S8257

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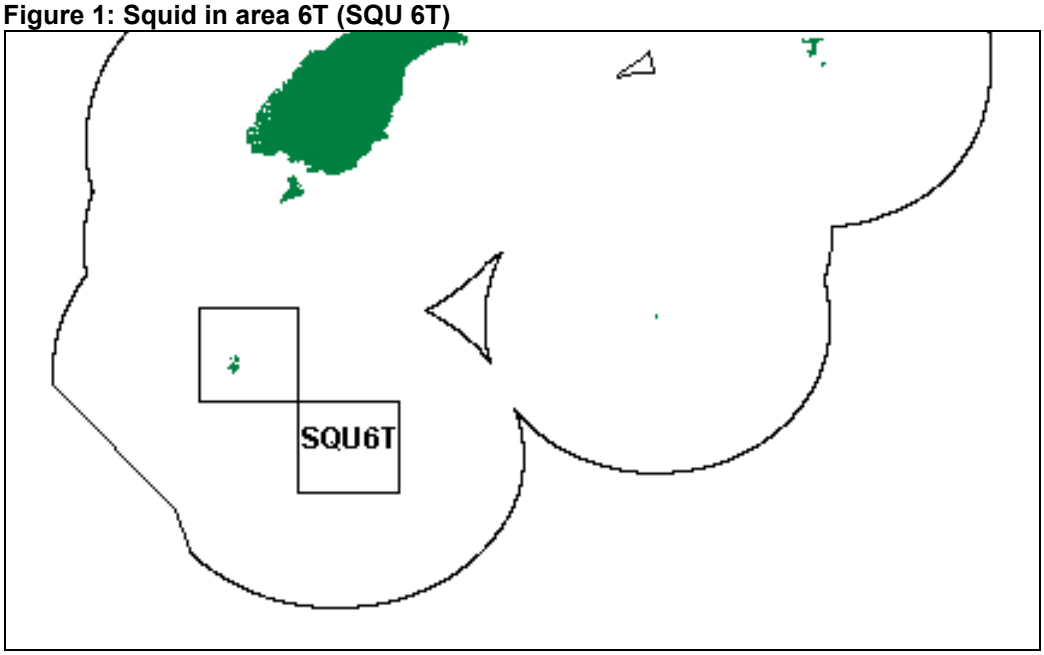
Minister of Fisheries

2007-08 SQU6T OPERATIONAL PLAN: FINAL ADVICE PAPER

1 This paper provides you with the Ministry of Fisheries (MFish) recommendations for the management of the interactions between the squid (SQU6T) fishery and New Zealand sea lions during the 2007-08 fishing year. Management of these interactions will be implemented through an Operational Plan under s 15(2) of the Fisheries Act 1996 (the Act).

Figure 1: Squid in area 6T (SQU 6T)



Executive summary

2 Under s 15(2) of the Act you may take such measures as you consider are necessary to avoid, remedy, or mitigate the effect of fishing-related mortality on any protected species, and such measures may include setting a limit on fishing-related mortality (FRML). The proposed management regime is similar to that used in previous years and focuses on the use of a FRML to constrain sea lion mortalities to an acceptable level.

3 If you agree a FRML is required, then a range of FRMLs is available to you based on the harvest control rules, assessed with the Breen-Kim model, which met the management criteria. Given the uncertainty associated with the Breen-Kim model and the fluctuations in sea lion pup numbers, MFish recommends that you set the FRML based on one of four harvest control rules: Rule 4, 320, 330 or 340. This recommended set of rules results in a FRML that is higher than that submitted by those with an environmental interest, and lower than that submitted by industry, although 222 is less than the 150 limit which industry have agreed to voluntarily implement. However, you may choose any FRML you consider appropriate.

4 A predetermined strike rate is used to assess fishing performance against the FRML. You are required to select the strike rate for the coming season. In past seasons this has been set at 5.3%, which is the mean strike rate observed between 1997 and 2003. MFish has reviewed the strike rate for the coming season to reflect the increase in tow duration observed in recent seasons; tow duration is one of the factors that influence the rate of sea lion captures.

5 Two possible strike rate options are presented. Option 1 is the status quo (5.3%); Option 2 (5.65%) is based on the mean of the predicted distribution based on observed (actual) and non-observed (estimated) captures between 2004-2006. There is uncertainty associated with each option but MFish considers they are both valid for your consideration.

6 Vessels that deploy an approved sea lion exclusion device (SLED) (see Appendix 1) have received a discount of 20% on the strike rate in the past to reflect the increased likelihood that sea lions can escape from nets fitted with these devices. There is continued uncertainty over the survivability of sea lions entering SLEDs, but MFish has included new information in this FAP relevant to SLED efficacy and has provided a range of possible SLED discounts from 20% to 40% for your consideration.

7 New information has been used to develop the management options presented in this FAP for your consideration. This information includes:

a) An increase in tow duration

b) Changes to SLED design

c) Performance of operators in deploying and using SLEDs during the 2006-07 season.

d) Necropsy[1] data on returned sea lions

e) 2006-07 pup count numbers.

8 MFish will continue to work closely with the Deepwater Stakeholder Group (DWG) to ensure the appropriate monitoring and reporting requirements are achieved during the 2007-08 fishing season.

Summary of options

9 MFish recommends you consider the following measures to manage the interactions between the SQU6T fishery and sea lions for the 2007-08 season:

[1] Necropsy is the examination of a dead animal to determine cause of death.

a) Implement an Operational Plan for the 2007-08 SQU6T fishery

b) Choose one of the following harvest control rules to set the fishing-related mortality limited (FRML) for the season:

   i) Rule 4: FRML of 81 sea lions

   ii) Rule 320: FRML of 111 sea lions

   iii) Rule 330: FRML of 167 sea lions

   iv) Rule 340: FRML of 222 sea lions

   v) Or any other FRML you consider appropriate.

c) Choose a predetermined strike rate of:

   i) 5.3%

   ii) 5.65%

   iii) Or any other strike rate you consider appropriate.

d) Permit vessels that deploy an approved SLED and where the requirements of the Operational Plan are fully met to receive a discount on the strike rate of:

   i) 20% (status quo)

   ii) 30%

   iii) 40%

   iv) Or any other discount rate you consider appropriate.

e) Close the SQU6T fishery under s 15(5) of the Fisheries Act 1996 in the event the FRML is reached.

Consultation

10 Your decision on management measures for the 2007-08 SQU6T fishery is made under sections 15(2) and 15(5)(b) of the Act and therefore the consultation requirements of s 12 apply.

11 Consultation on the IPP was undertaken with such persons or organisations representative of those classes of persons having an interest in the stock or the effects of fishing on the aquatic environment in the area concerned, including Maori, environmental, commercial and recreational interest.

12 The IPP was circulated to relevant stakeholders and was posted on MFish's website.

Submissions received

13 The following submissions were received:

a) Dr. Steve Dawson, Associate Professor, Marine Science Department, University of Otago **(Dawson)**

b) Deepwater Group Ltd and the Seafood Industry Council **(DWG/SeaFIC)**

c) Liz Slooten, Associate Professor, Department of Zoology, University of Otago (**Slooten)**

d) Te Runanga o Ngai Tahu **(TRoNT)**

e) New Zealand Wildlife Health Centre, Institute of Veterinary Animal and Biomedical Sciences, Massey University **(Wildlife Health Centre).**

14 A summary of submissions is available in Part 2 of this paper and copies of the full submissions are provided in Part 3.

15 Submissions revealed strongly held opposing views on where the FRML should be set for the coming season. DWG/SeaFIC support a FRML of 250 sea lions for the coming season although their submission does note that industry are willing to voluntarily limit the number of sea lion captures to 150.

16 Dr. Dawson supports setting the FRML using Rule 310 which is analogous to the PBR approach.[2] Under this rule the FRML for the coming season would be 53 sea lions. Liz Slooten also recommends that the sea lion limit is set using the PBR approach.

17 The Wildlife Health Centre did not comment specifically on the FRML but rather their submission addressed some technical issues regarding how the necropsy information was presented in the IPP. The Wildlife Health centre supports a SLED discount rate of 30% for the coming season.

18 TRoNT recommends that MFish adopts strategies and management measures necessary to minimise the death of sea lions as a bycatch of fishing activity in order to ensure that the Otago and Southland sea lion populations increase to a sustainable level.

Background information

19 The foraging range of sea lions that inhabit the Auckland Islands overlaps the fishing grounds of the SQU6T fishery and leads to the incidental capture of sea lions by trawl vessels.

20 The New Zealand sea lion is amongst the world's rarest sea lion and is currently listed as a threatened species under s 2(3) of the Marine Mammals Protection Act 1978. However, threatened species classification is made on the basis of the small number of breeding colonies, rather than the estimated adult population size of approximately 12,000 animals. Under this classification, the New Zealand sea lion is considered not immediately threatened with extinction, but could be vulnerable to population decline.

[2] Potential Biological Removal (PBR). The PBR approach is a recognised approach for determining the maximum number of animals, not including natural mortalities that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population when there is a clear understanding of the management goals but minimal information is available. However, for the Auckland Islands sea lion population there are considerable data that can be used and the Breen-Kim model was developed specifically to incorporate all of this data.

21 Section 15 of the Act sets out your responsibilities for managing the fishing-related mortality of marine mammals. In the absence of a Population Management Plan (PMP) which is the case for sea lions, you are required to consult with the Minister of Conservation before taking such measures as you consider necessary to avoid, remedy, or mitigate the effects of fishing-related mortality on sea lions.[3] Available measures include setting a limit on sea lion mortality.

22 DWG/SeaFIC submit that you are only required to take necessary measures to avoid, remedy or mitigate 'adverse' effects on the sea lion population. This view is based on the Court of Appeal decision by Justice Young in 2004[4] which states that 'we see this as implicit in the way s.15 (2) is expressed; the Minister may only take measures which he or she 'considers necessary' in terms of avoiding, remedying or mitigating adverse effects of fishing on a protected species'. While s.15 (2) of the Act does not explicitly include the word adverse, it could be argued that by its very nature 'fishing related mortality' on any protected species could be considered adverse.

23 In making your decision on management measures for the SQU6T fishery you are required to balance utilisation opportunities and the sustainability risk to the sea lion population. In particular you are required to consider:

a) The purpose of the Act and the need to provide for utilisation while ensuring sustainability.

b) Section 15 (2) of the Act requires you to take measures you consider **are necessary** to avoid, remedy or mitigate the effects of fishing-related mortality on any protected species.

c) Section 10 requires that any decision made should be based on best available information recognising that not all the information available is of the same standard.

d) That some of the best available information is uncertain. When dealing with uncertain information you are required to adopt a cautious approach that is appropriate to the circumstances.

e) Environmental principles set out in section 9 of the Act

   i) Associated or dependent species should be maintained above a level that ensures their long-term viability

   ii) Biological diversity of the aquatic environment should be maintained

   iii) Habitats of particular significance for fisheries management should be protected.

f) The sea lion is a protected species under the Marine Mammals Protection Act 1978.

24 You should also be particularly mindful of:

a) The impact the abundance of squid in any particular fishing season has on the likelihood of the FRML being reached

b) The uncertainties associated with the Breen-Kim model

[3] MFish does note that DOC are currently consulting on a PMP for sea lions. MFish has provided you with an initial briefing on this issue and further briefings will follow as required.
[4] Court of Appeal decision to set aside the 2003-04 Operational Plan, SFMC v Minister of Fisheries (CA39/04)

c) The uncertainties that surround the predetermined strike rate

d) The uncertainties that surround the levels of sea lion survival after they come into contact with and escape from the SLED.

25 Finally, the selection of the FRML, the predetermined strike rate and the SLED discount factor are individual and separate management decisions.

Rationale for management options

Fishing related mortality limit (FRML)

26 Under s 15(2) of the Act you may set a limit on fishing related mortality for sea lions. The FRML sets a limit on the maximum number of sea lions that can be caught annually as bycatch in the SQU6T fishery.

27 Since the 2003-04 fishing season the Breen-Kim model has been used to calculate an appropriate FRML. The model, in itself, does not determine FRMLs; these are calculated annually from the various harvest control rules that, in 2003, met the three management criteria described below. The Breen-Kim model allows the impact of different levels of sea lion mortality, or 'harvest control rules', to be examined, both in terms of their biological effects on the sea lion population and the potential fishing opportunities foregone as a result of constraining fishers from catching the squid Total Allowable Commercial Catch (TACC). A paper describing the Breen-Kim model in more detail can be found in Appendix 2.

28 Each harvest control rule is assessed against the following three management criteria:

a) Provide for an increase in the sea lion population to more than 90% of carrying capacity, or to within 10% of the proportion of carrying capacity that would have been attained in the absence of fishing.[5]

b) Attain the levels in (a), with 90% certainty, over 20-year and 100-year projections.

c) Attain a mean number of mature mammals that exceeded 90% of carrying capacity in the second 50 years of 100-year projection runs (to allow for build up of numbers in hypothetical depleted populations over time).

29 Table 1 below details the performance of twelve harvest control rules against the management criteria (performance of rules 360 and 370 do not appear explicitly in the 2003 Breen and Kim results). The model also details the impact of each rule against levels of sea lion bycatch and potentially lost utilisation.

30 To help interpret Table 1 the following provides an explanation for the numbers relating to Rule 320:

a) The chances that the model population will be at a level greater than 90% of carrying capacity or within 10% of the proportion of carrying capacity that would have been attained over a 20 year period is likely 99,989 times out of 100,000 (99.98% of cases).

[5] Carrying capacity of an ecosystem is the maximum size of a group (population, subpopulation, stock, etc) that can be supported by the ecosystem in which it lives.

b) The chances that the model population will be at or above 90% of carrying capacity or within 10% of the proportion of carrying capacity 90% of the time that would have been attained over a 100 year period is likely in 487,109 times out of 500,000 (97.42% of cases).

c) The requirement that the model population will be at or exceed the 90% carrying capacity criteria in the second 50 years of a 100-year projection run is likely in 93.4% of cases.

d) On average (based on 5,000 model runs) if the FRML is set using Rule 320 the fishery will forego 328 tows.

e) On average (based on 5,000 model runs) if the FRML is set using Rule 320 the fishery could potentially close early in 23% of seasons.

f) The maximum sea lion bycatch in any one year in 100 years will not on average exceed 151 sea lions, as calculated by the model.

g) The average annual bycatch over the same 100 year period will be 76 sea lions.

Table 1: Harvest Control rule performance against key indicators from the base case projections from Breen and Kim 2003

Harvest control rule	Crit20 [a]	Crit100 [b]	Nmat/K [c]	Lost fishing effort [d] (tows)	Seasons closed [e]	Max bycatch [f] (100yr runs)	Mean annual [g] bycatch
0	na	na	98.2%	2 910	100%	0	0
305	100 000	500 000	96.4%	1 614	77%	39	31
310 (Wade)	100 000	499 052	95.0%	904	52%	77	53
Rule 4	99 997	489 846	93.5%	350	24%	169	75
320	99 989	487 109	93.4%	328	23%	151	76
330	99 810	473 902	92.6%	138	11.1%	222	87
340	99 409	464 642	92.2%	64	5.7%	290	92
350	99 006	458 702	92.0%	31	3.2%	355	95
380	98 264	451 181	91.8%	0	0.7%	516	98
390	98 131	450 181	91.8%	0	0.5%	540	98
Cusp (392)	98 115	450 003	91.8%	0	0.4%	542	98
1	97 781	447 570	91.7%	0	0.0%	545	99

[a] **Crit20**: Whether the number of mature animals in the population in a specific year are **either** above 90% of *K* **or** above 90% of the numbers that would have occurred with no fishing, evaluated over the first 20 years of each run only with a pass level for this index of 90 000 out of 100 000 projection-run years.

[b] **Crit100**: Whether the number of mature animals in the population in a specific year are **either** above 90% of *K* **or** above 90% of the numbers that would have occurred with no fishing, evaluated for each of the half million years in a set of runs, and that it should be true for least 90% of years, ie 450 000 out of 500 000 projection-run years.

[c] ***Nmat*/*K***: the median of the numbers in the final year of each run expressed as a percentage of *K* - pass level for this index is 90% of *K*.

[d] **Lost fishing effort**: the median (of the 5 000 runs) of the mean tows lost through the operation of the harvest control rule during the run (as a measure of cost to the fishing industry), this is based on average annual fishing effort (2 871 tows) conducted during the years 1988-2003. It is not possible to determine percentage of tows lost at this stage, unless the model is run again with further indicators included.

[e] **Seasons closed**: the median % of seasons closed early through the operation of the harvest control rule during the run.

[f] **Max bycatch (100 yr runs)**: the median of maximum annual bycatch in each run.

[g] **Mean annual bycatch**: the median of mean annual bycatch in each run.

31 With the exception of Rule 1 (which models unconstrained fishing activity) all harvest control rules met the three management criteria detailed above when the model was developed in 2003. These harvest control rules remain unchanged from season to season and

each rule is used to calculate a possible FRML each season. The actual FRML will vary from year to year because the model input, the average of the previous two year's pup production numbers, can vary annually. As this average goes up, the calculated FRMLs for each of the harvest control rules will go up, and vice versa.

32 For the 2007-08 fishing season the rules use the average of the 2005-06 and 2006-07 pup production estimates from the Auckland Islands. The pup count estimates have increased slightly in the most recent year and for this reason the FRML based on each rule is slightly higher than it was last year. For example, Rule 320 produced a FRML of 109 for 2006-07 and a FRML of 111 for 2007-08

Breen-Kim model

33 The Aquatic Environment Working Group (AEWG) has accepted the Breen-Kim model as the best available model for testing whether rules for setting FRMLs achieve the specified management outcomes. However, a degree of uncertainty surrounds the results produced by this model; particularly around the likelihood of some of the higher rules continuing to meet the management criteria. More information on the types of uncertainty associated with the model is described later in this paper.

34 NIWA has recently been contracted to update the Breen-Kim model and this work is currently underway. The updated model will be available by mid 2008 and will be used to inform those making management decisions in future seasons irrespective of whether those decisions are made through a PMP or under section 15 of the Fisheries Act.

Strike rate

35 Once the FRML has been determined, fishing activity is then monitored against this limit. However, the actual number of sea lions that are incidentally caught in squid fishing gear cannot be directly recorded due to the use of SLEDs, which are designed to prevent sea lions from getting trapped in the trawl cod end.

36 Therefore a proxy for mortal interaction between squid vessels and sea lions is used. This is known as the predetermined strike rate (strike rate) and in recent seasons it has been set at 5.3% which was calculated from the actual strike rate from observed vessels from 1996-1997 to 2002-03. Applying this strike rate means that for every 100 tows undertaken in the squid fishery 5.3 sea lions are presumed killed and counted against the FRML.

Sea lion exclusion devices (SLEDs)

37 SLEDs are installed inside trawl nets to reduce sea lion mortality levels by allowing live animals to escape from the net. Three factors influence how effective SLEDs are at reducing sea lion mortalities:

a) Survival of animals that come into contact with the SLED grid[6]

b) The escapement rate of individuals from the net through the escape hatch following interaction with the grid

c) The survival rate of animals that do escape.

[6] The purpose of the grid is to prevent sea lions finding their way into the cod end. It is unlikely that any animal that passed through the grid into the cod end would be able to find their way back to the escape hatch.

38 Industry considers the deployment of SLEDs on SQU6T vessels results in far fewer sea lion mortalities and therefore vessels deploying SLEDs should be able to undertake more tows before reaching the FRML. However, information on SLED efficacy is incomplete; in particular the rate of survivability of sea lions that escape from SLEDs is still unknown.

39 In previous seasons vessels deploying approved SLEDs received a 20% discount on the strike rate. This discount rate was derived following an analysis of necropsy data from 7 sea lions caught in the cover net after 'escaping' from the SLED during the 2001-02 season. This discount reduces the strike rate from 5.3% to 4.24%, meaning that for every 100 tows from a vessel deploying a SLED, 4.24 sea lions are counted against the FRML.

40 In order for vessels to secure this discount, vessel operators must deploy an approved SLED and fulfill all monitoring and reporting obligations set out in the Operational Plan. These obligations are discussed in more detail in the later section on monitoring.

Assessment of management options

FRML

41 Fourteen harvest control rules have been assessed, using the Breen-Kim model, for the 2007–08 season. FRMLs have been produced for each of these rules (See Table 2 below). Rule 1 was the only rule that did not meet the three management criteria described above. In theory this permits you to set the FRML between 0 and 513 sea lions.

Table 2: FRMLs for the 2007-08 SQU6T fishing season for each of the 14 harvest control rules using latest pup production estimates.

Rule	Estimated FRML (numbers rounded)
Rule 0	no fishing (0 sea lions)
Rule 305	28 sea lions
Rule 310	56 sea lions
Rule 4	**81 sea lions**
Rule 320	**111 sea lions**
Rule 330	**167 sea lions**
Rule 340	**222 sea lions**
Rule 350	278 sea lions
Rule 360	333 sea lions
Rule 370	389 sea lions
Rule 380	445 sea lions
Rule 390	500 sea lions
Cusp Rule	513 sea lions
Rule 1	none

42 Rules at the lower end of the spectrum provide for less utilisation, whereas rules at the higher end of the spectrum provide opportunity for greater levels of utilisation. Conversely, rules at the higher end of the spectrum represent a greater risk to the sea lion population, whereas rules at the lower end of the spectrum represent little or no risk. When selecting an appropriate rule you should consider the extent of an increase or decrease in potential utilisation in the SQU6T fishery against the extent of an increase or decrease in possible sea lion mortalities and the impact this may have on the sea lion population.

43 In choosing where to set the FRML for the coming season you should be mindful of the fact that there is some degree of uncertainty surrounding the outputs from the Breen-Kim model given:

a) The recent period of decline in sea lion pup numbers

b) Acknowledged limitations with the Breen-Kim model.

Sea lion pup production numbers

44 Pup production from the Auckland Islands is used to estimate sea lion population size for that region. Table 3 below details the pup production estimates from 1998 – 2007. Although the 2007 pup count is higher than that of 2006, since 1998 pup production from the Auckland Islands overall has declined by 26.4%. There is no information to suggest that fluctuations in sea lion pup numbers are the direct result of fishing activity.

45 FRMLs calculated from the various harvest control rules take into account pup production in the two most recent years when modeling harvest control rules. Therefore the recent pup count increase is reflected in the FRMLs calculated for the 2007-08 season. This means that the FRMLs calculated for each of the harvest control rules are slightly higher than those same harvest control rules in the 2006-07 season.

46 DWG/SeaFIC are concerned that the decline in pup production numbers is being considered out of context. They submit that the 1998 pup production estimate was the highest recorded and it is unlikely that such a figure would remain stable, even in the absence of fishing activity, and therefore a decline in numbers is to be expected. They also submit that since the Breen-Kim population model already estimates year to year variation in pup production and includes this variability in the FRMLs produced, it is not necessary for there to be additional caution when setting the FRML resulting from pup production.

47 MFish has considered these points but notes that while a certain level of variability in pup production numbers was built into the model, current pup numbers are outside this range.[7] Therefore, MFish recommends you continue to be cautious when deciding where to set the FRML for the coming season.

[7] Recent pup counts were lower than the minimum estimates generated by the model, suggesting that insufficient process error was allowed in the model. The model cannot reproduce the declines seen recently, and survival rate or pupping rate may have changed. The effect of introducing more variability would be that high-numbered harvest control rules would no longer meet the 90:90:90 sustainability criterion, and the cusp rule would be some lower-numbered rule than 392. Lower pup counts would also cause uncertainty in the minimisation of the model because it assumes observation error and no process error.

Table 3: Pup production estimates from the Auckland Islands rookeries combined, 1998-2007 (Source: Department of Conservation).

Year	Pup numbers
1998	3021
1999	2867
2000	2856
2001	2858
2002	2282
2003	2518
2004	2515
2005	2148
2006	2089
2007	2224

Breen-Kim model limitations

48 Although the Breen-Kim model is being updated, AEWG considers the existing version to be the best available model to use when assessing the various harvest control rules. There are a number of limitations with this version of the Breen-Kim model that are acknowledged by MFish, AEWG and stakeholders and you should be mindful of these limitations when making your decision on where to set the FRML for the coming season. These limitations are described below:

a) The model is a representation of the actual squid fishery and sea lion population interaction. What is sustainable in theory may in reality be unsustainable if the model is not an accurate representation of real life. This means there is an inherent level of uncertainty associated with using this, or indeed any model.

b) Paul Breen, co-developer of the model, raised a number of possible issues at a 2006 AEWG meeting. He asserts that when these issues are tested they are likely to indicate that the existing model may have been pessimistic in some areas but is more likely to be optimistic in the majority of areas. These issues are discussed in more detail in Appendix 3

49 The model has also not been used in the way it was originally intended. The assessment of the ability of the harvest control rules to meet the sustainability criteria was based on an application of a particular rule for 100 years. The model's original purpose was to predict the likely management outcomes of a range of control rules applied consistently over 100 years. The expectation is that a rule is selected and the annual FRML is set using this rule. However, this is not how the model has been used; rather a FRML is selected on an annual basis irrespective of the rule that is used to generate it. It is not possible to assess how using the model in this way, changing the rules from year to year, will affect the model outputs.

50 DWG/SeaFIC actively support the use of the Breen-Kim model as it was originally intended - selecting a specific rule and applying it for an agreed period (possibly five years). MFish agrees and notes that this is the approach set out in the draft PMP. In the absence of a PMP MFish will progress this approach through a fisheries plan in time to drive the 2008-09 fishery.

51 Many of the issues raised by Slooten and Dawson in their submissions focus on concerns with the current iteration of the Breen-Kim model. These concerns have been discussed at AEWG and have been provided to NIWA for consideration as part of the work to update the

Breen-Kim model. MFish acknowledges there are concerns with the current iteration of the model and therefore recommends caution when interpreting the model results. MFish considers that disregarding the higher numbered harvest control rules (Rule 350 to the Cusp) should ensure the issues raised by Slooten and Dawson are suitably mitigated.

FRML for the 2007-08 season

52 In deciding where to set the FRML you must balance the utilisation opportunities in the squid fishery and the risks to the sea lion population. MFish recommends that you select a FRML within the range of 81 to 222 sea lions (rule 4 to rule 340).

Utilisation

53 The potential lost utilisation associated with the harvest control rules is difficult to determine accurately for the following reasons:

a) The availability of squid varies from fishing season to fishing season, which influences the number of tows undertaken and the amount of squid caught per tow.

b) Market price is influenced by the size and quality of squid, and the global availability and demand for squid. Market prices are currently depressed as New Zealand squid competes on the global market with squid from the South Atlantic.

c) Accurate information on the value of squid caught from the SQU6T fishery is not available. In its place MFish uses average port price per kg, which for 2007-08 is $790 per tonne. This is an indication of gross product (greenweight) value.

d) The ACE trading price is also a useful indicator of value since it provides an indication of the value of the fish less fishing costs. The current ACE trading price is within the range of $50 - $717 per tonne, with a weighted average price of $187 per tonne. Based on the current TACC the estimated value of the SQU6T fishery to operators is $8.37m.

54 Squid is one of the more important export earners for the seafood industry. In 2006 the total export value for squid was $118 million. This figure relates to exports from the entire squid fishery and it is not possible to determine how much of this export value has come from squid harvested in SQU6T. However, SQU6T produces approximately 30% of the total squid landings. Typically squid harvested from SQU6T is larger and commands a higher price.

55 This view is supported by DWG/SeaFIC who submit that the overall value of the squid fishery over time is the most important consideration. In their opinion 'point in time' fish prices are of little relevance given that infrastructural and market commitments and fishing contracts may be made over much broader time frames. DWG/SeaFIC consider the SQU6T export value is the best indicator of the value of the fishery.

56 In the past when preparing IPPs and FAPs MFish has estimated potential lost utilisation opportunities in terms of tows forgone and landed value of squid using the port price. However, MFish does not consider it useful to compare the potential lost utilisation opportunities associated with each FRML in terms of percentage of the TACC forgone.

57 MFish notes that the FRML imposes a theoretical cap on utilisation which may result in lost revenue but there are also other relevant factors:

a) Fluctuations in squid abundance mean that in many years it would not have been possible to catch the full TACC, even without the constraints of a FRML. Equally in years of good abundance the TACC may act as the limit in the fishery, not the FRML.

b) The use of port price to determine squid value is problematic and is likely to provide conservative estimates of lost revenue.

c) Calculating potential loss of earnings based on port price does not take into account the fixed and variable costs associated with fishing activity.

58 If you choose a FRML from the lower end of the range available this is likely to constrain fishing activity and may reduce both export earnings and the direct value of the fishery to industry, particularly if squid abundance is good.

59 You should also note that if the 2007-08 squid season is poor the FRML is likely to be reached with relatively little squid having been caught. It could also mean that the squid vessels will abandon the fishery before the FMRL is reached.

Analysis of harvest control rules

60 The three management criteria outlined in paragraph 28 set the threshold beyond which management intervention would be considered necessary. However, even if the management criteria have been met, you are still permitted to adopt a cautious approach, given the uncertainties associated with the Breen-Kim model, the fluctuations in the Auckland Islands sea lion population and the uncertainties associated with the strike rate used to monitor performance against the FRML. However, in choosing a cautious approach the appropriate degree of caution is that which is necessary in the circumstances.

61 As noted, Rule 1 does not meet the three management criteria and therefore is not included for further consideration. The remaining rules met the management criteria in 2003 when the original modelling was done but the uncertainties associated with the Breen-Kim model now means the higher rules may no longer meet the agreed criteria. This is being considered as part of the Breen-Kim model update currently underway.

62 The Cusp Rule is the rule that only just met the management criteria when the model was developed in 2003 and can therefore be used as the starting point for assessing which is the most appropriate rule to select. The further away from the Cusp Rule, the greater the likelihood that any uncertainties and risk will be mitigated.

63 Given the 26.4% decline in pup count numbers since 1998 and the uncertainties associated with the model, MFish does not recommend you set the FRML based on the higher rules (Rule 350, Rule 360, Rule 370, Rule 380, Rule 390, Cusp Rule). Although these rules met the management criteria when the model was developed in 2003, if the FRML is based on these rules, the assumption is that the pup numbers and model uncertainties are insignificant or of marginal effect. MFish does not believe this to be the case.

64 In addition, on average rules greater than 340 result in relatively small increases in utilisation opportunities but allow for greater levels of sea lion mortality as expressed in the higher FRMLs produced from these rules.

65 Setting the FRML, for the 2007-08 season, based on a harvest control rule lower than Rule 4

(Rule 0, Rule 305, Rule 310) provides for low levels of sea lion bycatch but could potentially considerably reduce fishing effort and therefore potential utilisation opportunities. At this time MFish does not consider the risk to the sea lion population warrants such a measure and setting an FRML based on these rules would likely over estimate the risk to the sea lion population that results from utilisation in the squid fishery. Therefore MFish does not recommend you set the FRML based on one of these four rules.

66 Therefore MFish recommends that you dismiss the higher and lower rules and set the FRML for the 2007-08 fishing season based on one of four harvest control rules as follows:

a) Rule 4: FRML of 81 sea lions

b) Rule 320: FRML of 111 sea lions

c) Rule 330: FRML of 167 sea lions

d) Rule 340: FRML of 222 sea lions.

67 A summary of each of the preferred rules follows:

a) Rule 4 is an adaptive rule and is based on sea lion bycatch relative to pup production estimates. Rule 4 is more responsive to the risk posed to the sea lion population when pup production is at low levels, but it also provides for more fishing opportunities when pup production is at higher levels. In relatively low pup production years, such as is currently the case, choosing Rule 4 places greater emphasis on the sustainability risk associated with fishing activity and the societal benefits associated with maintaining and protecting the sea lion population.

b) Choosing Rule 320 continues to place greater emphasis on sustainability at some risk to utilisation opportunities.

c) Choosing Rule 330 to set an FRML of 167 sea lions is unlikely to constrain the number of tows fishers can make since the number of tows permitted under this FRML (3,939 tows)[8] is in excess of the mean annual tows of 2,871. This is also well in excess of the average level of effort recorded in recent years (approx. 1724 tows).

d) Choosing Rule 340 places a greater emphasis on utilisation and will provide for greater levels of fishing effort. This rule will not provide for much additional utilisation opportunity beyond that provided for by Rule 330, but it will give industry greater headroom to fish to the limit of the TACC should there be a high level of squid abundance in the 2007-08 season. Of the four recommended harvest rules, this option poses the greatest risk to the sea lion population.

68 DWG/SeaFIC do not support selecting the FRML from one of these four rules as they believe it would unnecessarily constrain utilisation. In their opinion, a FRML less than 250 cannot be justified even on the most precautionary basis and they recommend you select a FRML of 250 sea lions for the coming season. They also submit that industry is willing to voluntarily limit the number of sea lion captures to 150 for 2007-08.

69 MFish does not support the approach of simply selecting a number without considering its relationship to the management objectives as it disregards the accepted management approach to choosing a FRML. This approach also contradicts the points made by

[8] This calculation includes the 20% SLED discount rate on the current strike rate of 5.3%

DWG/SeaFIC elsewhere in their submission when they comment on how the Breen-Kim model and harvest control rule should be used.

70 Slooten and Dawson both submit that the FRML should be based on the PBR approach which would equate to setting a FRML of 56 sea lions based on Rule 310. As noted previously, the PBR approach is a valid approach to use when there is a clear understanding of the management goals but minimal information is available. This is not the case for the sea lion population where there is considerable data available and the Breen-Kim model was developed specifically to incorporate all this data. MFish also considers choosing the FRML based on this rule would be more restrictive than is necessary because it would overestimate the risk that results from utilisation in the squid fishery to the sea lion population.

71 MFish does acknowledge there is strong public opinion on this issue in favour of greater sea lion protection. This is reflected in the many public awareness campaigns requesting you to reduce the levels of sea lion mortality from fishing to close to zero. In deciding where to set the FRML for the coming season you may take into account other factors that you consider relevant, such as societal values. For instance, you may consider this public interest when deciding how much risk is acceptable and where the FRML should be set so as to ensure uncertainty is appropriately managed.

72 DWG/SeaFIC do not support you explicitly considering societal values when choosing a FRML as they believe these views are already incorporated into the wider consideration of 'utilisation', as per the definition of this term set out in the Act. MFish does not support this view and considers, conversely, that the very fact that 'social and cultural wellbeing' are explicit components of the Purpose of the Act means you are required to consider these factors, alongside pure economic utilisation, when choosing management measures for the coming season.

73 MFish also notes that TRoNT in their submission state that government should adopt strategies and management measures necessary to minimise the death of sea lions as a bycatch of fishing activity in order to ensure the Otago and Southland sea lion populations increase to a sustainable level. TRoNT also state that at some point in the future Ngai Tahu Whanui would like to be able to exercise their customary right to sustainably harvest sea lions. MFish considers that meeting the 90:90:90 management criteria should provide for sea lion expansion into other communities which may mean Nagai Tahu can exercise their customary right in the future.

74 MFish considers that, given the status of the current pup production estimates, uncertainties with the Breen-Kim model and the difficulties in setting an accurate strike rate, selecting the FRML from the four rules described above is appropriate.

Strike rate

75 MFish proposes to continue to estimate sea lion mortalities using a predetermined strike rate. The IPP presented two options for an appropriate strike rate for the 2007-08 fishing season, 5.3% (status quo) and 5.65%.

76 The 5.3% rate used in past years was based on a simple average (the mean) of the actual strike rate amongst vessels operating in the SQU6T fishery during seven fishing seasons from 1996-97 to 2002-03. This average is based on observed seasonal strike rates which ranged from 2.8% to 11.8% in any one year. Therefore there is some uncertainty associated

with the actual annual strike rate and it is likely to vary from year to year. In some years (when the actual strike rate is at the higher end of the range) the number of sea lion mortalities could be underestimated by 55%. In other years the actual strike rate in a season could reflect the lower end of the range and the number of sea lion mortalities could be overestimated by 90%. This level of variation between years is not necessarily a problem, as long as over time the actual average strike rate is close to 5.3%. In effect a higher actual strike rate in one year is offset by a lower actual strike rate in other years.

77 Since 2003 the actual strike rate has not been monitored because the use of SLEDs means it is not possible to assess the actual number of sea lion interactions with squid trawl gear as sea lions now have a method of escape.

78 Fishing practices appear to have changed in recent years, including an increase in observed tow duration.[9] The median tow length observed in 2006-07 was 6.8 hours, compared to median tow duration of 5.8 hours in 2005-06 and 4.0 hours in the 2002-03 fishing season. Research indicates there is a correlation between tow duration and rate of sea lion capture, although tow duration is not the most significant factor to influence capture rates (for example, distance from the sea lion colony and time of year of capture are more important). This means the current strike rate of 5.3% could underestimate the extent of the interactions between squid fishing vessels and sea lions.

79 The recent observed increase in tow duration is likely influenced by two factors:

a) Since performance against the FRML is measured in tows, the incentive is for vessel operators to maximise the potential squid harvest from each tow – one way to achieve this is to tow for longer.

b) Different vessels engage in different fishing practices to reflect gear configuration and market demands. As a result some vessels tow for longer periods as part of their normal fishing practice. MFish considers a greater number of these vessels are now operating in SQU6T.

80 To inform the decision on strike rate, MFish requested NIWA to model the mean strike rate for SQU6T vessels for each of the following three fishing seasons; 2003-04, 2004-05 and 2005-06. These three years also coincide with a period of continuous increased tow duration. This analysis produced a mean strike rate of 5.65%. However, there is a high degree of uncertainty associated with this value because it is based on tows where there is a strong likelihood that some form of SLED was used. Therefore this modelled value is based on limited data and consequently there is a high degree of uncertainty associated with it.

81 In contrast the existing strike rate of 5.3% is based on actual observed interactions from vessels that were not deploying a SLED; however this strike rate does not take into account the recent increases in tow duration.

82 DWG/SeaFIC do not consider there is any credible basis on which to increase the strike rate. MFish disagrees with this view and considers that the available information supports either the 5.3% or 5.65% options.

83 DWG/SeaFIC propose that before an appropriate strike rate can be determined there should

[9] Tow duration represents the length of time nets are engaged in trawling – it does not include shooting and hauling time.

be a clear statement of the management objective behind setting the strike rate. They submit that the default management objective is that there is a 50% risk that the true bycatch is lower or higher than that estimated from the strike rate.

84 MFish supports the approach of developing an explicit management objective on how performance against the FRML should be determined but considers this would require a level of analysis and engagement with stakeholders that is not permitted within the timeframes of this advice paper. MFish proposes to work with stakeholders to progress this issue as part of the squid fisheries plan. MFish has discussed this with SeaFIC and they agree that this is a better way to address this issue.

85 MFish has also considered options to improve information to assess the strike rate. One option could be to request some vessels in the SQU6T fleet to fish without SLEDs or to use SLEDs with cover nets tied down, thus preventing sea lions escaping from the SLED and enabling them to be recovered for counting.

86 DWG/SeaFIC also do not support undertaking this type of research because it is not clear what the management value of such research would be. In contrast Slooten and Dawson support this research as they believe it will improve information on actual interactions between squid vessels and sea lions.

87 MFish does not consider this research is necessary at this time. However MFish does note that it will become increasingly more difficult to obtain information on strike rate as SLED design improves and the number of sea lions retained in the net reduces. Alternative methods to calculate the strike rate or to monitor performance against the FRML, that doesn't include the deliberate drowning of sea lions, may need to be developed. MFish considers such work can be progressed, as appropriate, as part of the fisheries plan development process.

88 MFish is providing you with two options for the strike rate for the 2007-08 season:

a) Option 1 (status quo): 5.3%

b) Option 2: Increase the strike rate from 5.3% to 5.65% as per the average strike rate estimated from the past three fishing seasons, to reflect the recent increase in tow duration.[10]

89 There is uncertainty associated with the two strike rate options and you must be mindful of this uncertainty when making your decision, but MFish considers they are both valid for your consideration. You may also set the strike rate at any level that you consider appropriate.

SLED Discount Rate

Calculation of discount rate

90 In recent seasons a 20% discount on the strike rate has been applied to tows where vessels deploy approved SLEDs and where vessel operators have complied with the monitoring and

[10] Tow duration has increased further in the 2006-07 recent fishing season, which was not included in the NIWA analysis.

reporting requirements of the Operational Plan. This means that for eligible tows the strike rate was reduced from 5.3% to 4.24%.

91 This 20% discount rate was derived following an analysis of necropsy data from 7 sea lions caught during the 2001-02 season. These animals were selected because they were caught in vessels where SLEDs were deployed and where cover nets were tied down, preventing the animals from escaping. These recovered animals had in theory escaped from the net through the escape hatch in the SLED.

92 These necropsies indicated that 5 of the 7 sea lions were unlikely to have survived the trauma associated with their capture, had they not drowned. This assessment was made because many of the animals displayed severe head trauma that may have been caused by interacting with SLED grid bars. This study therefore assumed that 29% of sea lions would be likely to survive following interactions with a SLED, had they been able to escape. Given the small sample size and the uncertainty associated with the study, a discount factor of 20% was considered appropriate.

93 There are a number of factors that may suggest that an increase to the 20% discount is appropriate:

a) Considerable work has gone into improving the design and deployment of SLEDs since the study was conducted in 2001-02. This work is ongoing and is described in more detail below.

b) The necropsy data from animals recovered in 2005-06 and 2006-07 suggests that many of the sea lions interacting with the SLED grid did not sustain severe or fatal injuries and were likely to have survived had they managed to escape. MFish does acknowledge that sea lion prognosis is inherently subjective. This is discussed in greater detail below.

c) Necropsy data also suggests that soft tissue bruising of the body wall and head has also been found in sea lions that were caught when no SLED was deployed which would indicate that some of the trauma observed is not necessarily caused by animals interacting with SLEDs.[11]

94 The Wildlife Health Centre, which performs the sea lion necropsies, submits that preliminary necropsy work carried out earlier this year indicates that some of the necropsy findings previously believed to reflect significant trauma (and therefore to imply a poor prognosis) are actually likely to be artefacts of the freezing of the sea lion bodies. While this work is in its early stages it could have important implications for how the sea lion prognosis is determined in the future, particularly for those animals categorised as experiencing moderate trauma.

95 Environmental NGOs have not supported the use of a discount factor in the past because:

a) They considered the sample size from the 2001-02 study was too small to produce any meaningful results.

b) There is limited information to support the efficacy of SLEDs.

[11] Personal communication between Wendi Roe, Veterinary Pathologist, Massey University and the DWG forwarded to MFish.

Recent and ongoing improvements in the developments and deployment of SLEDs

96 MFish agrees that a 20% discount rate was appropriate in the early years of SLED development as improvements were required to the SLED design, and there was some uncertainty with the quality of SLEDs used by some operators.

97 In recent years, industry has engaged in a continuous programme to update and improve SLED design through the SLED working group. Much of these recent improvements have focused on the design and manufacture of the SLED grid; particularly the grid bar spacing and the material used in its construction. In previous seasons, the grid failed in some cases and sea lions were recovered from the codend. However, none of the 8 sea lions caught in the most recent season were found in the codend. This suggests that the improvements to the SLED grid are ensuring that sea lions remain in the area of the net close to the escape hatch.

98 However, in spite of the improvement to the grid design and construction, 8 actual sea lion mortalities were recorded for the 2006-07 season. Two vessels were responsible for five of these deaths and the SLEDs from these two vessels underwent a post-season audit to assess what, if anything, may have contributed to the high number of fatal interactions. Evidence from the net manufacturer who undertook this audit, who is experienced in net structure and water dynamics, suggests that the sea lions were unable to exit the escape hatch following interaction with the SLED grid. Following this audit, further technical improvements to SLEDs have been devised for the coming season. These improvements will be made in time for the start of the 2007-08 season and relate to the SLED hood and kite.

99 This focus on the escape mechanism is supported by recent camera footage from one of the vessels operating in SQU6T in the 2006-07 season.[12] The footage taken during a commercial squid fishing tow, using an infra red camera at a depth of 182 meters, shows that when kites and hoods are not constructed with sufficiently robust material and are not attached correctly, water pressure can force the escape hatch to close over, which means a sea lion would have no way to get out of the net. MFish is confident this issue will be addressed in the coming season, as all SLEDs used in the 2007-08 squid fishing season will be modified to ensure that the hoods, kites and escape hatches are working effectively.[13]

100 MFish acknowledges the steps that industry has taken step to improve the SLED design in an effort to provide maximum opportunity for sea lions to escape from squid trawl nets. However, the success of these modifications cannot be known with certainty since there is no known method of measuring the survivability of sea lions that interact with SLEDs. MFish believes these ongoing improvements to SLED design should lead to greater levels of sea lion survival than have occurred in the past. For this reason MFish recommends you consider a higher discount rate at this time.

Necropsy data

101 The original discount rate of 20% was based on necropsy information from sea lions caught in the 2001-02 fishery when SLEDs were in place with cover nets closed. Every year sea lions caught in the SQU6T fishery are necropsied to assess, amongst other things, the likely cause of death, the extent of injuries and the link between these injuries and the death of the

[12] This camera footage is from an ongoing industry funded project to gather evidence on sea lion interactions with SLEDs.
[13] These improvements are being funded by DOC and DWG with support from MFish.

sea lion.

102 As SLED use has increased (although MFish believes that full SLED deployment compliant with specifications was only achieved in the current fishing year) the nature of the sea lion injuries and the impact they have on survivability have likely changed. In recent years, injuries have been classed as mild, moderate and severe. Animals displaying mild to moderate injuries are considered likely to survive if they had escaped the SLED. Animals displaying severe injuries are deemed unlikely to survive. The Wildlife Health Centre does note that determining a prognosis can be very subjective.

103 More recent sea lion necropsy data indicates that in the majority of cases animals that interact with SLEDs are unlikely to incur fatal or serious injuries which would limit their survivability should they escape from the net.[14] For example, necropsy data from the 10 sea lions caught during the 2005-06 fishing season indicates that three of the animals had injuries classed as severe by the pathologist, which would suggest they would not have survived if they had successfully escaped from the SLED.[15]

104 The necropsy results from the 8 sea lions caught during the 2006-07 confirm that interaction with SLEDs do not always result in life threatening injuries. Of the 8 sea lions, the pathologist classed the injuries of 2 of the sea lions as 'severe'. As discussed previously, additional work on fur seal autopsies also suggests that some of the injuries observed in sea lions in previous seasons may have been due to the impact of freezing on the sea lion carcass.[16] This research will have important implications for future sea lion prognoses, particularly for the 'moderate' trauma group.

105 This information is in contrast to the necropsy date from 2001-02, which was used to set the current discount rate, when five of the seven animals were believed to have experienced severe trauma which would have limited their survivability if they had escaped. The greater frequency of severe injuries in early years may be related to poorer quality SLED design and deployment than that employed currently.

106 In recent seasons, the necropsied animals have been recovered from vessels where SLEDs were deployed and where cover nets were open. Therefore deaths of these animals reflect a failure in the operation of the SLED. The continued improvements in SLED design and their deployment are designed to address these failures.

107 MFish intends to commission the necropsy of sea lions captured in other fisheries. This will allow for a comparison of injuries to sea lions in both SLED and non-SLED fisheries. A

[14] However the necropsy data is based on a small number of animals and it is difficult to be certain that this is a trend rather than a statistical blip.

[15] 11 sea lions were caught in the 2005-06 season but one of the sea lions caught was in a decomposed state which suggests it was dead before it was hauled up.

[16] Blood-tinged fluid was present in the abdominal cavity of all autopsied sea lions. Two fur seals were autopsied both before and after freezing, as part of an evaluation of whether freezing is a plausible source of this fluid. Neither fur seal had fluid in the abdominal cavity prior to freezing, and both had such fluid after having been frozen from 4 to 5 weeks (150 ml and 250 ml). Therefore, "the results of this initial trial indicate that the fluid seen in the abdominal cavities of bycaught sea lions is consistent with that expected to occur as a direct result of freezing. This observation, in conjunction with the lack of observed trauma to body organs and major vessels strongly suggests that the presence of blood-tinged abdominal fluid is not a result of blunt trauma, and should not be included in any assessment of trauma severity or survival prognosis." Source: Necropsy of marine mammals captured in New Zealand fisheries in the 2006-07 fishing year. Report prepared by W.D. Roe , Institute of Veterinary, Animal and Biomedical Sciences, Massey University.

comparison of injuries will assist in determining the extent to which the cause of death is related to the SLED as opposed to drowning, pre-existing injuries or handling on deck.

108 MFish considers necropsy data provides useful information which suggests that a greater number of sea lions do not experience fatal injuries when interacting with SLEDs and therefore have a greater likelihood of long-term survival if they manage to escape from the net. This further reinforces the need to improve the escape hatch design, which is the focus of the current programme of pre-season SLED audits.

109 MFish does acknowledge that the sea lions caught in nets with SLEDs which are returned for necropsy may not be representative of sea lions that escape. MFish also acknowledges the limited sample size used and the fact that any assessment of prognosis is inherently subjective and is particularly difficult to determine in the group of animals found to have moderate levels of trauma.

Discount rate options

110 The information available gives no clear guidance on the efficacy of SLEDs in mitigating fishing vessel and sea lion interactions. However, in recent years there have been ongoing improvements in the development and use of SLEDs. This is supported by the necropsy data which indicates (albeit not conclusively) that fewer sea lions appear to be receiving severe injuries from interactions with SLEDs, and that SLEDs may have the potential to be more effective than the current discount rate of 20% suggests.

111 Based on this assessment, in the IPP MFish proposed the following discount rates for the coming season:

a) Option 1 (Status Quo): A discount of 20% on the predetermined strike rate

b) Option 2: A discount of 30% on the predetermined strike rate

c) Option 3: A discount of 40% on the predetermined strike rate.

112 DWG/SeaFIC do not support any of the options proposed in the IPP and consider that the best available information suggests that a discount factor of 53% should be applied. This figure is based on a SeaFIC/DWG interpretation of the necropsy data as being directly indicative of the likely survivability of sea lions that interact with squid gear and SLEDs.

113 The Wildlife Health Centre considers an increase to the discount rate may be appropriate but that an increase greater than 30% is not warranted at this time.

114 Dawson does not support any increase to the discount rate as he believes there is no convincing evidence that the survivability of sea lions that have escaped through the SLED has improved.

115 MFish considers it is likely that sea lion survivability from encounters with SLEDs has the potential to be higher than the current 20% discount if the escapement mechanism can be perfected or significantly improved. For this reason MFish considers a discount rate of greater than 40% is not warranted given the unproven effectiveness of the current improvements to SLED design. If in future seasons the improvements to the escape hatch result in fewer animals drowning in SLEDs then the discount rate will be reviewed.

116 MFish considers there is sufficient information to suggest increasing the discount rate from

20% and therefore recommends a 30% discount rate is set for the coming season. MFish acknowledges that Options 2 and 3 are not based on an analysis that 30% or 40% (respectively) of sea lions are surviving; the discount rate is not equivalent to the survival rate of sea lions because there are still some fatal interactions between sea lions and squid trawl gear that contains SLEDs. Instead these are increases over the current rate of 20% that you may consider reasonable given the above information.

117 As decision maker, you must be satisfied that recent necropsy results and improvements in SLED design are likely to result in increased survivability of sea lions warranting a discount rate greater than 20%. You are not limited to the options listed above and may set the discount rate at whatever level you consider best meets your obligations under the Act.

118 The following table details the likely impact of these discount options on the strike rate options for the coming season.

Table 4: Proposed strike rate options for the 2007-08 SQU6T and relationship with discount factor

	Discount factor		
Strike rate	Option 1 20%	Option 2 30%	Option3 40%
5.30%	4.24%	3.71%	3.18%
5.65%	4.52%	3.96%	3.39%

119 MFish recommends you select one of the following options for the SLED discount rate for the coming season:

a) Option 1 (Status Quo): A discount of 20% on the predetermined strike rate.

b) Option 2: A discount of 30% on the predetermined strike rate (MFish recommended option)

c) Option 3: A discount of 40% on the predetermined strike rate

d) Or such other discount factor as you consider necessary in the circumstances.

Monitoring and reporting requirements

120 MFish proposes to implement the same monitoring and reporting procedures that were in place for the 2006-07 season. This will require:

a) The fishing vessel operator to notify the MFish Observer Programme at least 72 hours before leaving port to ensure there is sufficient time to place an observer on board the vessel before it sails. This notification may also be used as an opportunity for fishery officers to undertake a port inspection of the SLED.

b) The Master of the fishing vessel is required to report to MFish, at the end of the fishing trip, any encounter with a marine mammal that resulted in death or injury. MFish observers will notify the Observer Programme immediately following the capture of sea lions.

c) All vessels in the SQU6T fishery will participate in a weekly reporting regime managed by the Deepwater Group Ltd (DWG). When 70% of the FRML is reached, reporting will be daily. The information reported will include:

i) Each tow undertaken in the SQU6T fishery

ii) Whether the tow was observed by an MFish Observer

iii) If an approved SLED was deployed during the tow

iv) If any sea lions were caught during the tow and whether they were released alive, retained or returned dead to the sea.

121 Before a vessel can receive the recommended SLED discount rate certain conditions must be met.

a) Vessels must deploy a SLED that meets the approved design specification (Mark 3/13 design).

b) The SLED must be deployed with the escape hatch open at all times during fishing operations.

c) Each SLED must be stamped with a unique number and photographed before the start of the fishing season by the DWG.

122 MFish will continue to work closely with the DWG to ensure these conditions are met and there is accurate monitoring against the FRML throughout the squid fishing season. This will include participating in the pre-season briefing with all operators on the 15 November 2007. MFish is confident that the good performance experienced in the 2006-07 will continue and further improvements will be made.

123 Information received by MFish that a vessel intends to deploy an approved SLED during the 2007-08 season will be made available to the both the MFish Observer Programme and MFish Compliance to enable observers and fishery officers to inspect SLEDs to ensure:

a) The vessel is carrying the SLED for which it was given approval and,

b) The SLED has not been adjusted or modified and is in working order.

124 As in previous seasons, MFish intends to retrospectively remove the discount rate accreditation for all tows where a non-approved SLED was deployed or where the reporting requirements have not been met.

125 MFish also intends to request vessel operators, in cooperation with DWG, to return all dead sea lions caught during the SQU6T season irrespective of whether the vessel is carrying an MFish observer. These sea lions will be returned to Massey University for necropsy.

126 MFish also intends to continue with a target of 30% observer coverage across the SQU6T fishery during the 2007-08 fishing season. In 2006-07, 41% of tows were observed in the fishery.

Closure procedures

127 Under s 15 (5) of the Act you may close the SQU6T fishery when the FRML is reached.

128 MFish will work with the DWG to monitor in-season performance against the FRML. Should the estimated mortality get close to the FRML, MFish will advise you of this fact so you may close the SQU6T fishery by Gazette Notice.

129 This closure will be undertaken without consultation but MFish will ensure all participants in the fishery are kept updated on levels of fishing activity against the FRML throughout the fishing season. For the past two seasons, MFish has sent weekly reports to all stakeholders

providing information on progress towards the FRML, so ample warning of the closure will be available.

Future management

130 MFish and the DWG are in the process of developing a squid fisheries plan that will include the SQU6T fishery. This plan will build on recent initiatives to manage seabird and marine mammal interaction and will also include key bycatch species. The draft squid fisheries plan will be consulted on widely with stakeholders before being provided to you for approval for the start of the 2008-09 fishing season.

Statutory considerations

131 The following statutory considerations have been taken into account in developing this advice paper on the interactions between the SQU6T fishery and sea lions.

132 **Section 8:** MFish considers the management options presented in this paper provide for utilisation in the SQU6T fishery while ensuring the sustainability of the squid stock and managing non-fish interactions.

133 In deciding where to set the FRML you must balance the need to provide for utilisation while ensuring the sustainability of sea lions and other non-fish bycatch. If you choose a higher FRML you are giving greater emphasis to utilisation over sustainability. If you decide to choose a lower FRML you are giving greater emphasis to sustainability over utilisation.

134 **Section 5(a) International and Settlement Obligations:** Decision-makers are required to act in a manner consistent with New Zealand's international obligations relating to fishing, including the Law of the Sea and the Fish Stocks Agreement as well as regional fishery management agreements. Decision-makers must also act in a manner consistent with the provisions of the Treaty of Waitangi (Fisheries Claims) Settlement Act 1992. MFish considers the proposed options are consistent with both New Zealand's international obligations relating to fishing and the provisions of the Treaty of Waitangi (Fisheries Claims) Settlement Act 1992.

135 **Section 9 (a):** The management proposals recommended to you in this advice paper have been developed so as to ensure the sea lion population around the Auckland Islands will be maintained above a level that ensures their long term viability.

136 **Section 9 (b) and (c):** The specific impact of squid trawling in the SQU6T fishery on biological diversity and habitats of particular significance is not known. Squid vessels engage in both mid-water trawling and bottom trawling in SQU6T.

137 **Section 10:** MFish considers the information used to support the proposals set out in this paper is the best available information. Given the uncertainties associated with some aspects of this information the management options proposed balance the risks to both potential utilisation and the sustainability of the sea lion population.

138 **Section 11A – Fisheries plans:** There is currently no fisheries plan in place in the SQU6T fishery. However, work is progressing on developing a fisheries plan for squid which will include SQU6T and this is discussed in this advice paper in the section on future management.

139 **Section 15 (2):** MFish considers that providing recommendations on a FRML satisfies your requirements to take such measures as you consider necessary to avoid, remedy or mitigate the effect of fishing-related mortality on the sea lion population.

140 **Section 15 (5):** This section provides you with the discretionary power to prohibit all or any fishing if the fishing-related mortality limit has been met. This has been addressed in this final advice paper in the section on the assessment of management options.

Ngai Tahu Claims Settlement Act 1998

141 Section 288 of the Ngai Tahu Claims Settlement Act 1998 requires the Crown to acknowledge the cultural, spiritual, historic, and traditional association of Ngai Tahu with their taonga species. Section 287 prescribes the New Zealand sea lion (or Rapoka/Whakahao) as a taonga species under this Act.

Recommendations

142 MFish recommends you consider the following management measures to manage interactions between the SQU6T fishery and the sea lions for the 2007-08 fishing season.

a) **Agree** to implement an Operational Plan for the 2007-08 SQU6T fishery to ensure the management objectives for the sea lion population are met;

b) **Agree** to choose one of the following harvest control rules to set the FRML for the season:

i) Rule 4: FRML of 81 sea lions

or

ii) Rule 320: FRML of 111 sea lions

or

iii) Rule 330: FRML of 167 sea lions

or

iv) Rule 340: FRML of 222 sea lions

or

v) Any other FRML you consider appropriate.

c) **Agree** to use a predetermined strike rate, to estimate the total number of sea lion mortalities against the FRML, of either

i) 5.3% (status quo)

or

ii) 5.65%

or

iii) Any other strike rate you consider appropriate.

d) **Agree** to apply a discount on the strike rate (discount factor) to those vessels deploying an approved SLED and where the prescribed reporting procedures have been met of either:

i) 20% (status quo)

or

ii) 30% (MFish recommended option)

or

iii) 40%

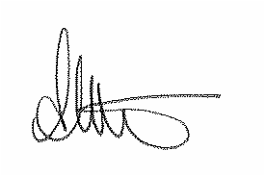
or

iv) Any other discount factor you consider appropriate.

e) **Note** that you may close the SQU6T fishery under s 15 (5) if the Fisheries Act in the event the FRML is reached.

f) **Note** that Ministry officials are available to brief you on this issue at your convenience.

g) **Note** you are required to consult with the Minister of Conservation. An additional copy of this Final Advice Paper and a letter to the Minister of Conservation are provided.



Stefan Leslie
Manager, Deepwater Fisheries

APPROVED/NOT APPROVED/APPROVED AS AMENDED

Hon Jim Anderton

Minister of Fisheries

/ 11 /2007

SLED Specification October 2006

MK. 3/13 SLED Specification

For the use in the 2006/07 SQU 6T Fishing Season

The SLED required for use by all vessels in the 6T squid fishery is an approved type that meets the following criteria:

1. The SLED must consist of a lengthener section of net, with either 2 or 4 seams, containing a 2 (or 3) piece grid, hinged along the middle. The grid should be set in the net at about 45° ±5° downstream from the vertical and continuously sewn to the net meshes around its circumference.

2. The grids must be constructed of **minimum 20mm stainless steel bar** and should be shaped to conform to the working parameters of the net.

3. Vertical **grid bars** must be **evenly spaced** at a **maximum distance** of **23cm between bars** (see diagram). There will be no minimum number of bars, provided they are **evenly spaced** and do not exceed the recommended maximum spacing.

4. The Escape Hatch must be triangular and let into the upper surface of the lengthener section. The hatch must be a **minimum of 1metre wide at the base**, along the top bar of the grid. The apex of the triangle must be a **minimum of 1metre forward** (upstream) of the base (refer diagram).

5. Above the Escape Hatch, a hood-shaped mesh scoop must be attached with its open (leading) end facing into the water-flow and its closed (trailing) end attached one to three meshes behind the top bar of the grid. The leading edge of the Hood must be a **minimum of 80cm high** when fully extended.

6. The Hood must have a strip of semi-rigid material (Kite) under the meshes of the Hood. The leading edge of the Kite must be attached to the leading edge of the Hood. The leading corners of the Hood must extend forward of the Escape Hatch.

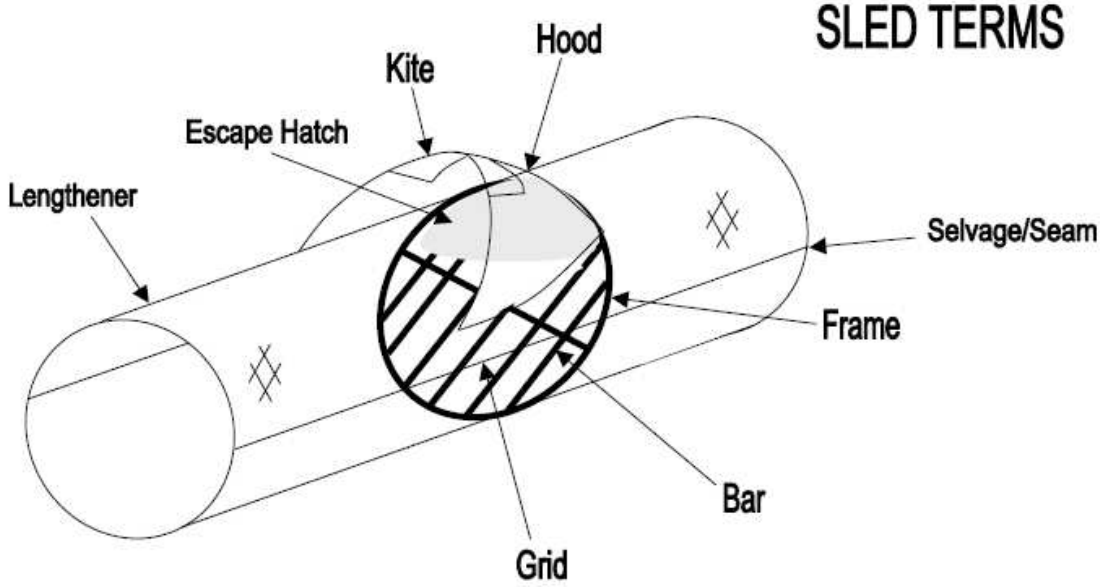
7. The SLED must be inserted into the trawl with the Escape Hatch on the upper surface when the net is fishing.

8. There are elements of the SLED configuration that may vary including, the presence or absence of floats attached to the grid or kite, the shape, width and height of the grid, the number of vertical bars in the grid, the number of meshes in the hood, the number and size of meshes in the lengthener section depending on the net in which the SLED is inserted.

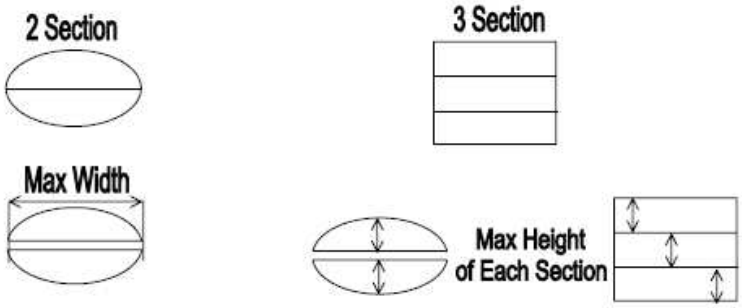
9. Each SLED grid frame must have a unique registration number, identifying it as an approved unit, clearly stamped into the frame bar at each end of each hinge section. Each SLED registration number will be recorded by Deepwater Group Ltd. DWG's register of SLED numbers must be provided to MFish as required.

10. **Clarification:** For clarity please note that while the specification calls for bar spacings in the grid to be even, it may be necessary to have the last spacings between the final bar and the grid frame differing from the rest of the spacings. Provided they are **always LESS THAN 23cm** apart between bars and frame.

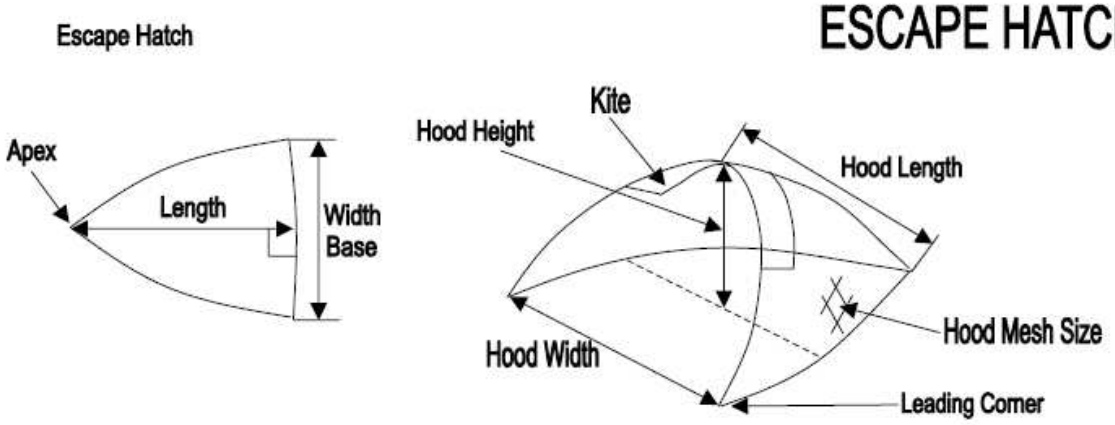
SLED TERMS



GRID



ESCAPE HATCH



BREEN AND KIM NEW ZEALAND SEA LION POPULATION MODEL

1. INTRODUCTION

This paper provides general information on Bayesian inference[17] and the Breen and Kim (2006)[18] model. It is intended to be read in conjunction with Breen and Kim (2006).

Paul Breen and Susan Kim developed a sea lion population model on contract to The Ministry of Fisheries (Breen & Kim 2006; MFish Research Project MOF2002/03L) to "...explore the effects of the New Zealand or Hooker's sea lion (*Phocarctos hookeri*) bycatch in the arrow squid (*Nototodarus sloanii*) fishery in SQU6T and to explore the effects of alternative bycatch control rules[19] on the sea lion population and squid fishery." This project is an extension of an earlier modelling exercise where Breen *et al.* (2003)[20] fitted a Bayesian model to sea lion pup production data from the Auckland Islands. The revised model used updated pup production estimates and a variety of other sea lion population data provided by the Department of Conservation in association with an agreed-upon management goal (see Section 2).

The work was further refined with an agreed management goal to maintain the population above 90% of carrying capacity (K)[21] and to maintain the population above 90% of the unfished level in years when it is less than 90% K. This was presented to the Symposium – Sea lions of the world: Conservation and research in the 21st Century held on 30 September – 3 October 2004, Anchorage, Alaska.[22]

The Breen & Kim model (B&K model), as developed for the Ministry of Fisheries (MOF2002/03L) is a Bayesian sea lion population model – it does not, in itself, determine what any particular level of bycatch should or should not be. Rather, it is used to evaluate a range of Harvest Control Rules to determine if they meet the management goal criteria agreed to by the Aquatic Environment Working Group (AEWG) convened by the Ministry of Fisheries.

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[17] Bayesian statistical inference is discussed in Sections 3 and 4 of this paper.

[18] Breen, Paul A. and Susan W. Kim. 2006. Exploring alternative management procedures for controlling bycatch of Hooker's sea lions in the SQU6T arrow squid fishery. Final research report for Ministry of Fisheries Research Project MOF2002/03L, Objective 3 Revision 5. 3 February 2006. Copies available from the Ministry of Fisheries, Wellington.

[19] Bycatch Control Rules are referred to in this and some documents as Harvest Control Rules.

[20] Breen, P.A., R. Hilborn, M.N. Maunder and S.W. Kim. 2003. Effects of alternative control rules on the conflict between a fishery and a threatened sea lion (*Phocarctos hookeri*). *Canadian Journal of Fisheries and Aquatic Sciences* 60: 527-541.

[21] Carrying capacity (abbreviated as K) refers to the population size (in this case, the number of sea lions) that the resources of the habitat (both biological and physical) can support.

[22] Breen, P.A. and S.W. Kim. 2006. An integrated Bayesian evaluation of Hooker's sea lion bycatch limits. Pp 471-494 in: Trites, A.W., S.K. Atkinson, D.P. DeMaster, L.W. Fritz, T.S. Gelatt, L.D. Rea and K.M. Wynne (eds.) Sea lions of the world. Alaska Sea Grant College Program, University of Alaska Fairbanks. 664 pp.

The driving factors are the Harvest Control Rules, not the Breen and Kim Model, when determining the Fisheries Related Mortality Limits (FRML)[23] that are specific for each rule.

2. MANAGEMENT GOAL

The management goal as agreed to by the Aquatic Environment Working Group consists of three criteria: the first and second criteria, for 100- and 20-year runs[24] respectively, are to

- have bycatch managed such that there is a 90% likelihood, for each year, of either the population being at or above 90% of carrying capacity (*K*) or
- the population being at or above 90% of where it would be in the absence of fishing.
- The third criterion is that the mean of mature numbers (as defined in Breen & Kim (2006)) as a percentage of *K* should be at least 90% over the second 50 years of the 100-year runs.

This management goal is known colloquially as the 90-90-90 goal.

3. BAYESIAN STATISTICS

The Bayesian statistical approach builds upon earlier understandings of a phenomenon by formally combining these earlier understandings with currently measured data.[25] In Bayesian statistics, the earlier understanding, obtained from data, an experiment or any other source or sources, is known as the *prior* or *prior belief*. The prior is expressed as a "prior" probability distribution of parameter values[26]. When new data become available, they are combined with the prior to produce a new probability distribution. The new belief, in the form of a probability distribution resulting from the introduction of new data and examining how well they conform to preconceived ideas, is the *posterior* or *posterior belief*. The updating process is referred to as Bayesian statistical inference.

Bayesian inference therefore consists of two parts: a part that relies on subjective or objective belief and understanding held *prior* to carrying out further data gathering, and a part that depends upon the new observational or experimental data. The *posterior* resulting from one Bayesian analysis may therefore become the *prior* in a future Bayesian analysis when additional and independent data become available.

The Bayesian method concentrates on what is known (the data), while the true value of the parameter (fixed point expressed by, e.g., the mean) is unknown, *i.e.*, in Bayesian statistical inference the parameter is considered to be a random variable. Bayesian methods, therefore, result in probability distributions of parameters that incorporate uncertainty. Although Bayesian results are given in terms of probability (a distribution), Bayesian statistical inference can be used to estimate a parameter's own mean and confidence interval based on the data (this is not the same as

[23] A Fishing Related Mortality Limit (FRML) is a management tool that sets a limit on the number of sea lion bycatch mortalities that may occur incidental to commercial fishing operations in SQU6T trawl fisheries.

[24] 100- and 20-year runs refers to computer simulations of the population for 100 and 20 years respectively.

[25] Press, S. James. 2003. Subjective and objective Bayesian statistics. Principles, models, and applications. 2nd edition. John Wiley and Sons, Inc. Hoboken, NJ. 558pp.

[26] In frequentist analyses, a parameter is a constant (fixed) that is estimated from the data. Bayesian statistical inference treats parameters as random variables.

estimating the parameter's *true value* and its confidence interval) while expressing the uncertainty surrounding these parameter estimates.

Consequently, a median or mean parameter value can be calculated using Bayesian methods from a predetermined number of computer simulations using e.g., Markov Chain Monte Carlo (MCMC) techniques. These analyses start with an estimated distribution for each parameter arising from the modelling known as the joint posterior distribution. The mode of the joint posterior distribution is abbreviated as the MPD.

Bayesian methods can make use of all available information when formulating a prior, and they provide results (the posterior distribution) in terms of probability.

4. PROS AND CONS OF THE BAYESIAN METHOD

Bayesian analyses rely on prior probabilities, which may be intrinsically subjective. Many see this as a fundamental drawback to Bayesian statistics. However, supporters of the Bayesian approach argue that those who use frequentist methods also rely on subjective choices. While this debate has been the source of contention between supporters of the two statistical paradigms, followers of the Bayesian approach also argue that it is a proven method (and arguably the only method) of making consistent and sound decisions in the face of uncertainty.

Bayesian statistical inference is becoming increasingly popular and, in the view of many, is more appropriate to conservation biology than the more traditional statistical methods.[27]

5. HARVEST CONTROL RULES

The Harvest Control Rules that were assessed with the Breen & Kim model are used to calculate the Fisheries Related Mortality Limits considered for managing sea lion bycatch. **The Breen and Kim model in itself does not determine FRMLs**; these limits are calculated using the individual equations associated with the corresponding Harvest Control Rules. Such limits change annually depending on data input into the equations, *i.e.,* pup production estimates.

6. BREEN AND KIM MODEL RESULTS

Breen and Kim (2006) provide, among other things, mean catch values and maximum catch values that arise from 5000 simulations (drawn from regularly spaced samples from 30 million MCMC iterations) associated with the various harvest control rules assessed by their model (see Tables 11a&b *in:* Breen and Kim (2006)). They provide results based on the posterior distributions of predicted quantities obtained by their Bayesian analyses for each of the harvest control rules assessed.

Example 1. If sea lion bycatch were managed under rule 320, and some other conditions were met[28], on average 76 sea lions would be taken annually by the fishery[29] (the median of the 5000

[27] Wade, Paul R. 2000. Bayesian methods in conservation biology. Conservation Biology 14(5): 1308-1316.

[28] These include: the average annual attempted fishing effort does not increase from the period studied by Breen & Kim; the catchability of sea lions does not increase over that in the period studied by Breen & Kim; the fishery does not exceed the FRML.

[29] Breen & Kim's estimates did not take SLEDs into account.

posterior distributions obtained through the analysis.) In any one year, the maximum number taken as bycatch in 100 years had an average (over the 5000 simulations) of 151 sea lions. Conversely, far fewer than 76 sea lions could be taken in some years. The actual number taken will depend on a range of circumstances or conditions specific to the year in question including, for example, the amount of effort put into the fishery, the number of vessels operating in the fishery, the abundance of squid, the distribution and movements of sea lions at sea, and how effective vessels are at avoiding sea lions when trawling. Using the formula associated with rule 320 and incorporating the most recent two years' pup production estimates, the sea lion FRML for the 2007 squid fishery would be 109 sea lions.

Example 2. If sea lion bycatch were managed under the Cusp rule, on average, 98 sea lions would be taken annually by the fishery (the median of the 5000 posterior distributions.) However, over 100 years the maximum bycatch averaged 542 sea lions. This does **not** mean that 542 sea lions could be taken annually under the Cusp rule. Rather, the average maximum number resulting over the 5000 simulations was 542. Using the formula associated with the Cusp rule and incorporating the most recent two years' pup production estimates, the FRML for the 2007 squid fishery would be 504 sea lions. However, it is extremely unlikely under current fishing effort and conditions that anything approaching 542 sea lions (or for that matter 504 sea lions) would ever be taken in any one year.

The Auckland Islands subpopulation could not sustain an annual incidental kill of 500 sea lions – it would decline rapidly with this level of exploitation.

There are a few things to note about the Breen & Kim model.

- The B&K model is not a 'fisheries' model; a model is a representation of the real world irrespective of what is being modelled, be it fish, large mammals, insects, whatever
- The B&K model is a population model using Bayesian techniques that incorporates available biological and fisheries data
- The B&K model does not calculate a FRML
- The B&K model does not make any recommendations as to what harvest Control Rule should be applied in any given year, other than to identify those rules that meet the 90-90-90 management criteria
- Various Harvest Control Rules are assessed with the B&K model to determine if they meet the management criteria (90-90-90 goal)
- Potential FRMLs are calculated using the various Harvest Control Rules that meet the management criteria
- Results would change with different management criteria; the management criteria affect the outcome of the analyses (the testing of the various Harvest Control Rules with the B&K model to see if they meet the agreed upon management criteria)
- Results (whether or not individual harvest Control Rules meet the 90-90-90 criteria and their associated formulas for calculating a FRML) also are likely to change once the B&K model is updated with the most recent sea lion biological and fisheries data
- Input into the formulas associated with the Harvest Control Rules consists of the most recent two years' pup production
- Sea lion pup production is used as a proxy for sea lion numbers, because pup production is the only quantity that can be measured

- Sea lion pup production is calculated by Department of Conservation staff annually following a consistent and robust mark-recapture experimental design and procedure
- The FRML calculated from the same Harvest Control Rule may change annually depending on pup production
- The maximum catch calculated using the Harvest Control Rules assessed with the B&K model is not the same as the average number of animals taken annually from the sea lion population
- The average number of animals taken annually is considerably fewer than the possible maximum catch that may be taken in any one year during the 100-year runs. This gap increases as the potential bycatch allowed by the various rules increase from no fishing to no bycatch limit

As is the case with all models, the Breen and Kim (2006) sea lion model should be updated on a regular basis (e.g., every five years) as new data become available and methods to improve the model are identified. The 2006 model is based on information made available in 2003. The Breen and Kim model currently (2007) is being revised and updated by Paul Breen.

Additional information on the use of Bayesian methods in conservation biology can be found in:

Ellison, A.M. 1996. An introduction to Bayesian inference for ecological research and environmental decision-making. Ecological Applications 6(4): 1036-1046.

Wade, Paul R. 2000. Bayesian methods in conservation biology. Conservation biology 14(5): 1308-1316

Rob Mattlin
22 May 2007

APPENDIX 3

Current issues with the Breen-Kim model, raised by Paul Breen at the AEWG meeting held 1 September 2006.

1. Recent pup counts were lower than the minimum estimates generated by the model, suggesting that insufficient process error was allowed in the model. The model cannot reproduce the declines seen recently, and survival rate or pupping rate may have changed. The effect of introducing more variability would be that high-numbered harvest control rules would no longer meet the 90:90:90 sustainability criterion, and the cusp rule would be some lower-numbered rule than 392. Lower pup counts would also cause uncertainty in the minimisation of the model because it assumes observation error and no process error.

2. Late-season pup mortality estimates were not included in the original model. Late season mortality appears to be more variable than early season mortality. This suggests that the model should include process error on pup mortality.

3. Some other data sets not available in 2003 have since become available.

4. The 2003 model had no implementation error, even though actual mortality of sea lions is poorly known.

5. The 2003 model was restricted to SQU6T even though some sea lions are caught elsewhere and some other fisheries have sea lion interactions in the SQU6T box.

6. It was acknowledged that, in hindsight, different parameterisations of survival might have been better to avoid parameter correlations.

7. The model assumed homogeneous dynamics in the four rookeries and this may not be realistic.

8. The "strike rate" may have a time trend but this was not modelled in the 2003 projections.

9. The very low growth rate favoured by the model is thought to be unrealistic and suggests problems in the specification of density dependence. It is possible that there is density dependence in survival as well as, or instead of, in pupping rate.

10. Catch and effort data are assumed known.