WWF-New Zealand
Level 6 Davis Langdon House
49 Boulcott Street
Wellington 6011

Tel: 04 499 2930

WWF for a living planet®

WWF-New Zealand submission on the Draft New Zealand Sea Lion Threat Management Plan

August 2016

Amanda Leathers, Research and Policy Officer, WWF-New Zealand
aleathers@wwf.org.nz +64 (0) 4 815 8524

Contents

1 Introduction

1.1 Background

New Zealand sea lions are the rarest in the world and they live only in Aotearoa. They are a precious taonga and are under threat of extinction. Their population has undergone a dramatic decline and they are now classified “vulnerable” by the IUCN and “Nationally Critical” by the Department of Conservation (DOC).

Very low pup counts at the largest breeding grounds on the Auckland Islands in recent years triggered the development of a Threat Management Plan (TMP) (starting in 2014) to provide a better understanding of all the threats to NZ sea lions and identify management options for reducing threats. The TMP development process, lead jointly by DOC and the Ministry for Primary Industries (MPI), involved bringing together experts from around the world to take part in workshops to help develop the TMP. The expert panel provided critical advice to National Institute of Water and Atmospheric Research (NIWA) for the development of a quantitative risk assessment model (the NIWA model), and also provided advice about managing threats to sea lions.

1.2 Has the TMP achieved its purpose?

The purpose of the TMP process was to devise management options to reduce threats to sea lions. This purpose has been partially achieved as there are proposals to address some threats. There is a proposal to fund important research about Klebsiella – the top threat identified by the NIWA model. However, research alone will not reduce the threat. And actions, such as development of a vaccination, would likely be many years off. There are also proposals to actively reduce the threat of deliberate human harm of sea lions and the threat of pups drowning in holes, and this work is important because it is targeting threats that we can do something about. However, although this is useful work, these threats are relatively minor compared to Klebsiella, trophic effects (food limitation), and the direct effects of fishing.

The TMP falls short of achieving its purpose, because it fails to produce clear management options to actively reduce the top human caused threat to sea lions – death due to interaction with fishing nets. To achieve the most effective results for sea lion population recovery, it is important to focus on threats that we can actively reduce. The biggest threat that we have direct control over is fishing.

1.3 Why have fishing threats not been addressed?

It is unclear why management options have not been developed to reduce the fishing threat. One possibility is that no analysis was provided to inform how much the fishing threat should be reduced to achieve the population goals. This kind of analysis was a key purpose of the risk assessment process and the expert panel recommended it be done to inform the development of management options. There is some indication that this analysis may have been done, but it has not been made available to the interested stakeholders or the public.

Another possible reason that options to reduce fishing threat has not been a focus in the TMP is that the government is standing by its position that the direct fishing threat is "minimal"[1], which to date has been a claim made in order to justify avoiding action to mitigate fishing impacts.

1.4 Inaction to reduce threat from fishing is unjustified

The NIWA model, however, makes it more difficult to maintain the argument that the fishing threat is minimal. The model shows that fishing needs to be reduced along with other threats if the NZ sea lions are to recover.

There remain significant uncertainties about the government's assumptions about fishing related mortality, and experts that have reviewed the evidence have warned that they could be overly "optimistic"[2]. In acknowledgement of the uncertainties, the NIWA model explored different levels of fishing-related mortality and found, as expected, that if the best estimate of fishing mortality is actually underestimated, then actions to reduce the threat will slow the decline even further and quicker.

The indirect effects of fishing on food availability for sea lions is a potentially important threat that the NIWA model could not quantify (due to lack of data). If a proportion of what the model measures as 'trophic affect' was due to fishing driving food limitation, then the total impact from fishing is not "minimal".

1.5 WWF-New Zealand's top three recommendations

The following three important findings of the risk assessment process show that further inaction to reduce threats to sea lions is unjustifiable: 1) it is possible for the New Zealand sea lion population to recover if multiple threats are reduced enough, 2) reducing a risk that acts on any of the demographic parameters is also likely to positively affect the others as well, and 3) if threats are not reduced, New Zealand sea lions will decline to extinction.

WWF-New Zealand recommends:

1. The government should act to reduce the top human driven threats to sea lions.

[1] In a Letter to Stakeholders, Hon David Carter, Minister for Primary Industries stated that "*current information demonstrates the direct effects of fishing are minimal*" (Ministerial B12-049. July. 2012.)
[2] "*Given the uncertainty associated with cryptic mortality and the intractability of its quantification, we consider that a value of 0.82 is more likely to be optimistic than pessimistic*" (Bradshaw et al., 2013, p24).

2. Where lack of information is a barrier to action, as in the case of indirect fishing impacts on food limitation, the government should take immediate action to fill research gaps.
3. Research to resolve long-standing uncertainties about the direct fishing related mortality must be undertaken as soon as possible to inform the development of policy options to reduce this risk. Until this research is done, more precautionary discount rates associated with sea lion exclusion devices (SLED) should be used in key fisheries.

2 Structure of this submission

In this submission we first discuss four key issues: 1) that the draft TMP does not actively reduce threats; 2) the TMP needs demographic targets as well as population goals; 3) there is no analysis of management options; and 4) the quantification of fishing threat remains uncertain. We then look at four top threats – Klebsiella, direct fishing related mortality, trophic effects (food limitation), and cumulative impacts. We review how the draft TMP proposes to manage these threats and make recommendations about how management could be improved. We then provide some concluding comments and a full list of recommendations at the end.

3 Key issues with the Draft TMP

3.1 The plan does not actively reduce threats

The draft TMP is heavily focused on monitoring and research, rather than taking actions that would directly reduce threats. Furthermore, despite the focus on research over action, there is no definite commitment to fund and carry out critical research as part of the TMP.

The government clearly wants to be able to say it is engaged in "active management"[3], but this would require taking further steps to reduce threats, or at the minimum – committing to filling important research gaps which are impeding management action. These include uncertainties about direct and indirect effects of fishing outlined in sections 3.4, 4.4.1, and Appendix 1.

WWF-New Zealand recommends that DOC / MPI:

- Develop management actions to actively reduce top threats to sea lions. Where action is not possible due to lack of information, action should be taken to fill the research gaps.

[3] According to the Background Document on the NZ SLTMP (DOC/MPI, 2016) the TMP programme "*involves monitoring and **active management** to allow for incorporation of new information on the sea lion population as it becomes available*". (emphasis added)

3.2 Need demographic targets as well as population goals

The continued and improved collection of baseline data about the populations means that the population goals will be measurable.[4] The NIWA model can also determine how much the survival of pups and/or adults needs to increase in order to achieve particular population goals.

During the second TMP workshop, the expert panel identified that the NIWA model should be used to develop demographic targets such as for pup counts, pup survival and adult survival to enable transparent monitoring of progress towards the population goals.[5] These targets would also be useful to inform the development of population based performance measures for the assessment of management actions.[6]

WWF-New Zealand recommends that DOC / MPI:

- Develop demographic targets for pup counts, pup survival and adult survival to enable transparent monitoring of progress towards the population goals.

3.3 Lack of analysis of management options

A key purpose of the Risk Assessment was to provide useful analysis of management options to inform development of the TMP – it should "*estimate the likely consequences of actual or potential actions*" (DOC/MPI, 2016, p4). However the TMP provides no analysis of management options for reducing threats to sea lions. The draft plan provides no information about how much particular threats might be reduced, and there has been no identification of which actions might achieve the biggest gains towards the population management goals.

The expert panel recommended that the NIWA model be used to analyse how much particular threats and/or combinations of threats would need to be reduced to achieve population goals, and that this should be used to inform management.[7] The 2nd TMP

---

[4] The population management goals are measurable since they have specified an absolute number to be above of (11,800) and the TMP proposes pup counts and tag re-sights so that population size can be estimated through time. The data and modelling can also estimate the likely trends so the 5-year goal can be addressed too.

[5] The expert panel during the 2nd workshop 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".* (Progress Report – NZSL Threat Workshop 2, P17)

[6] Chapter 9 of Goldsworthy et al. (2010) provides an example of how performance indicators have been developed to evaluate the effectiveness of different by-catch mitigation options for Australian sea lions.

[7] The report from TMP workshop two states: "*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,*

workshop report indicates that 'evaluation strategy' using the NIWA Model may have been carried out in order to examine how different management actions would affect adult and/or pup survival, however this analysis has not been provided to stakeholders or the public.[8] The Summary of the Risk Assessment also states: "*One of the greatest values in the more in depth modelling aspects of the risk assessment was that it allowed for better measurement of progress against management actions*". WWF-New Zealand recommends that the government make this analysis available for robust and transparent management decisions.

Without analysis of management options, the draft TMP does not achieve its purpose. It does not enable robust discussion and good decisions about what needs to be done to save NZ sea lions.

WWF-New Zealand recommends DOC and MPI:

- Provide risk reduction strategy evaluations using the NIWA model. Clearly and transparently show how much particular threats need to be reduced in order to reach population goals, and use this to develop threat reduction targets.

3.4 Quantification of the fishing threat remains uncertain

There remain unresolved uncertainties about the number of sea lion-fisheries interactions, post-interaction survival, and indirect effects of fishing on availability of food to sea lions[9]. This means that the NIWA model may not accurately be quantifying the level of fishing threat. Please see Appendix 1 for detail about the uncertainties in the quantification of fishing threat.

The Summary of the Risk Assessment of Threats to New Zealand sea lions, identified that any risk assessments should "*maintain transparency about the requisite assumptions and inputs, and associated uncertainty*". (DOC/MPI, 2016, p4). Some important uncertainties were acknowledged and explored in the TMP process, and others were not.

The Quantitative Risk Assessment did acknowledge uncertainties about the number of sea lions that survive encounters with fishing nets due to SLEDs (SLED efficacy): "*The assessment*

---

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'". (Progress Report – NZSL Threat Workshop 2, P17)

[8] "*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." (Progress Report – NZSL Threat Workshop 2, p22)

[9] Indirect effects of fishing make up an unknown proportion of the NIWA models quantification of 'trophic effects'

for some of the key threats was hampered by incomplete information…[including the] potential cryptic commercial trawl related mortality". (Roberts & Doonan, 2016, p2). DOC notes during the TMP workshop state that there is "big" uncertainty about SLEDs and associated cryptic mortality.[10] This uncertainty was to some extent explored in the NIWA model, by looking at a range of discount rates as sensitivities.[11]

The TMP process also acknowledged that there is not currently enough evidence to know how much fishing affects food limitation.

However, the NIWA Risk Assessment did not address uncertainties about the sea lion – fishery interaction rate (the numbers of sea lions that are coming into contact with fishing nets). If the strike rate or catchability has increased, then the best estimate of fishing mortality used in the NIWA model would be optimistic.

3.4.1 Uncertainties will not be addressed in the TMP

Uncertainties about SLED efficacy and effects of fishing on food limitation are recognised as high priorities for research (Draft TMP, Table 3). However, no commitment has been made to fund this research as part of the TMP. Despite recommendations from the expert panel – that interaction rates need to be addressed as a matter of priority, this has not been included in the TMP 'research priorities' (TMP, Table 3).[12]

There appear to be strong incentives to continue using current assumptions and not test them. The existing assumption that 82% of sea lions survive trawl nets with SLEDs has enabled the fishing Industry and the government to claim that the impact of fishing on sea lions (within the trawl fisheries that used SLEDs) has been largely addressed. What this means in practice is that the amount of fishing and number of tows that can take place is less limited.[13]

We understand that the Government may want to avoid further legal challenges by the fishing industry associated with proposals to restrict fishing; however this should not be a barrier to taking necessary conservation action. Legal challenges by the fishing industry in the past have usually focused on whether the "best available information" shows action to

[10] See Appendix 1.

[11] "*The effects of assuming intermediate levels of commercial trawl mortality was assessed using alternative values of the SLED discount rate (a trawl management setting which gives a "discounted" strike rate to apply to all tows when an approved SLED is used; i.e. there is a decrease in mortality with increasing discount rate) from 20% to 82%, the value that is currently used.*" (Roberts & Doonan, 2016, p28)

[12] "*Efforts should be made to better quantify strike rates in trawl fisheries, such as by use of cameras to detect entry of sea lions into nets.*" (Development of the Threat Management Plan for New Zealand sea lions: Progress Report - NZSL Threat workshop 1, p 13)

[13] Based on the Fisheries Related Mortality Limit (FRML) of 68, the 82% discount rate reduced the strike rate from 5.89% to 1.06% - which allows 4,200 tows rather than 1,154 tows in SQU6T.

restrict fishing is necessary.[14] We consider that the 'best available information' produced by the risk assessment shows that action to clarify uncertainties and to reduce top threats (including fishing) is clearly necessary.

3.4.2 Consequences of uncertainty

One of the most significant consequences of not addressing uncertainties is that the assumption that the fishing threat is minimal – will prevail, and continue to be used to justify inaction to restrict fishing.

Another consequence of not addressing uncertainties is that we may be missing opportunities to achieve significant conservation gains. If the 2013 expert panel is correct and fishing mortality is higher than currently estimated[15], then benefits of action to reduce fishing threats are being underestimated, and there could be greater potential to more quickly reverse the population decline. For example, if SLEDs were only 35% effective and the sea lion-fishery interaction rate was higher than currently estimated (i.e. it could be more proportional to the 50% increase in average tow length), then reducing the fishing threat would have an even greater positive impact on the sea lion population rate (see Table 1, as below). Added benefits may come from management measures that also reduce indirect effects of fishing (food limitation) including increased reproduction rates and survival of pups.

Table 1: The rate of population increase or decline (at 2037) if fishing related threats were removed

Threat	**Annual long term rate of rate of population decline (at 2037) when threat is removed**
Trophic (food limitation)	2.6% decline
Trawl 82% discount	3.6% decline
Trawl 35% discount	2.9% decline
Trawl interactions 0% discount	2.3% decline

Continued inaction to address the uncertainties in the TMP follows inaction in previous years and effectively ignores these uncertainties, and legitimises potentially inaccurate assumptions. It is problematic when accepted and untested assumptions are used to justify inaction. WWF considers that the assumption that fishing threat is minimal can no longer be justified due to the unresolved uncertainties.

---

[14] See: Squid Fishery Management Co. vs Minister of Fisheries (13 July 2004, CA39/04; New Zealand Federation of Commercial Fishermen Inc. et al v Minister of Fisheries and Chief Executive of Ministry of Fisheries High Court, Wellington, 23 February 2010, CIV 2008-485-2016

[15] An expert panel brought together in 2013 to review the models and data underpinning the management of fishing-related mortality of NZ sea lions in the SQU6T fishery (the 2013 expert panel) explained: "*Given the uncertainty associated with cryptic mortality and the intractability of its quantification, we consider that a value of 0.82 [SLED discount rate] is more likely to be optimistic than pessimistic*" (Bradshaw et al., 2013, p24).

WWF-New Zealand believes the uncertainties about the size of fishing threat should be reduced as a matter of priority. Effective management requires accurate information and while complete certainty may not be unattainable, there is scope for improvement. It is concerning that the current management approach requires proof that SLED mitigation doesn't work in order to trigger further action, instead of requiring a higher degree of certainty that it does work before allowing fishing to expand. This is the reverse of the precautionary approach and is not international best practice.

The expert panel in 2013 recommended that a more precautionary SLED discount rate be used until uncertainties were reduced: The "most plausible value" for the discount rate would be one that is "deliberately low to provide a precautionary approach".[16] In light of the continued uncertainty about the science used to justify the increase in SLED discount rate from 35% to 85% in 2013, we recommend reverting back to the former discount rate of 35%.

WWF-New Zealand recommends that DOC / MPI:

- Undertake research to reduce long-standing uncertainties about the direct fishing related mortality – including SLED efficacy and the current interaction/strike rate.
- Until research is done, the more precautionary SLED discount rate of 35%[17] should be instated in key fisheries.

4 Key threats

4.1 Klebsiella

The NIWA model found that bacterial infection due to Klebsiella pneumoniae is the top natural threat affecting the decline in sea lion population – with particular impacts on pup survival.[18] Klebsiella is responsible for significantly increasing early pup mortality on the sub-Antarctic islands to at least two or three times average levels in some years (Row et al., 2014). In Sandy Bay (Auckland Islands) between 2009-2014, Klebsiella was diagnosed to be the cause of death in approximately 55% of pups that were necropsied (Row et al., 2014).

If the threat of Klebsiella was removed, the population would be increasing at a rate of 0.5% by 2037. This would be a 4.4% change from the baseline population rate (which assumes no threat is addressed).

[16] Bradshaw et al. (2013), p25
[17] A discount of 35% was used before it was increased to 85% in 2013. Since there is significant uncertainty about the science used to justify this increase, we recommend reverting back to the former discount rate. .
[18] The disease can cause septicaemia or localised infections in many different organs including the lung, brain, intestine and lymph nodes.

In consideration of how best to prioritise management of the different threats, it is important to question how practical and realistic it is to mitigate a naturally occurring disease and whether the current proposal will lead to mitigation.

As indicated in the TMP, there are no proven methods to treat or prevent infection in sea lions, and developing mitigation measures (such as a vaccine) would take long-term funding of research and development.[19] The financial commitment to produce a vaccine for sea lions is considerable.[20]

We support the development of mitigations for disease, however we consider that due to the time and cost involved in this work, addressing threats we have more control over is a higher priority.

4.1.1 TMP proposed management of Klebsiella

Government is proposing to fund and support (for three years) research to better understand Klebsiella. We support this proposal, recognising that further research is required in order to understand whether and how the disease could be mitigated.

It is important that this research has a practical management focus on determining how to best tackle Klebsiella, and to come up with management actions. For example, if there are factors (such as poor nutrition) that make pups more susceptible to the disease, are human activities (such as fishing) contributing to the problem?

Currently, Table 1 of the TMP has "identification of actions to deal with disease" as a 'measurable outcome'. WWF suggests making this objective more specific.

WWF-New Zealand recommends that DOC / MPI:

- Include a research objective: to identify opportunities and management options to mitigate Klebsiella, and the underlying factors driving the spread of the disease and/or exacerbating its impact.

4.2 Direct fishing-related mortality

The NIWA model found that sea lions being caught as by-catch in trawl fisheries is the second most significant driver (and top anthropogenic driver) of the decline of the sub-Antarctic sea lion populations. Over the last 20 years, it is estimated that about 1013 sea

[19] Experts at the pup mortality workshop in 2014 discussed the practicality of developing a vaccine. It was stated: "*Yes, it is possible, but could take millions of dollars and at least 5 years of research*".
[20] Please see Forest & Bird's submission for more discussion on disease research.

lions have died in fishing operations (see Table 2).[21] Over the last 5 reported years (2009/10 to 2013/14), the average annual fishing related mortality across all fisheries affecting sea lions is 25.2 sea lions (AEBR, 2015).[22]

Incidental captures of NZ sea lions occur mostly in the commercial southern arrow squid trawl fishery (SQU 6T) surrounding the Auckland Islands, and the Southern blue whiting trawl fishery (SBW) on the Campbell Rise (ibid).

It is currently estimated that for every 100 tows in SQU6T, 1.06 NZ sea lions die. This strike rate assumes that 82% of the sea lions that come into the net survive because of SLEDs. Over the 5 years from 2009/10 – 2013/14, on average, 4.8 sea lions die per year in SQU 6T (ibid).

In the Southern blue whiting (SBW) trawl fishery, the number of captures has varied and is sometimes significant i.e. 21 observed captures (mostly male) in 2012/13. SBW trawl fishery started using SLEDs after this high capture in 2013 (ibid). Sea lions are also by-caught in several other fisheries including Auckland Island scampi trawl, and trawl and set net fishing around Otago and Stewart Snares Shelf. However, estimates are very uncertain due to low observer coverage and relatively low levels of capture.

Even a low level of fishing mortality can have significant impacts on sea lion populations. Low levels of fishing mortality were sufficient to drive decline in Australian sea lions due to low population size and productivity (Goldsworthy & Page, 2007). Similarly, a recent genetic study of Chatham Island sea lions shows that low levels of hunting may have driven them to extinction over 200 years (Rawlence et al., 2016). The level of threat and impact of fishing mortality on sea lion populations depends on the extent of mortality relative to the population size, and on other factors that can affect survival and natality, including trophic affects and food limitation (NIWA, 2015, p6).

[21] There is spatial and temporal overlap of squid fishing and breeding female's at-sea foraging and suckling from February to July. There is also significant overlap of southern blue whiting trawl fishing and breeding males being dispersed at sea or at haul outs from September and October (MPI, 2014)

[22] AEBR, (2015) (http://data.dragonfly.co.nz/psc/ Data version v20150003)

Table 2: Estimated captures of sea lions in commercial trawl fisheries between 1995 and 2014, (AEBR, (2015), http://data.dragonfly.co.nz/psc/ Data version v20150003)

Trawl fisheries in which sea lions are by-caught	Deploys SLEDs	Estimates of total capture of sea lions between 1995-2014	Annual estimated capture (average of 2009/10 – 2013/14)	Average % observed between 2009/10 – 2013/14
Auckland Islands squid trawl fishery	Yes	662	4.8	55%
Auckland Islands scampi trawl fishery	No	148	6	10.6%
Auckland Islands trawl fisheries targeting 'other' species	No	21	0.2	39.8%
Campbell Island southern blue whiting (SBW)	Yes	110	12.4	71.8%
Stewart-Snares shelf trawl fisheries (mainly squid)	No	72	1.6	52%
All modelled commercial trawl fisheries		1013	25.0	46%

4.2.1 TMP proposals to manage fishing threats

The TMP proposes no new fisheries measures, beyond increasing observer coverage in the Steward Island and Otago Coast fisheries. All decisions about how fishing threats will be managed are to take place through the MPI fisheries operational plans and Aquatic Environment Working Group (AEWG) processes, and no detail about management options has been provided in the draft TMP.

4.2.1.1 Operational plans and cost benefit analysis of fishing restrictions

Management of fisheries threats under the SQU6T and SBW operational plans (where the strike rate, discount rate FRML is decided) will be reviewed and developed through the AEWG process. The government is also intending to base future decisions about whether additional fisheries restrictions are appropriate and required for the conservation of sea lions on cost/benefit analyses of restricting fishing in sea lion foraging areas (proposed in Table 3 of the TMP). WWF-New Zealand has serious concerns with these proposals.

First and foremost, scientific assessment of threats and the likely contribution of threat mitigation to slowing or arresting the decline of the NZ sea lion population should be used to determine whether further fishing restrictions are required. Cost-benefit analysis is not an appropriate tool to determine whether action is necessary.

Second, cost-benefit analysis will inevitably entail ascribing an economic value to the lives of individual sea lions and/or the sea lion population as a whole. While the economic costs of restricting fishing will be relatively straightforward to quantify, the economic benefits of reducing sea lion mortality are arguably impossible to measure. This will make the exercise highly arbitrary and its results highly dubious and of little use as a guide to action.

We have been told by DOC and MPI that the cost-benefit analysis will follow a similar methodology as carried out by MPI to inform the Minster for Primary Industries about the economic costs of fishing restrictions for Māui dolphins. The scope and methodology used in this case were narrowly focused on quantifying the cost to the fishing industry and failed to properly quantify the benefits.

It seems pointless attempting to repeat this exercise for New Zealand sea lions. But if this work does proceed, at the very least, the methodology used to assess costs and benefits must follow international best practice. This requires robust analysis of benefits of restricting fishing such as the value of NZ's brand reputation, social and cultural benefits, and wider ecosystem benefits; as well as assessment of costs to the fishing industry. Appendix two provides advice commissioned by WWF International about methods for estimating ex ante benefits of marine conservation activities to inform Cost Benefit Analysis.

Third, if this work does proceed, it makes no sense to aim for completion by the end of June 2017 – before the research to improve the estimate of interaction rate and SLED efficacy is finished.[23] It is important that decisions resulting from this work are not based on current unproven assumptions that the fishing threat is minimal;[24] which would likely create a foregone conclusion that costs will outweigh 'benefits'. If this work does proceed, it should at the very least be based on a more accurate assessment of how many sea lions are dying due to fishing.

Therefore, before the operational plans and cost benefit analysis are carried out, the government must first fund and carry out robust and research to improve scientific understanding of threats from fishing, as a priority for financial year 2017/18. Improved estimates of fishing threats need to be run through the NIWA model and TMP should be updated accordingly.

4.3 Options for improving management of fishing threats

In the absence of any analysis of management options for reducing fishing threats in the TMP, we provide some options below:

- Fishing threat reduction targets

[23] At a meeting between E-NGOs and government on 18 July 2016, it was reported by MPI that consultation on the operational plans will likely take place between Dec -April as they will need a few months to summarise and present minister with a decision before the June deadline.
[24] See Appendix 1 for evidence that the current assumptions about fishing threat are unproven.

- Spatial management options for SQU 6T and Otago
- Improve observer coverage
- Transition from trawling for squid to jigging.

4.3.1 Fishing threat reduction targets

It would be useful to set threat reduction targets based on what is required to achieve the population goals. For example, the risk assessment model indicates that achieving a stable population size over the long term, requires an increase in adult survival from 0.88 to 0.97 (9%) and pups from 0.38 to 0.6 (22%). This works out to be about 153 breeding age females, and 350 pups.[25]

However, the model also shows that over the short term, an increase of adult survival by 0.02 or about 34 breeding females would result in an immediate increase the adult population trend for up to 5 years (after which it would start declining again). This can be seen in figure 1. The benefits of increasing adult population over 5 years would likely have a positive effect on pup population as well.

While (according to the NIWA model) the reduction of fishing threat alone would not stabilise the population over the long term. It is one of the few threats that we have control over. So targets should aim to reduce the threat by as much as possible – towards zero by-catch.

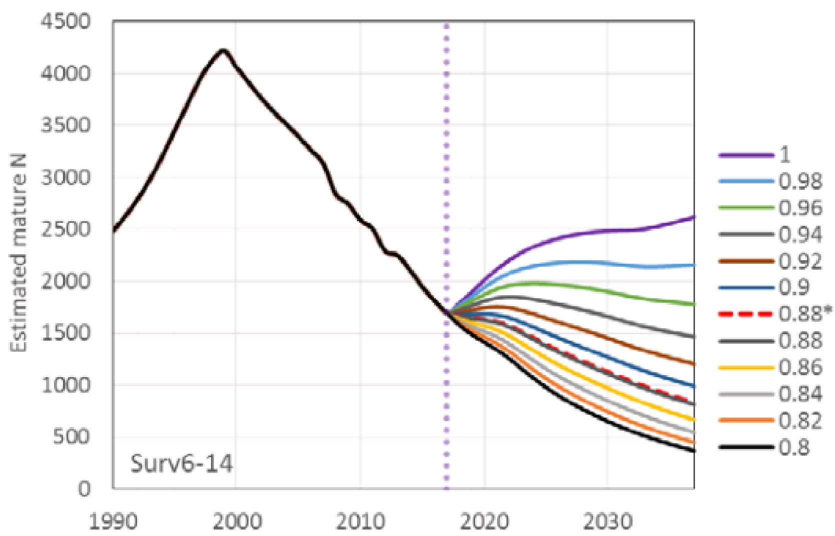


Figure 1. Demographic rate scenario projection for the Auckland Islands adult sea lion population in the period 1990-2037. Dashed red line is projection using the mean demographic rate from 2005-2014. (Graph from Roberts & Doonan, 2016, p33).

[25] These are our calculations based on the NIWA model data. The approximate total number of breeding age females is about 1700 as shown by Roberts & Doonan, (2016), p33, Figure 18. A 9% increase from 1700 is of that is ~153 breeding age females. If we assume that there are about 1575 pups on Auckland Is., and they need to increase 22%, then an extra 350 pups need to survive per year.

4.3.2 Spatial management options

Spatial management, such as marine reserves or spatiotemporal fishing closures, have the potential to reduce multiple threats including direct and indirect effects of fishing, including food limitation, which could in turn improve the condition of pups and their resilience to disease.

Spatial conservation measures have proven successful in South Australia where gillnets were removed from the foraging range of Australian sea lion colonies around Dangerous Reef. The Dangerous Reef population is the only Australian sea lion population known to have undergone a recent recovery in numbers and the explanation for this is likely to be linked to the restriction of gillnet fishing in the region following closures in 2001 (Goldsworthy, et al., 2007). Marine spatial management areas have also been effective at reducing fishing threats to South African penguins and Hectors dolphins (Pichegru et al., 2010; Gormley et al., 2012).

Two potential spatial management options are an adaptive management proposal that would restrict fishing in the most important foraging areas for the Auckland Islands for 5 years; and to restrict fishing to protect the Otago Coast sea lions and their foraging grounds.

4.3.2.1 Adaptive management proposal to close North West fishery for 5 years

Forest & Bird has developed an adaptive management proposal to reduce the direct threat of fisheries by-catch for the Auckland Island sea lions, and enable study of the indirect effects of fishing on food limitation. The proposal includes restricting fishing in an important foraging area for Auckland Island sea lions.

From a discussion with MPI and DOC about this proposal (18th July 2016 at DOC), we understand that some key barriers to this proposal from MPIs perspective include:

- Economic impact to fishers. It may not be economic for fishers to fish elsewhere.
- Difficulty of measuring success and showing causal links between population increases/ pup survival and fishery closure.

These important issues can be worked through. There is the ability to catch the quota in SQU6T in other areas (for example SQU1T or SQU1J[26]), and there may be ways to support the fishing industry to make the necessary changes.

Furthermore, studies from around the world show that it is possible to measure success of conservation benefits of fisheries closures (Goldsworthy et al., 2010; Pichegru et al., 2010;

[26] The current Total Allowable Commercial Catch (TACC) for SQU6T is 32,369 tonnes. In SQU1 area, there is 44,740 tonnes set aside for trawling and 50212 tonnes for jigging (SQU1J). In 2008, only 3% of the SQU1J TACC (1371 tonnes) was harvested, and total amount of squid harvested was 56,000 tonnes, from a total allocation of 127,332 tones. This means that 32,369 tonnes of TACC could be accommodated in SQU1 under the combined TACC for trawling and Jigging.

Gormley et al., 2012). The design of the protected area or spatial measure can help to minimise uncertainties and difficulties in tracking the effects of the measure, for example ensuring there is close overlap between the fisheries closure and foraging area. Spatial management options are particularly useful where there is high foraging site fidelity (Augé et al., 2013).

WWF-New Zealand recommends that the government supports the further development of this adaptive management proposal.

4.3.2.2 Fishing restrictions to protect Otago Coast sea lions

While actions to reduce top threats to the largest breeding colonies should be the top priority for management, a focused effort for the Otago breeding colony is also important for two reasons. Firstly, Otago see lion population has the potential to grow quickly, due to abundant food.[27] According to Jason Baker (NOAA Hawaiian monk seal research programme): "*Evidence suggests that mainland NZ represents under-occupied habitat that may hold great potential for population recovery of sea lion*s".[28] Secondly, Otago sea lions should be a priority for management because small population is extremely vulnerable to any extra (non-natural) mortality.

The death of even one female may currently have a significant impact on the success of the colonisation of Otago Peninsula by NZ sea lions (Lalas & Bradshaw, 2003).[29]

For the Otago Coast breeding site, the top two threats are fishing and deliberate human mortality. The NIWA model identified set netting as the biggest threat to Otago sea lions; however bottom trawling may also damage important benthic habitats used by sea lions, [30] as could the harvesting of bladder kelp.[31]

As the recolonisation progresses and sea lion number increases, increased by-catch in fisheries and resource competition between sea lions and fishers is likely because both sea lions and commercial fishers target barracoota and jack maceral in the Otago foraging grounds (Augé, et al., 2013).

TMP proposed management for Otago sea lions

---

[27] Studies show that Otago sea lions don't have to forage as far, or dive as deep as sub-Antarctic sea lions. Rich sources of food are readily available. (Roberts et al., 2015, Augé et al., 2013)

[28] Day 4 TMP Workshop notes. Released under the Official Information Act.

[29] The extreme vulnerability of small sub-populations of Australian sea lions to fishing mortality is discussed in Goldsworthy & Page (2007), and Goldsworthy et al., (2010).

[30] The primary foraging habitat of female NZ sea lions at Otago is characterised by shallow rocky reefs and bryozoans thickets (Augé et al., 2011). Bottom trawling is known to damage benthic habitat (Jones, 1992; Shephard, Brophy & Reid, 2010) and is used off the Otago Peninsula in the bryozoans area (Ministry of Fisheries, Warehou database, unpubl. data).

[31] Bladder kelp *Macrocystis pyrifera*, the main kelp species on shallow rocky reefs at Otago (Fyfe et al., 1999), was recently introduced in the NZ Quota-Management System as a commercial species. Its exploitation may alter and physically disturb foraging sea lions (Augé et al., 2013).

There is some good work planned to manage human interactions – beach management; improve incident response capacity e.g. related to entanglement, vehicle collisions, and other human induced injuries; and to better understand threats of male aggression. According to DOC/ MPI: "*The risk assessment has identified that deliberate human impacts should be managed to maximise future population growth [of Otago sea lions]*". (Background document)

WWF-New Zealand supports the work planned; however we are concerned that there is no detail about how the top threat (set net fishing) will be reduced. Currently the TMP Regional Programme – includes "monitoring and quantifying sea lion captures in Otago coast trawl and set net fishing; and minimising incidental captures." However, no details of how threats will be minimised are provided.

It is important that management options to address fisheries related threats to the Otago sea lions, including spatial conservation measures, are developed. Due to the nature of the threats that affect Otago sea lions, the fact that they forage in a relatively small area and have high foraging site fidelity,[32] spatial conservation measures (e.g. protected areas such as marine reserves and gear-restricted areas) may be the best options to manage the threats affecting Otago sea lions (Augé, Moore & Chilvers, 2012).

4.3.3 Transition to jigging

Another option to minimise sea lion by-catch in the squid fishery is to change from trawling to jigging. Squid jigging has a high specificity for target species and is considered a safer method of fishing that decreases the risk of interaction with marine mammals and seabirds (Australian Fisheries Management Authority, 2004; Barton, 2002).

Jigging has minimal impact on the seafloor and compared with trawling, causes less disruption to ecosystem structure and function – critical for sustaining healthy squid stocks (Barclay, 2003). There may also be economic benefits to jigging as quality of jig-caught squid is higher and can be sold for a premium price over trawl caught squid (Australian Fisheries Management Authority, 2004; Barclay, 2003).

Squid jigging is successfully used in Australia, Japan and the Falkland Islands.

4.3.4 Observer coverage

There are two important goals of observer coverage with respect to protected species. First, observers are important to provide an accurate estimation of by-catch, and secondly

[32] Otago female NZ sea lions exhibit foraging site fidelity throughout the year (Augé et al., 2013).

they can help improve and monitor operational practices, some of which can affect the by-catch rate.[33]

The use of SLEDs means that few sea lions remain in fishing nets, and observers will therefore not be able to improve understanding of interaction rate, or survival rate (ibid). Therefore the focus of observer coverage for fisheries that deploy SLEDs to mitigate sea lion by-catch – such as Auckland Islands squid, and southern blue whiting – should be to improve fishing operational practices to minimise by-catch as much as possible.

It may be more important to improve and increase observer coverage in fisheries that do not deploy SLEDs, such as the Auckland Island scampi, Auckland Island "other" non-squid trawl fisheries. For these fisheries, observer coverage will be useful both to improve understanding of by-catch rate, and to improve on board fishing practices in ways that can minimise by-catch.

Increasing the observer coverage in the Auckland Islands scampi trawl fishery would be particularly useful because currently, there is large uncertainty in the estimates of by-catch in the scampi trawl (with wide confidence intervals, and large potential for error) due to low observer coverage. For example, only 10.6% average observer coverage between 2009/10 and 2013/14. Improving accuracy of by-catch estimate in the scampi fishery is also important because it has the second most significant total by-catch estimate – with an estimated 148 sea lions being by-caught between 1995-2014 (see Table 2, p.13).

Increasing the observer coverage in the Steward Island trawl and set net fisheries, and the Otago trawl and set net fisheries should also be a priority because there is a lack of robust information to estimate by-catch levels; and because these small breeding colonies have good potential to grow, and are also extremely vulnerable to any mortality level higher than the natural rate (Lalas & Bradshaw, 2003).[34]

WWF-New Zealand recommends that DOC and MPI improve management of fishing threats:

- Halt the fisheries operational plan development until research to determine the efficacy of SLEDs and improve estimates of the current strike rate has been carried out and the NIWA risk assessment model has been updated and run with the new information.
- Take fisheries management decisions based on a scientific assessment of threat reduction, not on the basis of cost-benefit analysis.

[33] Aspects of observer operational practices that can affect by-catch include: tow length, number of turns or hauls, time of day, gear type.

[34] Ian Doonan (NIWA) explains: "*Very low populations have a stochastic effect, where by chance they can decline since there is not enough adults to average out the random chance of moralities etc. Fishing could make the latter situations worse. Very low population size is below 100 adult females (e.g. Stewart Island & mainland)*". (Doonan, Pers. comms. 18 July 2016)

- If a cost-benefit assessment of management measures is to be undertaken, ensure it follows international best practice, and includes analysis of non-monetary benefits including ecosystem services, as well as the monetary costs.
- Develop fishing threat reduction targets to reduce the threat by as much as possible – towards zero by-catch.
- Develop and explore spatial management options including the Forest & Bird adaptive management proposal to reduce threat of fishing for Auckland Island sea lions; and options to protect Otago sea lions and their habitat from fishing threats.
- Work with scientists (i.e. dragonfly) to determine what level of observer coverage would significantly improve the by-catch estimates for the fisheries below and enable that level of observer coverage as soon as possible for

✓ Auckland Islands scampi trawl fishery
✓ Auckland Island "other" non-squid trawl fisheries
✓ Steward Island trawl and set net fisheries
✓ Otago trawl and set net fisheries.

- Develop a programme to transition squid trawling to squid jigging.

4.4 Trophic effects – food limitation

The NIWA model finds that trophic effects (food limitation) are one of the top threats to sea lions. The alleviation of trophic effects (food limitation) slowed the rate of decline by 1.3% by 2037.[35] The Southern Ocean environment has changed rapidly in the last few decades or more, including increasing water temperature, lowered water pH, changing sea ice conditions, and possibly altered fish and cephalopod community structure and abundance arising from commercial fisheries (Bradshaw et al., 2013).

There is strong evidence for nutritional stress affecting the Auckland Islands population during the period of decline (NIWA, 2015, p14).[36] Also on Campbell Island, about 50% of pup deaths were caused by starvation in 2014.

The key factors driving the sea lion population decline identified by the NIWA model – low pup survival, low adult survival and low pupping rate/delayed age at first breeding – are all linked via maternal nutrition. Availability of prey at maternal foraging grounds affects maternal diet and quantity and quality of milk fed to pups. Sea lion pups gain the bulk of their nutrition from their mothers' milk for up to about 10 months. Variation in the quantity

[35] (λ2037 = 0.974, 95% CI 0.905–1.038)
[36] AEBAR (2015, p42) states that at the Auckland Islands: "*A number of indicators of nutritional stress have been identified during the period of population decline, including a temporal shift in diet composition to small-sized prey, low pupping rate/delayed age at first pupping, low pup/yearling survival rate, and reduced maternal condition*".

and quality of milk will affect pup growth and their susceptibility to disease or other stressors) (Row, et al., 2014).

Several factors may be impacting food availability for sea lions including climate change, natural variations in marine ecosystems and fishing. At least three of the main prey species of the Auckland Islands population (hoki, red cod and southern arrow squid) are subject to commercial fisheries around NZ (Meynier et al., 2009). Meynier (2010) estimated that sea lions eat 17,871 tonnes of prey per year. Sea lion annual southern arrow squid consumption may be similar to annual catches by the commercial fishery (Meynier, 2009). Impacts of fishing on prey may be driving low pup survival.

4.4.1 Uncertainty about quantifying the indirect effects of fishing

There is limited scientific understanding available about how exactly food limitation is affecting the sea lion population, and there is currently insufficient data to determine how much of the trophic effect quantified in the NIWA model is caused by fishing.

Despite this lack of understanding, most scientists rate it among the most significant threats, and the NIWA model found it to be the second or third most significant threat (depending on the applied discount rate to the trawl threat). The expert panel highlighted that it is highly likely that its potential population effect in the NIWA assessment is underestimated (MPI/DOC, 2016; Observer Notes).

4.4.2 Proposed management of trophic effects in the TMP

There are a range of different research projects to study trophic effects proposed in Table 3 (Research Priorities, TMP), however the government has not committed to fund any of these.

As food limitation is likely to be one of the most significant drivers of population decline, this threat needs to be addressed in the TMP.

4.4.3 WWF-New Zealand recommendations for improving the management of trophic effects

WWF-New Zealand considers that fisheries should be managed to maintain the biomass of key prey of sea lions at a level that buffers against climate effects on local availability. This kind of management requires good information about trophic effects including the range of important drivers of food limitation (potentially including indirect effects of fishing, impacts from other human uses of marine environments, natural variation in marine ecosystems, and the effects of climate change) (Roberts & Lalas, 2015).

The first important step towards enabling management of food limitation is building essential scientific understanding about which are the prey species sea lions can't do without. This means determining: what the factors are that affect their availability to sea lions (including fishing); what the demographic effects of food limitation are; and most importantly – how we can mitigate these.

A sensible first step is to enable a review of the diet and nutritional status of New Zealand sea lions to pull all the information about sea lion diet together and write a journal paper that summarises:

- colony differences in diet, highlighting the key prey for each
- year/seasonal variation in diet
- foraging distribution of adult females later in lactation and juveniles
- biological evidence (e.g. pup or maternal mass) for year/location effects on nutrition.

It is important that research to explicitly explore the indirect effects of fishing (resource competition) is included in the Regional Programme of the TMP. We are most concerned with understanding the human impact on food limitation because New Zealand can more readily control its own resource use behaviour compared to global climate change or natural variability.

WWF-New Zealand recommends that DOC / MPI:

- Fund essential research to better understand trophic effects, and in particular – indirect effects of fishing on food limitation, be included in the TMP Regional Programme and provided adequate funding.

4.5 Cumulative impacts and interrelated threats

The NIWA model shows that no single threat is significant enough to explain the population change alone, and that a lethal combination of threats is to blame. There could be several important links between threats. For example, the availability of prey affects the quantity and quality of maternal milk, pup growth and their susceptibility to disease or other stressors (Row et al., 2014). The impact of fishing related mortality may be more extreme for populations that are compromised by disease and or nutritional stress (NIWA, 2015; Goldsworthy& Page, 2007).[37]

4.5.1 TMP proposed management for cumulative impacts

There is no reference to cumulative impacts of threats in the TMP, despite recommendations by the expert panel that regression modelling be conducted for all of the

[37] In Australia, incidental fishery mortality was identified as one of the main threats to Australian sea lion populations despite low numbers of mortalities, which were found to be sufficient to drive population decline due to low population size and productivity (Goldsworthy & Page, 2007).

main hypothesized threats to better understand the interactions of all of the threats, and the relative impact of specific threats.[38]

WWF-New Zealand recommends that DOC / MPI:

- Undertake regression modelling for all of the main hypothesised threats to better understand the interactions of all of the threats, and the relative impact of specific threats.

5 Concluding comments

New Zealand sea lions are the rarest in the world and they live only in Aotearoa. They are a precious taonga and are under threat of extinction. Their population has undergone a dramatic decline and they are now classified “vulnerable” by the IUCN and “Nationally Critical” by DOC. The government and other stakeholders should be doing the maximum possible to ensure the population recovers, rather than the minimum that they can get away with.

The best available science suggests there are multiple and possibly interlinked reasons for the population decline, yet the Threat Management Plan (TMP) largely focuses on a single threat – the disease Klebsiella – and proposes no new action to actively reduce the other top threats. Most importantly, the TMP proposes no new action to curb fishing related mortality and contains an inadequate response to addressing the uncertainties relating to the availability of food for sea lions.

Whether assumptions about fishing used in the NIWA model are accurate or not, the model findings show that it is a significant threat and recovery of sea lion population requires action to reduce the threat. The unwillingness of government to adequately address this threat in the TMP is effectively passing the buck to the next generation. The less that is done now, the more action will be needed later and at a higher cost.

The perilous situation with Māui dolphins on the North Island’s West Coast should provide a salutary lesson of what happens when action is delayed and half measures are taken. WWF-New Zealand urges the government to re-think the sea lion TMP and address all of the main threats as a matter of priority in a considered and coordinated way.

This is the first TMP for sea lions, and it will set the tone for management for years to come. It provides an important opportunity for New Zealand to act to save this precious endemic species.

[38] 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 (Progress Report – NZSL Threat Workshop 2).

6 List of recommendations

WWF-New Zealand recommends that DOC / MPI:

- Develop management actions to actively reduce top threats to sea lions. Where action is not possible due to lack of information, action should be taken to fill the research gaps.
- Develop demographic targets for pup counts, pup survival and adult survival to enable transparent monitoring of progress towards the population goals.
- Provide risk reduction strategy evaluations using the NIWA model. Clearly and transparently show how much particular threats need to be reduced in order to reach population goals, and use this to develop threat reduction targets.
- Undertake research to resolve long-standing uncertainties about the direct fishing related mortality - including SLED efficacy and the current interaction/strike rate.
- Instate the more precautionary SLED discount rate of 35% should be instated in key fisheries until uncertainties have been resolved.
- Include a research objective: to identify opportunities and management options to mitigate the Klebsiella, and/or the underlying factors driving the disease.
- Halt the fisheries operational plan development and the proposed cost/benefits analyses work until research to determine the efficacy of SLEDs and improve estimates of the current strike rate has been carried out and the NIWA risk assessment model has been updated and run with the new information.
- Ensure cost-benefit assessment of management measures to address fishing threats follows international best practice, and includes analysis of non-monetary benefits including ecosystem services, as well as the monetary costs.
- Develop fishing threat reduction targets to reduce the threat by as much as possible – towards zero by-catch.
- Develop and explore spatial management options including the Forest & Bird adaptive management proposal to reduce threat of fishing for Auckland Island sea lions; and options to protect Otago sea lions and their habitat from fishing threats.
- Work with scientists (i.e. dragonfly) to determine what level of observer coverage would significantly improve the by-catch estimates for the fisheries below and enable that level of observer coverage as soon as possible for
    - Auckland Islands scampi trawl fishery
    - Auckland Island “other” non-squid trawl fisheries
    - Steward Island trawl and set net fisheries
    - Otago trawl and set net fisheries.
- Develop a programme to transition squid trawling to squid jigging.
- Fund essential research to better understand trophic effects, and in particular – indirect effects of fishing on food limitation, be included in the TMP Regional Programme and provided adequate funding.

- Carry out regression modelling for all of the main hypothesised threats to better understand the interactions of all of the threats, and the relative impact of specific threats.

References

Augé, A.A., Moore, A.B., & Chilvers, B.L. (2012) Predicting interactions between marine mammals and fisheries: defining precautionary management. *Fish. Manag. Ecol*. 19, 426–433.

Australian Fisheries Management Authority. (2004) *Draft assessment report – southern squid jig fishery*. April 2004, p.95.

Australian Fisheries Management Authority. (2006) Southern squid jig fishery: *Bycatch Action Plan* 2004.

Barclay, P. (2003) Dancing the squid jig. *Big Fish – an occasional series*, 2: 51-53.

Barton, J. (2002) Fisheries and fisheries management in Falkland Islands Conservation Zone. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 12(1): 127-135.

Bowen, W. D. (2011) *A review of evidence for indirect effects of commercial fishing on New Zealand sea lions (Phocarctos hookeri) breeding on the Auckland Islands*. Halifax, Nova Scotia.

Bradshaw, C.J.A.; Haddon, M.; & Lonergan, M. (2013) *Review of models and data underpinning the management of fishing-related mortality of New Zealand sea lions in the SQU6T trawl fishery.*

Chilvers, B. L., Wilkinson I. S., & Childerhouse, S. (2007) New Zealand sea lion, Phocarctos hookeri, pup production—1995 to 2005, N.Z. *Journal of Marine and Freshwater Resources*. 41, 205-213.

Goldsworthy, S.D., & Page, B. (2007) A Risk assessment approach to evaluating the significance of seal by-catch in two Australian fisheries. *Biological Conservation* 139: 269-285.

Goldsworthy S.D., Page, B., Shaughnessy, P.D., & Linnane, A. (2010) Mitigating Seal Interactions in the SRLF and the Gillnet Sector SESSF in South Australia Final Report to the Fisheries Research and Development Corporation, FRDC PROJECT NUMBER: 2007/041.

Goldsworthy, S.D., Page, B., Shaughnessy, P.D., & Linnane, A. (2010) *Mitigating seal interactions in the SRLF and gillnet sector SESSF in South Australia*. Final report to the Fisheries Research and Development Corporation (FRDC), Project no. 2007/041.
SARDI publication no. F2009/000613-1, SARDI Report Series no. 405. (pp. 213).

Goldsworthy, S.D., Shaughnessy, P.D., Page, B., Dennis, T.E., McIntosh, R.R., Hamer, D.J., Peters, K.J., Baylis, A.M.M., Lowther, A., & Bradshaw, C.J.A. (2007) *Developing population monitoring protocols for Australian sea lions*. Final report to the Department of the

Environment and Water Resources. SARDI Aquatic Sciences Publication Number F2007/000554. SARDI Research Report Series No: 219. (pp. 75).

Gormley, A.M., Slooten, E., Dawson, S., Barker, R.J., Rayment, W., DuFresnes, S., & Brager, S. (2012) First evidence that marine protected areas can work for marine mammals. *J. Appl. Ecol*. 49, 474–480.

Hamilton, S., & Baker, B.B. (2015) Review of research and assessments on the efficacy of sea lion exclusion devices in reducing the incidental mortality of New Zealand sea lions *Phocarctos hookeri* in the Auckland Islands squid trawl fishery, *Fisheries Research* 161 (2015) 200-206.

Hon. David Carter, Minister for Primary Industries. Letter to Stakeholers. Ministerial B12-049. July. 2012.

Lalas, C., & Bradshaw, C.J.A. (2003) Expectations for population growth at new breeding locations for the vulnerable New Zealand sea lion using a simulation model. *Biol. Conserv.* 114, 67–78.

Meyer. S.; Robertson, B.C.; Chilvers, L.; & Krkošek, M. (2015) Population dynamics reveal conservation priorities of the threatened New Zealand sea lion Phocarctos hookeri, *Mar. Biol.* 162:1587–1596.

Meynier, L. (2009) *Feeding ecology of the New Zealand sea lion (Phocarctos hookeri)*. PhD thesis, Massey University, Palmerston North.

Meynier, L. (2010) *New Zealand sea lion bioenergetics modelling*, final report for project IPA2009-09. Cited in MPI 2014 AEWG.

Meynier, L.; Mackenzie, D.D.S.; Duignan, P.J.; Chilvers, B.L.; & Morel, P.C.H. (2009) Variability in the diet of New Zealand sea lion (Phocarctos hookeri) at the Auckland Islands, New Zealand. *Marine Mammal Science* 25: 302–326.

Ministry for Primary Industries (MPI). (2015) Aquatic Environment and Biodiversity Annual Review, 2014 – Summary of environmental interactions between the seafood sector and the aquatic environment.

MPI. (2016) *A Summary of the Risk Assessment of Threats to New Zealand Sea lions*. MPI Information Paper No. 2016/03.

NIWA. (2015) *Review of threats to the recovery of NZ sea lions and other otariid species – FINAL REPORT*.

Pichegru, L., Grémillet, D., Crawford, R.J.M., & Ryan, P.G. (2010) Marine no-take zone rapidly benefits endangered penguins. *Biol. Lett.* 6, 498–501.

Blezard R.J., & Burgess, J. (1999) Observer reports from squid jigging vessels off the New Zealand coast 1999. Conservation Services Levy Programme, Department of Conservation PO Box 10-420 Wellington.

Rawlence et al. (2016) Human-mediated extirpation of the unique Chatham Islands sea lion and implications for the conservation management of remaining New Zealand sea lion populations, *Molecular Biology*.

Roberts J., & Lalas, C., (2015) Diet of New Zealand sea lions (Phocarctos hookeri) at their southern breeding limits, *Polar Biol* (2015) 38:1483–1491.

Robertson, B.C, & Chilvers, B.L. (2011) The population decline of the New Zealand sea lion *Phocarctos hookeri*: a review of possible causes. *Mammal Review*, 41:253-275.

Row, W., Roberts, J., Michael, S., & Childerhouse, S. (2014) *Discussion paper on New Zealand sea lion pup mortality: causes and mitigation*.

Row, W.D., & Meynier, L. (2012) Review of necropsy records for bycaught New Zealand sea lions (Phocarctos hookeri), 2000–2008.

Thompson, F.N., & Abraham, E.R. (2009) Estimation of the captures of New Zealand sea lions in trawl fisheries from 1995-96 to 2006-07, *New Zealand Aquatic Environment and Biodiversity Report*, No. 41.

Wallace, J.S., Director Fisheries Management. Aide-memoire for the Minister for Primary Industries: ‘Recent sea lion captures in the southern squid fishery (SQU6T)’, 7 March 2013.

Appendix 1: Unresolved uncertainties about fishing threat

The government assumes that due to the use of sea lion exclusion devices (SLEDs) that 82% of sea lions survive interactions with trawl nets. Documents released under the Official Information Act show that the information provided to the Minister for Primary industries included that: "*SLEDs are very effective at allowing sea lions to escape from the trawl gear, as evidenced through the significant decline in the number of sea lion captures that has been observed*." And that "*the use of SLEDs significantly reduces the risk of sea lion mortality, as sea lions that enter the net are able to escape*".[39]

Minister for Primary Industries Hon David Carter stated: "*I am suitably persuaded that, irrespective of some remaining uncertainty, SLEDs facilitate sea lions escapes from trawl gear and contribute greatly to their ability to survive an interaction with a trawl net*." And that "*current information demonstrates the direct effects of fishing are minimal*".[40]

There remain long-standing significant uncertainties that cast these government assumptions in doubt. These are described below.

6.1 Uncertainty about sea lion and commercial fishing interactions

Estimates of the number of sea lions that come into contact with fishing nets – the 'interaction rate'[41] has become increasingly uncertain – with the most recent interaction estimates being effectively "unbounded" (MPI, 2015, p30). For example, in the year 2012/13 the 95% confidence interval related to the estimated interactions ranged between 53-313, and in 2013/14 it ranged between 14 and 184. This wide range of possible interactions represents the increasing uncertainty.

The main reason for the increasing uncertainty is that SLEDs mean that sea lions pass through nets (either dead or alive) so can not be counted by onboard observers. According to MPI: "*Following the introduction of SLEDs, the number of NZ sea lions interacting with trawls and the proportion of those surviving are considerably more difficult to estimate*".

Since the introduction of SLEDs, estimates of the number of NZ sea lions interacting with trawls have to be made using a predetermined strike rate[42], based on rates observed on vessels without SLEDs from 2003/04 – 2005/06 (strike rates over these three years was 5.9, 5.1, 4.9) (MPI, 2015). Over the last 10 years, fishing practices may have changed in ways that mean that these old estimates are no longer accurate. For example the strike rate and catchability of sea lions may have increased because the average tow duration in the SQU6T

[39] Wallace, J.S., Director Fisheries Management. Aide-memoire for the Minister for Primary Industries: 'Recent sea lion captures in the southern squid fishery (SQU6T)', 7 March 2013. AM12-183.

[40] Hon David Carter, Minister for Primary Industries. Letter to Stakeholers. Ministerial B12-049. July. 2012.

[41] 'Interactions' are the number of sea lions that would be predicted to have been caught if no SLEDs had been used.

[42] The 'strike rate' is the number of NZ sea lions that would be caught per 100 tows if no SLEDs were fitted.

fishery has doubled since the introduction of SLEDs (see table below). An expert panel brought together in 2013 to review the models and data undermining the management of fishing-related mortality of NZ sea lions in the SQU6T fishery (the 2013 expert panel) explained: "*The question remains whether increasing the length of tows increases the effectiveness at catching NZSL*" (Bradshaw et al, 2013, p15).

Table 3.9: Tow duration in the SQU6T fishery (based on trawl fishing targeting SQU in statistical areas 602 and 618). Years are calendar years. Data from MPI databases.

Year	No. of tows	Mean tow duration (hours)	Percentage of tows		
			Less than 4 hours	Between 4 & 8 hours	More than 8 hours
1995	4014	3.7	64.2	33.5	2.2
1996	4474	3.6	64.3	34.2	1.5
1997	3719	3.8	62.7	33.7	3.7
1998	1446	3.2	74.4	24.7	0.9
1999	403	3.5	73.0	24.3	2.7
2000	1213	3.5	70.3	27.0	2.7
2001	583	3.3	72.9	26.6	0.5
2002	1647	3.8	59.8	38.8	1.4
2003	1467	4.1	52.4	44.0	3.6
2004	2598	5.0	36.7	53.6	9.7
2005	2693	4.7	43.7	48.6	7.7
2006	2462	6.3	26.0	49.6	24.3
2007	1317	7.3	18.9	46.3	34.8
2008	1265	6.2	20.4	58.7	20.9
2009	1925	6.5	21.1	51.4	27.5
2010	1190	7.9	16.4	37.4	46.2
2011	1585	6.8	24.7	42.8	32.4
2012	1283	6.6	23.5	49.3	27.3
2013	1027	7.1	18.7	49.4	31.9
2014	737	6.9	17.8	51.5	30.7

Despite recommendations from an expert panel in 2013[43] no robust studies have been done to better understand the relationship between tow length and the change in rate of sea lion captures (OIA response; MPI, 2015 AEBR). Furthermore, despite recommendations from the expert panel convened to help develop the draft TMP, the government is not planning to improve science about interaction rate.[44]

6.2 Uncertainties about the efficacy of SLEDs

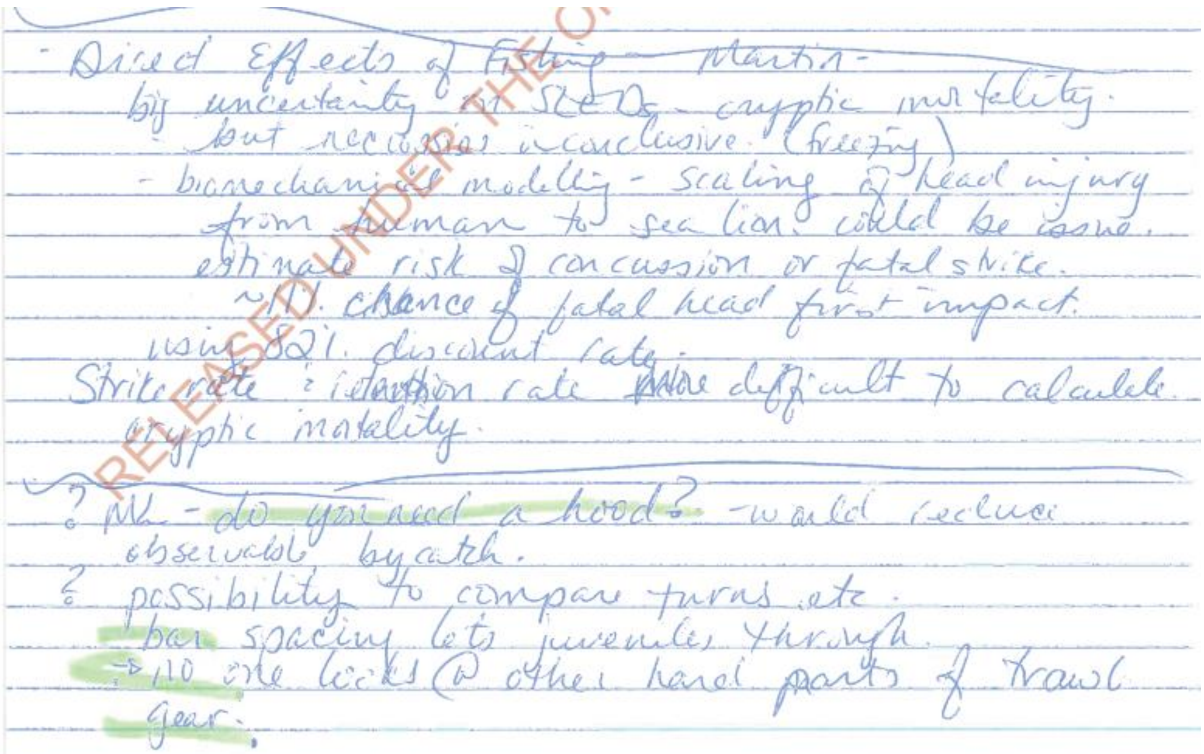
The fraction of sea lions that exit trawls through SLEDs alive or dead is "unknown" (MPI, 2015, p30). Therefore the decline in observed captures is not evidence that sea lions that enter the net are able to "escape". We don't know if the SLEDs are masking the mortality rate by allowing drown sea lions to fall out of the SLED escape hole during hauling (Row & Meynier, 2012). There is no evidence that the hoods are effective at containing dead animals, and there have been no specific studies to assess the hoods (Hamilton & Baker, 2015).

[43] See Bradshaw et al., (2013)

[44] In an Official Information Act request we asked MPI: Is the government planning to improve the science about interaction rate e.g. fund studies to improve accuracy of interaction estimates? The response was: "There are no contracts for this type of research at present".

An expert panel brought together by the government in 2013 to review the models and data undermining the management of fishing-related mortality of NZ sea lions in the SQU6T fishery stated: *"Recently, the numbers of NZSL carcasses brought on board trawlers has declined substantially (Thompson et al., 2013), but there remains uncertainty about whether those animals are all that have been killed in the fishery. Biomechanical testing has estimated a low risk of head injuries from impact with SLEDs (Ponte et al., 2010; 2011), but cannot resolve wider issues about whether other individuals are drowned but not recovered".*

At the more recent TMP workshop, DOC hand written notes state that there is "big" uncertainty about SLEDs and associated cryptic mortality.


- Direct Effects of Fishing – Martin –
big uncertainty of SLEDs – cryptic mortality.
- but necropsies inconclusive. (freezing)
- biomechanical modelling – scaling of head injury from human to sea lion could be issue.
estimate risk of concussion or fatal strike.
~1% chance of fatal head first impact.
using 82% discount rate.
Strike rate : retention rate more difficult to calculate cryptic mortality.
? ML – do you need a hood? – would reduce observable bycatch.
? possibility to compare turns etc.
- bar spacing lets juveniles through.
→ 10 one looks @ other hard parts of trawl gear.

6.3 Uncertainties about cryptic mortality

We don't know the rate of survival once sea lions leave the SLED or net (Bradshaw et al., 2013; Robertson & Chilvers 2011). It is possible that some sea lions exceed their dive limit and drown before reaching the surface after escaping from either the SLED or the front of the net.[45] Such sources of 'cryptic mortality' are presently "unquantified and are not reflected in the estimated overall survival rate of encounters with trawls" (MPI, 2015, p43).

[45] There is evidence that sea lions operate at their energetic limit, and have to travel long distances and diver very deep to find enough food (Meynier, 2010; Meynier et al., 2009). If the time it takes to navigate out of the net may be longer than they have planned for, they will drown either in the net or on their way back to the surface.

Investigation into post SLED mortality was recommended by the 2013 expert panel: "*We recommend that means of investigating post-exit SLED mortality be investigated to assess the practicality of reducing this source of uncertainty in their real role in reducing NZSL deaths*" (Bradshaw et al., 2013, p4). However this work has not yet been done.

Appendix 2: Methods for estimating ex ante benefits of marine conservation activities in New Zealand to inform Cost Benefit Analysis

As discussed in section 4.2.1, it is essential that any cost benefit analysis of potential fishing restrictions follows international best practice and looks at the full range of benefits as well as costs.

On the next page is analysis produced by Michael Verdone, Natural Resource & Environmental Economist (BBC Research and Consulting – Denver Colorado). It looks at the methods for estimating ex ante benefits of marine conservation activities to inform Cost Benefit Analysis.

BBC RESEARCH & CONSULTING
1999 Broadway
Suite 2200
Denver, Colorado 80202-9750
303.321.2547 fax 303.399.0448
www.bbcresearch.com
bbc@bbcresearch.com

MEMORANDUM

To:	Aimee Leslie, WWF Switzerland & Amanda Leathers, WWF New Zealand
From:	Michael Verdone, Natural Resource & Environmental Economist (mverdone@bbcresearch.com)
Re:	Methods for estimating ex ante benefits of marine conservation activities in New Zealand to inform Cost Benefit Analysis
Date:	August 3rd, 2016

Background

The Government of New Zealand would like to measure the effectiveness of marine conservation efforts using Cost Benefit Analysis (CBA). In simple terms, CBA is a tool to help decision makers understand and navigate the trade-offs of different decisions in terms of costs and benefits. In order for CBA to accurately depict the trade-offs of different activities it is important that the analysis includes as full an accounting of the benefits and costs as possible.

Marine conservation produces a number of benefits. Recent literature suggests conserving or enhancing marine species diversity can enhance primary and secondary productivity, improve nutrient cycling, and increase the stability of marine ecosystems against external shocks. Recent studies have also shown that marine ecosystems with greater species richness have lower observed rates of collapse and extinction of commercially important species over time. Marine ecosystems where biodiversity loss has occurred have been observed to support fewer fisheries, contain less habitat for oyster reefs, seagrass beds, and wetlands, and provide fewer filtering and detoxification services which leads to lower water quality and the rise of algal blooms, fish kills, beach closures, and dead zones. (Worm et al., 2006).

A CBA that only looks at the primary production benefits of marine conservation will grossly underestimate the true benefits of conservation activities. While the scientific literature has shown that marine conservation can have a profound impact on the marine environment and the services it provides, the difficulty lies in measuring the benefits of any particular marine conservation program/activity. Determining the ecological impact of conservation activities on the oceans requires methods for translating human activities into ecosystem-specific impacts.

Methods for Measuring Benefits of Marine Conservation

To understand which measurement approaches may be the most appropriate in the context of New Zealand it is worthwhile to look at the types of marine conservation activities that are taking place in the country which have direct and measureable impacts on marine resource and ecosystem services. WWF New Zealand supports a variety of marine conservation activities including:

- Advocating and advising the Government of New Zealand to establish a representative network of marine protected areas for the protection and enhancement of marine biodiversity
- Protecting the biodiversity, geodiversity and heritage values of the Kermadec marine region. In addition to the direct benefits to biodiversity, the protection efforts will also create benefits to New Zealand's image overseas, creating tourism and marketing opportunities
- Promoting the adoption of ecosystem-based fisheries management
- Leading efforts to save the Maui dolphins from extinction
- Making seabird-safe fishing practices are compulsory
- Valuing the Antarctica and Southern Ocean so that the ecosystem is used wisely and protected

The marine conservation activities being undertaken in New Zealand produce a large number of benefits that span the disciplines of biology, ecology, economics, and sociology. Measuring these benefits requires tools from each discipline (Table 1). Every conservation activity can be reasonably assumed to create positive impacts on species diversity, ecosystem resilience, water quality, and fish stocks. Some activities, such as creating MPAs and protecting specific marine regions will have positive impacts on coastal protection. All of the activities can also be reasonably assumed to positively impact social values, including: livelihoods, tourism, heritage/cultural values, existence values, bequest values, and option values.[1]

---

[1] Economists have long recognized that wildlife and ecosystems, especially rare, threatened, and endangered ones, have economic values beyond just viewing. This is supported by a series of legal decisions and technical analyses. The US Court of Appeals in 1989 first clarified that the US Department of the Interior, in assessing damages in Natural Resource Damage Assessment cases, should include what it termed as "passive use values," that is, existence, bequest, and option values provided to non-users of the species or ecosystems, as a compensable value in addition to any use value. Existence values are the values people derive from simply knowing that a species exists. Bequest values are the values that people receive from knowing that a species or ecosystem is conserved and protected to such a degree that it can be safely assumed that it will be enjoyed by future generations and option values reflect the values that people get from knowing that they have the option of

Table 1: Methods for Estimating Selected Benefits of Marine Conservation in New Zealand		
Benefits of Marine Conservation Activities in New Zealand	**Ex Ante Methods**	**Ex Post Methods**
Species diversity	Meta analysis	Direct sampling
Ecosystem resilience	Meta analysis	Direct sampling
Fish stocks	Bio-ecological models (e.g. InVest)	Direct sampling
Coastal protection	Bio-ecological models (e.g. InVest)	Direct measurement
Water quality	Bio-ecological models (e.g. InVest)	Direct sampling
Livelihoods	Socioeconomic analysis/ Meta analysis	Social surveys and regional statistics
Tourism	Socioeconomic analysis/ Meta analysis	Social surveys and regional statistics
Heritage/Cultural values	Benefit-transfer	Social surveys
Existence values	Benefit-transfer	Social surveys
Bequest values	Benefit-transfer	Social surveys
Option values	Benefit-transfer	Social surveys

There are two types of benefit estimates that are prevalent in evaluations of marine conservation policy. Ex ante benefit estimates measure the expected benefits of a conservation activity during the planning and design phase of a project. These types of benefit estimates rely on previously published data and generalizable models to estimate the benefits that a particular conservation activity would be expected to have in a specific setting. Ex post benefit estimates measure the actual benefits of a conservation activity as it is happening or after it has happened. Ex post benefit estimates rely on baseline information to measure how specific impact metrics (e.g. number of different species) have changed over time and rely on a different set of tools and methods.

We focus the remainder of this memo on ex ante approaches since we believe WWF and the Government of New Zealand are interested in determining which new activities should be funded, which makes it much more important to estimate ex ante benefits. However, BBC can also write a separate memo documenting methods for ex post benefit estimates beyond what is contained in Table 1.

Meta Analysis

The ex ante benefit of a conservation activity on species diversity and ecosystem resilience can be estimated with a meta analysis of previously published literature on the observed effects of conservation activities on species diversity and ecosystem

---

being able to see a certain species (e.g. the Maui dolphin) or visit a certain place (e.g. the Kermadec Islands) at some point in the future.

resilience from similar or comparable marine habitat. Meta analysis has been used in a number of marine conservation settings. Mosquira et al. (2000) was the first to use a meta analysis to demonstrate the effectiveness of using MPAs to increase fish populations. Worm et al. (2006) used a meta analysis to show how changes in marine ecosystems affected the associated ecosystem services over time. There are disadvantages to using meta analyses. It can be time consuming to find appropriate studies that measure the impacts that are of interest to decision makers. It may also be difficult to find studies that apply to the geographic area where a decision is being made.

Bio-ecological Modeling

The ex ante benefit of a conservation activity on fish stocks, coastal protection and water quality can be estimated with bio-ecological models. A number of bio-ecological models are available to estimate the ex ante benefits of marine conservation on fish stocks, coastal protection and water quality, but the Integrated Valuation of Ecosystem Services Tradeoffs (InVEST) model is perhaps the most well known (McKenzie et al. 2012). InVEST is a freely available spatial mapping and modeling software that allows users to predict the impact of conservation activities on a variety of ecosystem services. The InVEST tool contains models on fisheries, coastal protection and marine water quality. There are dozens of other bio-ecological models available as well and websites to help analysts choose the model that is most appropriate for their needs (See: http://ecosystemsknowledge.net/resources/tools/tool-assessor).

Socioeconomic Analysis

Livelihood and tourism benefits can be estimated ex ante through well-constructed socioeconomic studies that combine information from the bio-ecological models with information on the economic characteristics of a site/region to predict how livelihoods and tourism are likely to change. Livelihood analyses commonly look at how dependent communities are on marine resources, the infrastructure and institutions that govern how the communities harvest those resources, and what livelihood alternatives are available to people. Analyses of tourism often look at previous trends in tourism visitation and spending in addition to analyzing whether or not the site/region has infrastructure to support new or additional tourism demand. It is also possible to estimate the ex ante livelihood and tourism effects of marine conservation activities using a meta analysis if studies of similar activities from comparable areas are available.

Benefit-transfer

The ex ante benefits of increasing heritage/cultural values, existence values, bequest values, and option values can be estimated through benefit-transfer methods. The benefit-transfer method relies on transferring benefit values derived from studies of a similar conservation activity in one geographical location and transferring them to another location. Adjustments to the values can be made by factoring in differences in incomes or prices from one area to the other. Typical criticisms of this method focus the belief that species and ecosystems in one area are unique and simply transferring the value associated with them in one location to another location does not capture local qualities.

About BBC Research and Consulting

BBC Research and Consulting has analyzed the development, use and regulation of natural resources for government and non-profits over the past four decades. Our work ranges from examining the socioeconomic impacts of conservation measures to supporting the creation of sophisticated conservation plans for government ministries. We have experience working on marine conservation issues in the South Pacific, forest conservation issues in West and East Africa, and species habitat conservation in the Western United States. We have also examined the impacts of new regulations and activities and developed cost-benefit evaluation methods for government agencies. Our strength lies in the breadth of our experience and our reputation as objective analysts.

Contact: Michael Verdone, Ph.D. at mverdone@bbcresearch.com

Sources:

1. McKenzie, E., et al. (2012). Developing Scenarios to Assess Ecosystem Service Tradeoffs: Guidance and Case Studies for InVEST Users. World Wildlife Fund, Washington, D.C.
2. Mosqueira, I., et al. (2000). Conservation Benefits of Marine Reserves for Fish Populations. *Animal Conservation* 4, 321-332.
3. Worm et al. (2006). Impacts of Biodiversity Loss on Ocean Ecosystem Services. Science, 314 (3).