New Zealand sea lion Interim Research Priorities Sept 2014 – April 2016

Purpose

The Department of Conservation (DOC) and the Ministry for Primary Industries (MPI) are jointly developing a Threat Management Plan for New Zealand sea lions. Once the TMP is in place it will provide a five year programme aimed at reducing the decline of the sea lion population, and with a longer-term aspirational goal of reversing the decline to the point the sea lion population is thriving.

The purpose of this list of research priorities is to provide a more detailed plan for the 2014/15 summer season and outline high level priorities for the following year's research, to ensure that the right information is being collected in a robust manner to inform the assessment of current risks to the sea lion populations.
It is recognised that of the potential threats to sea lions, some may sit outside the mandate of MPI and the DOC Conservation Services Programme, and therefore this plan aims to draw both the fishing and non-fishing related elements of work together in one place.

Guiding policies and legislative framework

The plan is guided by the responsibilities and legislative framework of DOC and MPI. DOC is the leading central government agency responsible for the conservation of New Zealand's natural and historic heritage, which includes New Zealand sea lions. MPI is responsible for managing fisheries and their impacts on protected species. There are a number of key policies and pieces of legislation that guide agencies responsibilities which are described in more detail in Appendix 1. Briefly these are the;

- Fisheries Act 1996
- Marine Mammals Protection Act 1978
- Resource Management Act 1991
- Marine Mammals Protection Regulations 1992
- Conservation Act 1987
- Conservation General Policy 2005
- New Zealand Biodiversity Strategy
- Department of Conservation Marine Mammal Action Plan
- Sea lion species management plan

Context

Up until the late 1700s New Zealand sea lions were common throughout New Zealand. Sealers dramatically reduced their populations and they are now only found in the subantarctic Islands, Stewart Island and the Otago and Southland coasts.
Currently their largest breeding grounds are on the Auckland Islands where most of the pups are born each year. This breeding population has been monitored over the last 20 years and pup production has declined by 50% since 1998. New Zealand sea lions are listed as 'nationally critical', with a total population size of around 10,000 individuals and still declining.

Reasons for the observed decline are unclear and it is likely the complex interaction of a range of threats is responsible. An initial list of threats that may impact the sea lion populations are detailed in the Species Management Plan 2009-2014, this included a range of both human induced and non-human induced threats. An updated list of threats is

included as Appendix 2. Due to the potential for interaction between threats and the cumulative impact of multiple threats we need to better understand the whole system in order to design effective protection measures.

To do this a Threat Management Plan is being developed, which will review and assess all the potential threats to New Zealand sea lions in order to explore and develop the most appropriate and feasible management measures to protect and ensure the survival of the population.

There are three key work streams within the development of the Threat Management Plan. The first stream is the risk assessment phase which is important for reviewing and prioritising different threats. The risk assessment work stream will involve gathering and consolidating existing information to inform conducting a quantitative risk assessment that addresses the threats to the New Zealand sea lion population where there is enough data to support this approach. An expert panel will be convened to undertake a qualitative risk assessment to evaluate the effect of all the threats and assist with understanding the overall risk to New Zealand sea lions.

Once the risk assessment has been finalised and the key threats identified, this will inform the development of management options for minimising threats which will be consulted on. To inform the risk assessment four key steps have taken place to date;

- A workshop to discuss options to better understand and mitigate the impact of pup mortality on the sea lion population was held.
- A stocktake of all information currently known on New Zealand sea lions and a literature review of similar overseas examples is being considered; e.g. Steller sea lions and Hawaiian monk seals; and
- The New Zealand sea lion demographic research project has been finalised and will form the basis of the risk assessment model development going forward,
- A review and consolidation of information on incidental captures of New Zealand sea lions.

This work has identified a number of information gaps that should be filled to better inform the wider Threat Management Plan process. A working paper provided by Childerhouse et al (2014) is provided as Appendix 3 which summarises the key information gap areas. Not all gaps will be able to be addressed in one field season so DOC and MPI have prioritised a few key areas of focus broadly speaking the key information gaps fall into the following main categories:

1. Improving our understanding of pup mortality on the Auckland Islands, including quantifying the relative importance of *Klebsiella*, hookworm and drowning in mud bogs and possible mechanisms for treatment or mitigation, and understanding the influence of pup mortality on the overall population decline;
2. Understanding the effects of nutritional stress on female survivorship as well as indirect effects on pup mortality,
3. Understanding population trends at Campbell Island, including pup production and levels and causes of pup mortality,
4. Understanding the population trends, survivorship and potential threats faced by sea lions on the Mainland.

The information gaps that can be filled through sampling during the 2014/15 field season will be finalised in time to be incorporated into the quantitative risk assessment modelling work. This plan also outlines high level priorities for the 15/16 season, the interim results of which will be incorporated into the risk assessment process qualitatively via the expert panel due to the timeframe the process has been scheduled to allow Ministerial decisions in early 2016.

Interim Research Priorities

In an effort to pull all New Zealand sea lion research planned for this summer into a collaborative approach to inform the TMP process, this interim research plan includes;

1. The annual CSP pup monitoring plan, and

2. Research that supports the two science-based themes of the Threat Management Plan process (see Figure 1);
    a. Risk assessment, and
    b. Monitoring and active management

This research plan details the annually planned work for DOC CSP, which involves pup counts and tagging on the Auckland Islands (Enderby, Dundas, South East Point and Figure of Eight).

It briefly outlines those programmes of work required for the risk assessment stream of the TMP process. This may include the actual development of a risk assessment model as well as work to quantify threats and parameters for inclusion in the model.

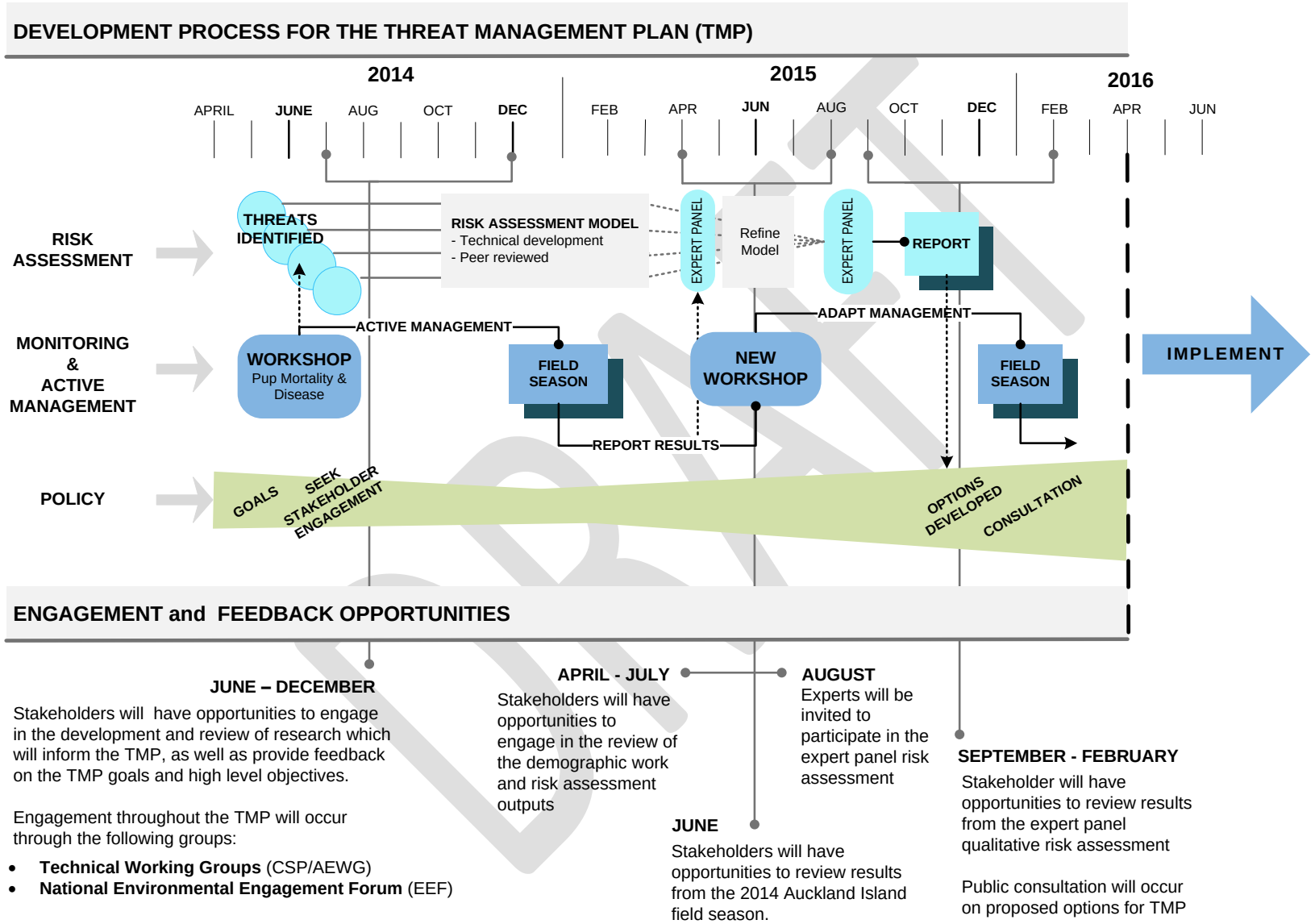
It also outlines other research that could be conducted through the course of this plan to fill the information gaps identified above. The projects undertaken in the 2014/15 field season may also feed into the risk assessment process. Not all projects proposed here have been prioritised to commence in the 2014/15 summer season, however, those that were not successful this year would be a high priority to commence in the following summer.

A brief overview of the relevant projects are outlined in Table 1 and followed with more detailed project descriptions.

Department of Conservation
Te Papa Atawhai

Ministry for Primary Industries
Manatū Ahu Matua

Figure 1



JUNE – DECEMBER

Stakeholders will have opportunities to engage in the development and review of research which will inform the TMP, as well as provide feedback on the TMP goals and high level objectives.

Engagement throughout the TMP will occur through the following groups:

- **Technical Working Groups** (CSP/AEWG)
- **National Environmental Engagement Forum** (EEF)

APRIL - JULY

Stakeholders will have opportunities to engage in the review of the demographic work and risk assessment outputs

AUGUST

Experts will be invited to participate in the expert panel risk assessment

JUNE

Stakeholders will have opportunities to review results from the 2014 Auckland Island field season.

SEPTEMBER - FEBRUARY

Stakeholder will have opportunities to review results from the expert panel qualitative risk assessment

Public consultation will occur on proposed options for TMP

Department of Conservation
Te Papa Atawhai

Ministry for Primary Industries
Manatū Ahu Matua

Table 1: Research projects and monitoring programmes proposed or planned for New Zealand sea lions

This table broadly lays out the range of projects to support the development of a Threat Management Plan for sea lions in a short-term time frame. They are not listed in order of priority, but are ordered by work stream:

- **Conservation Services Programme - Ongoing**: work already committed by DOC CSP as part of the long-term demographic study on New Zealand sea lions
- **Risk assessment stream of TMP**: these are stand alone risk assessment projects that have been signalled as a core component of the wider Threat Management Plan, including collation of existing information and a two stage risk assessment analysis.
- **Active management stream of TMP**: these are projects that result in direct actions to prevent mortality,
- **Monitoring stream of TMP**: these are projects that have arisen from the initial sea lion stocktake and pup mortality workshop to assess where information gaps currently are and which are the highest priority to fill to inform wider TMP

*Opportunistic sampling of environmental samples, scats, regurgitates and hair, are all possible within the three main research streams, the analysis of these samples would contribute to filling information gaps on understanding disease and pup mortality, as well as female nutritional stress. Sampling can be undertaken at little to no cost, however, the analysis of the samples will require funding which will need to be prioritised.

For the projects which fit into the active management stream, it is also noted which of the four key information gaps the proposed project would contribute to.

For each of the projects the Status is also noted, this can be either:

- Committed – there is funding committed to the project
- Underway – the project is already underway and due to be completed
- Seeking sponsorship – DOC and MPI are seeking co-funding or sponsorship. Note in some cases, a project can be committed but sponsorship is also sought. Sponsorship is not required for all of these projects to commence but to keep options open for potential co-funding, it is not being restricted to specific projects.
- Proposed – This project has been proposed and could occur this summer or if funding is unavailable this year funding could be sought to run the project in the following season.

Project #	Topic	Work stream	Indicative $	Information gap filled	Status	Timeframe	Organisation lead
1	Conservation Services Programme Annual Auckland Island Ground survey	CSP ongoing	$200,000	Ongoing monitoring of trends on the Auckland Islands	Committed	Annually (Jan/Feb)	CSP
2	Sea lion stock take and literature review	Risk assessment	Internal resourcing	Gap analysis to inform risk assessment model	Underway	Current to July 2015	DOC
3	Risk Assessment Model	Risk assessment	$200-250,000	Quantitative risk assessment for risks where enough data exists, expert assessment of model inputs and qualitative risk assessment	Committed	March 2014 - June 2015	MPI/DOC

4	Otago and Southland demographic data analysis	Risk assessment	$10,000	4 – Quantifying Mainland trends for input into risk assessment	Committed	Summer 14/15	DOC/NZSLT
5	Understanding public perceptions of sea lions on the Mainland *Can include collection of opportunistic samples	Risk assessment	$6000	4- Quantifying Mainland threats for qualitative risk assessment	Committed	Summer 14/15	DOC/WPI
6	Campbell Island pup count[1]	Risk assessment	$80,000-115,000	3 – Quantifying Campbell Island trends for risk assessment	Committed	Summer 14/15	DWG
7	Stable isotope analysis	Risk assessment	$42,000	2 – nutritional stress	Committed	Summer 14/15	MPI
8	Installing ramps to prevent pups falling into holes	Active management	$4500	1 –pup mortality	Committed / Seeking sponsorship	Summer 14/15	DOC
9	Non-CSP extension to subantarctic field season[2] • Necropsy • Case control study • Opportunistic sampling	Active management/ information gaps	$65,000	1 – pup mortality 2 – nutritional stress	Committed	Summer 14/15, AND Summer 15/16	DOC/Massey
10	Analysis of environmental samples	Monitoring	$10,000	1 – pup mortality	Committed & seeking sponsorship	2015	DOC/Massey
11	Analysis of necropsy	Monitoring	$10,000	1 – pup mortality	Committed	2015	Massey

[1] This work is proposed as a separate project to conduct a more complete pup count on Campbell Island. If funding was not secured for this project this year, it would be considered a high priority to undertake in the following season and would be committed then.

[2] If P6 does not go ahead in the summer of 2014/15 then a 10 day information gathering trip to Campbell Island could be included within this project.

	samples from the 2014/15 field season						
12	Female nutritional stress project	Monitoring	$TBC	2 – nutritional stress	Proposed	Summer 2015/16	DOC
13	Estimating changes in sea lion diets using Bayesian modelling	Monitoring	$48,000	2 – nutritional stress	Proposed	2016	DOC/MPI
14	Analysis of opportunistic and historic diet sampling (scats and regurgitates)	Monitoring	$TBC	2 – nutritional stress	Proposed	2016	DOC/Massey
15	Analysis of historic necropsy samples – pups	Monitoring	$130,000	1 – pup mortality	Proposed	NC	DOC/Massey

Project descriptions

Conservation Services Programme - Ongoing

P1: CSP annual ground survey

Rationale:
New Zealand sea lions are classified as Nationally Critical[3], and are incidentally killed each year in southern commercial trawl fishing operations targeting species including squid, scampi and southern blue whiting. The foraging areas of New Zealand sea lions at the Auckland Islands have been shown to overlap with commercial trawl fishing activity, particularly SQU6T and SCI6A. Approximately 70% of New Zealand sea lions breed at the Auckland Islands, where population data have been collected since the mid-1990s, including estimates of pup production and resighting of marked animals. Since 2001 there has been a considerable decline in pup production at the Auckland Islands. A literature review to identify potential indirect effects of commercial fishing on the Auckland Islands population as part of CSP project POP2010-01 has recently been completed (Bowen 2012). The review highlighted a number of key information gaps that currently prevent a full understanding of any such potential indirect effects.

In order to manage the commercial fisheries impacts on New Zealand sea lions at the Auckland Islands it is critical to understand the population level and key demographic factors driving trends in the population. CSP project POP2012-02 analysed population data collected during previous years in order to determine the key demographic factors driving the observed population decline of New Zealand sea lions at the Auckland Islands. This project will extend the time series of population data available for further analyses.

Outcomes:

- Data collected, in an electronic format suitable for upload into the New Zealand sea lion database.
- New Zealand sea lion database updated and made available to relevant investigators. Any changes to the structure of the database must be fully documented.
- A technical report (or reports) detailing the methods used, a summary of data collected and estimates of New Zealand sea lion pup production at the Auckland Islands.

Indicative cost: $200,000 from CSP budget
Status/dependencies: Committed, part of the CSP annual plan 2014-15; dependant on having suitable tender to carry out the work
Funding: CSP

Risk assessment stream of TMP

P2: Sea lion stocktake and literature review

Rationale:
There is a large amount of scientific and grey literature dedicated to research on the New Zealand sea lion and threats to New Zealand sea lions. Much of the literature is from the Auckland Islands population, however, some exists for the Campbell, Stewart Island and Mainland populations or breeding sites. A compilation of all of this information into one place for storage and access will assist in the risk assessment and other components of the Threat Management Plan development. In addition there are international examples with similarities to the New Zealand situation, for example, Steller sea lions, and Hawaiian monk

[3] Baker, C.S.; Chilvers, B.L.; Constantine, R.; Du Fresne, S.; Mattlin, R.H.; van Helden, A.; Hitchmough, R. 2010: Conservation status of New Zealand marine mammals (suborders Cetacea and Pinnipedia), 2009. *New Zealand Journal of Marine and Freshwater Research 44(2)*: 101–115.

seals. A compilation of information on these species and the research and management actions pertaining to them will be valuable for a literature review and input into the New Zealand sea lion Threat Management Plan process.

Outcomes:
This project can be undertaken in stages with the first stage being compilation of literature and data sources. This is structured in two spreadsheets, one for literature, which includes fields for quick searching by a range of features, e.g. topics, methods, study location, and links to the full article or report. The second spreadsheet compiles sources of data, which individual, group or organisation holds the data, and what access approvals are required for access for future analysis of the data.

The second stage would involve taking the compiled literature and undertaking a review with the output of a background document on New Zealand sea lions, the threats to the sea lions, and comparison with similar international examples.

Indicative cost:
$10,000-$15,000 for both stages, this amount includes internal resourcing.
Status/dependencies: The first stage was completed internally. The second stage is likely to be outsourced.
Funding: DOC/MPI

P3: Risk assessment

Rationale:
A crucial component of the Threat Management Plan is an assessment of all risks to sea lion populations, including fishing-related mortality and other threats. This project provides for a thorough quantitative assessment of demographic rates and risks for sea lions as part of a wider risk assessment process.

MPI has worked with DOC to determine an appropriate risk assessment approach consisting of a quantitative risk assessment, along with independent input from an expert workshop during model development, and a subsequent expert panel review. The development of policy for threat management options will allow the quantitative risk assessment to undertake management strategy evaluations that will contribute to the development of options in the Consultation paper. The final expert panel review will allow for consideration of risks where sufficient data is available for quantitative modelling and will also inform options for consultation.

Previously the Breen-Fu-Gilbert sea lion model and management strategy evaluation has been used to evaluate the impacts of fishing on the Auckland Islands population of sea lions. This model was reviewed by a panel of international experts in July 2013. Although the panel concluded that the modelling framework used was robust and capable of performing the tasks required from it, they made many suggestions for different approaches to the modelling, data and assumptions. This project provides for additional work to increase our understanding of the extent to which fishing-related mortality and other drivers affect the population. Existing or new models could be used.

Since then a demographic analysis of population trends has been undertaken to examine underlying causes of the decline of the Auckland Islands sea lion population. A correlative analysis has examined the potential relationships with trends seen in the wider marine environment. These analyses have added another dimension to the previous modelling exercises but they have not been able to include tag loss which will lead the analysis to underestimate adult survival.

The Contractor will estimate demographic parameters for Auckland Islands and other areas (Otago) and present the results to the Aquatic Environment Working Group and an initial expert workshop. Following this the Contractor will conduct management strategy evaluation quantitative estimates for Auckland Island and other areas (including Otago and Campbell Islands) and present draft report to Aquatic Environment Working Group and a second expert workshop.

Outcomes:

- Demographic parameters for Auckland Islands and Otago sea lions
- Estimates of population trends, impacts of threats over time for sub-populations modelled
- Management strategy evaluations
- Expert panel review

Indicative cost: $200,000-250,000 over two years
Status/dependencies: Contract nearly finalised (as at 14/11/2014)
Funding: MPI/DOC

P4: Otago and Southland demographic data analysis

Rationale:
Extensive research has been conducted on the Auckland Islands population of New Zealand sea lions going back to the 1980's. This data set has allowed for a rich understanding of the population including the ability to calculate population estimates, estimate survival of different age classes, and female breeding success. While the Mainland population is only small, it has been increasing and has the potential to meet the criteria of a breeding population which would move the New Zealand sea lion to a lesser threat classification. Considerable monitoring data in the form of Photo ID sightings have been collected on the small breeding groups on the Otago and Catlin coasts. However, it needs to be processed to allow for calculation of population size, assess trends, and estimate survivorship. Once photos are processed and databases are current, the appropriate analyses can be undertaken and feed into the risk assessment model which will inform the Threat Management Plan options for consultation. The final outputs can also include a report that is made available via the DOC and NZSLT websites.

Outcomes:

- Photos from 10 years of monthly and/or biannual surveys processed and catalogued
- Resightings up to date and data prepared/ QAd
- Data in a state to be analysed for demographic parameters for use in the risk assessment model

Indicative cost: $10,000 (intern)
Status: Support from NZ sea lion trust, and intern will commence work in mid November
Dependencies: funding
Funding: DOC

P5: Public awareness and perceptions about New Zealand sea lions on the Mainland

Rationale:
With the majority of breeding restricted to the Auckland Islands, the New Zealand sea lion is incredibly susceptible to any impacts. Small breeding sites with the potential for expansion exist on the South Island of New Zealand (Otago and Southland coasts), and on Stewart Island. If this population continues to grow it would contribute to the overall status and

resilience of the species as a whole. However, the closer proximity to human activities means these sea lions are exposed to a different range of threats than those at the more isolated locations, for example; malicious acts, dog attacks, tourism interactions, feeding of sea lions etc.

Many of the threats the New Zealand sea lions are exposed to on the Mainland and Stewart Island can be managed through education and awareness material. The Department of Conservation in collaboration with the New Zealand sea lion Trust has developed a suite of material for a range of audiences, including school activities. The question remains whether or not this material is reaching its intended audience and whether or not the public are assimilating the information.

It is proposed to assess the effectiveness of awareness and educational material developed previously for New Zealand sea lions through a review, and public survey. Information gained from the survey would feed into the risk assessment and development of options for minimising threats to sea lions on the New Zealand mainland.

Outcome:

- Assessment of the effectiveness of the work done to date to minimise the impact of non-fishing related threats to sea lions on the mainland
- Assessment of perceptions and willingness to change behaviour to minimise impacts on sea lions
- Advice on options that remain could be included in the TMP options paper.

Indicative cost: $10,000 (accommodation and travel, if including Stewart Island)
Status: Support from NZ sea lion trust and DOC district staff, application submitted
Dependencies: A student group has started preparation for this project and will commence in New Zealand in Jan 2015. They will initially cover the Mainland, and Stewart Island may also be included funding dependent
Funding: DOC

P6: Campbell trip for full pup count

Rationale:
New Zealand sea lions are classified as Nationally Critical owing to a severely declining pup production estimate at the largest population, the Auckland Islands (50% decline since 1989), and are incidentally killed each year in southern commercial trawl fishing operations targeting species including squid, scampi and southern blue whiting. The second largest breeding population of the New Zealand sea lion, where 21% of pups are born, is Campbell Island. This population has been monitored occasionally, with the two most recent pup count estimates undertaken in 2007 and 2010. From these two counts there is evidence of a possible increase in pup production[4]. However, the scientists also noted that this population had the highest recorded pup mortality of any breeding area (55%). These two counts are not methodologically comparable to previous counts as previous counts were undertaken later in the season once sea lions have moved away from the colonial breeding sites. Due to the methodological difference as well as the high pup mortality estimate it is difficult to say if the Campbell Island population is in fact increasing, and if it is, if this increase can be sustained. It is therefore critical to undertake regular ground survey pup counts on Campbell Island, comparable to the last two pup counts in order to more fully understand trends in pup production on Campbell Island.

[4] Maloney, A.; Chilvers, B.L.; Muller, C.G; Haley, M. 2012: Increasing pup production of New Zealand sea lions at Campbell Island/Motu Ihupuku: can it continue? *New Zealand Journal of Zoology, 39(1):* 19-29.

This project is critical to understand trends in the population and the key demographic factors that could be driving trends in the population. This project will extend the time series of population data available for further analyses.

Outcomes:

- Pup count comparable to the 2007 and 2010 counts
- Tagging, resighting data in an electronic format suitable for upload into the New Zealand sea lion database.
- Necropsy data
- A technical report (or reports) detailing the methods used, a summary of data collected and estimates of New Zealand sea lion pup production at the Auckland Islands.

Indicative cost: $100,000
Status/dependencies: Committed
Funding: Deepwater Group

P7: Stable isotope analysis

Rationale:
Stable isotope values of marine predators can also serve as indicators of changes in the base of the food web and ocean conditions. This occurs because there are significant variations in the isotope values of primary producers when the nutrients available and productivity shift in the open ocean. These baseline values then propagate up the food web and are incorporated in the tissues of the predators, including teeth and bones. Therefore, by examining the isotope values of predators through time you can determine if there are shifts in the base of the food web (as reflected in the $\delta^{13}C$ values) and if there are shifts in foraging ecology or trophic position of the predator (as reflected in the $\delta^{15}N$ values). This approach is especially powerful when you can analyse samples that have archived this information consistently through time (e.g., otoliths, spines, teeth, and marine mammal whiskers. In this project we will analyse the annual bands in the teeth of NZ sea lions to assess the temporal changes in their foraging behaviour and to assess potential changes that occurred at the base of the food web around the Auckland Islands. This analysis will help us determine what changes occurred through time and if there are commonalities during different time periods that coincide with NZ sea lion pup production increases and declines. The results from this project will be important to inform on the sea lion risk assessment (see P3 above) and, potentially, for the successful management of the NZ sea lion population at the Auckland Islands.

Outcomes:

- Temporal changes in foraging behaviour and diet of sea lions which may better inform the risk assessment about underlying causes in population fluctuations

Indicative cost: $42,400
Status/Dependencies: Contract being finalised (as at 14/11/2014)
Funding: MPI

Active management stream of TMP

P8: Installing ramps at Enderby Island and Campbell Island to actively prevent pups from falling into holes

Rationale:
At some of the sea lion colonies there are large mud bogs which pups fall into. They are not always able to get out and some die in these bogs. This used to be an issue previously restricted to Dundas and Campbell Islands; however, last year the field team on Enderby reported pups falling into mud bogs. They pulled approximately 70 out safely, though it is not known how many of these pups fell in multiple times. It is proposed to install ramps on Enderby and repair or install new ones on Dundas and Campbell as needed. Paired with this, the field team would monitor the success of installing these ramps in conjunction with their other work.

Outcomes:

- Keep pups from falling into mud bogs
- Monitoring of success of ramps

Indicative cost: $4500 (materials)
Status: High priority low cost
Dependencies: Could be done in conjunction with P1, 6 or 9 but would require the equipment
Funding: WWF sponsorship

P9: Non-CSP extension to subantarctic field season

Rationale:
Pup production is recognised as the best indicator of population status, and since 1998 there has been an approximate 50% decrease in pup production at the Auckland Islands, resulting in the species being classified as 'nationally critical' as of 2010. Adult female mortality was initially believed to be the driver for the decline and therefore management has focussed on minimising adult/sub-adult mortality, but more recent analyses suggest that low fecundity and pup survival may also be important. In addition, the disease *Klebsiella pneumoniae* has been recognised as an additional (and potentially new) source of pup mortality. This disease is responsible for significantly increasing early pup mortality to at least two or three times average levels in some years. An expert workshop was held to discuss the potential causes of pup mortality and to develop recommendations for work to understand the causes and where possible seek to mitigate the causes. Some of the proposed options form the basis for the extension to the standard CSP field season this year. These are included here (taken from Appendix 3):

- Implement a significantly expanded field season from the 'standard' CSP field programme by extending the field season to three months from mid-December to mid-March;
- Team size of 3 from mid-December to mid-January, 6 from mid-January to mid-February, and 3 from mid-February to mid-March;
- Undertake autopsies of pups through the whole season by an experienced vet;
- Undertake Case Control Study at for pups and mothers from as early in the season to departure. This study would focus on (a) identifying cause of pup mortality and contributing factors, (b) effectiveness of worming treatment (c) impacts of marking and (d) influence of nutrition state on pup morality and reproductive rate;
- Undertaken study of adult female age structure and Sandy Bay (and ideally Dundas as well) to complement the Case Control study; and

- Undertake mitigation of pup mortality in holes by building ramps in appropriate places. This component is picked up in project 8 above, but will be implemented and monitored by the CSP and extended field team.

Not all components will be able to be conducted this field season, however, many will be, and those that are not carried out this season will be undertaken next field season.

Outcomes:

- The field season will start approximately 10 days earlier and will finish at the end of March.
- There will be a vet on Enderby the whole time conducting necropsies, and determining factors to be assessed in a case control study for the next season.
- There will be increased time on Dundas for resightings by splitting team of 6, 3 on Dundas and 3 on Enderby for the pup counts.
- Collection of a range of samples; teeth, seabirds, environmental and scat/regurgitate samples to inform disease origins and presence of nutritional stress
- Two days at the end of the field season checking other islands in the Auckland group for movement of pups and evidence of mortality.

Indicative cost: $85,000
Status: Committed, contracts in progress
Dependencies: Transport and logistics, permits
Funding: DOC

Monitoring stream of TMP

P10: Analysis of environmental samples

Rationale:
The disease *Klebsiella pneumoniae* has been recognised as an additional and potentially new source of pup mortality in recent years. Since 2009 there has been an increase in the number of pup deaths related to infection with this bacterium being the cause of death for approximately 55% of pups necropsied between 2009 and 2014. It is not known how this bacterium gets into the sea lions environment and what the key source of infection is. It could be present in the environment, e.g. in the soil, sand, mud bogs, prior to the breeding season, or it could be brought in during the breeding season by an animal vector, e.g. other sea lions, birds, etc. This proposed piece of work would investigate the levels of *Klebsiella* in the sea lions environment before, and at different stages of the breeding season. This will aid in understanding the source of the infection in the pup population, and whether or not there may be practical ways of mitigating the spread of the disease (e.g. related to the installation of ramps above).

Outcome:

- Quantifying the presence of and level of *Klebsiella* in the sea lions' environment at different times during the breeding season.

Indicative cost: $10,000 (lab set up and analysis)
Status: High priority low cost
Dependencies: Samples collected early in the season by yellow-eyed penguin programme going in Nov, remaining samples collected by P1, 6, and 9, teams. Opportunistic samples are also being collected from Mainland haul-outs.
Funding: Funding dependent. DOC or possible to seek sponsorship (WWF)

P11: Analysis of the seasons necropsy samples for cause of death and presence of *Klebsiella*

Rationale:
The disease *Klebsiella pneumoniae* has been recognised as an additional and potentially new source of pup mortality in recent years. Since 2009 there has been an increase in the number of pup deaths related to infection with this bacterium being the cause of death for approximately 55% of pups necropsied between 2009 and 2014. It also appears that deaths due to *Klebsiella* are occurring later in the season, and after the field team has left. In response to this DOC will be extending the field season on Enderby by 10 days at the beginning and an extra 4-5 weeks at the end to attempt to quantify the level of *Klebsiella* related deaths that we may be missing. DOC will also be sending a vet to conduct necropsies of pups that die over the course of the season. While an initial cause of death may be possible to assess from gross pathology (visual assessment of the organs during necropsy), it is not possible to confirm the cause of death without further lab analysis.

Outcome:
- Quantifying the cause of death of pups from the season and presence of *Klebsiella*.

Indicative cost: $10,000 (guesstimate – have requested confirmation from Wendi)
Status: High priority low cost
Funding: Massey University

P12: Female nutritional stress

Rationale:
The preliminary results of a demographic assessment of the main breeding colonies at the Auckland Islands (POP2012-02) indicate variation in a number of key demographic rates since the early 1990s including: pup/yearling survival, juvenile/adult survival, pupping rate and age at first pupping. Together these will explain the observed variation in pup production through time. A reduction in adult survival can have a large an instantaneous effect on pup production because it affects breeders of a broad range of ages. At the Auckland Islands this is likely to have been exacerbated by low pup/yearling survival since 2004/05 that will have a delayed negative effect on breeder numbers and future pup production. Further literature is suggesting that female nutritional stress could be an important driver in the observed population decline and that this requires further investigation. It is proposed to develop a study that would look at this in more detail in the 2015/16 field season.

Outcome:
- The objective of the study would be to evaluate female condition and nutritional stress, ideally between populations with differing levels of fisheries interactions, and compare female condition and the subsequent impact on the pup with overlap in fish stocks and fisheries effort.

Indicative cost: $TBC
Status/dependencies: Proposed; funding dependent

P13: Estimating changes in sea lion diet using Bayesian modelling

Rationale:
Diets of New Zealand sea lion have been investigated using stomach contents and regurgitates, as well as from fatty acid composition and stable isotope analysis. While the former methods have provided data for many years, they remain snapshots of diets that may be biased by differential digestion and egestion rates of particular tissues (e.g., hard parts such as beaks and otoliths). The fatty acid composition of predators has the potential to reflect diets over longer periods, and to be unbiased by digestion and egestion rates. However, some fatty acids will be preferentially assimilated and metabolized (converted) by

the predator, so predators' fatty acid composition rarely reflects diet fatty acids directly. This process of assimilation and modification needs to be accounted for. This can be achieved by using a set of conversion coefficients estimated from captive feeding trials.

Outcome:

- Determining whether changes in sea lion pup-survival at the Auckland Islands between 2000 and 2006 are associated with changes in sea lion diet.

Indicative cost: $48,000
Status/dependencies: Proposed; funding dependent

P14: Analysis of opportunistic and historic diet samples

Rationale:
As nutritional stress of females has been highlighted as a potential driver of population decline, it is acknowledged that historic samples exist that remain to be analysed, and incorporated into our understanding of female nutritional stress and the impacts on the population. It is proposed that any new opportunistic samples and historic samples are worked up and made available for further demographic modelling and bioenergetic assessment.

Outcome:

- The objective of this work would include evaluation of sea lion diet over time and filling in gaps where there currently exist. This analysis could inform elements of P12 including further work on the bioenergetics of the New Zealand sea lion and the implication for changes in fish stock on female nutritional stress.

Indicative cost: $TBC – this will depend on the number of samples available, type, and tests that need to be run
Status/dependencies: Proposed; funding dependent

P15: Reassessment of historic necropsy samples – pups

Rationale:
Two key diseases have been highlighted as factors of pup mortality for New Zealand sea lions, hookworm and *Klebsiella*. While pups have been necropsied and samples collected over a number of years, samples were often assessed for a specific purpose or project. Klebsiella was initially observed in two causes of mass mortality; however, in more recent years results suggest the likelihood that it may be endemic within the population.
It is not clear the relative level of importance of hookworm and *Klebsiella* in pup mortality, the prevalence of *Klebsiella* in earlier samples, and potential interaction between *Klebsiella* and hookworm. A reassessment of historic pup necropsy samples would provide a more holistic picture of the causes of pup mortality over time.

Outcomes:

- Data on prevalence of *Klebseilla* in the population over the time span for which samples are available (approximately 10 years).
- Reassessment of primary and secondary causes of mortality
- Assessment of level of mortality associated to each potential cause

Indicative cost: $130,000
Status/dependencies: Proposed; funding dependent

Timeline

- Timeline diagram – a visual representation from Sept 2014 –/April – 2015 showing the work being undertaken that will input into the risk assessment. This will come later.

Appendix 1: Legislative and policy frameworks guiding DOC and MPI in the development of the New Zealand sea lion Active Management Research Plan 2014-16		
Legislative or Policy framework	**Guiding principle**	**Relevant Agency**
The Fisheries Act 1996 (FA)	• Purpose of the FA • Environmental principles (section 9) • Information principles (section 10) • Sustainability measures (section 11) • Avoid, remedy or mitigate the effect of fishing-related mortality on any protected species (section 15(2))	MPI
Marine Mammals Protection Act 1978 (MMPA)	To make provision for the protection, conservation and management of marine mammals within New Zealand fisheries waters (the Territorial Sea and EEZ). Two key tools within the MMPA are: • Marine Mammal Sanctuaries – an area designated by the Minster of Conservation within which specified activities can be regulated or restricted. • Population Management Plans – a management plan that sets maximum allowable human-induced mortality, and maximum allowable fishing-related mortality.	DOC
Resource Management Act 1991 (RMA)	**RMA Part 2 – purpose and principles – sections 5-8** • To promote the sustainable management of natural and physical resources… including safeguarding the life-supporting capacity of air, water, soil, and ecosystems (s 5(b)). • Recognise and provide for…the protection of areas of… significant habitats of indigenous fauna (s 6(c)). • Have particular regard to…intrinsic values of ecosystems (s 7(d)).	MfE/DOC/ Local authorities
	New Zealand Coastal Policy Statement (NZCPS) It is mandatory to have at least one in place at all times (s 57(1)) – NZCPS 2010 is the current one[5]. • The Minister of Conservation is required to prepare, monitor, and review the NZCPS. • The Minister of Conservation also approves regional coastal plans developed by regional councils and unitary authorities.	MOC/DOC

[5] http://www.doc.govt.nz/publications/conservation/marine-and-coastal/new-zealand-coastal-policy-statement/new-zealand-coastal-policy-statement-2010/

	• Local Authorities are required to give effect to the NZCPS in their Regional Policy Statements, Regional Plans and District Plans (sections 62(3), 67(3)(b) and 75(3)(b)). Local authorities must also have regard to the NZCPS when assessing consent applications. (section 104(1)(b)(iv))
	• A number of policies within the NZCPS are relevant to the protection of New Zealand sea lions, in particular around the Otago and Southland populations (e.g.);
	  ○ Policy 7 – Strategic planning
	  ○ Policy 11 – Indigenous biological diversity
	  ○ Policy 13 – Preservation of natural character
	  ○ Policy 14 – Restoration of natural character
	  ○ Policy 21 – Enhancement of water quality	

	Local Authorities (Regional, Unitary, City and District) must give effect to the NZCPS in their regional policy statements and plans. Regional Coastal plans (mandatory in all regions) can: • Include objectives, policies and rules • Can include spatial planning, e.g. zoning	Local authorities
Marine Mammals Protection Regulations 1992 (MMPR)	Regulations under the MMPA which provide a regulatory framework for behaviour around all marine mammals and a permitting regime for commercial tourism.	DOC
Conservation Act 1987 (CA)	New Zealand's principle Act concerning the conservation of indigenous biodiversity and promotes the conservation of New Zealand's natural and historic resources. It sets out the functions of DOC and the management of public conservation land in New Zealand.	DOC
Conservation General Policy 2005	Prepared under the CA and provides unified policy for the implementation of a number of Acts. It provides guidance for the administration and management of the MMPA. In particular: • 4.4(e) The Department should work with other agencies and interests to promote and develop a marine protected areas network, including marine reserves, wildlife reserves, sanctuaries and other protective mechanisms. • 4.4(f) Protected marine species should be managed for their long-term viability and recovery throughout their natural range. • 4.4(j) Human interactions with marine mammals and other protected marine species should be managed to avoid or minimise adverse effects on populations and individuals.	DOC

	• 4.4(l) The Department should work with other agencies and interests to protect marine species.	
New Zealand Biodiversity Strategy	Reflects New Zealand's commitment to the Convention of Biological Diversity. • Desired outcome for 2020:No human-induced extinctions of marine species within New Zealand's marine environment have occurred. Rare or threatened marine species are adequately protected from harvesting and other human threats, enabling them to recover. • Objective 3.7: Protect and enhance populations of marine and coastal species threatened with extinction and prevent additional species and ecological communities from becoming threatened.	DOC
Department of Conservation Marine Mammal Action Plan 2005-2010	Provides a guide for conservation management of New Zealand's marine mammals, including specific outputs and actions that should be taken over the five year duration of the plan. With regard to New Zealand sea lions the Species Management Plan process and now the Threat Management Plan process will subsume the actions and research prioritisation for this species	DOC
New Zealand sea lion species management plan 2009-2014	This plan provides a strategic framework to guide DOC in managing the recovery of the New Zealand sea lion (*Phocarctos hookeri*) to non-threatened status. The aim of the Plan is to make significant progress in facilitating an increase in the New Zealand sea lion population size and distribution. Successfully managing the recovery of the New Zealand sea lion, in terms of its threat status, within the Plan term (5 years) is unlikely given various biological constraints. Consequently, management measures will focus on a number of key areas to ensure that progress towards recovery is achieved: • Management of the adverse effects of human interactions • Protection provisions and compliance • Community relations	DOC
Sea lion TMP in development	The goal of the Threat Management Plan is to develop a five year programme aimed at reducing the decline of New Zealand sea lions, with a longer term aspirational goal of reversing the decline so that the sea lion population is thriving.	DOC and MPI

Appendix 2 Table 1: A list of potential threats to New Zealand sea lions based on known threats and threats to other marine mammals. The threats have been assessed for whether they are applicable to sea lions and if so, which population. They are also assessed as to whether they were likely to affect population trends within the next 5 years.

Threat Class	Threat	Applicable to population	Likely to affect population trends within the next 5 years
Fishing	Commercial trawl	All	
	Any other fisheries/recreational etc		
	Trophic effects	All	
	Vessel noise; displacement	NA	
Tourism	Boat strike	All	
	Vehicles	SI, ML	
	Noise	All	
	Disturbance	All	
	Displacement	All	
Other human impacts	Dogs	SI, ML	
	Shooting	SI, ML	
	Deliberate harassment	SI, ML	
Vessel traffic	Boat strike	NA	
	Disturbance	All	
Pollution	Agricultural run off	SI, ML	
	Industrial run off		
	Oil spill		
	Plastics		
	Marine debris/entanglements		
	Trophic effects		
	Sewage Stormwater		
Coastal development	Marinas / Ports	ML	
	Displacement, noise, pollution, sedimentation		
	Wave power generation	NA	
	Tidal power generation	NA	
Mining and oil activities	Noise (non-trauma)		
	Noise (trauma)		
	Pollution (discharge)		
	Habitat degredation		
Research	Physical		
	Disturbance		
Disease	Klebsiella		
	Hookworm		
	Stress induced		
	Domestic animal vectors		
Climate change	Temperature		
	Prey Availability		
	Displacement		
Small population effects	Stochastic and Allee effects		
Predation	Sharks		
Tsunami???? (from the SMP)			

Appendix 2 Table 2: A characterisation of threats to New Zealand sea lions which were considered to be relevant within the five year time span.

Threat Class	Threat	Mechanism	Type	Population component(s) affected
Fishing	Commercial trawl	Incidental capture, cryptic mortality	Direct	Juvenile or adult survival
	Any other fisheries/recreational etc			
	Trophic effects			
	Vessel noise; displacement			
Tourism	Boat strike			
	Vehicles			
	Noise			
	Disturbance			
	Displacement			
Other human impacts	Dogs			
	Shooting			
	Deliberate harassment			
Vessel traffic	Boat strike			
	Disturbance			
Pollution	Agricultural run off			
	Industrial run off			
	Oil spill			
	Plastics			
	Marine debris/entanglements			
	Trophic effects			
	Sewage Stormwater			
Coastal development	Marinas / Ports			
	Displacement, noise, pollution, sedimentation			
	Wave power generation			
	Tidal power generation			
Mining and oil activities	Noise (non-trauma)			
	Noise (trauma)			
	Pollution (discharge)			
	Habitat degredation			
Research	Physical			
	Disturbance			
Disease	Klebsiella			
	Hookworm			
	Stress induced			
	Domestic animal vectors			
Climate change	Temperature			
	Prey Availability			
	Displacement			
Small population effects	Stochastic and Allee effects			
Predation	Sharks			
Tsunami???? (from the SMP)				

Appendix 3: Discussion paper: Review of options for future research and mitigation for New Zealand sea lion pup mortality. Childerhouse et al. 2014
(attach PDF, DOCDM-1518502)

Discussion paper: Review of options for future research and mitigation for New Zealand sea lion pup mortality

Childerhouse S[1], Roe W[2], Roberts J[3]

22 July 2014

1. Introduction

New Zealand sea lions (*Phocarctos hookeri*, hereafter NZSL) are our only endemic seal species and historically bred all around NZ, though were extirpated from the mainland by early human settlers. The current population is estimated at fewer than 10,000 individuals, with more than 99% of breeding occurring at a small number of breeding sites at the Auckland Islands and Campbell Island of the NZ Subantarctic. Much smaller breeding sites are slowly increasing at Otago and Stewart Island.

Pup production is recognised as the best indicator of population status, and since 1998 there has been an approximate 50% decrease in pup production at the Auckland Islands, resulting in the species being classified as 'nationally critical' as of 2010 (Figure 1). Adult female mortality was initially believed to be the driver for the decline and therefore management has focussed on minimising adult/sub-adult mortality, but more recent analyses suggest that low fecundity and pup survival may also be important. In addition, the disease *Klebsiella pneumoniae* has been recognised as an additional (and potentially new) source of pup mortality. This disease is responsible for significantly increasing early pup mortality to at least two or three times average levels in some years.

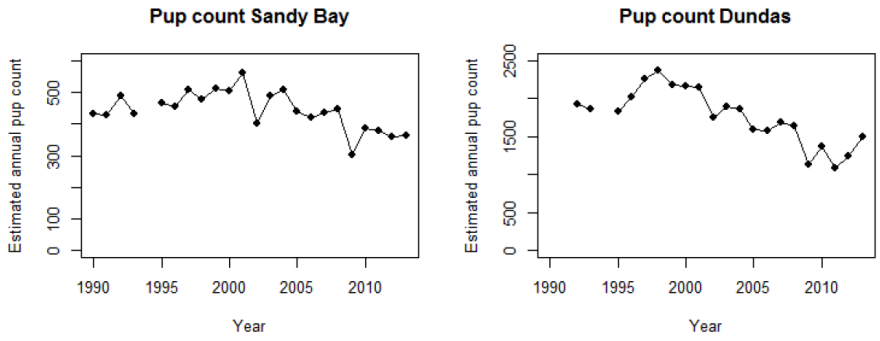


Figure 1. Estimated annual pup production at Sandy Bay and Dundas Island, the two largest breeding colonies of NZ sea lions at the Auckland Islands.

The preliminary results of a demographic assessment of the main breeding colonies at the Auckland Islands (POP2012-02) indicate variation in a number of key demographic rates since the early 1990s including: pup/yearling survival, juvenile/adult survival, pupping rate and age at first pupping (Figure

[1] Blue Planet Marine, Nelson, NZ. Email: simon.childerhouse@blueplanetmarine.com
[2] Institute of Veterinary Animal and Biomedical Sciences, Massey University, Palmerston North, NZ. Email: w.d.roe@massey.ac.nz
[3] NIWA, Greta Point, Wellington, NZ. Email: jim.roberts@niwa.co.nz

2; Roberts et al. 2013). Together these will explain the observed variation in pup production through time. A reduction in adult survival can have a large an instantaneous effect on pup production because it affects breeders of a broad range of ages. At the Auckland Islands this is likely to have been exacerbated by low pup/yearling survival since 2004/05 that will have a delayed negative effect on breeder numbers and future pup production.

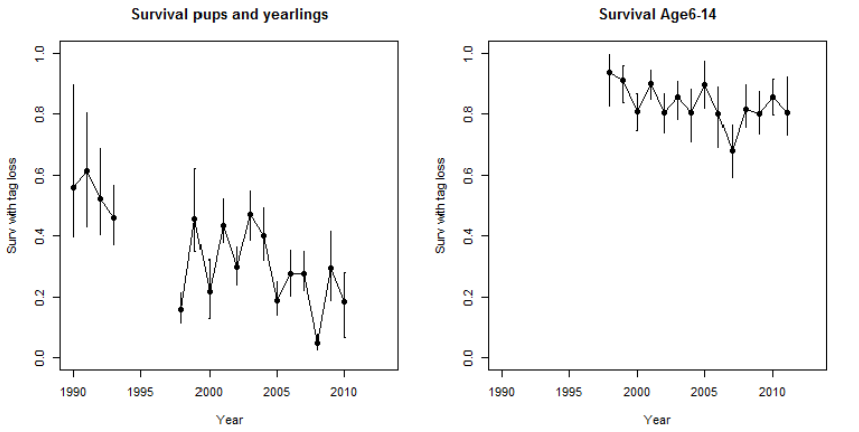


Figure 2. Model estimates of survival of pups/yearlings (cohort birth year) and adult females (age 6-14) at Sandy Bay, Auckland Islands. Bars are 95% confidence intervals, all estimates of survival confounded with tag loss rate. Source: Roberts et al. 2013

Over the last decade the Government and other groups have devoted considerable resources to the understanding, mitigation and management of the effects of fishing. However, little attention or resources have been allocated to focus on other issues that may be contributing to the decline of NZSLs. The focus of this discussion paper is to improve the understanding of the potential causes of sea lion mortality other than the direct effects of fishing and to explore other options for management and conservation action that could aid in halting the decline of the NZSL and directly aiding their recovery.

This discussion paper follows on from a previous paper (Roe, Roberts & Childerhouse (2014) Discussion paper on New Zealand sea lion pup mortality: causes and mitigation) and a joint DOC/MPI workshop on pup mortality held in Wellington on 10 June 2014. The aim of this paper is to provide a review of options for future research and mitigation of pup mortality in NZSLs. This work builds on the previous paper and outcomes of the Wellington workshop.

This discussion paper is not intended to be highly detailed, but to highlight and summarise issues with a view to generating discussion and positive action. The primary focus for this discussion paper is pup mortality at the Auckland Islands (and mainly Dundas Island and Sandy Bay). Some consideration is also given to Campbell Island, although optimal management actions may be different for each sub-population (e.g. Auckland Islands, Campbell Island, Stewart Island, Otago).

We note from the outset that increased pup mortality is only one of a range of factors likely contributing to this decline. We would like to strongly stress that all of these contributing factors should be carefully considered and managed appropriately but have chosen to review pup mortality

here as we believe this is an area in which targeted management action in the short term could potentially lead to positive outcomes for pup mortality and the overall population in the longer term.

2. Main knowledge gaps/areas requiring further research

Roe et al. (2014) identified the following knowledge gaps/areas requiring further research:

a. Improving our understanding of Klebsiella – specifically determining if it is endemic to NZSLs and its mechanism for transmission and infection;
b. Improved characterisation of pup mortality – this is important through the continuation of standardised autopsies including a review of over the length of the period that monitoring is important to correctly characterise the bulk of mortality;
c. Formal investigation into the feasibility of developing treatment for Klebsiella – this would include determining if a vaccine is feasible in both development and practical implementation for wide spread field application;
d. Detailed modelling of the influence of pup mortality on long-term survival – to investigate the potential benefit of any mitigation options and whether they are likely to be effective with respect to influencing population growth;
e. Carefully designed experimental approach to any adaptive management – any interventions that are undertaken need follow strict experimental designs (e.g. control vs. treatments) to ensure that any outcomes (either positive or negative) can be identified and quantified;
f. Nutritional stress – understanding the indirect effects of this on pup mortality is critical and the relationship between maternal nutritional status and pup mortality in particular; and
g. Reviewing impacts of research – it is important that informed decisions are made about research being undertaken on a nationally critical species and that any impacts are understood and weighed up against potential or expected benefits.

3. Outcomes from the Wellington workshop on pup mortality

A Workshop was held in Wellington on 10 June 2014 that had a specific focus on the investigation of NZSL pup mortality including contributing and influencing factors, likely and possible causes and potential options for research and mitigation. Some of the general agreements of that workshop included (based on draft minutes of the workshop):

- That during the 2014/15 field season, mitigation action should be taken to address the issue of pups dying in holes;
- Research on *Klebsiella* should be a priority including aspects such as genotyping, development of PCR test for it, and implementation of a concurrent case control study to better understand it. The case controls study should be run over 2 seasons and should include concurrent elements including worming trials (e.g. Ivomec) and the investigation of effects of tagging studies;
- There is a wealth of existing data and samples already collected and available that has not been fully analysed. It would be useful to undertake analysis of existing material including research prior to the 2014/15 season;
- An extended field season should be considered to allow for a complete characterisation of pup mortality later (and also potentially earlier) in the season;
- That there should be an review of potential marking techniques for NZSL pups including an assessment of potential impacts from each methods; and

- That nutritional stress has been identified as a contributing factor to pup mortality and this should be investigated further.

We note the finalised minutes of that workshop were not available to use when developing this paper and so we have not been able to directly cite the general agreements of the workshop but believe that these agreements reflect what was discussed and agreed.

4. Options for research and mitigation

Based on the outcomes of the Wellington workshop, we review here options for future research and mitigation to further investigate and/or reduce pup mortality. We use the agreements from the workshop above to guide our consideration of options. We have endeavoured to provide some suggestions and potential indicative costings for each option wherever possible.

It is also important to note that the indicative costings provided are not mutually exclusive of each other and therefore some costs (e.g. salaries) would only be need to be covered once to deliver outputs against several different items. Furthermore, a more detailed costing of each project should be undertaken to establish the true costs of the project and the estimates provided here should be regarded as only indicative and provisional.

We have also made the assumption that for the 2014/15 season there will be a research programme funded by CSP similar to the programme that was funded in 2013/14 but note that the decision on the exact nature and extent of the field programme has yet to be confirmed. We make the following assumptions for the CSP programme for 2014/15:

- There will be a team of at least four researchers on based on Enderby Island from 10 January until 23 February 2014;
- All costs for this team during this time (including transport to and from the Island) will be covered by the CSP programme; and
- All the DOC NZSL field equipment normally available to the field team will be available.

We won't go into the details of the issues to be addressed as details of these can be found in our original paper and also in the notes from the Wellington workshop.

Table 1. Potential research and mitigation options for NZSL pup mortality

Issue	Item	Research/Mitigation options	Indicative additional resourcing	Indicative cost
Characterising pup mortality	1.1	Research – Enderby Island: There was good support for the continued characterisation of pup mortality during future field seasons. Additional personnel and/or skills would be required (e.g. vet) to undertake autopsies which would ideally be undertaken from the beginning of the breeding season into February or March requiring a longer field season (e.g. 8 weeks extra time)	Salaries	<$20k salaries <$5k field support **TOTAL <$25k**
	1.2	Research – Campbell Island: This was not specifically mentioned but relates closely to Item 1.1 (i.e. the characterisation of pup mortality during field seasons). The same process as for Enderby but would be quite a different and more expensive operation as teams would be have to in place early on in the breeding season and would require separate transport and salaries. Cost sharing options may be possible with other work programmes on Campbell and with Item 2.2. Likely to be 8 weeks field work for 3 people	Transport; salaries; field support (e.g. food, etc.)	<$50k return charter <$60k salary <$15k field support **TOTAL <$125k**
	1.3	Research – There was good support for the continued characterisation of pup mortality, specifically a reanalysis of previously collected data at the Workshop. This work would allow for the consistent characterisation of causes of pup mortality over time to investigate any changes and confirm the most significant causes. This could be undertaken at Massey on existing samples.	Lab costs, salaries	<$30k PhD stipend <$100k for lab testing of 10 years archived samples **TOTAL <$130k**
	1.4	Research - While not specifically mentioned as an outcome of the Wellington workshop, we believe that there is good support for detailed modelling of the influence of pup mortality on long-term survival – to investigate the potential benefit of any mitigation options and whether they are likely to be effective with respect to influencing population growth.	Salaries	<$20k salaries **TOTAL <$20k**
Pups dying in holes	2.1	Mitigation – Enderby & Dundas Island: building ramps for pups to get out of pups. This has been trialled previously at Dundas and has been successful. Options are boardwalks (Dundas) or cutting steps or ramps (Sandy Bay). Would require team to put these in place prior to pups leaving the beach at Sandy Bay and Dundas but could be undertake alongside normal CSP work.	Materials for ramps (e.g. boardwalks, pegs); transport of materials to location	<$5k materials **TOTAL <$5k**
	2.2	Mitigation – Campbell Island: The same process as for Enderby and Dundas but would be quite a different and more expensive operation as teams would be have to in place prior to or early on in the breeding season (or it could be done during a winter trip) and would require separate transport and salaries. There is probably on a few days work on the Island if just building ramps is undertaken and nothing else. Cost sharing options may be possible with other work programmes on Campbell.	Materials for ramps (e.g. boardwalks, pegs); transport of materials & personnel to location; salaries; field support (e.g. food, etc.)	<$5k materials <$50k return charter <$5k salary <$5k field support **TOTAL <$65k**

Issue	Item	Research/Mitigation options	Indicative additional resourcing	Indicative cost
	2.3	Research – Monitoring of the effectiveness of mitigation is important. There are many technical ways that it could be done (e.g. Chip readers or cameras) but probably the best approach is just to undertake regular counts of the number of pups in holes. This is probably the best way to under simply and cheaply monitor.	None	Nil – concurrent with CSP programme
Klebsiella infection	3.1	Mitigation – Not really possible at this time given a lack of basic understanding of aetiology but standard practices should continue (e.g. quarantine between sites, equipment cleaned between individuals).	None	Nil – concurrent with CSP programme
	3.2	Research – Undertaking genotyping and development of PCR tests for presence. This will aid in further understanding the bacterium and hopefully lead to future mitigation	Lab costs, salaries	<$50k lab costs <$50k salaries **TOTAL <$100k**
	3.3	Research – Case Control Study: An experimental study undertaken on pups (and potentially their mothers) to investigate a range of issues including Klebsiella prevalence and aetiology and contributing factors. The study should be run over 2 seasons and could include concurrent elements including worming trials (e.g. Ivomec), the investigation of effects of tagging studies, and nutritional stress. Depending on the exact structure of such a programme, it would likely require additional personnel, skill sets and equipment (e.g. vet, vet sampling equipment, adult capture and handling experience & equipment for this). Extra person would be required for potentially a longer field season than the CSP programme and extra people to the standard CSP field team during that time. There would also be potentially significant cost and time involved in the analysis of samples that the field team bring back. See Appendix 1 for details.	Will depend on the exact nature of the study but likely to include: extra transport (e.g. extra early and later trips), salaries, field support (e.g. food, etc.), lab and analysis costs, field equipment (e.g. adult capture equipment)	<$5k field equipment <$40k return charter <$20k salary (field) <$10k salary (lab) <$10k field support <$10k lab costs **TOTAL <$105k**
Impacts of marking	4.1	Research – It would be useful to review potential marking methods (e.g. tagging, chipping, branding, photo-ID) including their advantages and disadvantages[4]. This would need to be undertaken once clear aims for an ongoing marking programme were confirmed and stated so the different techniques could be evaluated against them. This should also include an evaluation of minimum sample sizes required to deliver robust outcomes against those (e.g. estimate age specific survival rates with a CV of 0.2)	Salaries	<$10k salaries **TOTAL <$10k**

[4] For example see Beausoleil et al 2004. http://www.doc.govt.nz/Documents/science-and-technical/MarkingMethods.pdf

Issue	Item	Research/Mitigation options	Indicative additional resourcing	Indicative cost
	4.2	Research – it would be useful to undertake an evaluation of any impacts of the existing making programme (e.g. tagging, chipping). This could be done by the existing CSP team but would require supplemental skills (e.g. vet) to undertake autopsies. This would ideally form part of the case control study described in Item 3.3 rather than a stand alone project.	Salaries	<$5k salaries **TOTAL <$5k**
Nutritional stress	5.1	Research - This would ideally form part of the Case Control Study (e.g. Item 3.3) and would allow for the investigation of the effect of adult and pup nutrition on pup morality. Costs as per Item 3.3.	See 3.3	See 3.3
	5.2	Research - There is good support for detailed modelling of the influence of nutritional status on pup mortality. This project would include further modelling of existing data complemented by the addition of specific data collected on this issue from the 2014/15 season (e.g. collected as part of 3.3)	Salaries	<$50k salaries **TOTAL <$50k**
Other issues	6.1	Research & Mitigation - Hookworm treatment: This could be undertaken to following on from the work of Chilvers et al. (2009). This is proposed as part of the Case Control Study outlined in Item 3.3	See 3.3	See 3.3
	6.2	Research – Pup production estimate for Campbell Island: This was not a specific recommendation of the Wellington workshop but would complement the other work possibly proposed at Campbell Island (e.g. building ramps for holes 2.2, investigating pup mortality 1.2). This work would require much the same resourcing as identified into Item 1.2 but two options are available: (a) a single long season with a marking (e.g. tagging) of pups at breeding colonies and resighting of marked and unmarked pups as they disperse from the colonies or (b) two separate trips with an early (January) marking trip and a later (March) resighting trip. It would be useful to explore which is likely to be the more cost effective choice balancing increased salaries for (a) against increased charter costs for (b).	See 2.2	See 2.2 but an additional 1-2 transport trip may be necessary if the trip is split into two parts
	6.3	Research – Age structure of breeding females at Auckland Islands: This was also no a specific recommendation of the Wellington workshop but would complement other work proposed at Enderby and Dundas and the existing CSP programme. Reproductive females could be caught and/or resighted at Sandy and Dundas Island to develop an age structure of females that would be directly comparable with that undertaken in 1999 to 2001. The costs would be similar to Item 3.3 but it would likely require 2 additional personnel to undertake adult female captures and (if Dundas was to be included) regular access to Dundas Island by helicopter or boat. Some additional field equipment would also be required (e.g. anaesthetic machine, anaesthetic) and a vet	See 3.3 plus two additional personnel, 3 additional trips to Dundas Is, field equipment & supplies	See 3.3 plus <$15k salaries <$5k field equipment <$5k field supplies

5. Our recommendations

Based on a review our recommendations, the agreed outcomes of the Wellington Workshop and our expectation of the knowledge required for the NZSL Threat Management Plan, we would recommend the following approach to address the key research gaps and to immediately mitigate some of the NZSL pup mortality:

Auckland Islands

a. Implement a significantly expanded field season from the 'standard' CSP field programme by extending the field season to three months from mid-December to mid-March;
b. Team size of 3 from mid-December to mid-January, 6 from mid-January to mid-February, and 3 from mid-February to mid-March;
c. Undertake autopsies of pups through the whole season by an experienced vet;
d. Undertake Case Control Study at for pups and mothers from as early in the season to departure. This study would focus on (a) identifying cause of pup mortality and contributing factors, (b) effectiveness of worming treatment (c) impacts of marking and (d) influence of nutrition state on pup morality and reproductive rate;
e. Undertaken study if adult female age structure and Sandy Bay (and ideally Dundas as well) to complement the Case Control study; and
f. Undertake mitigation of pup mortality in holes by building ramps in appropriate places.

An indicative cost for this full project would be in the order of $160,000.

Campbell Island

a. Implement a field programme at Campbell Island;
b. Two field seasons: one month in January and one month in March with a team size of three (subject to a review of the cost effectiveness of the two options);
c. Undertake autopsies and sample collection of dead pups as per the Auckland Islands at the two main colonies and where ever else dead pups are found;
d. Undertake a mark-recapture estimate of abundance by marking pups in January and recapturing them in March; and
e. Undertake mitigation of pup mortality in holes by building ramps in appropriate places.

An indicative costs for this full project would be in the order of $125,000.

Targeted research

a. Undertaking genotyping and development of PCR tests for the presence of Klebsiella;
b. Analysis of all existing samples related to pup mortality to develop a definitive and comparable data set;
c. Modelling of the influence of pup mortality on long-term population trends and any benefits that may be achieved;
d. A review potential marking methods (e.g. tagging, chipping, branding, photo-ID) including their advantages and disadvantages; and
e. Modelling of the potential influence of nutritional status on pup mortality, reproductive rate and population growth.

An indicative cost for each of these projects is in the order of $5,000 to $40,000 each.

6. References

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[5] http://www.doc.govt.nz/Documents/conservation/marine-and-coastal/marine-conservation-services/pop-2012-02-sea-lion-demographic-model-selection.pdf
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7. Appendix 1: Preliminary outline of case control study for sea lion pup mortality

Sea-lion pup mortality epidemiological studies

The following is a preliminary design. Note that, depending on number of pup deaths and outcomes, more than one season of data may be required to generate meaningful results.

A concurrent case-control study with two nested randomised controlled trials will be used to evaluate risk factors for *Klebsiella* infection specifically, and for mortality more generally. Outcome variables are as follows:

Case-control study

- All cause mortality
- *Klebsiella*-associated mortality

Randomised controlled trials (RCTs)

- All cause mortality
- *Klebsiella*-associated mortality
- Growth rate?
- Faecal hookworm
- Blood parameters? (e.g. anaemia)

The risk factors considered (explanatory variables) could include age, gender, age/parity of mother, number of skin wounds, body condition score, location, date of death, ivomec status (from RCT1), tag method (from RCT2), plus any others identified as likely.

Case control study design

For each dead pup select at random three healthy pups from the live population at the time of post-mortem (note controls can become cases at a later date). Random selection can be done by a number of methods – e.g. randomly select direction of transect, then randomly select the number of pup encountered. Collect risk factor information and release.

Randomised controlled trial 1 (RCT1)

Recruit a dynamic cohort of pups (e.g. as they are born). Randomly allocate half to Ivomec treatment group, the other a placebo (or untreated). Blind the allocation if possible

Randomised controlled trial 2 (RCT2)

Randomly allocate using an alternative method to RCT1 (or another randomisation event) either:

1) Half of the young to receiving a single flipper tag vs two flipper tags; or

Dependent on whether PIT tag reading will be possible/possible sample sizes:

2) Half of the young one (two) flipper tag(s) and PIT tag and the other half a PIT tag only (Gauthier-Clerc et al. 2004).
3) Third of the young a single flipper tag, a third two flipper tags, and a third a microchip (PIT) tag only.