24	7	10	41	17

Source: Victorian non-linear I-O table

- Gross output/turnover effects of \$21.6 million
- Additional GSP of \$13.3 million
- Additional factor income of \$7.6 million
- Support for 41 FTE jobs throughout the economy.

Table A2(b) Annual Impacts of Phillip Island Tourism (International) Lower Scenario (\$m)

	Final Demand	Industry Effects	Consumption Effects	Total	Flow-on
Gross Output	17.9	7.8	8.1	34.8	16.9
Value added	12.9	3.7	4.2	20.8	7.9
Factor Income	8.5	1.5	1.8	11.8	3.3
Employment supported**	38	11	16	64	27

Source: Victorian non-linear I-O table

- Gross output/turnover effects of \$34.8 million
- Additional GSP of \$20.8 million
- Additional factor income of \$11.8 million
- Support for 64 FTE jobs throughout the economy.

Table A2(c) Annual Impacts of Phillip Island Tourism (Domestic) Medium Scenario (\$m)

	Final Demand	Industry Effects	Consumption Effects	Total	Flow-on
Gross Output	15.4	6.2	7.00	28.4	13.2
Value added	10.8	3.1	3.5	17.5	6.6
Factor Income	7.2	1.2	1.5	10.0	2.8
Employment supported**	32	10	12	54	22

Source: Victorian non-linear I-O table

- Gross output/turnover effects of \$28.4 million
- Additional GSP of \$17.5 million
- Additional factor Income of \$10.0 mMillion
- Support for 54 FTE jobs throughout the economy.

Table A2(d) Annual Impacts of Phillip Island Tourism (International) Medium Scenario (\$m)

	Final Demand	Industry Effects	Consumption Effects	Total	Flow-on
Gross Output	19.8	8.5	10.0	38.3	18.5
Value added	14.1	4.1	4.6	22.7	8.7
Factor Income	9.3	1.6	2.0	12.9	3.6
Employment supported**	42	12	18	72	40

Source: Victorian non-linear I-O table

- Gross output/turnover effects of \$38.34 million
- Additional GSP of \$22.7 million
- Additional factor income of \$12.92 million
- Support for 72 FTE jobs throughout the economy.

Table A2(e) Annual Impacts of Phillip Island Tourism (Domestic) High Scenario (\$m)

	Final Demand	Industry Effects	Consumption Effects	Total	Flow-on
Gross Output	20.6	8.7	9.2	37.7	17.9
Value added	14.4	4.1	4.7	23.2	8.8
Factor Income	9.5	1.7	2.0	13.2	3.7
Employment supported**	42	13.	17	72	30

Source: Victorian non-linear I-O table

- Gross output/turnover effects of \$37.7 million
- Additional GSP of \$23.2 million
- Additional factor income of \$13.2 million
- Support for 72 FTE jobs throughout the economy.

Table A2(f) Annual Impacts of Phillip Island Tourism (International), High Scenario (\$m)

	Final Demand	Industry Effects	Consumption Effects	Total	Flow-on
Gross Output	26.5	11.3	13.0	50.7	24.2
Value added	18.8	5.4	6.1	30.3	11.5
Factor Income	12.4	2.2	2.6	17.2	4.
Employment supported**	55	16	23	94	39

Source: Victorian non-linear I-O table

- Gross output/turnover effects of \$50.7 million
- Additional GSP of \$30.3 million
- Additional factor income of \$17.9 million
- Support for 94 FTE jobs throughout the economy.

Comparisons with Tourism Victoria Study

It is hard to make direct comparisons with the results cited above for the Tourism Victoria study because the basis for the study and its methodology is not clear. One area for potential comparison is in the amount of gross output used to support one direct job.

Table A3: Comparison of gross output for direct employment

Gross Output per direct job	\$, 000s
Tourism Victoria (2005)	338,383
Victorian non-linear model (FTE) (domestic)*	525925
Victorian non-Linear model (FTE) (International**)	532500
Victorian non-linear model (adjusted for part time and casual jobs (Domestic-Medium Scenario)	368147

Initially it appears as if there is considerable disagreement between the job estimates, with the non-linear model predicting fewer jobs per million. However the non-linear estimates are for FTE jobs. It is believed that the Tourism Victoria estimates include part-time and casual jobs. After adjustment of the non-linear figures to include part-time and casual jobs, the comparison between the value of output per job costs from Tourism Victoria (\$338,383) and the Victorian non-linear model (\$368,147) is relatively close, particularly allowing for inflation between the dates.

Scenario analysis

Table A4: Scenario 1 - Economic impact of visitors to the penguin parade

	Final demand	Flow-on (indirect) effects		Total flow-on	Total
		Industry	Consumption		
Gross output (\$ m)	35.2	14.7	17	31.7	66.9
Value added (\$ m)	24.9	7.2	8.1	15.3	40.2
Factor income (\$ m)	16.5	2.8	3.5	6.4	22.9
Employment (FTEs)	74	22	30	62	136

Source: Victorian non-linear I-O table

Table A5: Scenario 2 - Economic impact of visitors to the penguin parade

	Final demand	Flow-on (indirect) effects		Total flow-on	Total
		Industry	Consumption		
Gross output (\$ m)	20.7	8.2	9.4	17.6	38.3
Value added (\$ m)	13.9	4.0	4.5	8.5	22.4
Factor income (\$ m)	9.2	1.6	1.9	3.5	12.7
Employment (FTEs)	41	12	17	29	70

Source: Victorian non-linear I-O table

Table A6: Scenario 3 - Economic impact of visitors to the penguin parade

	Final demand	Flow-on (indirect) effects		Total flow-on	Total
		Industry	Consumption		
Gross output (\$ m)	5.1	2.1	2.5	4.6	9.7
Value added (\$ m)	3.5	0.9	1.2	2.1	5.6
Factor income (\$ m)	2.3	0.4	0.5	0.9	3.2
Employment (FTEs)	10	3	5	8	18

Source: Victorian non-linear I-O table

4 Conclusions and recommendations

A number of recommendations for adaptation activities to protect the Phillip Island penguin population arise from this work, the effect of which will be to limit future changes in penguin populations to that envisaged in MJA's Scenario 1.

6.1 Potential effects, including loss of breeding habitat through inundation and erosion, of sea-level rise on distribution and abundance of penguins

There will be some small loss (<< 1 %) of breeding habitat on the Summerland Peninsula due to sea level rise in the next 100 years but it is considered that breeding habitat is unlikely to be limited on the Peninsula in this period. However, there is likely to be some erosion in the vicinity of Whaleshead Creek and further east. Accordingly, there are some implications for the viewing of penguins at the Penguin Parade. It is anticipated that there will be some loss of productivity of inshore waters in Bass Strait, which may ultimately result in reduced food availability for penguins.

Resilience building and recommendations for actions including future research

- Removal of Marram Grass on the beach profile of Summerland, Cowrie & Shelly Beaches and Cat Bay (and replace with native species, e.g. Spinifex).
- Incorporate the "Future Coasts" data into the Phillip Island Nature Parks' GIS system to allow better determination and visualisation of areas on the Summerland Peninsula likely to be most affected by sea-level rise and storm surge (see Appendix 1 for more details of the "Future Coasts" project).
- Complete the purchasing of all private property in the Summerland Estate to allow the extension of penguin breeding areas further inland.
- Encourage the penguins to colonise the eastern side of the current breeding area at the Penguin Parade through active management (see Dann 1996) particularly by:
 - eradicating foxes from Phillip Island
 - improving access for penguins on the east side of the Parade
 - optimising vegetation type and cover for breeding penguins

6.2 Potential effects of decreasing rainfall and humidity on distribution and abundance of penguins

It is predicted that there will be little appreciable direct impact of decreased rainfall and humidity on adult Little Penguins over the next century. However it seems likely that fire risk will increase and needs to be managed to ensure penguin survival is unaffected. In addition, if the availability of anchovies is reduced by decreased rainfall, then adult survival (and possibly breeding productivity) may be reduced.

Resilience building and recommendations for actions including future research

- Increase appropriate ground vegetation cover in penguin breeding habitat to reduce evaporation of soil moisture during periods of decreased rainfall and to reduce erosion after high rainfall events
- Investigate the role of burrow temperature and humidity in determining the breeding success of penguins, particularly hatching success and chick growth
- Honours project on relationship between burrow location and structure on nest temperature and humidity- commence June 2009. Project brief in Appendix 2.
- Reduce fire risk on Summerland Peninsula through:

- planting fire resistant local vegetation, particularly succulent species where appropriate,
- give high priority to fire response planning and training,
- ensure all power supply on Summerland Peninsula is underground.
- Establish if relationships exist between stream inflows (and temperature) into Port Phillip Bay and anchovy spawning and production.

6.3 Potential effects of ambient temperature rise on distribution and abundance of penguins

Increasing temperatures in burrows during daylight are likely to increase adult and chick mortality and, based on a tripling of days greater than 35 °C and assuming a conservative linear function, will constitute c. 0.51% of annual adult mortality by 2070. Increasing burrow temperatures may also have a role in determining breeding success and this warrants investigation as does the scope for mitigation of burrow microclimates through vegetation management and artificial burrow design.

Resilience building and recommendations for actions including future research

- Increase appropriate ground vegetation cover in penguin breeding habitat to reduce internal temperatures of burrows on hot days
- Investigate the role of burrow temperature in determining the breeding success of penguins, particularly hatching success and design an artificial burrow with optimal microclimate (temperature & humidity) - see Section 2. A project to examine breeding success in relation to temperature in artificial burrows is currently in train (Chiaradia *et al.*) and a project brief for a study to look at temperature and humidity in natural burrows is given in Appendix 2.
- Compare breeding success and ambient temperatures of Little Penguins on northern (warmer) & southern (cooler) sides of the Summerland Peninsula between 1984 and 2008.

1.4 Summary of potential impacts of oceanic changes on distribution and abundance on penguins

Increasing sea-surface temperatures in Bass Strait may result in an earlier start to the breeding season, increases in breeding success and increases in first-year survival. Decreases have been predicted in adult survival, but more work is required to confirm the direction of this relationship. More productive breeding seasons and higher first-year survival should improve recruitment into the breeding population. Increased stratification of the water column may reduce productivity and, correspondingly, food availability for penguins but, conversely, increase foraging efficiency of Little Penguins.

Resilience building and recommendations for actions including future research

- Continue Phillip Island Nature Park's commitment to long-term studies of breeding, demography and foraging of Little Penguins. Long-term datasets are the key to documenting and understanding the response of species to climate change and the Little Penguin study at Phillip Island is one of the longest running studies of a marine species in Australia
- Model the impact of shortening or lengthening the breeding season has on productivity of penguins

- Investigate if the timing of breeding of penguins at Phillip Island has continued to track the autumn SSTs in Bass Strait following the apparent change in trend since 2000
- Review the linkages between SSTs in autumn and the timing and success of breeding in penguins, giving priority to those involving prey species
- Determine with more confidence the relationship between sea-surface temperatures and adult survival with more confidence
- Determine if there are any competitive interactions between fisheries and Phillip Island penguins. Building resilience to reductions in food availability for penguins could include reducing competition from fisheries
- Investigate the role of climate on fish recruitment (spawning and survival) in Bass Strait

1.5 Summary of potential impacts of wind, the southern oscillation index and ocean acidification on distribution and abundance on penguins

Decreasing winds in the region are likely to reduce the recruitment of fish populations and hence the availability of food for penguins, with potential impacts on their survival and breeding success. It is unknown if wind direction and velocity directly affect penguin foraging success. Decreasing SOI may reduce adult survival and increase juvenile survival but the mechanisms are unknown for either. Increasing acidification may reduce food availability for penguins.

Resilience building and recommendations for actions including future research

- Develop a trophic model of the Bass Strait ecosystem to allow assessment of sensitivities to oceanic variables for higher predators and potential interactions.
- Determine the effects of wind on the foraging success of Little Penguins
- Analyse the relationships between SOI and survival of adult and first-year penguins

1.6 Summary of tourism-related issues for further research

The impacts of climate change on the Little Penguin population of Phillip Island could have repercussions for the Phillip Island economy, and that of the Bass Coast Shire more broadly. The penguin population contributes to a strong and viable tourism industry on the Island. Of the more than 1000 businesses in the Shire, over half benefit directly from tourism. In 2007/08, a total of 491,780 people visited the Nature Park to see the penguin parade. Of these, 308,465 were international tourists spending a total of \$19.7 million, and 183,315 were Australian visitors spending a total of \$15.4 million.

Tourism scenarios under climate change

As noted, the impacts of climate change on the penguin population have not been detailed as yet. Nor has the impact on tourism of penguin population decline. Accordingly, three scenarios have been developed to hypothesise tourism decline, and the resulting economic impacts modelled. Scenario one models a small penguin population decline, with no notable change in economic impact. Scenario 2 involves significant population decline with similar economic impacts. And Scenario 3 models extreme population decline and associated visitation. These scenarios are summarised below.

Scenario	Features	Impact on visitation
Small population decline	Climate change causes population decline, but penguin parade continues every night.	Negligible change. Domestic and international tourism continues.
Large reduction in population	Population declines significantly, causing penguin sightings to become sporadic during winter months	Park closure to the public for winter months. International visitation suffers significant decline (50%) as tours remove penguins from itinerary. Domestic visitation declines during winter months only (30%).
Extreme reduction in population	Population declines dramatically, causing sporadic penguin sightings year round and rare sightings during winter months	International visitation collapses (90%) and domestic visitation dramatically reduced (80%). Viability of tourism threatened.

Source: MJA analysis

Scenario one models a small penguin population decline, with no notable change in economic impact. Scenario 2 involves significant population decline with similar economic impacts. And Scenario 3 models extreme population decline and associated visitation. Scenario 2 involves a sizeable decrease in economic activity once tourism is notably affected by penguin population decline. This involves a decline in direct economic output of \$14.5m per year, and with flow-on, a decrease in total gross output of \$28.6m per year. The decrease in direct value added associated with Scenario 2 is \$11m per year, and with flow-on, \$18m per year. Total employment loss in the Bass Coast Shire (direct and indirect) is estimated at 66 full time jobs.

Scenario 3, involving more extreme penguin population decline, is modelled to have more dramatic impacts on associated tourism. This involves a decline in direct economic output of \$30m per year, and with flow-on, a decrease in total gross output of \$57m per year. The decrease in direct value added associated with Scenario 3 is \$21.4m per year, and with flow-on, \$34.6m per year. Total employment loss (direct and indirect) is estimated at 118 full time jobs.

MJA stresses that these scenarios are purely hypothetical. They have been compiled in the absence of detailed understanding of the likely impacts on penguin population of climate change and without survey analysis of visitor preferences relating to penguin tourism.

Further work in these areas could establish a more robust understanding of the regional economic impacts of climate change on the Phillip Island Little Penguin colony.