Development of the Threat Management Plan for New Zealand Sea Lions:
Progress Report – NZSL Threat Workshop 2

Purpose of Document:

This document reports on the outcomes of Workshop 2, held 1-3 September 2015, including a summary of the outputs of the risk assessment modelling, and reports on the next steps for the development of the TMP.

Background:

The TMP is a five year plan that works towards the TMP Vision for New Zealand sea lions. The TMP will assess all threats on the population, prioritise threats for management and mitigation, and will include all sub-populations and breeding sites.

For further information on the process involved in the development of the New Zealand sea lion TMP, please see http://www.doc.govt.nz/nzsl-tmp.

The purpose of the second workshop was to review a number of topics associated with the development of the TMP including:

- the draft management goals,
- the demographic modelling approach developed at the first workshop,
- a second modelling approach developed by Otago University, and
- initial threat projections using the demographic model.

For full details of the purpose of the workshop, please see the Terms of Reference for the Workshop in **Appendix 1**.

Invited subject matter experts were present in the capacity of 'Advisors' to provide support to the Expert Panel on their particular topic of expertise. The Expert Panel was comprised of the same four people as first NZSL Threat Workshop, who were considered independent of current New Zealand sea lion research or management, yet have expertise relevant to the assessment of risk to the sea lion. A list of participants is included in **Appendix 2**.

Workshop 2 Outputs:

Key outcomes:

1. A document detailing all three days of discussions, including outcomes and recommendations from the Expert Panel, is included in **Appendix 3**.

Management goals

2. A number of suggestions were made on the draft management goals, mostly pertaining to the population goal and the importance of ensuring that progress is able to be measured against the goal. The revised management goals will be made available on the TMP website.

Demographic modelling

3. The expert panel made some minor technical recommendations to fine-tune the NIWA demographic modelling, but overall considered the approach to be robust and appropriate to underpin the development of the TMP. The only issue that the panel noted was that, due to the complexity of the model, it takes a long time to produce outputs which could affect the ability to prioritise management actions in a timely manner. Some suggestions to improve the running time of the model were made.

4. The panel were presented with an additional model developed by the University of Otago (Otago Model). The panel considered the Otago model provided largely similar outputs to NIWA's model, but was too simple to accurately reflect the complexities of the Auckland Island population dynamics. For this reason the Panel agreed that the NIWA-developed model continue to be used as a tool for developing management options.

Retrospective analysis – Auckland Islands

5. The NIWA model was used in a retrospective analysis that estimated the population trajectory if each of the identified threats had been removed in the year 2000. This analysis indicated that no single threat was responsible for the decline in the sea lion population at the Auckland Islands.

6. The retrospective analysis suggested that the population would have declined even with the removal of any of the threats modelled. It was estimated that the removal of *Klebsiella* would have resulted in a 30% decline instead of the observed 50% decline. Likewise, the removal of unmitigated direct effects of fishing would have resulted in a 40% decline instead of the observed 50% decline. This supports the need for an integrated management response addressing a number of the identified threats.

Forward projections removing effects of threats – Auckland Islands

7. The model was used to examine the impact of removing mortalities caused by each threat from 2017 onwards. Results showed that the removal of any single threat would not be enough to reverse the decline in the population.

8. The results of the projections suggest that the greatest gain is likely to result from addressing the effects of the bacterial disease *Klebsiella*. There are currently no known methods for treating *Klebsiella* in sea lions, and research is considered as the first step in addressing *Klebsiella*. Research programmes are currently being implemented to address this threat, but are still in early planning.

9. The direct impacts of fishing were modelled under a number of assumptions regarding the number of mortalities caused by fishing activity. Even under an assumption that all sea lions that come into contact with fishing gear are killed, the population continues to decline, albeit at a marginally slower rate.

Mainland breeding population

10. The mainland breeding site was also modelled by NIWA and forward population projections with the removal of the effects of identified threats were completed. Overall, the population on the mainland was modelled to be increasing significantly, and projected to continue to increase under all threat scenarios. However, removal of certain threats could help improve the rate of population growth.

Campbell Island and Stewart Island breeding sites

11. There is insufficient information for a full demographic model for either the Campbell Island or Stewart Island breeding sites.

12. The expert panel recommended that, given nearly 30% of the total sea lion population breeds at Campbell Island, it will be increasingly important to understand the population dynamics at Campbell Island.

13. Stewart Island will also require ongoing monitoring, and the expert panel noted the importance of collecting additional demographic data about Stewart Island and initiating educational campaigns to minimise impacts of humans interacting with sea lions.

Research priorities

14. A number of research priorities were identified by the expert panel. These were mainly focused on continuing or establishing monitoring programmes, and research to understand the sources and behaviour of, and potentially identify treatment options for *Klebsiella*.

15. One priority specifically mentioned was sampling and data collection at Campbell Island. In recognition of the costs, a three-year intensive programme was proposed, with less frequent but regular field seasons following.

APPENDIX 1: New Zealand sea lion Threat Management Plan Workshop 2 Terms of Reference

Department of Conservation
Te Papa Atawhai

Ministry for Primary Industries
Manatū Ahu Matua

New Zealand sea lion Threat Workshop 2 September 1-3

Introduction

There are concerns for the New Zealand sea lion (NZSL), primarily because pup production at the Auckland Island, the main breeding area, has been in a decline for over a decade. In 2014 the Minister of Conservation and Minister for Primary Industries instructed officials to begin work to develop a Threat Management Plan (TMP) as a means to further the recovery of the species throughout its range.

A number of potential factors are thought to be contributing to the sea lion decline. In developing the NZSL TMP it is envisaged that the Department of Conservation (DOC) and Ministry for Primary Industries (MPI), in consultation with iwi and stakeholders, will look at all potential threats to all breeding sites, and develop management options to minimise or mitigate key threats to the sea lions.

A plan and timeline for developing the NZSL TMP was agreed by Ministers in April 2014. An integral part of developing the NZSL TMP is conducting a comprehensive risk assessment for the whole sea lion population. As the amount of information on each possible threat to sea lions varies it was decided that two workshops were needed to inform the risk assessment.

The first workshop was held in April 2015 and focused on characterising threats and reviewing the demographic assessment framework. The second workshop is being held in September 2015 and will be focused on reviewing the outputs of the risk assessment model.

The final outputs of the risk assessment will be used to inform management options that might make up the NZSL TMP. Prior to the finalisation of the NZSL TMP, and to aid decision-making, a public consultation over the draft NZ TMP will be undertaken. It is expected that Ministers will be presented with the options on the content of the NZSL TMP, as well as all submissions, in April 2016.

Purpose

The purpose of this workshop is to review the following topics:

1. TMP population goal and criteria (Day 1)
2. Updates to the demographic model (Day 1)
3. Model review (Day 1)
4. Threat characterisation (Day 2)
5. Risk triage projections (Day 2)
6. Retrospective impact analysis (Day 2)
7. Population projections under different threat scenarios (Day 2)
8. Treatment of the Campbell Island/ Stewart Island populations (Day 3)
9. Treatment of low information threats that may still be managed within the TMP (i.e. shootings, dogs) (Day 3)

Scope

The focus of the workshop is risk assessment. Development and evaluation of threat management options will be addressed separately, however, identification of threat management options, including mitigation and/or research priorities will be considered.

Conduct of the Workshop

The workshop will be conducted in a professional, collegial and scientifically objective manner. Members of the Advisory Group will have their own views and interpretations of available evidence and are expected to provide these views objectively, explaining how they consider them to be supported by the available evidence. A clear distinction will be made between evidence-based interpretation and personal opinion.

All members of the Scientific Panel will be accorded equal opportunity to express their views, and are required to respect the views of other participants, whether they share those views or not.

All workshop participants will commit to:

- facilitating an atmosphere of honesty, openness and trust;
- having respect for the role of the Chair; and
- listening to the views of others, and treating them with respect.

All Members of the Scientific Panel and Advisory Group will further commit to:

- participating in the discussion in an objective and unbiased manner;
- adopting a constructive approach.

Participants who do not adhere to the above protocols of participation may be excluded by the Chair from a particular part of the workshop or, in more serious instances, from the remainder of the workshop.

Participants

The workshop participants will include:

- An independent workshop Chair;
- A facilitation group of nominated DOC and MPI scientists that will assist the chair;
- A science panel comprising invited national and international experts to address each workshop topic;
- A group of advisors consisting of nominated national experts; and
- Observers.

The workshop is open for observers, however due to limited space being available at the workshop venue, space will be made available first and foremost for the expert panel and invited advisors. Expectations and responsibilities of participants are explained in more detail below.

Chairperson

The Chair of the workshop will be an independent scientist selected by MPI and DOC to be an objective, impartial and respected scientists in their field. The Chair is primarily a facilitator, and is responsible for:

- ensuring that all participants adhere to the workshop terms of reference and agenda, including adhering to allotted times specified in the agenda.
- implementing the rules of procedure consistent with the workshop's purpose and scope;
- promoting full participation and constructive discussion by all participants;
- working to achieve consensus from the Expert Panel where possible, based on available evidence. Where consensus cannot be reached, the Chair may refer to the facilitation group for support in identifying or clarifying and recording alternative views; and
- identifying and managing conflicts of interest.

Expert Panel

The expert panel will be comprised of invited national/international persons with expertise relevant to the assessment of risk to the sea lion, who are considered not to be directly invested in NZSL research or management. The expert panel members will be responsible for:

- familiarising themselves with the material circulated to them prior to the workshop
- adhering to the workshop terms of reference
- provide constructive review/input into all discussions
- drawing on the information and experience of the invited advisors

The panel is not required to produce any reports as a result of this workshop. However they are asked to review the workshop meeting notes to ensure their thoughts/ideas and recommendations have been effectively and accurately communicated.

Advisors

Advisors are national experts that have been invited to attend the workshop by the TMP Project Team to advise the panel and to ensure transparency in the scientific process.

Advisors are responsible for:

- adhering to the workshop terms of reference
- providing information to the expert panel on the topic which they have been invited to communicate on

Observers

Those participating as observers are only there to observe the proceedings. To facilitate transparency and understanding of the process observers will not be permitted to contribute to workshop discussion unless specifically asked to by the Chair.

Observers will include any persons who are interested in attending the workshop and are not participating as a chosen advisor or expert panel member. Observers are responsible for adhering to the workshop terms of reference.

Conflicts of Interest

Participants will be asked to declare any interests that may give rise to actual, perceived or likely conflicts of interest before involvement in the workshop is approved. Expert panel members and advisors will be expected to declare any conflicts of interest that arise during the workshop. These will be clearly documented in the notes of the workshop. Observers will be expected to register on the sign in sheet the group or groups which they represent.

The Chair will be responsible for managing any conflicts of interest that arise during the workshop in consultation with the facilitation group, to ensure that conflicts of interest do not jeopardise the objectivity of the workshop outcomes.

Documents and record-keeping

The workshop will be run formally with an agenda and background documents circulated prior to the workshop and formal records kept of recommendations, conclusions and action items.

Other than publically available published reports, workshop working documents circulated to participants are done so in confidence. Participants may not distribute these to others without the prior agreement of DOC and MPI in

writing. Participants who do not maintain the confidentiality of workshop papers will be excluded from the workshop.

The overall responsibility for record-keeping rests with nominated DOC and MPI staff, including:

- Recording any recommendations, conclusions or follow-up actions; and
- In cases designated by the facilitation group, recording the extent to which agreement or consensus was achieved, and recording any disagreement.

Material provided to the International experts will be circulated prior to the workshop so everyone is aware of the material. Information provided in advance will have been reviewed by both the MPI Aquatic Environment Working Group and the DOC Conservation Services Programme Technical Working Group.

TMP Expert Panel Workshop – Participants

Chair: Neil Gilbert
MPI and DOC Facilitators: Nathan Walker and Laura Boren
Record Keeping and Workshop Administration: Katie Clemens-Seely and Tiffany Bock
Expert Panel Members:

- Mark Hindell
- Jason Baker
- Mike Lonergan
- David Hayman

TMP Expert Panel Workshop – Schedule

DAY 1: Tuesday 1 September

9:00 am	**Coffee and Welcome (general admin)**
	Introductions
	DOC and MPI present TMP management goals
10:30 am	Morning Tea
	Review of updates to the demographic model (NIWA)
12:30 – 1:00	Lunch Break
	Review of updates to the demographic model (NIWA)
2:30 pm	Afternoon Tea
	Meyer modelling approach (Otago)
4:30 pm	**MEETING CLOSES**
	Icebreaker session

DAY 2: Wednesday 2 September

9:00 am	**Coffee and Welcome (general admin)**
	Review outcomes of day 1
	Threat characterisation (DOC & MPI – Ian)
10:30 am	Morning Tea
	Risk Triage (NIWA)
12:30 – 1:00	Lunch Break
	Retrospective impact analysis (NIWA)
	Threat scenarios used for population projections (NIWA)
3:00 pm	Afternoon Tea
	Population projections (NIWA)
4:30 pm	**MEETING CLOSES**

DAY 3: Thursday 3 September

9:00 am	**Coffee and Welcome (general admin)**
	Review outcomes of day 2
	Treatment of Campbell Island
10:30 am	Morning Tea
	Treatment of Stewart Island (Rakiura)
	Treatment of low information risks
12:30 – 1:00	Lunch Break
	Focussed discussion on how to do strategy evaluation using the model
3:00 pm	Afternoon Tea
	Focussed discussion on alternate management options
	Focussed discussion on research priorities
4:30 pm	**Wrap-up and concluding remarks**
5:00 pm	**MEETING CLOSES**

DAY 4: Contingency day – Friday 4 September

There is currently not a schedule for this day as it may not be needed. However, if the Panel and Chair feel it is useful to have a session to finalise their recommendations then time can be allocated on this day.

APPENDIX 2: List of Attendees

Chair:
Neil Gilbert

TMP Project Team Attendees:
Nathan Walker, Laura Boren, Katie Clemens-Seely, Tiffany Bock

TMP Project Executive:
Ian Angus, Vicky Reeve

Independent Expert Panel:
- David Hayman
- Jason Baker
- Mark Hindell
- Mike Lonergan

Advisors:
- Simon Childerhouse
- Ed Abraham
- Darryl MacKenzie
- Paul Breen (observer only for Otago model presentation)

Observers:
- Richard Wells
- Dave Middleton
- Martin Cryer
- Katrina Goddard
- Amanda Leathers

APPENDIX 3: Discussion outcomes, including recommendations from the panel members

Day 1 – September 1st 2015

The first day of the workshop: presented the threat management plan's draft management goals and criteria, an update on the NIWA demographic model, and an alternative model approach developed by Otago University.

Threat Management Plan Goals & Criteria

The draft, overarching management goals and criteria of the threat management plan (TMP) were presented for the panel's consideration.

- The panel suggested that an annual process be initiated to monitor progress against the population goal. This would not involve any significant reworking of the model parameters or structure, just imputation of the new data and running the model. This would allow for an annual check on progress against targets and the status/success of management actions.
- The panel commented that the scope of the research covered in the research and monitoring goal should address both sea lion population and threats. MPI and DOC acknowledged that it is intended to be wider than just sea lion population research, and would include research and monitoring in relation to identified and potential threats to sea lions. This will be clarified in the management goals.
- The panel suggested that target setting should be based on realistic numbers, and not be affected by the fear that some targets may not be met. The point was made that failure to meet a target may trigger response action, including potential urgent reporting to Ministers, which may result in more readily available resources.
- Support for the management criteria was expressed in that they focus on the most important issue at hand, that is, unfavourable vital rates that are driving a decline. In the future, these criteria can be altered to address emerging issues as appropriate.
- The panel agreed to review the goals (in particular the Population Goals) again after seeing the outputs from the modelling. The project team will also provide some minor updates to the goals and criteria based on feedback received to date, prior to that review on Day 3.

Update on Demographic model

NIWA provided a progress report on the development and testing of the demographic model.

- It was noted that if age structure of the population is considered an important input to the model, consideration should be given to repeating this work in the near future, especially since it easier now with the tags and chips including more information on the age of animals.
- A practical problem was identified and discussed with the speed that the MCMC runs are progressing at. At the current rate, it is estimated that they may take another 3 weeks to complete. The reason for this is unknown, although it was attributed to the number of states and parameters (incl. tag loss classes).
- It was noted that the Otago population is small and volatile and as such, may not be a top priority for modelling going forward with the TMP. However, it was noted that based on age

structure and vital rates observed to date, the existing model suggests that it is highly unlikely that the Otago population will become an official "subpopulation" within 20 years.

- It was suggested that showing confidence intervals would be crucial for management to understand what the impacts of management would need to be in order to see measurable changes in projections.
  It was also suggested that the demographic rate scenario graph rates should/could be converted back into numbers, and then they could be used to inform management options (i.e. to get from pup survival from 0.4 to 0.6, how many animals need to be saved).
- It was noted that using the most recent 10 years' observations to project into the future doesn't include past observations of more favourable rates. To investigate the effects of this, we might want to evaluate the sensitivity of the triage results to which set of years are drawn from for projections to help demonstrate robustness of conclusions. This exercise will be time consuming unless the MCMC process can be accelerated.
- As a recommendation for future work, the Panel suggested that because of the low numbers of individuals in the population, parameters be estimated for each individual, instead of resampled, i.e. stochasticity in projections. This would allow some scope for one off events that could significantly affect a small population like this.

Alternative model approach

Otago University provided an alternative model that the workshop agreed would be appropriate to assess as a comparative or benchmarking exercise.

- There was a question about whether branded & chipped individuals were included in his analysis, or whether they were ignored. An Advisor mentioned that as long as the model only used those that were identified as "tagged" then there might not be a significant problem.
- There was a question about the scale used for survival. It was suggested that the data be transformed (arc sin transformation), which has helped others in the past with similar issues.
- There was a concern expressed about the low pup survival estimate. This led to additional concern that other parameters may be poorly or wrongly estimated in the model as well.
- There was interest from the Panel in getting more information on exactly why the estimation of pup survival is lower than the NIWA model.
- It was noted that a simple binominal, yes or no disease was present, is overly simplistic to assess if disease is compensatory. There needs to be a measure of the level of effect of disease in those particular years to be able to confirm whether or not you are seeing a compensatory effect of disease on the overall population.
- It was noted that in the years with high pup mortality, pup production rate was also depressed at the same time, potentially as a result of disease. It doesn't appear that any conclusions can be drawn from the model, given its simplicity, as to the presence or absence of any compensatory mechanism because it cannot detect changes in pup survival and the relative impacts due to disease. It is inappropriate to look at the effects of epizootics in isolation.
- With regard to the analysis that was presented of the correlation of bycatch with the number of adult females that must be prevented to maintain a stable population, many questions were raised, including the concern that the use of just Sandy Bay sea lion data to correlate with the captures of sea lions in northern portion of the Auckland Island squid

fishery is overly simplistic It was also noted that the difference in the timing of the kernel density (foraging) plots threw some doubt as to the confidence with which these areas could be attributed back to home colonies (i.e. Sandy Bay and Dundas Island). The different foraging locations could just as easily be a function of different foraging strategies by both groups between the two time periods.

Feedback from Panel

- The panel concluded that the most appropriate model would be an approach that incorporates the available data and gives the smallest uncertainties with regards to the forward projections.
- It was considered reassuring that while there were some distinctions, the two models seem to generate largely similar parameter estimates.
- Overall, the panel concluded that they continue to have confidence in the work that has been done on the NIWA model and that it should be carried forward. The panel appreciates that all models rely on assumptions and have pitfalls (for example: BFG - density dependence, Otago - not able to deal with complexity of the situation and the data available, & NIWA - takes a long time to run with current model configuration and observations used).
- It was agreed that the projections are likely to provide the real differentiation between the models, as the model that can demonstrate its applicability and can produce projections with less uncertainty, is likely to be best at using the available data to inform projections and subsequent management.

Day 2 – September 2nd 2015

The second day of the workshop: revisited the Otago model, described the updates to the threat characterisation process, and discussed the risk triage outcomes, the best estimate projections, and the retrospective impacts analysis. The workshop also briefly considered the cumulative effects of threats.

Discussion outcomes, including recommendations from the panel members:

Revisit of Otago Model

Darryl MacKenzie provided a technical review of the compensatory mortality used in Stefan Meyer's model. A written assessment was provided, which has been recorded with other technical workshop outputs.

The Panel liked the simplicity of the model, yet had reservations about the resulting parameter estimates (i.e. low pup survival and high juvenile survival). Likely this was because the model was too simple to deal with complexities in the data. The Panel also noted that the interpretation regarding the impacts of fishing is highly questionable. For example the assertion that all Auckland Island mortalities were attributed to the Sandy Bay population is unlikely.

The Panel considered that for the TMP purposes, whilst the Otago model was broadly in agreement with the NIWA model that is being used, there is no value in pursuing the Otago model further for this process. The Panel concluded that the model might potentially be useful for some applications if it could be improved slightly, but in its current state the Panel agreed that it is unable to add anything to the TMP process.

Threat Characterisation – Laura Boren (DOC) & Nathan Walker (MPI)

It was suggested that a new metric for estimating bycatch be used, potentially employing a cryptic mortality approach as a multiplier on the estimated observable captures. This approach has the advantage of transparency and simplicity. A running mean approach could be taken, using a multiplier on the observable capture rate over a 5-y period, for example. However, the difficulty with this approach would be developing the methods to estimate the cryptic mortality multiplier.

The Panel recommended that:

- There needs to be confidence that sufficient upper bounds have been selected, and that other potentially high threats are not being neglected during the triage stage.
- The upper bound and best estimate of female mortality from male aggression should be reviewed.
- The upper bound and best estimate of pups in holes should be reviewed by the project team. The current upper bound value, which assumes that all drowned pups died, may be an overestimate.
- The upper bound and best estimate of female (adult) mortality from deliberate mortality should be reviewed as the resight probability of females that have been shot is very low. There is confirmation of one female being shot, but there is an obvious struggle in determining how to accurately represent those that are in fact being killed.
- The upper bound and best estimate of shark predation is likely to be underestimated, given the lack of observation of mortalities from shark predation. 27% of adult sea lions at Sandy Bay have shark scars (according to a single speculative study without details of methods or confirmation of predatory species).

There was further discussion around the interaction with Sea Lion Escape Devices (SLEDs). The Panel noted their concern that because of a lack of data informing the later model results, there were large upper bounds of interactions and the upper 95 percentile of the estimate of strike rate is likely skewed above the mean to an implausible level.

Risk triage outcomes – Jim Roberts (NIWA)

A question was raised about why only mature females were modelled. Dr. Roberts noted that the population goals were originally focused on female survival, hence the modelling on mature females. Dr Roberts also reminded the workshop that the triage is not a detailed analysis of impacts, but instead identifies what threats need to be carried forward to more detailed analyses.

There was discussion around which threats are included in the triage, which need to be modelled, which should be modelled, which have come out looking odd (i.e. lower than anticipated), and how to address these issues. It was suggested that pups drowning in holes be included in the projections going forward because of the possibility to manage this particular threat.

Questions were raised around how 'trophic effects' were estimated and incorporated into the triage projections. Dr Roberts noted that the four worst years were averaged. The panel noted that the upper bound of trophic effects is probably set too low, given that it was set during a time of decline. It was suggested that it could be more appropriate to compare 2005-2008 (low years) to a period when the population was growing (i.e. the early 90s, as was done for *Klebsiella*), and adjust demographic rates manually for *Klebsiella* and trophic effects.

With regards to cumulative effects, the Panel agreed that no single threat is likely to be responsible for the demographic changes that have been seen. Therefore, eliminating any single threat through triage might be futile, and the best estimate of total cumulative threats may be achieved by including the best estimates in the next stage, then removing them all, and comparing the outcome with growth patterns observed in the 1990s.

It was noted that the λ of Otago and Campbell Island populations is around 1.07 or 1.08 at present, and that this growth rate could be used as an aspirational target of growth for the population as a whole.

There was a concern that the effect of removing *Klebsiella* may be over estimated. Might need to re-examine how *Klebsiella* is represented in the best estimates/upper bounds.

Best estimate projections

<u>Auckland Island population projections</u>

It was recommended that "pup drowning in holes" and "male aggression" be added to the list of threats to model for the Auckland Islands.

There was a concern that estimates of pup mortality assume that the pre-weaning pup mortality and the pup mortality for the remainder of the year would be attributable to the same causes of mortality.

The Panel recommended that longer field seasons would allow for a determination of other possible causes of death later in the season, and would allow us to develop a proper disease mortality curve.

The Panel reiterated its view that no single intervention is likely to reverse the decline in the New Zealand sea lion population.

Fishing

- It was noted that the model projections indicate that removing the direct effects of fishing will not in itself reverse the population decrease. However, it was highlighted that potential indirect effects of fishing are currently considered as part of trophic effects and thus the removal of fishing effort may result in additional benefits.

Klebsiella

- It was noted that the model projections (using the mortality numbers in the threats spreadsheet as provided to Jim Roberts) indicate that the removal of *Klebsiella* does not result in an increase in the population.
- Based on the projections, it was estimated that resolving *Klebsiella* completely might have about a 50% chance of stabilising the population (assuming this mortality is additive, rather than compensatory).

- It was agreed that the occurrence of *Klebsiella* is likely to continue. It is not known if pups develop resistance to the infection. Such resistance might potentially result from evolutionary selection within the population due to mortality or improvements in the physical condition of the pups, though it is unclear how likely these responses might be, or when they might occur. Klebsiella has been found in the environment and other animals at Auckland Islands (and may have been found on Campbell Island as well). This disease ecology means that the threat from disease may continue because the infection is not maintained simply in the sea lion population. Molecular techniques could potentially identify if the arrival of the more aggressive form of *Klebsiella* was a modification of an already present bacteria or an entirely new infection introduction (based on genetic diversity).

Trophic

- The Panel noted the importance of clearly communicating what "trophic effects" incorporates. There remains a risk that this could be interpreted simply as the indirect effects of fishing, and that simple management of the fishery would negate this effect.
- The 'best estimate' for trophic effects was considered to be trivial given large uncertainties around what these impacts are and the scale of those impacts. The Panel recommended that publication of this information should be accompanied by caveats noting the lack of data and that this component is little more than an educated "stab in the dark".

<u>Otago population projections</u>

There was brief discussion on the amount of effort that should go into management and continued modelling for this sub-population. The current status and increasing projections imply that this population is not under any significant threat at this point. However, the projection is useful in that it indicates that, assuming current demographic rates continue without immigration, the Otago population is not likely to achieve "subpopulation" (35 pups per year) status within the next 20 years.

It was noted that it is important to recognise demographic stochasticity in the model, because chance events can have substantial impacts on small populations. The current setup also inherently assumes that one-off 'catastrophic' effects do not occur, which, if they did, could significantly affect the increase as modelled.

Retrospective Impacts Analysis

It was noted that starting in 2000 may not provide an accurate analysis of the impacts, since it is known that many of these threats were occurring prior to that time. The population impacts may have happened prior to 2000, but we are unable to see those impacts because this is only modelled from 2000. However, the outcome describing the effect on lambda as a result of alleviating the threats will not be influenced by where the positive change occurs given that the rate of decline has been fairly consistent since 2000.

Commercial fishing impacts could fairly easily be taken back to 1995 since information is available on both captures and interactions back to that year.

For some of the other impacts, there is little data that would support any extension backwards beyond 2000. Trophic effects and hookworm have very limited data before 2000, and even the census data, prior to 1998 is less reliable.

A better understanding of the impacts of *Klebsiella* and the potential of it having been in the population longer than currently thought is very important and would contribute to our ability to understand and monitor the overall threats to the sea lion population, especially at Auckland Islands. This could be considered a key area for research going forward (e.g. by analysing historic tissue samples for *Klebsiella*).

Actions/Recommendations

The extent of the reversal in threats that would need to be made to get to a λ of 1.0 and 1.07/1.08 will be conducted. The demographic scenario assessments will be expanded, and a plot similar to Figure 3 in Meyer's paper will be produced to show what management actions would be required to meet the management 'targets'.

It was noted that the NIWA model will need to be published in the primary literature. Otherwise, other analyses published in the primary literature will be viewed by the public as the authoritative source.

It was agreed that it would be helpful to improve the ability to assess the threats in a cumulative manner, and to consider options to address the fact that not all of the causes of the decline have been found and accounted for.

It was suggested that correlative analyses could be done in more detail using regression-based models with interaction terms, where outputs could provide more information on what is driving the changes in the population. These analyses would be useful for assessing the relative impact of specific threats. For example changes in catch per unit effort as proxies for trophic effects could be assessed against adult and pup survival now there is greater confidence in the age-specific mortality rates.

Input data

Male aggression – Auckland Island

The impact of male aggression on female (adult) survival got dropped out after the triage and was not carried forward to MCMC projections. This may have been due to a transcriptional error in the upper-bound. It is proposed that the best estimates and upper bound be amended and be re-run through the triage and then taken forward to MCMC runs.

Sharks

No change.

Drowning in holes

This threat should be taken forward to MCMC projections, as this is a manageable threat and it should have been included previously.

Trawling

It was noted that there is controversy around the 'interactions' number, which is likely related to the lack of transparency and understanding in how it is calculated and what data is used in its calculation (note 'interactions' are those sea lions that would have been observed as killed if there were no SLEDs).

Trophic/Klebsiella
It was noted that best estimate plots for disease will be subject to a high level of scrutiny and the parameters used must be defensible. The panel recommended a regression analysis on the proportion of pup mortality caused by disease might prove helpful to identify if there is a similar sized effect on first year survival to that from the model. This may also help provide better estimates of mortality from disease (noting that it is currently difficult to identify good vs. bad disease years).

General
The Panel recommended that regression modelling be conducted for all of the main hypothesized threats to better understand the interactions of all of the threats.

Given time constraints, it was agreed that the recommended regression analysis work could be progressed later, for the primary literature publication or in a separate piece of work as part of future research effort.

Cumulative effects

To determine if the estimated total magnitude of all threats identified is plausible, the Panel suggested that all of the effects be added up outside the model and compared to the best year for survival. This could show whether addressing everything that is known about would be sufficient or if there is still a gap due to other threats that are not currently understand or identified (i.e. if after all threats are removed lambda is still below 1.08, then it is possible that a threat has been missed, or the best estimates are not accurate). This could be a powerfully illustrative exercise to help communicate the level of understanding. If a lambda of greater than 1.1 is achieved then this could indicate that it is inappropriate to assume additive effects are at play.

Day 3 – September 3rd 2015
The third day of the workshop: considered the potential treatment of the Campbell Island and smaller Stewart Island populations; revisited the overarching threat management goals in light of the outcomes to the modelling work, and made use of the panel's expertise to begin to identify potential research, monitoring and management options. The workshop also briefly considered future strategy evaluation using the NIWA model.

Discussion of Data Poor Breeding Areas
<u>Campbell Island</u>

- It was recognised that data on the Campbell Island colony is limited. Noting that only a few NZ sea lions were found at Campbell Island before the late 1990s, it is unknown, for example, when the switch to colonial breeding may have occurred.
- Concern was raised that the early counts may have only counted a portion of the NZ sea lion population, and later counts were more methodical and likely counted the majority of the population. This is likely to have artificially inflated the growth rate of the population, though it was acknowledged the population has grown.
- It was suggested that it might be helpful to take a backwards look at the pup counts based on current pup count and a given lambda. A value less than 1.06, might be considered

suggestive of the early counts being an under estimation of pup production, though some caution is necessary given the limited information available on the various impacts on this population.

- Whilst *Klebsiella* was found in Campbell Island necropsies in 2014/15, no analyses of historical samples have been undertaken to determine its presence in earlier seasons. The extent of the effect of *Klebsiella* at Campbell Island remains unknown. It was noted that 62% of pup mortality in the 2014/15 season was due to starvation, most likely as a result of pups being stranded in holes.
- The Panel recommended more surveys on this population to determine what might be causing the pup mortalities and determine if the population is in fact reaching a plateau.

<u>Stewart Island</u>

- The Panel recommended that the most effective way to manage the main identified threats to the Stewart Island population (i.e. human impacts), given its small population, would be to invest in social campaigns and engagement.
- The Panel also recommended increased monitoring and a focus on the collection of better data to improve understanding of this population, which would allow for modelling to be undertaken in the future.

Threat Management Plan Goals & Criteria

- It was considered that the 5 and 20 year goals could be applied to the overall population and that rather than demographic or even population rate targets, the aim might be to have a New Zealand sea lion population at or above the current size by 2037. This approach might then be supported by site-specific subsidiary goals which would allow for the management responses to be targeted to each population. For example:
    - Auckland Islands – stop or reverse the decline based on demographic rates
    - Mainland – manage threats that may impair further growth
    - Campbell Island – monitor to allow for characterisation of population and trends
    - Stewart Island - manage threats that may impair further growth and monitor to allow for characterisation of population and trends
- It was agreed that it will be important to specify what aspect of the 'population' is being monitored, i.e. pup production, or mature females, or the whole population, or rate of decline. The potential for time lags in detection based on the part of the population being measured was also noted i.e. a change in pup survival will not be measurable until at least 2022.
- It was also suggested that the 20-year goal could be linked back to generation times for New Zealand sea lions.

Research/Monitoring/Management Recommendations

<u>Auckland Islands</u>

A wide range of research, management and monitoring options were proposed by the Panel in relation to the various threats at each of the colonies:

Impacts from the Trawl fishery

- Quantifying the encounter rate (i.e. how often sea lions do come in contact with trawl gear).
- A rigorous analysis of the historic proportional representation of tagged sea lions from the various subantarctic colonies caught in commercial fisheries may indicate whether Sandy Bay animals are disproportionately caught.
- Simultaneous tracking studies from Dundas and Sandy Bay may help to determine foraging separation and the potential for 'bias' in the animals that are bycaught in the squid fishery.

Impacts from *Klebsiella*

- Identifying environmental reservoirs of *Klebsiella*
- Determining the level of exposure to compare to actual disease occurrence
- Assessing the extent of survival of the bacteria amongst pups
- Using epidemiological models to estimate numbers infected throughout the entire year, preferably with data from extended field studies
- Determining if *Klebsiella* was present prior to the observed population decline
- Genetic investigation can help improve understanding of a number of factors related to the *Klebsiella* infection, including:
    - the history of the bacteria;
    - what made it suddenly more virulent or lethal;
    - increased vulnerability among sea lions;
    - any bacterial mutation that may have occurred, and
    - if *Klebsiella* found in the environment is the same as the one that kills the pups.
- Genetic and microbiological studies could also provide information on treatment options.
- Epidemiological analyses, e.g. case-control studies and randomised controlled trials, to determine risk factors for the disease. These will help inform management strategies.
- Treatment of sea lions is likely to be prophylactic. Treatment once clinical signs are observed is likely to be ineffective. Therefore risk factor analyses are important to inform therapy.
- It was noted treatment was likely to be an ongoing control measure if an environmental reservoir and lack of adaptation to resist infection exist.
- Mapping spatial development of cases across breeding sites could help identify how the disease is spread and should be part of a risk factor analyses. This may provide insights into risk and allow behavioural management of the sea lions to prevent disease spread.

Trophic impacts

- Researching the differences in and reasons for nutritional stress between populations (see Campbell Island).
- Monitoring pup growth and condition.

<u>Campbell Island</u>

- Monitoring for the specific drivers of pup mortality.
- A short high-intensity period (i.e. 3 yrs of annual) may provide the underlying information on variability and a number of demographic factors that could help determine what the frequency of monitoring might need to be in future. The timing of future field trip visits should allow for the management of holes that pups can fall into.
- The collection of further foraging information (tracking foraging behaviour) and diet information, from that population will inform differences between Auckland Islands and Campbell Island population

- Improving autopsy data to understand actual causes of mortalities.
- Enhancing monitoring and collection of demographic data wherever possible

Stewart Island

- Documenting the current sampling programme with an aim of increasing the effort and bringing observations forward to January.
- Characterising the distribution and improving estimates of abundance to support model development and projection, which in turn will yield better understanding of the Stewart Island population.

General

- The importance of extended field seasons, especially at Auckland Islands, in order to better understand the effects of *Klebsiella*.
- Improving collection of summer and winter diet information for a range of analyses.
- Further analysis of already-collected data and samples from previous years.
- Exploring opportunities for "value adding" science projects to existing and planned field trips
- The Panel noted the importance of thinking creatively about future research and management approaches rather than replicating historic approaches.
- It was noted that there is some information on the proportion of adult females that are bycaught in the fishery that have been necropsied and found to have been lactating. This information might be used to better inform the number of pups that may have died as a result of fisheries bycatch. (Currently 70% of females are considered to be breeding, yet the necropsies of bycaught animals, which is likely to include a number of immature animals (i.e. aged 3-7), suggests it's actually closer to 30%). Potentially resample breeding probability in the years that you're sampling the bycatch amount from?

Management Options

Mainland

- Social campaigns to minimise human interference and impacts on the populations. It was suggested that this could even include a rehabilitation and education centre if the Otago / mainland population continues to grow.
- Develop options for dealing with overly aggressive males.
- Use translocation intervention as a management tool for cases where mums and pups are in heavily populated locations.

Stewart Island

- Provide educational material (on sea lions) to hunters. It was noted that there is an ability to educate people as they enter the island due to limited entry points.
- Seek assistance from hunters and muttonbirders to report sea lion sightings (i.e. Titi Islands).

As a general comment, the Panel recommended that all data collected on sea lions should be made available, and serious efforts should be made to access any data that is not currently available, noting that unavailable data could impede understanding and subsequent management. The Panel commented that ongoing management of sea lions will need to be an all-of-New Zealand effort and international engagement should be sought wherever possible.

It was made clear that there cannot be any relenting on management processes that are currently in place with regards to mitigating/minimising sea lion captures in the fishing industry.

All management interventions will require rigorous and defensible experimental designs to be developed to ensure that the impacts of management actions can be measured.

Low Information Threats

There was a brief discussion on how to deal with the threats that were not carried through to the modelling, and it needs to be made clear that no threats have been left out entirely. The TMP Project Team confirmed that these will be included in full in the public reporting of the workshop outcomes. It was noted that these additional threats could all be components of the 'other environmental factors' category that is coming out in the model.

The Panel also highlighted the potential for one-off, unforeseen 'catastrophic events' may trigger the need for mid-term review of the TMP.

Evaluation Strategy Using the NIWA Model

- The preferred approach was to examine what combination of adult and pup survival would be needed to reach an increasing or stable population (Auckland Islands), and then examine what the effects on adult and/or pup survival would be following management action to address particular threats.
- A suggested approach for prioritisation was to identify those actions where the biggest gains towards achievement of the goal could be made.
- It was suggested that the MCMC process could be made more efficient by coding portions of the model in C. This could enable better estimates of uncertainty in addition to making it run faster.

Resourcing

The Panel recognised the challenges involved in attempting to fund New Zealand sea lion work solely from government sources. The Panel strongly recommended seeking external, including international collaboration and philanthropic funding. Globally, this is the only population of mammals where a bacterial disease is having such a major population impact, and there should be international interest from this point of view. There is also an established track record of strong international collaborations for studies of New Zealand sea lions and this needs to be maintained and even extended.

- It was also suggested that New Zealand sea lion research requirements be made clear to universities and other potential research providers who may be interested in tackling aspects of these.