

Hector's and Māui dolphin Threat Management Plan Toxoplasmosis science workshops Meeting Report

23, 27 October and 4 November 2020

Background

Hector's and Māui dolphins are small coastal dolphins found only in New Zealand. Hector's dolphins live mainly around the South Island and Māui dolphins are only found on the west coast of the North Island (WCNI). Hector's dolphin is ranked as Nationally Vulnerable by the New Zealand Threat Classification System (NZTCS, Baker et al. 2019) and has a population of around 15,000 individuals (MacKenzie & Clement 2014, 2016). Māui dolphin is ranked Nationally Critical under the NZTCS (Baker et al. 2019) and has an estimated population of 63 individuals above 1 year of age (95% c.i. 57-75).

The New Zealand Government's response to the threats facing these dolphins is determined through the Hector's and Māui dolphin Threat Management Plan (TMP)¹. A review of this TMP was conducted between 2017 and 2020. During this review, it became clear that, although there remain divergent views on impacts and best mitigation options, one serious threat is the disease toxoplasmosis, caused by infection with the unicellular parasite *Toxoplasma gondii*. Toxoplasmosis is a confirmed cause of death of both subspecies, and there is an urgent need to address this threat. This is particularly urgent for Māui dolphin due to their small population size, and the impact this disease can have on reproductive success. *Toxoplasma gondii* is spread through the faeces of felids (cat species). Aotearoa/New Zealand has no native wild cat species present but high numbers of the introduced domestic cat, which was introduced as recently as the late 18th Century, before which *T. gondii* is likely to have been absent from the New Zealand environment.

The TMP consultation document included a proposal to develop a toxoplasmosis action plan that would include targeted research to improve knowledge on *T. gondii* and impacts on New Zealand wildlife (including the effects on dolphins), inform management actions, and, ultimately, reduce the number of dolphin deaths attributable to toxoplasmosis to near zero. Many submissions received during the consultation process agreed that toxoplasmosis is a

¹ www.doc.govt.nz/tmp-review

significant threat to the dolphins and supported the development of an action plan to address this threat. The toxoplasmosis plan² drew heavily on a literature review carried out for the Department of Conservation (DOC)³, an executive summary of that review is available through the DOC website⁴.

Proposals for management of threats to the dolphins other than toxoplasmosis (such as interaction with fisheries, seismic surveying, seabed mining and tourism) were also included in the public consultation document, and final decisions are described in the updated threat management plan.

As part of addressing this challenging issue, national experts, including from stakeholder organisations (DOC, Ministry for Primary Industries (MPI), university researchers, and regional councils) have been engaged in a Toxoplasmosis Strategic Science Advisory Group (SSAG), which convened in late-2019. The SSAG process has been used in response to other complex government science issues, including kauri dieback disease and *Mycoplasma bovis* in dairy cattle. The SSAG will:

- provide advice and recommendations to the Hector's and Māui dolphin TMP Governance Group on the requirements for strategic science prioritisation
- aid in the coordination of research programmes focused on understanding and managing the effects of toxoplasmosis on these dolphins. Work across Government agencies, Crown research institutes, and other research institutes to maintain oversight and ensure any toxoplasmosis-related research is cohesive and complementary, and that funding of priority research informs management actions required to effectively reduce the risk of toxoplasmosis to the dolphins.
- ensure the best information available domestically and internationally is being considered in developing and implementing the science programme; and
- feed into the development and updating of the toxoplasmosis action plan.

Toxoplasmosis impacts many other species (including livestock, humans, other mammals and various native and endangered species of birds), and while this plan is focused on addressing the threat to the dolphins, it is likely that wider benefits associated with the research and actions proposed will be realised.

Purpose

As Part of the toxoplasmosis action plan, DOC undertook to run a series of workshops with key New Zealand researchers and significant input from international experts. The purpose was to refine research objectives, identify knowledge and research gaps and prioritise these in support of the development of a strategic science plan to address the impact of toxoplasmosis

² <https://www.doc.govt.nz/nature/pests-and-threats/diseases/toxoplasmosis-and-hectors-and-maui-dolphin/toxoplasmosis-action-plan/>

³ Roberts Jim O., Jones Hannah F. E., Roe Wendi D. (2020) The effects of *Toxoplasma gondii* on New Zealand wildlife: implications for conservation and management. *Pacific Conservation Biology* (<https://doi.org/10.1071/PC20051>)

⁴ www.doc.govt.nz/toxoplasmosis-action-plan.

on the dolphins. A second series of workshops will be held to develop the social science and management pathways.

The two sets of workshops will provide guidance to decision makers in DOC and to the Toxoplasmosis Strategic Science Advisory Group.

The first set of workshops were run virtually over three days from 9am to 2pm on Friday 23, Tuesday 27 October, and Wednesday 4 November 2020.

Objective

The overall objective of the workshops was to engage across disciplines to:

- determine the key knowledge gaps,
- suggest how these knowledge gaps might be filled,
- to rank these knowledge gaps to enable research prioritisation, and
- provide indicative costings to fund research and management programmes.

Participants

Angela Amlin (National Ocean and Atmospheric Administration (NOAA) USA), Stacie Robinson (National Marine Fisheries Service (NMFS) USA), Michelle Barbieri (NMFS USA), Karen Shapiro (University of California Davis (UC Davis) – USA), Pat Conrad (UC Davis – USA), Liz Van Wormer (University of Nebraska-Lincoln, USA), Michael Grigg (National Institute of Health – USA), Frances Gulland (US Marine Mammal Commission), Jim Roberts (Anemone), Wendi Roe (Massey University), Hannah Jones (Waikato Regional Council), Chris Niebuhr (Manaaki Whenua - Landcare Research), Graham Hickling (Manaaki Whenua -Landcare Research), Kelly Buckle (MPI), Imogen Basset (Auckland Council), Karen Stockin (Massey University – Auckland), Steven Hunt (Waikato Regional Council), Louis Tremblay (Cawthron Institute), Aurelie Castinel (MPI), Ben Sharp (Fisheries NZ), Larissa Howell (Massey University), Marco Milardi (Fisheries NZ), Clare Stringer (MPI), Mark Henderson (MPI), Erik Van Eyndhoven (MPI)

DOC: Lian Butcher, Mara Wolkenhauer, Katrin Webb, Ian Angus, Dave Lundquist, Kristina Hillock, Craig Gillies, Kate McInnes, Clement Lagrue, Peter Hardstaff, Michael Harbrow, Nicole Hancock, Marine Richardson, Hannah Hendriks, Helen Kettles

Facilitator: Keryn Weir

Technical facilitator: Helen Wise

Agenda: See Appendix 1 for agendas for all three days.

Terms of reference: See Appendix 2.

Workshop Day 1

A series of presentations were delivered to provide an overview of the issues and context for the meeting, including review of current knowledge in New Zealand and global perspectives around the disease toxoplasmosis, the parasite *Toxoplasma gondii*, and its environmental transmission.

Facilitated discussions were held after presentations to capture issues and questions arising that could be taken into Workshop Day 2 (identify and consolidate knowledge gaps and begin to design potential solutions/key research questions/pathways to filling identified knowledge gaps) and Workshop Day 3. (gather further information about knowledge gaps/questions, and identify top priorities, indicative costs and potential collaborations).

Presentations:

Lian Butcher [Director – aquatic unit at DOC]; An overview of the Hector's and Māui dolphin Threat Management Plan

Presentation summary:

The history and context of the Threat Management Plan (TMP) for Hector's and Māui dolphins and the Toxoplasmosis Strategic Science Advisory Group, focussing on the significance of Māui and Hector's. A brief overview the New Zealand science systems, and the funding landscape. The importance of this process was emphasised because of the considerable public expectations around the dolphins.

Jim Roberts [Anemone], Wendi Roe [Massey University], Hannah Jones [Waikato Regional Council]: "What's known about *Toxoplasma gondii* in New Zealand Wildlife"

Presentation summary:

An overview of what is known of the prevalence of *Toxoplasma gondii* infection and disease in New Zealand native wildlife species.

While a few individuals of a number of endemic bird species are now known to have died from toxoplasmosis, it is likely to be a greater population risk for Hector's and Māui dolphins, though few, if any, native species have been assessed very thoroughly. In addition, this presentation discussed how the different habitat preferences of certain NZ marine mammals may influence relative infection rate.

Toxoplasma gondii is a globally widespread protozoan parasite that can infect all bird and mammal species. Cat species (Felidae) are the only known definitive host for *T. gondii* and this parasite should have been absent from New Zealand prior to the introduction of the domestic cat (*Felis catus*) in the 18th Century. Clinical toxoplasmosis has recently been reported in multiple wild-living New Zealand native species, including: Hector's and Māui dolphins (*Cephalorhynchus hectori hectori* and *C. h. maui*, respectively), kākā (*Nestor meridionalis*), red-crowned kākāriki (*Cyanoramphus novaeseelandiae*), kererū (*Hemiphaga novaeseelandiae*) and several kiwi species (*Apteryx* spp.). However, the prevalence of *T. gondii* infection and associated disease are unknown for most New Zealand native species, and the wider

conservation risks of *T. gondii* remain poorly understood. The preliminary evidence suggests that fatal toxoplasmosis may be more frequent in Hector's and Māui dolphins relative to other native cetaceans and avifauna that have been assessed for infection. This presentation signalled some critical knowledge gaps.

Hannah Jones [Waikato regional council]: New Zealand hydrological context.

Presentation summary:

An overview of the transport of *Toxoplasma gondii* oocysts in water within a New Zealand hydrological context and the implications for management.

New Zealand's High rainfall and steep catchments lead to quick transport times. The direct piping of stormwater from urban areas to river systems and the ocean, and 90% loss of wetlands leads to little chance of oocyst retention.

Catchment models coupled with cat density estimates were used to model oocyst distribution to the marine environment and showed hotspots around river mouths that drain from pastoral and urban areas such as the Waikato river. The distribution of oocysts in the marine environment will be affected by currents along shore and out to sea (at least to 50m depth contour).

Toxoplasma gondii is likely widespread in the marine environment and represents a diffuse pollution problem.

Current stormwater and wastewater infrastructure will not remove or kill oocysts and often discharge directly to waterways. Management solutions once *T. gondii* enters waterways could potentially be managed through improved stormwater treatment and through wetland restoration. Such management would require action across wide spatial areas and involve multiple management agencies.

Craig Gillies [DOC Principal scientist – Biodiversity group – Threats]: Cats in New Zealand

Presentation summary:

A history of the introduction of cats to New Zealand and the establishment of feral populations. Cats are now present in most terrestrial New Zealand Habitats. An overview characterising feral cat populations, with comparisons of feral and owned cat prey and ranges.

Current and potential management of feral cats, including established best practice, and an assessment of current and potential approaches.

The challenges of managing feral cats for conservation were presented.

Current DOC research was described and thoughts on knowledge gaps with respect to *Toxoplasma gondii* loading to the environment.

Elizabeth (Liz) VanWormer [University of Nebraska-Lincoln, USA] & Karen Shapiro [UC Davis, California -USA]:

Presentation summaries:

Part 1: *Toxoplasma gondii* from cats to sea otters: Modelling and ecological perspectives from coastal California

From land to sea, the zoonotic parasite *Toxoplasma gondii* infects a wide range of warm-blooded animals, including humans and marine mammals. The parasite is an important cause of death in threatened California sea otters, which serve as sentinels for disease threats to people and animals sharing coastal environments. Contamination of coastal waters with *T. gondii* is thought to occur through delivery of environmentally resistant oocysts to the nearshore via runoff. Yet, the interconnected biophysical mechanisms that facilitate transmission from definitive hosts (cats) to marine mammals have remained largely unexplored. Using field, molecular, and spatial modelling approaches, a transdisciplinary project brought together experts in parasitology, epidemiology, oceanography, and hydrology to investigate *T. gondii* transmission from terrestrial to marine systems. Our linked parasite loading, and transport models highlight relative contributions of domestic and wild felids and demonstrate that coastal development and precipitation can greatly increase the numbers of oocysts that reach marine waters. Through laboratory experiments, we further explored the ecology of *T. gondii* in marine ecosystems and show that sticky gels enhance *T. gondii* association with marine aggregates, material consumed by organisms otherwise unable to access micron-sized particles. Adhesion to sticky biofilms on kelp also captures *T. gondii* from the water, rendering the parasite as bio-available to kelp-grazing snails, which can then transmit *T. gondii* to sea otters. Combined, our results highlight climatic and landscape-change mechanisms that favour the mobilization of oocysts from cat faeces into waterways and unravel novel mechanisms that promote *T. gondii* entry into marine food webs.

Part 2: Distribution and virulence of *Toxoplasma gondii* in California sea otters

The observation that only some *Toxoplasma gondii*-infected southern sea otters (*Enhydra lutris nereis*) develop fatal toxoplasmosis, while others have incidental or mild infections, has long puzzled parasitologists. This study combined molecular characterization of *T. gondii* isolates from southern sea otters with results from detailed post-mortem examinations, providing a unique opportunity to evaluate whether parasite genotype influences pathological outcome. Molecular findings were further combined with data on *T. gondii* genotypes circulating in sympatric terrestrial carnivores to examine spatial associations among parasite genotypes on land and sea. Genotyping was performed on 135 *T. gondii* isolates obtained from sea otter brain tissue; 116 of these same animals also received comprehensive pathological examination. In all cases, assessment of *T. gondii*-associated lesion patterns and disease outcome was performed by a pathologist with no knowledge of the *T. gondii* genotypes obtained from brain tissue through isolation in cell culture. The predominant *T. gondii* genotypes identified were Types X, atypical mixed II/X, and X variants. These atypical genotypes accounted for 79% of *T. gondii* isolates, with the remainder belonging to Type II. Type X or mixed X variants were the only genotypes isolated from the brains of otters that died from *T. gondii* as a primary cause of death. Spatial analysis revealed identical *T. gondii* genotypes circulating in terrestrial carnivores and sea otters in central California. Results demonstrate a land-sea connection of

virulent *T. gondii* genotypes and highlight the need for long-term interdisciplinary research for unravelling mechanisms of *T. gondii*-induced morbidity and mortality in wildlife populations.

Michael Grigg [Laboratory of Parasitic Diseases/ National Institute of Allergic and Infectious Diseases / National Institutes of Health – USA]: Emergence and control of protozoan parasites infecting marine mammals

Presentation summary:

An overview of the global spread of the parasite and an understanding of the distribution of genotypically different strains globally of the parasite *Toxoplasma gondii*. It is the most successful protozoan parasite on the planet and can infect any nucleated cell of a warm-blooded animal.

Human health issues were raised as part of a background understanding of the parasite. Whilst typically asymptomatic in humans the parasite is still the leading cause of food-borne death in the USA, and the leading form of infectious blindness globally (1 in 400 people). Most strains do not result in disease; however, some species are more susceptible than others (e.g., marsupials and mustelids).

Cats can produce between 100 million and one billion oocysts in one shedding event (a ten-day cycle). It takes only a single oocyst to cause infection in most vertebrates. The sexual cycle, through processes of reassortment and recombination is sufficient to develop pandemic lines through the variable fitness of their progeny.

Whilst bradyzoites have been implicated in transmission, through undercooked meat consumed by humans, oocyst transmission is responsible for the high prevalence of infection in marine mammals.

Cats can liberate strains into the environment, through sexual development of oocysts, through uptake of strains from intermediate host species. The intermediate host may not suffer from the disease but once that strain is released into the environment other species may be vulnerable.

Genotypes are very important. Some strains may only be virulent when coinfection (polyparasitism) is present and can be an important factor with protozoal disease in some marine mammals. The Genotype is a critical determinant of disease.

Stacie Robinson & Michelle Barbieri [NOAA - Hawaiian Monk Seal Programme, USA]: Exploring the environmental factors influencing *Toxoplasma gondii* infections in Hawaiian monk seals

Presentation Summary:

Toxoplasmosis is the major disease threat to Hawaiian Monk seals in the Main Hawaiian Islands, and is the 3rd highest cause of death to the seals behind anthropogenic trauma, and interactions with fishing gear. Breeding females are hardest hit by toxoplasmosis, for which the disease is the number one cause of death. This has population level impact and potential for declines in population growth.

The approach being taken in the National Marine Fisheries Service (NMFS) to stemming the threat from toxoplasmosis to the seals included running research workshops, and prioritisation of research activities, exploiting current data and resources, and generating new data streams to address critical knowledge gaps to inform management. The work is dependent on partnerships and stakeholder and community engagement. Particularly as NMFS does not hold jurisdiction over areas where management is required.

To assist decision making risk models are being developed and tested that incorporate recent work done on the correlation between large rainfall events and known cases of toxoplasmosis. The models incorporate the pathogen, environment, and host relationships to identify hotspots and evaluate the impact of various management scenarios to inform risk management and mitigation activities. This demands a multidisciplinary approach and strategic communication planning.

Chris Niebuhr and Graeme Hickling [Manaaki Whenua – Landcare Research, Wildlife Ecology & Management]: Toxoplasmosis: Agricultural landscapes and terrestrial wildlife

Presentation summary:

Toxoplasmosis is a significant cause of abortion in sheep in New Zealand, with the timing of infection in ewes critical in terms of impacts on lambs. Following infection, ewes develop robust immunity. Source of infection in sheep is contaminated pasture, food supplies and water. Potential loss of lambs due to toxoplasmosis is estimated at \$1-1.7 million, with the cost of prevention Toxovax® vaccine is just over \$300,000 (2009 estimates). Cat control appears to be prohibitively expensive when compared with sheep vaccine. Control of rodents, acting as intermediate hosts of *Toxoplasma gondii*, may also be necessary, which would have additional costs.

Rodents, especially mice (*Mus musculus*), can maintain *T. gondii* infections for multiple generations (via vertical transmission), and infection in cats occurs at a much higher rate from predation on infected intermediate hosts than from ingestion of oocysts from environment. For sparsely populated regions with low to moderate predation of rodents by cats, vertical transmission in rodent intermediate hosts is a deciding factor as to whether the disease modelling predicts *T. gondii* infection persistence or not. Modelling studies also suggest that less-intensive cat control is necessary if mouse populations are reduced concurrently.

Worldwide, *T. gondii* infections have been reported in a variety of mammal and bird species, including feral pigs, deer, gulls, and waterfowl, however the infection status of these groups is not known for New Zealand. Furthermore, the geographic and host distribution of various *T. gondii* genotypes in New Zealand are also understudied.

Michael Harbrow: Public awareness and socialisation - brief background and why we're not leaping into management.

Presentation summary:

Management efforts to reduce *Toxoplasma gondii* loading to the marine environment at source through either controlling numbers of unowned cats or through cat owner behaviour change

will require socialisation of ideas. There is current uncertainty around disease distribution in cat populations and catchments, however the critically low population size of Māui dolphins means we cannot wait for perfect information. So focussed attention will likely fall within catchments on the west coast of the North Island.

Most of DOCs management interventions for landscape scale controls of rats, stoats, and possums happen in areas away from areas where people live. As such many actions are out of sight and out of mind. This may not be the case with a response to *Toxoplasma gondii*.

Whilst Dolphins have high public support for greater protections, they are still *psychologically distant* for people who are more likely to support action in relation to things that they are aligned with from their direct and immediate experience. It will be hard to bridge the distance between cats shedding oocysts and the downstream impacts on dolphins. So, there is a need to reduce this psychological distance to increase chances of effective management. Increased knowledge and awareness alone do not always lead to action or changed behaviours, yet this is still important as a first step.

Social license is required and may be hard won and needs to be continually monitored and managed. If we fail to obtain or lose social license for the management of cats that could mean opposition that is strong enough to halt our management activities. As we have seen to some extent with 1080 in NZ. Because of high cat ownership, it will be really important when we look at management options around cats that we work hard to bring people with us.

Behaviour change is seldom achieved based on changed attitudes or awareness alone. There is a lot of groundwork required in design and implementation of behaviour change. Some of the management objectives may dovetail in with Predator Free 2050 objectives. However recent studies from NZ indicate that the best levers for changing cat owner behaviours for the outcomes we want may have nothing to do with biodiversity at all.

Other social aspects could be at play, including social norms around cat ownership, and views around who is responsible for the decline of Māui and Hector's dolphins. These human dimensions and the issues of psychological distance, social license, and behaviour change will need to be focussed on in addressing toxoplasmosis in the dolphins. This is a complex issue and leaping straight into management may be detrimental to the objectives of protecting the dolphins.

Workshop Day 2

Objectives for workshop Day 2:

1. Identify and consolidate the knowledge gaps resulting from Workshop Day 1.
2. Begin to design potential solutions/key research questions/pathways to filling knowledge gaps.

Morning sessions focussed on ensuring that all knowledge gaps and questions to work through were identified. Facilitated collective discussions were complimented by small break out groups, and collective feedback sessions.

Questions were collated and grouped for prioritisation in workshop three under different themes that emerged.

The key theme areas are:

- Dolphins
- Genotyping
- Cats
- Transmission
- Management and Miscellaneous

Workshop Day 3

Objectives for workshop three:

1. Gather further information about knowledge gaps/questions.
2. Identify top priorities, indicative costs and potential collaborations.

The key theme areas were further addressed through key guiding questions:

- Dolphins: How important is toxoplasmosis as a population risk to Hector's and Māui dolphins?
- Genotyping: How do we better understand the presence, distribution and prevalence of *T. gondii* genotypes in NZ and typical genotype found in fatal dolphin cases?
- Cats: What do we need to know about cats (and cat ownership) to better understand their role and the opportunities for management?
- Transmission: What are the risk factors for toxoplasmosis in Hector's and Māui dolphins? (This includes risk factors for exposure to oocysts as well as risk factors for disease.)
- Management and Miscellaneous: What specific research do we need to better characterise and monitor potential control/mitigation methods? And broader and miscellaneous questions.

Focused breakout groups were used to address themes 1-4. The management and broader miscellaneous questions were debated collectively by the whole group. The goal was to prioritise the identified questions and ensure these prioritisations were appropriately captured.

Prioritisation was guided by two key questions:

1. The degree of difficulty in answering the question, including whether tools and approaches, or programmes already existed or would need to be developed; and
2. Determine the importance of each question to inform management responses to help the dolphins.

Questions and group prioritisations were collated into a spread sheet for discussion by the broader group.

Further consideration was then given to the potential or relative cost of answering the research questions. The rationale for each question's importance was discussed and the group response was captured.

The final table has been circulated to participants for further feedback, which will inform the development of the science plan by the SSAG.

Appendix 1: Workshop agendas

Day One: 23 October 2020

9.00am – 9.30am	<p><u>Welcome</u></p> <p><u>Opening Karakia</u></p> <p><u>Outcomes of the workshops</u></p> <p>The overall objective of the workshops will be to engage across disciplines to:</p> <ol style="list-style-type: none"> 1. Determine what the knowledge gaps are 2. Suggest how the knowledge gaps might be filled 3. Prioritise pathways to fill these knowledge gaps 4. Provide indicative costings to support a substantial budget bid to Government to support research and management programmes <p>Today:</p> <p>Overview of the issue and context for the meeting, including review of current knowledge in New Zealand and global perspective around the disease toxoplasmosis, the parasite <i>Toxoplasma gondii</i>, and environmental transmission of the parasite.</p> <p><u>Introductions</u></p> <p>While we don't have a lot of time, it's important that we each at least have an opportunity to say who we are, where we are and what our discipline is.</p> <p>In the interests of time, I'm going to call out your name and ask you to do that. Will do that alphabetically by first name.</p> <p><u>Process</u></p> <ul style="list-style-type: none"> • How the day will work, e.g., presentations followed by questions. • It would be useful if questions were related to knowledge gaps/research questions. 	Keryn	30 mins
		Helen Anton Keryn Helen – share objectives on screen	

	<ul style="list-style-type: none"> • We may not be able to hear and discuss every question during the day, so if you have one, please record it in the chat box. • When we come to the discussion parts of the day, if there are questions you want to raise, please use the ‘raise hand’ tool. • If there are ‘other’ questions/comments that may not be as relevant today, feel free to note them and someone will get back to you to discuss. • We are very tight for time, and I may need to move things on. Apologies in advance if I need to do this. <p><u>Agreements</u></p> <p>You have all seen the Terms of Reference for these workshops, and your presence is predicated on your acceptance of them.</p> <p>I do want to point out one of the points in the standards of conduct, conflict of interest. If you feel you have conflict of interest, please do let us know.</p> <p>I would also like to suggest that we have some broad agreements about the way we operate in these workshops, to ensure we achieve the outcomes that we’re all here for. I’ve listed a few over here.</p> <p>Be respectful of others One at a time (and use the raise hand option) Be on time Be clear and concise Confidentiality</p> <p><u>Tech tips</u></p>	<p>Helen – share on screen</p> <p>Keryn</p> <p>Keryn</p> <p>Keryn</p>	
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		Helen	
9.30am – 9.40am	An overview of the dolphin TMP and the SSAG, and the significance of Māui and Hector's. Brief overview of the scientific landscape of New Zealand.	Lian Butcher – Director Aquatic DOC	10 mins
9.40am – 10.00am	What's known about <i>Toxoplasma gondii</i> in New Zealand Wildlife	Jim Roberts	20 mins
10.00am – 10.20am	Transport of <i>T. gondii</i> oocysts in water: New Zealand's hydrological context and implications for management	Hannah Jones	20 min
10.20am – 10.40am	Discussion re the NZ context	Facilitator	20 mins
10.40am – 10.50am	Break		10 mins
10.50am – 11.05am	Distribution and virulence of <i>Toxoplasma gondii</i> in California sea otters.	Karen Shapiro	15 mins
11.05am – 11.20am	<i>Toxoplasma gondii</i> from cats to sea otters: Modelling and ecological perspectives from coastal California.	Liz Van Wormer	15 mins
11.20am – 11.35am	Emergence and control of protozoan parasites infecting marine mammal sentinels	Michael Grigg	15 mins
11.35am – 11.50am	Landscape-level risk factors	Stacie Robinson	15 mins
11.50am – 12.20pm	Discussion re international perspectives	Facilitator	
12.20pm – 12.50pm	Break		25 mins
12.50pm – 1.20pm	Cats in NZ - populations, management, legislation	Craig Gillies,	30 mins (20 mins presentation, 10 mins questions)
1.20pm – 1.30pm	Toxoplasmosis: Agricultural landscapes & terrestrial wildlife	Chris Niebuhr & Gary Hickling	10 min presentation
1.30pm – 1.40pm	Public awareness and socialisation - brief background and why we're not leaping into management	Michael Harbrow	10 mins
1.40 pm – 2.00pm	Summary of questions that have come out of Day 1 and wrap up. Closing karakia	Keryn Anton	20 mins

Day Two: 27 October 2020

Time	Activity	Facilitator	Resources
9.00am	<p>Welcome.</p> <p>Karakia</p> <p>Objectives for Day 2: 1. Identify and consolidate the knowledge gaps that fall out of the presentations. 2. Begin to design potential solutions/key research questions/pathways to filling knowledge gaps.</p> <p>Review of Day 1, with a focus on presenting back the questions that have been raised.</p> <p>Anything people would like to comment on from day one?</p>	<p>Keryn</p> <p>Anton</p> <p>Keryn (Helen to share on screen)</p> <p>Anton</p>	
9.30am – 11.00am	<p><u>Breakout Groups: Session 1</u></p> <p><i>Purpose of this session is to ensure that we know all the knowledge gaps and questions to work on.</i></p>	Keryn	
10 mins	<p>The first stage is to capturing areas that need further examination. We have some questions that have come out of day one (Anton to share), now we would like to check that these are the right questions to be here and add any others.</p> <p>Explain process:</p> <ul style="list-style-type: none"> Split into random groups of 5 or 6 (check numbers at the beginning of the session) 	Anton to share questions	
45 mins	<ul style="list-style-type: none"> In groups: <ol style="list-style-type: none"> Are these the ‘right’ questions to be asking? Are there any secondary questions? Is there anything missing? What do we need to know that we don’t know now? Prepare to report back to wider group. Nominate a person in your group to share. 20 minutes in breakout rooms. 	Helen to send into breakout rooms.	
10 mins	<ul style="list-style-type: none"> Report back to wider group (5 minutes each) 		

	<ul style="list-style-type: none"> • Discussion on broad set of questions • Confirm questions to work on in next session <p>INCLUDE A BREAK IN HERE AT RELEVANT TIME</p>	Anton to scribe on shared screen	
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11.00am	<p>Whole Group: Session 2</p> <p>As a whole group, cluster the questions into themes/potential research questions/projects</p> <p>Explain next session and decide who would work in which group.</p>	Anton to scribe on shared screen	
12.00	LUNCH		
12.30pm	<p>Working Groups: Session 2</p> <p><i>Purpose of this session is to be developing solutions.</i></p> <ul style="list-style-type: none"> • Back into working groups • How do we find out the answers? What should the work look like? E.g., identify approaches, methodologies, tools, collaborations, dependencies. • What answers will this give to decision makers? • Use the current action plan as a straw man – use ‘keep, start, stop’ approach to analyse? <p>Report back.</p>		
1.30pm	Wrap Up		

Day Three: 4 November 2020

Time	Activity	Facilitator	Resources
9.00am	<p>Welcome.</p> <p>Karakia</p> <p>Objectives for Day 3:</p> <p>3. Gather further information about knowledge gaps/questions.</p> <p>4. Identify top priorities, indicative costs and potential collaborations.</p>	<p>Keryn</p> <p>Anton</p> <p>Keryn (Helen to share on screen)</p>	

	<p>Review of Day 1, with a focus on presenting the questions.</p> <p>Anything people would like to comment on from day one?</p>	Anton	
9.30am – 11.00am	<p><u>Breakout Groups: Session 1</u></p> <p>Today we are going to work in 4 groups:</p> <ul style="list-style-type: none"> • Dolphins • Genotyping • Cats • Transmission <p>We will work on the management and miscellaneous questions later in the morning. At the moment, those who were in the management group will need to go into another group.</p> <p>Work out which group each person will be in.</p> <p>In your breakout groups, work through the following questions:</p> <ul style="list-style-type: none"> • What are the priority areas to work on? Why? (Rationale) • What dependencies exist? <p>(30 mins in breakout groups)</p> <p>Report back to wider group and discuss.</p>	<p>Keryn</p> <p>Helen to send into breakout rooms.</p>	
10.30am – 10.45am	<p><u>Management Questions</u></p> <p>Facilitated group session to determine which of the management questions are priorities, why, and dependencies.</p>		
12.00pm – 12.30pm	<p><u>Lunch</u></p>		
12.30pm – 1.30pm	<p>Continued facilitated group session to consolidate which priorities and consider dependencies. With consideration to relative costs and benefits.</p>		
1.30pm – 2.00pm	<p><u>Wrap up and next steps.</u></p> <p><u>Final karakia</u></p>		

Appendix 2: Terms of Reference

DOC Toxoplasmosis Workshop series:

Friday 23, Tuesday 27 October, and Wednesday 4 November 2020.

Terms of Reference

Background

Hector's and Māui dolphins are small coastal dolphins found only in New Zealand. Hector's dolphins live mainly around the South Island and Māui dolphins are only found on the west coast of the North Island (WCNI). Hector's dolphin is ranked as Nationally Vulnerable by the New Zealand Threat Classification System (NZTCS, Baker et al. 2019) and has a population of around 15,000 (MacKenzie & Clement 2014, 2016). Māui dolphin is ranked Nationally Critical under the NZTCS (Baker et al. 2019) and has an estimated population of around 63 individuals above 1 year of age.

The New Zealand Government's response to the threats facing these dolphins is determined through the Hector's and Māui dolphin Threat Management Plan (TMP) www.doc.govt.nz/tmp-review. A review of this TMP was conducted between 2017 and 2020. During this review it became clear that, although there remain divergent views on impact and best mitigation options, one serious threat is the disease toxoplasmosis which is a confirmed cause of death in these dolphins, and that there is a need to address this threat. Particularly for Māui dolphin because of their small population size, and the impact this disease can have on reproductive success. Toxoplasmosis is spread through the faeces of felids (cat species). Aotearoa/New Zealand has no wild cat species present but has the introduced domestic cat.

The consultation document for the threat management plan included a proposal for the development of a toxoplasmosis action plan that would include targeted research to inform action, improve knowledge on toxoplasmosis (including the effects on dolphins and other wildlife) and, ultimately, reduce the number of dolphin deaths attributable to toxoplasmosis to near zero. Many submissions received during the consultation process agreed that toxoplasmosis is a significant threat to the dolphins and supported the development of an action plan to address this threat.

As part of addressing this challenging issue, national experts, including from stakeholder organisations (DOC, Ministry for Primary Industries (MPI), university researchers, regional councils) have been engaged in a Toxoplasmosis Strategic Science Advisory Group (SSAG), which held its first meeting on 20 November 2019. The SSAG process has been used in response to other complex government science issues, including kauri dieback disease and *Mycoplasma bovis* in dairy cattle. The purpose of the SSAG is to provide advice and recommendations to the Hector's and Māui dolphin Threat Management Plan Governance Group on the requirements for strategic science prioritisation and aid in the coordination of research programmes focused on understanding and managing the effects of toxoplasmosis on these dolphins in New Zealand. The SSAG will provide high-level recommendations to the Hector's and Māui dolphin Threat Management Plan Governance Group on the requirements

for strategic science prioritisation and aid in the coordination of research programmes focused on understanding and managing effects of toxoplasmosis on these dolphins in New Zealand.

The SSAG and associated specialised science groups will work across Government agencies, Crown research institutes, and other research institutes, to maintain oversight and ensure any toxoplasmosis-related research is cohesive and complementary, and that funding of priority research provides the knowledge of management actions required to effectively reduce the risk of toxoplasmosis to the dolphins. The SSAG is to ensure the best information available domestically and internationally is being considered in developing and implementing the science programme.

Note that toxoplasmosis also impacts other species (including livestock and humans), and so although this plan is focused on addressing the threat to the dolphins, it is expected that there are likely to be wider benefits associated with the research and actions proposed. Proposals for management measures for threats to the dolphins other than toxoplasmosis (such as interaction with fisheries, seismic surveying, seabed mining and tourism) were also included in the public consultation document, and final decisions are described in the updated threat management plan.

The action plan drew heavily on a literature review carried out for the Department of Conservation (DOC) (J.O. Roberts, W.D. Roe and H.F.E. Jones 2020: The effects of *Toxoplasma gondii* on New Zealand wildlife: implications for conservation and management – submitted to the Journal of Pacific Conservation Biology – Manuscript ID PC2005) and references therein [The action plan and an executive summary of that review is available here www.doc.govt.nz/toxoplasmosis-action-plan].

The toxoplasmosis action plan is the result of feedback by the SSAG. It was recognised that it would be beneficial to the SSAG process to include further stakeholders (such as Ministry of Business, Innovation and Employment (MBIE), public health agencies and officials and Crown Research Institutes (CRIs)) and overseas experts experienced in dealing with toxoplasmosis in other marine mammal species, to refine research direction and identify knowledge gaps to support their development of a science plan.

Purpose

As Part of the toxoplasmosis action plan DOC has undertaken to run this series of workshops with key researchers and with the participation of international experts. The purpose is to refine research objectives and identify knowledge and research gaps and prioritise these in support of the development of a strategic science plan to address the impact of toxoplasmosis on the dolphins.

In time a second series of workshops will be held to develop the social science and management pathways.

Outputs from both sets of workshops will provide guidance to decision makers in DOC and to the Toxoplasmosis Strategic Science Advisory Group.

Scope of first workshop series

These first series of workshops seeking to support the development of a science plan will be run over 3 online sessions from 9am to 2pm on Friday 23, Tuesday 27 October, and Wednesday 4 November 2020.

These workshops are not a forum to advocate for particular management approaches.

Documents and record keeping

The workshops will be run formally with an agenda and with a dedicated facilitator.

Any documents circulated to participants are done so in confidence and are not to be distributed outside the list of participants without the express agreement of DOC (and the author/s?) in writing.

The workshops will be recorded for the express purpose of facilitating work of the SSAG to deliver on the development of the science.

Participants

Expectation of participants: Workshop participants are expected to comply with the standards of conduct set out in Appendix I.

Facilitator

The Facilitator of these workshops is Keryn Weir.

Conflicts of interest

Participants will be asked to declare any “actual, perceived or likely conflicts of interest” before involvement in the workshop is approved, and any new conflicts that arise during the process should be declared immediately. These will be clearly documented in the notes of the workshop.

Management of conflicts of interest, including perceived conflicts of interest can be raised through the facilitator to be considered by the workshop facilitation group.

Confidentiality and information

General confidentiality requirements

- Discussions within these workshops should be treated In-Confidence.
- Any person presenting information to these workshops, whether written or oral, may request that that information be treated as confidential by workshop participants.
- If there is a desire to release the information, DOC will seek agreement from anyone who supplied confidential information for confidentiality to be waived.
- Where information is already in the public domain (through no fault of a workshop participant), the confidentiality requirements do not apply to that information.

Privacy Act

- Participants must at all times comply with the requirements of the Privacy Act 1993 and keep information about identifiable individuals confidential.

Official Information Act and Local Government Official Information and Meetings Act 1987

- All information provided to these workshops will be treated as official information under the Official Information Act 1982 and, subject to the requirements of that Act, may be released to the public if there are no grounds for withholding it. Local Government have similar requirements under the Local Government Official Information and Meetings Act 1987.
- If information is required to be released under the Official Information Act 1982 it will only be released to the extent necessary.
- If DOC is considering releasing information under the Official Information Act 1982, DOC will attempt to consult with the person who provided the information before making a final decision on release.

Terms of Reference Appendix I

Expected standards of conduct

All workshop participants are expected to adhere to the following principles:

1. **Diligence** – Members will use their best endeavours to attend meetings and to prepare thoroughly. Members are expected to participate fully, frankly and constructively to discussions and to bring the benefit of their particular knowledge and skills, and their sector, industry or organisation perspective to the table.
2. **Conflicts of Interest** – A conflict of interest will occur when a members' private interest interferes, or appears to interfere, with an issue that faces the workshop. A conflict of interest may also occur when there is a possibility that a benefit may apply to the sector, industry or organisation that they represent. Any situation that involves or may be expected to involve a conflict of interest must be declared immediately to the facilitator.
3. **Corporate opportunities** – Each member must not exploit any opportunity that is discovered through access to information within the SSAG for their own personal gain or that of the industry, sector or organisation that they represent.
4. **Transparency** – All information should be provided in a manner that is timely, precise and easily understandable.
5. **Fair Dealing** – Members shall deal fairly with each other and shall not take unfair advantage of anyone through manipulation, concealment, abuse of privileged

information, misrepresentation of material facts, or any other unfair dealing practices.

6. **Advocacy** – Members should avoid actively promoting a standpoint or cause of their industry and should rather participate in meetings with the aim of reaching an outcome that is acceptable to all members.
7. **State Services Standards of Integrity and Conduct** – Government staff have statutory demands under the State Services Standards of Integrity and Conduct. In the case of any conflict between the obligations outlined there and the ones in this document, those of the Standards and Integrity of Conduct shall preside.
8. **Alternative obligations** – Any alternative rules or statutes that govern members standards of conduct shall continue to do so, however in any case of conflicting duties the Chairperson must be notified as soon as reasonably possible.