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# Scientific Working Group: additional analyses for the Australian sea lion management strategy

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# Summary

The Scientific Working Group: Australian Sea Lion Management Strategy (SWG, 7 February 2011) recommended analyses to assist in refining the trigger system within the Australian Sea Lion Management Strategy (hereafter referred to as the strategy). This was in response to concerns raised by reviews of the strategy.

The Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) and South Australian Research and Development Institute (SARDI) were commissioned by the Australian Fisheries Management Authority (AFMA) to undertake some of the analyses. The draft results were presented to Australian Government agencies (28 February 2011) and other scientific working group members (1 March 2011). The results of the analyses were presented to the strategy's second quarterly review meeting (4 March 2011). This technical report describes the analyses and results.

## Responses to the requested analyses:

*1 Are the two observer programs (the 2006–09 SARDI research observer program and the July–December 2010 AFMA dedicated sea lion observer program) representative of the total fishing effort during the time of each program, in terms of the probability of sea lion bycatch?*

While not covering all regions defined in the Australian Sea Lion Management Strategy of June 2010, the two observer programs were representative of the total fishing effort in terms of the likelihood of encountering foraging Australian sea lions. That is, the observed gillnet shots were not conducted at points in the fishery where sea lions were significantly more or less likely to be encountered.

The July–December 2010 AFMA observer program, however, covered gillnet shots that had shorter soak times and net lengths than the total industry fishing effort. This could reflect the normal fishing patterns of the observed vessels, and might result in an underestimate of the sea lion bycatch over that period, depending on the influence of soak time and net length on bycatch rates. The scale of any difference is unclear.

*2 Are the two observer programs comparable in terms of whether they covered gillnet shots with similar likelihood of encountering sea lion bycatch?*

The two observer programs are comparable in this respect. Therefore, any differences in observed bycatch rates cannot be explained by differences in the chance of encountering sea lion bycatch. Any difference should be accounted for, as the observer program is critical to the success of the trigger system.

3 *Can the regions within the strategy be subdivided into zones where the likelihood of sea lion bycatch is different, so that triggers and observer coverage can be tailored to reflect the likelihood of bycatch?*

The Scientific Working Group discussed the possibility of subdividing each region into three zones:

- an **inner zone**, close to colonies but outside the current closed areas, with high probability of sea lion bycatch and potentially high levels of observer coverage
- a **middle zone** with lower probability of bycatch and moderate levels of observer coverage
- an **outer zone** (>120 m depth) with very low probability of bycatch, potentially requiring no dedicated sea lion observer coverage.

ABARES examined possible subdivision of each region on the basis of the sea lion foraging model (Goldsworthy et al. 2010). In the range of scenarios presented the outer zone remains constant, but the inner and middle zones are defined on the percentage of the highest foraging densities that are covered.

The results suggest the management regions could be further divided for the trigger system to provide greater protection in zones with a higher likelihood of encountering sea lion bycatch. Subdividing the regions (with revised triggers and observer coverage) on the basis of foraging density would be the most efficient way of limiting bycatch overall. If the observer coverage is higher in the zone where bycatch is most likely, this will also provide robust estimates of bycatch rates.

However, a three-zone approach based on foraging densities will not provide sufficient protection to smaller colonies, as foraging density is influenced by the size of colonies. Subdivision on the basis of distance from the closest colony was also examined because it might provide greater protection for smaller colonies. Such a subdivision would be less efficient in terms of the amount of area closed and the overall reduction in bycatch.

A hybrid system was examined for defining zones based on a combination of foraging density and distance from the nearest colony. This appears effective at balancing overall bycatch reduction and protection for smaller colonies.

Uncertainties in these analyses primarily reflect uncertainties and assumptions in the foraging model, and the limited observer data.

# 1 Introduction

The Australian Sea Lion Management Strategy (hereafter referred to as the strategy) was implemented by the Australian Fisheries Management Authority (AFMA) in July 2010. A Scientific Working Group: Australian Sea Lion Management Strategy was established and met on 7 February 2011. This meeting recommended analyses to assist in refining a potential trigger system (Attachment A) in response to concerns raised by reviews of the strategy (Goldsworthy and Lowther 2010; Costa unpublished).

## **Australian Sea Lion Scientific Working Group meeting outcomes – 7 February 2011**

Provided by AFMA 15 February 2011.

The Scientific Working Group clarified the need for the following work before the next review of the Australian Sea Lion Scientific Working Group scheduled for 4 March 2011.

This work consisted of:

- 1 an analysis of the representativeness of observer effort to date to ensure that observer coverage reflects actual fishing effort. This involves comparing distances from colonies during normal fishing operations with distances when observers are on board. This can be done by using the South Australian Research and Development Institute (SARDI) model to overlay fishing effort with maps of Australian sea lion foraging density.
- 2 the combination of initial SARDI observer information with AFMA observer coverage collected since mid-2010 during the strategy, in order to examine consistency with the previous bycatch mortality results (incorporating e-monitoring shots as an additional and optional layer to this analysis, noting caveats around the ongoing verification of the use of cameras).
- 3 the identification of refined management zones and levels of focused observer coverage that better reflect the probability of Australian sea lion (*Neophoca cinerea*) bycatch. Current management regions could be split into three zones based on the low, medium or high probability of encountering Australian sea lions. Low probability zones would extend inwards from 183 m depth closure to a line of bathymetry reflecting 120 m depth (maximum Australian sea lion foraging depth) and have little/no observer coverage. The boundary of the medium (moderate coverage ~30 per cent suggested) and high probability zones (100 per cent coverage / mandatory cameras) would reflect a compromise between the modelled distribution of foraging effort (as in figure 7.22 of Goldsworthy et al. 2010) and fishing effort. It was suggested that the line follow the outline of the yellow or red gradient lines of foraging effort. The effect of these refined zones on trigger levels and population survivability is also to be analysed.

- 4 a revision of the identification of small colonies included as 'viable subpopulations' when setting triggers. This was to be done with input from SARDI, the Australian Antarctic Division and Department of Sustainability, Environment, Water, Population and Communities. A tentative level of more than 5 pups per breeding cycle was suggested for inclusion as an indicator of likely ongoing viable populations.
- 5 the refinement of estimates of 'maximum bycatch rate' using figures of 2 per cent and 1.5 per cent per breeding cycle (rather than the current estimate of 3 per cent mortality per breeding cycle) and the examination of how these figures would affect the trigger levels per zone and the survivability of smaller colonies.

ABARES and SARDI were commissioned by AFMA to undertake most of the analyses identified by the Scientific Working Group (analyses 1, 2, 3 and 5). The draft results were presented to government agencies (28 February 2011), other Scientific Working Group members (1 March 2011) and the strategy's second quarterly review meeting (4 March 2011).



# 2 Representativeness of observer programs

## Method

Of interest to the Scientific Working Group is whether the SARDI and AFMA observer programs are representative of the industry's fishing efforts at the time they were conducted. These two programs were:

- the 2006–09 research observer program managed by SARDI (described in Goldsworthy et al. 2010), and
- the July–December 2010 AFMA dedicated sea lion observer program.

A relevant basis on which to evaluate the representativeness of the observer coverage and industry effort is the probability of encountering foraging Australian sea lions. The best method for the required evaluation is the foraging density predictive model described in Goldsworthy et al. (2010). The foraging densities used in subsequent analyses are a sum of the foraging densities of males, females and juveniles (fig. 7.15 in Goldsworthy et al. 2010). Foraging densities for each of these parts of the Australian sea lion population were modelled separately, and each could be separately applied to analyses to reflect behavioural differences, but since the gender of bycatch cannot be reliably recorded, the averaged density was used.

Estimates of Australian sea lion foraging density were calculated for the observed gillnet shot locations ( $n = 234$  and  $208$  for SARDI and AFMA observer program data, respectively), and compared with random samples of equivalent size for observed gillnet shots from the industry effort data (a 'bootstrap' approach). The product of soak time, net length and density was also calculated and the mean of this from the observed gillnet shots was compared to the industry effort data. This was done because Goldsworthy et al. (2010) suggested that the product of density, net length and soak time better reflects the probability of encountering Australian sea lions than density alone.

The analysis was applied to data from the entire area of waters off South Australia, not on a region by region basis. This was because smaller datasets would result from considering each region separately, giving poorer quality results.

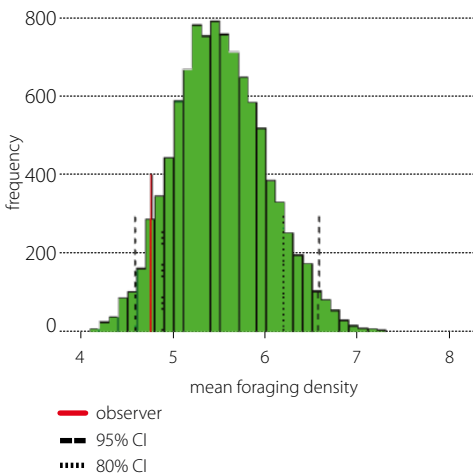
We present the means of random samples of foraging density from the fishing effort data here as histograms, and compare them with the mean density for actually observed gillnet shots (placed on the histogram). For perspective, confidence intervals (80 per cent, 95 per cent) are also given on the histograms.

## Results

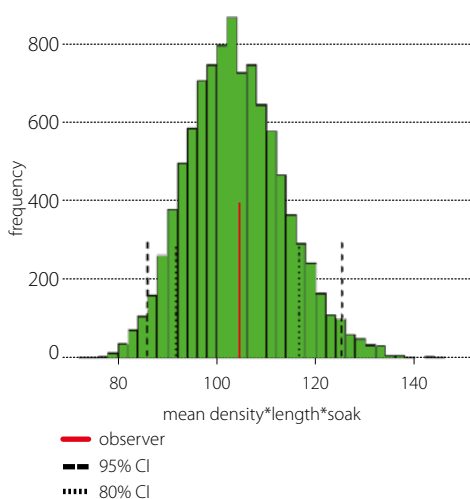
### 2006–09 research observer program managed by SARDI

Comparisons between observer and industry effort data in terms of the probability of encountering foraging Australian sea lions are considered for the period 2006–2009 (234 observations). The coincidence of the two data sets over time is assumed, but not actually known. The density comparisons suggest the observed gillnet shots were at points less likely, but not significantly less likely, to see Australian sea lions than the industry effort (figure 1). When considering the product of soak time, net length and density, observed gillnet shots were very comparable to industry effort (figure 2). This assumes that the product of density, net length and soak time better reflects the probability of encountering Australian sea lions than just density alone.

**1** Location of mean foraging density for observed gillnet shots from the 2006–09 SARDI research observer program (n=234, red line), compared with bootstrapped samples from the corresponding industry effort data (n=17 492, histogram), showing confidence intervals



**2** Location of mean foraging density × net length × soak time, for observed gillnet shots from the SARDI research observer program (n=234, red line), compared with bootstrapped samples from the corresponding industry effort data (n=17 492, histogram), showing confidence intervals

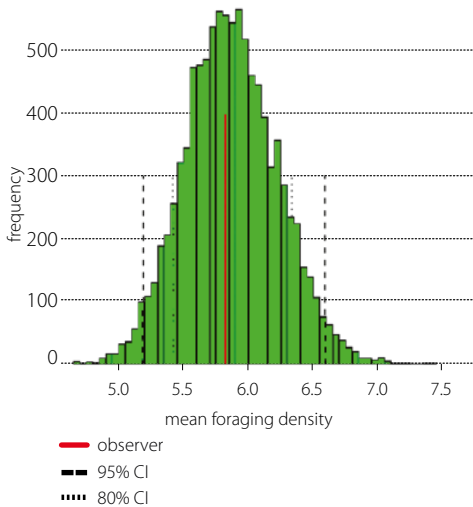


### July–December 2010 AFMA dedicated Australian sea lion observer program

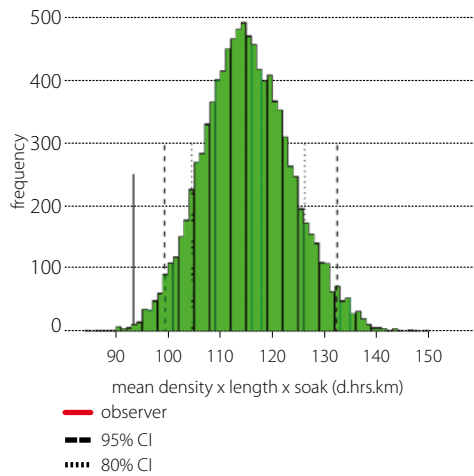
Comparisons between observer and industry effort data in terms of the probability of encountering Australian sea lions are also considered for the period July–December 2010 from the AFMA dedicated Australian sea lion observer program. For these data (208 observations), the timing of observer and effort gillnet shots is known to be comparable. The density

comparisons suggest the observed gillnet shots are representative of industry effort, in terms of the probability of encountering Australian sea lions (figure 3). However, when considering the product of soak time, net length and density, observed gillnet shots had significantly lower probability of observing Australian sea lion bycatch than industry effort (figure 4).

**3** Location of mean foraging density for observed gillnet shots from the July–December 2010 AFMA dedicated Australian sea lion observer program (n=208, red line), compared with bootstrapped samples from the corresponding industry effort data (n=2 340, histogram), showing confidence intervals

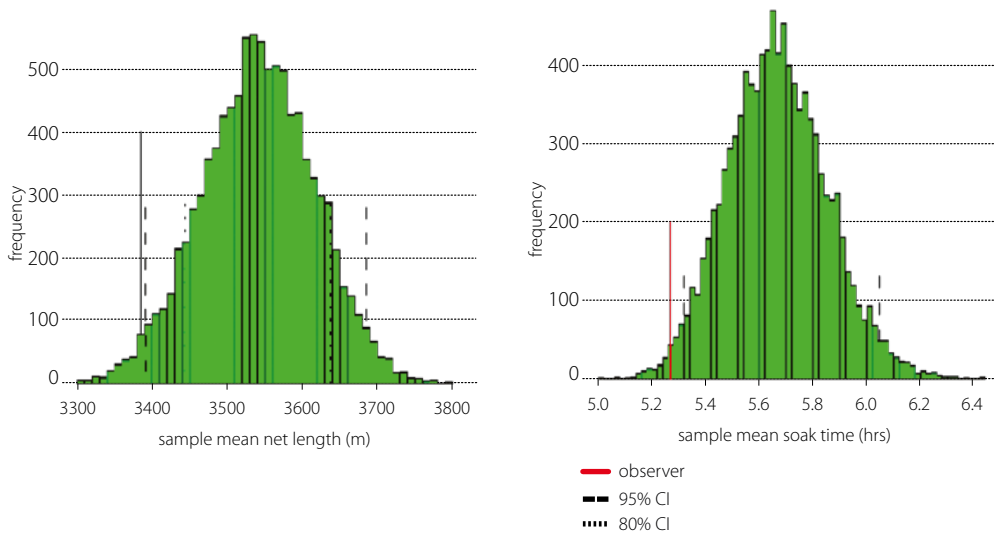


**4** Location of mean foraging density  $\times$  net length  $\times$  soak time for observed gillnet shots from the July–December 2010 AFMA dedicated Australian sea lion observer program (n=208, red line), compared with bootstrapped samples from the corresponding industry effort data (n=2 340, histogram), showing confidence intervals.



The comparisons suggested that soak time, gillnet length, or a combination of the two, were less for the observed gillnet shots than industry effort gillnet shots. The bootstrap approach was again adopted to test the difference between observed gillnet shots and industry effort in terms of these two variables. It was found that observed gillnet shots had significantly ( $p < 0.05$ ) shorter soak times and shorter net lengths than the industry effort over the same period (figure 5).

**5** Location of mean net length (left) and soak time (right) for observed gillnet shots from the July–December 2010 AFMA dedicated Australian sea lion observer program (n=208, red line), compared with bootstrapped samples from the corresponding industry effort data (n=2 340, histogram), with confidence intervals



## Conclusion

To different extents, the two observer program data sets were representative of the industry fishing effort (in terms of the probability of encountering foraging Australian sea lions) for the corresponding time periods. The possible effects of net length and soak time on the incidence of bycatch mean that our conclusion inherently contains some uncertainty. If the net length and soak time have no effect, then the 2006–09 observer program managed by SARDI had less chance of observing bycatch than would be expected given the fishing effort, due to the location of observed gillnet shots (13 per cent lower; figure 1). Since net length and soak time do influence the chance of observing bycatch, the SARDI research observer program is more representative of the fishing effort than the AFMA observer program (figure 2).

The July–December 2010 AFMA dedicated Australian sea lion observer program was representative of the industry fishing effort, in terms of the location of observed gillnet shots and probability of encountering foraging Australian sea lions. However, as a result of shorter net lengths and shorter soak times for observed gillnet shots (figure 5), the AFMA program will become less representative of fishing effort, according to the degree to which net length and soak time affect the probability of bycatch. If the latter are linearly related to the probability of observing bycatch, then the AFMA program was significantly less representative of fishing effort (18 per cent lower probability; figure 4).

The above conclusions hold if the probability of observing bycatch is linearly related to foraging density. While Goldsworthy et al. (2010) showed that the probability of bycatch strongly increases with foraging density, the degree to which the relationship is linear is unclear. If the relationship between foraging density and the probability of observing bycatch is nonlinear, the statistical analyses above become invalidated and these conclusions would need to be retested. This would require analysis of the individual bycatch observations from both the SARDI and AFMA data sets.

# 3 Comparison of SARDI observer data with AFMA 2010 observer data

## Method

It is critical to establish whether bycatch observations from the 2006–09 SARDI research program and the AFMA July–December 2010 dedicated Australian sea lion observer program can be compared. The comparability of the two sets of observations was tested using foraging densities from the Goldsworthy et al. (2010) foraging model. This allowed us to evaluate the possible significance of differences between the two programs in terms of the probability of encountering Australian sea lions. Comparisons were made directly with foraging densities, and again with densities adjusted by net length and soak times. The data are heavily skewed, so comparison of the two observer data sets was evaluated using a non-parametric statistical test, the Kruskal–Wallis rank sign test.

## Results

The Kruskal–Wallis test suggests that there is no significant difference between the two observer programs (table 1), in terms of their underlying likelihood of encountering Australian sea lion bycatch. This was both in terms of foraging density alone, and with the product of foraging density, net length and soak time.

### 1 Mean and median foraging density and product of foraging density, net length and soak time for gillnet shots in the two observer programs

observer program	foraging density		Kruskal–Wallis rank sum test		
	mean	median	Chi-squared	df	p-value
2006–09 SARDI program	4.75	2.72	439	419	0.241
Jul–Dec 2010 AFMA program	5.83	4.77			
observer program	density × net length × soak time		Kruskal–Wallis rank sum test		
	mean	median	Chi-squared	df	p-value
2006–09 SARDI program	104.4	56.9	439	435	0.4373
Jul–Dec 2010 AFMA program	93.4	62.6			

Note: The results of the Kruskal–Wallis rank sign test comparing the means of the two observer data sets are also shown.

## Conclusion

The observed gillnet shots appear comparable, in that there is no significant difference in underlying likelihood of having encountered Australian sea lion as bycatch, either by foraging density, or foraging density adjusted by net length and soak time. Any difference in observed bycatch between the two sets of observer data does not appear to be due to underlying chance of encountering Australian sea lion as bycatch. However, the two observer data sets appear to differ in estimating the underlying rate of bycatch, with the AFMA program reporting lower bycatch than the SARDI program. If shown to be significant, this difference needs to be accounted for, because accurate reporting of all bycatch is critical to the effectiveness of the AFMA management plan.

# 4 Potential for splitting each bycatch region into outer and inner bycatch zones

## Method

To facilitate more efficient estimation of bycatch rates while maintaining small colony protection, the Scientific Working Group suggested that it may be possible to subdivide each AFMA bycatch region into three separate zones. The zones would reflect differences in the probability of encountering Australian sea lions and would have different degrees of observer coverage. This could provide greater protection to Australian sea lions by modifying fishing behaviour over zones within regions.

The Scientific Working Group discussed the possibility of subdividing each region into three zones:

- an **inner zone**, close to colonies but outside the current closed areas, with high probability of Australian sea lion bycatch and potentially high levels of observer coverage
- a **middle zone** with lower probability of bycatch and moderate levels of observer coverage
- an **outer zone**, extending from the 183 m depth closure to a line of bathymetry reflecting 120 m depth (reflecting maximum female Australian sea lion foraging depth), with very low probability of bycatch, potentially requiring no dedicated observer coverage.

The incentive for a modification of this sort would be that it would create zones that differ in the probability of encountering Australian sea lion, and would then allow observers to focus on zones where bycatch is most probable. This could maximise the quality of bycatch data, and allow modification of fishing behaviour by having those who fish in high bycatch zones bear observer costs. The boundary between the inner and middle zones would reflect a compromise between foraging effort and fishing effort. The issue of protection for small colonies would also need to be considered.

The following analyses explore scenarios for dividing the inner and middle zones, and the possible impact of this. The adaptive management component of the strategy assumes that imposing a short term acceptable rate of bycatch will reduce the rate of sea lion deaths, while focusing observer effort on areas where bycatch is most likely. In the absence of any more explicit aim, previous ABARES work assumed a 'maximum bycatch rate' of 3 per cent of the population per breeding cycle (ABARES unpublished). The review by Professor Costa (unpublished) recommended a more conservative value, and the Scientific Working Group then suggested that a 'maximum bycatch rate' of 1.5 per cent or 2 per cent of the population per breeding cycle be examined.



## Considerations in splitting regions into zones

One consideration in splitting bycatch regions into an inner and a medium zone is how to 'allocate' the 'maximum bycatch rate' between these zones, assuming that there is no bycatch in the outer zone. It should be noted that male Australian sea lions may interact with the fishery in the outer zone, as they forage to deeper depths (Goldsworthy et al. 2010), but the focus has been on reducing bycatch of females. The allocation is complicated by the purpose of the separate zones.

As different observer coverages are proposed in each zone, fishing effort must be accounted for in allocating acceptable bycatch across zones.

The creation of middle and inner zones is to allow closure of the inner zone if bycatch is too high in that zone, while fishing could continue in the middle zone where Australian sea lion bycatch is less likely. This means that separate maximum bycatch limits would be needed for each zone. The purpose of the limit in the inner zone would be to detect bycatch levels that are too high in the zone where bycatch is most frequent. A limit in the middle zone would need to account for additional bycatch from displaced fishing effort. The overall estimate of bycatch is also needed in order to efficiently monitor bycatch at the fishery level.

Our assessment used two measures of the effect of splitting regions, a split based on areas affected, and a split on the level of acceptable bycatch in each zone. The first measure uses the full foraging model, while the latter measure uses foraging model data at fishing effort locations. The allocation of bycatch across zones would be best done according to the sum of foraging densities within zones (Goldsworthy et al. 2010), but weighted to the fishing effort. Finally, calculation of triggers in each region within each zone requires fore-knowledge of observer coverages.

Calculation of subdivisions and modelling of expected bycatch in each zone within each region require details of recently closed areas in the strategy. Thus, zones within regions are first defined by the area over which bycatch can be expected (Goldsworthy et al. 2010 foraging model). A critical foraging density is chosen to split the inner and middle zones. Scenarios are presented using selected percentiles of the highest of all foraging densities across the entire area of waters off South Australia.

Finally, calculation of expected bycatch in each zone uses the foraging densities associated with fishing effort. The foraging density is weighted by fishing effort to apportion expected bycatch in each zone.

To select suitable critical values to define the demarcation between inner and middle bycatch zones, density percentiles were calculated from the data, both overall and within each zone. Thus in region A, the highest 10 per cent of foraging densities have density values greater than 2.627 (table 2). Across all bycatch regions, the highest 10 per cent of foraging densities are greater than 6.306 (table 2).

## 2 Percentiles for foraging density within the AFMA bycatch regions A to G, and across all regions

highest n% of foraging densities	region							total
	A	B	C	D	E	F	G	
10	2.627	7.447	7.705	5.140	5.193	13.418	7.731	6.306
20	1.349	3.864	5.223	4.184	4.440	10.181	4.985	3.924
30	0.908	2.613	3.600	3.607	3.726	7.533	3.193	2.640
40	0.653	1.886	2.615	3.066	3.095	5.517	2.142	1.788
50	0.519	1.357	2.096	2.505	2.710	4.088	1.353	1.210
60	0.422	0.900	1.573	1.840	2.166	3.162	0.945	0.835
70	0.323	0.648	1.038	1.259	1.732	2.571	0.700	0.586
80	0.234	0.447	0.711	0.961	1.298	1.914	0.482	0.403
90	0.169	0.229	0.412	0.751	0.959	1.240	0.231	0.225
Minimum	0.061	0.108	0.168	0.109	0.104	0.469	0.003	0.003

Note: Using the Goldsworthy et al. (2010) modelled foraging density data. Percentile foraging densities are critical densities that separate the highest n per cent of densities from the (100-n) per cent lowest densities, across each region (or overall).

### Initial splitting of bycatch regions into zones

The Scientific Working Group suggested examining the division of the zones on the basis of probability of Australian sea lion bycatch, that is, by using foraging density. This basis provides an efficient mechanism to observe bycatch over the Australian sea lion population as a whole, because observer effort is concentrated in areas with a high probability of bycatch. However, allocating observer effort on the basis of foraging density alone will poorly protect smaller colonies, since population size drives foraging density as much as does distance from a colony. Another basis for dividing zones is distance from the closest colony. In conjunction with a trigger to close zones, this approach will better protect the smaller colonies, but protects the overall population less well than a foraging density basis.

Another way of dividing zones is by using a hybrid of both distance from the closest colony and foraging density. To determine the best combination of critical values to use to divide zones that protect both the overall Australian sea lion population, and also smaller individual colonies, various single criterion scenarios were considered.

Scenarios for the definition of bycatch zones used the following assumptions:

- the current adult female Australian sea lion population is 5078 animals, apportioned into zones according to the Goldsworthy et al. (2010) foraging model
- the maximum bycatch rate of either 2 per cent or 1.5 per cent a year
- the breeding cycle is 17 and a half months, and the expected Australian sea lion bycatch in total is double the expected female bycatch
- foraging density is directly proportional to the probability of bycatch, and this probability is then constant over regions and seasons

- the inner and middle zones account for all bycatch in a region, with the distribution of bycatch in each of these zones being determined by the sum of foraging densities over fishing effort. Fishing effort used the 2006–09 gillnet shot data from AFMA.

The inner and middle zones were split using 10, 20, 70 and 80 percentiles for foraging density (across all AFMA bycatch regions) and 10, 20 and 30 km minimum distances from the nearest colonies. These are given for 1.5 per cent maximum bycatch rates.

For each scenario in each zone the following information was used from Goldsworthy et al. (2010) (table 3):

- the number of females
- the expected bycatch of females per breeding cycle
- the industry effort in gillnet shots (based on the 2006–09 data).

For each scenario, the following was predicted:

- the area accounted for by the inner, middle and outer zones
- the expected total Australian sea lion bycatch per year in the inner and middle zones, at the maximum bycatch rate (1.5 per cent per year).

### 3 Summary of the estimated number of females in colonies, predicted bycatch of females per breeding cycle (1.5 per cent) and industry effort (annual)

region	no. of females in colonies	predicted female bycatch	no. of gillnet shots (2006–09)
A	271	4.1	837
B	1 077	16.2	2 009
C	583	8.7	3 069
D	157	2.4	1 363
E	1 559	23.4	1 113
F	468	7.0	1 608
G	963	14.5	2 676
<b>Total</b>	<b>5 078</b>	<b>76.2</b>	<b>12 675</b>

Source: Goldsworthy et al. (2010)

**4** Scenarios for the division of AFMA bycatch regions into inner and middle zones, based on highest foraging density percentiles (table 2; 10, 20, 70 and 80 per cent), assuming a 1.5 per cent maximum bycatch rate

highest foraging densities dividing inner and middle zones %	region	inner zone		middle zone		outer zone	
		area of the region %	estimated bycatch (all animals per year) at maximum bycatch rate	area of the region %	estimated bycatch (all animals per year) at maximum bycatch rate	area of the region %	estimated bycatch (all animals per year) at maximum bycatch rate
<b>10</b>	A	0.6	3.6	74.4	2.0	25.0	
	B	10.1	18.8	74.9	3.3	15.0	
	C	13.5	10.3	76.5	1.7	10.0	
	D	3.5	2.8	71.5	0.5	25.0	
	E	2.3	20.1	52.7	12.0	45.0	
	F	34.0	8.6	61.0	1.1	5.0	
	G	14.0	13.5	81.0	6.3	5.0	
	Total/Mean	11.1	77.7 (67%)	70.3	26.7 (33%)	18.6	
	A	4.6	4.0	70.4	1.6	25.0	
	B	16.7	19.8	68.3	2.4	15.0	
<b>20</b>	C	25.2	11.1	64.8	0.9	10.0	
	D	18.3	3.0	56.7	0.3	25.0	
	E	15.2	25.8	39.8	6.3	45.0	
	F	48.8	9.1	46.2	0.6	5.0	
	G	24.0	16.3	71.0	3.6	5.0	
	Total/Mean	21.8	89.0 (81%)	59.6	15.5 (19%)	18.6	
	A	32.9	5.4	42.1	0.2	25.0	
	B	62.1	22.1	22.9	0.1	15.0	
	C	75.5	11.9	14.5	0.1	10.0	
	D	73.0	3.2	2.0	0.0	25.0	
<b>70</b>	E	55.0	31.9	0.0	0.1	45.0	
	F	94.8	9.6	0.2	0.0	5.0	
	G	71.7	19.8	23.3	0.0	5.0	
						5.0	continued...

## 4 Scenarios for the division of AFMA bycatch regions into inner and middle zones, based on highest foraging density percentiles (table 2; 10, 20, 70 and 80 per cent), assuming a 1.5 per cent maximum bycatch rate continued

region	inner zone		middle zone		outer zone	
	area of the region %	estimated bycatch (all animals per year) at maximum bycatch rate	area of the region %	estimated bycatch (all animals per year) at maximum bycatch rate	area of the region %	estimated bycatch (all animals per year) at maximum bycatch rate
highest foraging densities						
dividing inner and middle zones %						
Total/Mean	66.4	104.0 (99%)	15.0	0.5 (1%)	18.6	
A	46.8	5.5	28.2	0.0	25.0	
B	69.5	22.1	15.5	0.0	15.0	
C	81.3	12.0	8.7	0.0	10.0	
D	75	3.2	0	0.0	25.0	
E	55	32.0	0	0.1	45.0	
F	95	9.6	0	0.0	5.0	
G	79.1	19.8	15.9	0.0	5.0	
Total/Mean	71.7	104.3 (100%)	9.8	0.2 (0%)	18.6	

Note: The table shows for each region the percentage area that would be in the inner, middle and outer zones and the estimated bycatch per year of all animals in the inner and middle zones (no bycatch expected in the outer zone). The total (and percentage) estimated bycatch within the inner and middle zones across all regions is provided, and the mean percentage of regions covered by the inner and middle zones (this mean has not been weighted by the size of each region).

## 5 Scenarios for division of AFMA regions into bycatch zones within regions, based on maximum distance from the nearest Australian sea lion colony (10, 20 and 30 km), given 1.5 per cent maximum bycatch rate

maximum distance from nearest colony km	region	inner zone		middle zone		outer zone	
		area of the region %	estimated bycatch (all animals per year) at maximum bycatch rate	area of the region %	estimated bycatch (all animals per year) at maximum bycatch rate	area of the region %	estimated bycatch (all animals per year) at maximum bycatch rate
10	A	0.3	0.4	74.7	5.2	25.0	
	B	0.8	2.9	84.2	19.3	15.0	
	C	0.6	0.2	89.4	11.8	10.0	
	D	1.5	0.2	73.5	3.0	25.0	
	E	1.2	2.6	53.8	29.5	45.0	
	F	1.2	0.3	93.8	9.3	5.0	
	G	0	0.0	95.0	19.8	5.0	
	Total/Mean	0.8	6.6 (6%)	80.6	97.9 (94%)	18.6	
20	A	3.2	2.3	71.8	3.3	25.0	
	B	7.4	12.5	77.6	9.7	15.0	
	C	15.2	4.2	74.8	7.8	10.0	
	D	25.5	1.8	49.5	1.4	25.0	
	E	7.2	7.2	47.8	24.8	45.0	
	F	11.1	3.0	83.9	6.6	5.0	
	G	1.1	2.3	93.9	17.5	5.0	
	Total/Mean	10.1	33.4 (32%)	71.3	71.0 (68%)	18.6	
30	A	7.8	3.4	67.2	2.2	25.0	
	B	14.5	16.4	70.5	5.8	15.0	
	C	38.9	10.2	51.1	1.8	10.0	
	D	50.0	2.9	25.0	0.3	25.0	
	E	15.0	10.5	40.0	21.6	45.0	
	F	26.0	4.5	69.0	5.1	5.0	
	G	4.1	5.2	90.9	14.6	5.0	
	Total/Mean	22.3	70.8 (51%)	59.1	51.4 (49%)	18.6	

Note: For each region the table shows the percentage that would be in the inner, middle and outer zones and the estimated bycatch per year of all animals in the inner and middle zones. It gives the total estimated bycatch within the inner and middle zones across all regions, and the mean percentage of regions covered by the inner and middle zones (this mean has not been weighted by the size of region).

## Findings

The predicted fishing areas and numbers of expected bycatch that fall into the inner and middle zones (tables 4 and 5) suggest suitable criteria on which to base zones.

Table 4 suggests taking the highest 10 per cent of foraging densities to form the inner zone, which would give 67 per cent of the predicted bycatch in 11 per cent of the possible fishing area. Increasing the inner zone to 20 per cent of the highest foraging density nearly doubles the area that the inner zone encompasses, and increases the expected bycatch to 81 per cent of the total. Where the inner zone encompasses 70 per cent and 80 per cent of the highest foraging densities, about 70 per cent of the fishing area accounts for nearly 100 per cent of the expected bycatch. The latter scenario provides inefficient bases for detecting bycatch.

Table 5 shows predicted fishing area and expected bycatch for zones generated by distance from the nearest Australian sea lion colony. The table shows that a 10 km basis for dividing inner and middle zones is inefficient, in predicting 6 per cent of the bycatch in 1 per cent of the fishing area. A 20 km basis predicts that 10 per cent of the fishing area accounts for 32 per cent of the predicted bycatch. Better again is a 30 km distance, that predicts 51 per cent of the bycatch in about 22 per cent of the fishing area, but this is less efficient than the 67 per cent of bycatch in 11 per cent of the area, as provided by the 10 per cent highest of foraging densities.

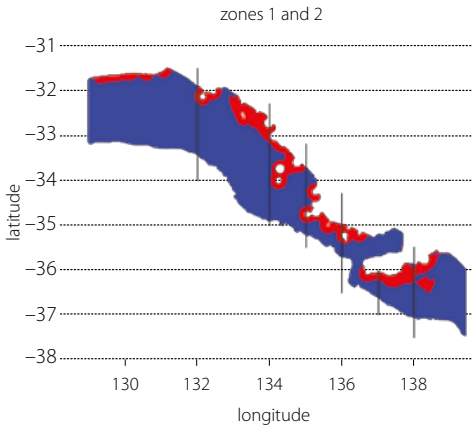
## Hybrid approach to splitting bycatch regions into zones

Table 4 shows that the top 10 per cent of foraging densities accounts for about 66 per cent of the expected bycatch, yet on average occupies only 11 per cent of the fishable area in each bycatch region. This is a good basis for defining the inner zone, except that it does not sufficiently protect the smaller Australian sea lion colonies.

A 10 km buffer around colonies defines a small area of about 1 per cent that would contain only 5 per cent or 6 per cent of the expected bycatch. Twenty and 30 km buffers are more efficient in encompassing 30 per cent and 50 per cent of the expected bycatch respectively, and might be more suitable for the inner zone.

Thus, a mix of a 25 km maximum distance from the nearest colony and the 10 per cent highest foraging densities was used for an illustrative hybrid model to define inner and middle zones in each AFMA bycatch region (table 6, figure 6). This scenario was used to obtain fishing area and bycatch estimates under 2 per cent and 1.5 per cent maximum bycatch rates (table 6).

**6** Map of the inner (red) and middle (blue) zones for the gillnet sector of the Southern and Eastern Scalefish and Shark Fishery in which Australian sea lion bycatch is expected, with division into zones based on spatial points which are less than 25 km from the nearest colony, or in the highest 10 per cent of foraging densities



## Findings

Table 6 shows that zones defined by 25 km distance from the nearest colony or by the highest 10 per cent of foraging densities accounted for 74 per cent of the predicted bycatch from 22 per cent of the fishing area. This is less efficient than zones defined by the 10 per cent highest foraging density alone, but provides better protection to smaller colonies. The foraging density and distance criteria may not be optimal, but illustrate the benefits of a hybrid model and a way of assessing its efficiency.

Other scenarios could be investigated after consideration of issues such as practical decisions on the shapes of zones and the level of bycatch reduction required.

## Conclusions

The results suggest the management regions could be further divided for the trigger system to provide greater protection in zones with a higher likelihood of Australian sea lion bycatch.

- Foraging density is most efficient in terms of overall bycatch. If the observer coverage is higher in the zone where bycatch is most likely, this will also provide robust estimates of bycatch rates, but this approach will not provide sufficient protection to smaller colonies.
- Distance from the closest colony provides greater protection for smaller colonies, but is less efficient in terms of the overall reduction in bycatch and the area closed.
- A hybrid system based on a combination of foraging density and distance from the nearest colony appears effective at balancing overall bycatch reduction and protection for smaller colonies.

The results present illustrative scenarios that show how size and predicted bycatch are likely to vary with different criteria for dividing the zones. The range of uncertainties in these analyses primarily reflects uncertainties and assumptions in the foraging model, the limited observer data, and whether the observer program can accurately record and measure actual Australian sea lion bycatch across the fishery.



## 6 Scenarios for division of AFMA bycatch regions into zones within regions, based on less than 25 km distance from the nearest Australian sea lion colony or the highest 10 per cent of Australian sea lion foraging densities, given 2 per cent and 1.5 per cent maximum bycatch rates

maximum bycatch rate	region	inner zone		middle zone		outer zone	
		area of the region %	estimated bycatch (all animals per year) at maximum bycatch rate	area of the region %	estimated bycatch (all animals per year) at maximum bycatch rate	area of the region %	estimated bycatch (all animals per year) at maximum bycatch rate
2%	A	5.4	4.82	69.6	2.60	25.0	
	B	13.7	25.09	71.3	4.46	15.0	
	C	30.7	13.78	59.3	2.21	10.0	
	D	39.5	3.71	35.5	0.59	25.0	
	E	11.3	26.81	43.7	15.95	45.0	
	F	38.8	11.42	56.2	1.42	5.0	
	G	14	17.99	81	8.43	5.0	
	Total/Mean	21.9	103.61 (74%)	59.5	35.66 (26%)	18.6	
1.5%	A	5.4	3.61	69.6	1.96	25.0	
	B	13.7	18.82	71.3	3.34	15.0	
	C	30.7	10.33	59.3	1.66	10.0	
	D	39.5	2.78	35.5	0.45	25.0	
	E	11.3	20.10	43.7	11.96	45.0	
	F	38.8	8.57	56.2	1.06	5.0	
	G	14	13.49	81	6.32	5.0	
	Total/Mean	21.9	77.70 (74%)	59.5	26.75 (26%)	18.6	

Note: For each region, the table shows the percentage that would be in the inner, middle and outer zones and the estimated bycatch per year of all animals in the inner and middle zones. The total estimated bycatch within the inner and middle zones across all regions is provided, along with the mean percentage of regions covered by the inner and middle zones (this mean has not been weighted by the size of region).

## Additional protection for small vulnerable colonies

The amount of protection required for smaller colonies is currently unclear (because it is influenced by the timeframe of the strategy, operational objectives and the assumptions around sub-population differentiation). If any female bycatch from the smaller colonies is not acceptable in the timeframe of the strategy, a trigger system cannot ensure this. If any bycatch mortality from the smaller colonies is not acceptable, then these zones should be combined with specific areas within which fishing is excluded, most likely based on proximity to these smaller colonies, and possibly accompanied by higher observer coverage in nearby areas.

This would be independent of any trigger system, but of sufficient size to reduce possible bycatch to amounts that are in practical terms insignificant for high value colonies.

# A Australian Sea Lion Scientific Working Group: meeting outcomes – 7 February 2011

The group clarified that several items of further work were required prior to the next review of the ASL working group scheduled for 4 March 2011.

These analyses were:

- 1 Analysis of the representativeness of observer effort to date to ensure that observer coverage reflects actual fishing effort i.e. examine distance from colonies during normal fishing operations compared to when observers are on board. This analysis will require use of the SARDI model to overlay fishing effort with sea lion foraging maps.
- 2 Combining initial SARDI observer information with observer coverage collected since mid 2010 during the ASL management strategy to examine consistency with the previous bycatch mortality results (incorporating e-monitoring shots as an additional and optional layer to this analysis, noting caveats around the ongoing verification of the use of cameras).
- 3 Identify refined management zones and levels of focused observer coverage that better reflect probability of encountering ASL bycatch. As a potential option, current management zones are to be split into three subsections based on low/med/high probability of encountering ASL. Low probability zones were to extend inwards from 183m depth closure to a line of bathymetry reflecting 120m depth (reflecting maximum ASL foraging depth) and have little/no coverage. The boundary of the medium (moderate coverage ~30% suggested) and high probability zones (100% coverage / mandatory cameras) was to reflect a compromise between the modelled distribution of foraging effort (as per Figure 7.22 of the SARDI report) and fishing effort. It was suggested that the line follow the outline of the yellow or red gradient lines of foraging effort. The effect of these refined zones on trigger levels and population survivability are also to be analysed.
- 4 Identification of which small colonies were to be included as viable subpopulations when setting triggers was to be revised with input from SARDI, AAD/ SEWPaC. A tentative level of greater than 5 pup production per breeding cycle was suggested for inclusion for now as an indicator of likely ongoing viable populations.
- 5 Refine estimate of 'maximum bycatch rate' using figures of 2 per cent and 1.5 per cent per breeding cycle (rather than the current short term estimate of 3 per cent mortality per breeding cycle i.e. 2 per cent per year) and examine how these figures would affect the trigger levels per zone and the survivability of smaller colonies.

**Action item: ABARES to work collaborative with SARDI and AFMA to achieve above analyses through integration of initial SARDI research with AFMA data acquired under first two quarters of the strategy (fishing effort, observer program shots monitored, e-monitoring observed shots)**

It was suggested that clear decision rules would need to be discussed by the ASL Working Group at the second quarter review regarding: the required amount of observer effort, triggers per zone and penalties associated with reaching triggers (i.e. rolling temporal closures).

The need for comment on this work prior to the second quarter review was raised. It was suggested that a concept paper be written that could be disseminated to participants outlining the proposal recommended by the scientific working group and detailing the:

- revised approach
- implications of the revisions
- feasibility of the proposed measures.

It was considered that it would be crucial to get industry feedback on the feasibility of the proposed measures prior to the second quarter review.

**Action item: AFMA to prepare a concept paper to be given to the working group prior to the second quarter review to gauge reaction to proposed measures**

## Other General Issues

The issue was raised that the need for further changes to the management strategy would need to be communicated clearly to the fishing industry, prior to the second quarter review. The rationale behind any changes and potential rezoning i.e. representativeness of achieved observer coverage and recent genetic work, needs to be communicated in an easy to understand manner to all stakeholders.

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Australian Government Department of Climate Change and Energy Efficiency	Horticulture Australia Limited
Australian Government Department of Resources, Energy and Tourism	Industry & Investment NSW
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