

Estimated population size and decline of Maui's dolphins

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ABSTRACT

Maui's dolphins (*Cephalorhynchus hectori maui*) are the smallest and rarest marine dolphins on earth and inhabit coastal waters up to a water depth of 100 metres. Numbers decreased dramatically since the 1970s as a result of fishing. The dolphins occur in a small, declining remnant population on the west coast of New Zealand's North Island. Fisheries bycatch has reduced the population from 59 (55 individuals 1 year and older) in 2010/11 to an estimated 42 - 47 individuals or 10-12 mature females in 2014/15. Maui's dolphins can sustain just one human-induced fatality every 10-23 years. However, annual bycatch alone depletes the population by 3.28-4.16 individuals - over 54 times the sustainable level or PBR (Potential Biological Removal). Protection for trawling remains at less than 5% of Maui's dolphin habitat. Two small extensions to areal protection from gillnetting, introduced in 2012/2013, increased the protected area by 3 % from 16% to 19% for this fishery. The estimated rate of annual population decline decreased from 9.4% to 7.1% or 5.6%. Extinction as a result of fisheries bycatch could occur as early as 2029 under these conditions. In 2014 the IWC Scientific Committee reiterated its recommendation to offer Maui's dolphins full protection from gillnetting and trawling across their habitat. No additional protection has been provided in response to this recommendation. In the absence of anthropogenic factors, the population could have grown to 63 individuals or 17 mature females since 2010/11 and recovery to 250 mature individuals could be achieved in 87 years. In 2012, an expert panel of New Zealand and international scientists, convened by the New Zealand government, attributed 95.5% of all Maui's dolphin mortalities to gillnetting and trawling. Since then there has been an upsurge of seismic testing in and near the dolphins' habitat, as well as a rise oil and gas production related activities, which further threaten the survival of this subspecies.

INTRODUCTION

Maui's dolphins (*Cephalorhynchus hectori maui*) are the North Island subspecies of New Zealand's Hector's dolphin (*Cephalorhynchus hectori hectori*). Collectively, both subspecies are referred to as Hector's or New Zealand dolphins (*Cephalorhynchus hectori*). Both subspecies inhabit coastal waters up to a depth of 100 m (red line Figure 2) (Dawson et al. 2004; Slooten et al. 2004; Rayment et al. 2010, 2011; MacKenzie & Clement 2014). Since the 1970s fishing related mortality has caused significant population decline (DOC & MFish 2007; MPI & DOC 2012; Currey et al. 2012) and range contraction (Russell 1999) in both subspecies. Today, Maui's dolphins occur in a small and declining remnant population on the west coast of New Zealand's North Island (Currey et al. 2012, Slooten 2014). Hamner and colleagues (2012) used genotype capture-recapture (GCR) analysis to obtain the most recent abundance estimate of 55 Maui's dolphins (95% CI: 48–69) aged one year and older in 2010/11.

In 2012, the New Zealand government convened a panel of local and international scientists to estimate human-induced mortalities for Maui's dolphin for the subsequent five year period (Currey et al. 2012). The panel attributed 95.5% of all human-induced Maui's dolphin deaths (5.27 individuals per annum) to trawling and commercial and recreational gillnetting. Population projections based on the panel's estimated total mortalities indicated a 95.7% likelihood of population decline if threats levels remained unchanged.

By 2012, Maui's dolphins had become so rare that the population could sustain only a single human-induced death every 10-23 years (0.044 – 0.1/year, Currey et al. 2012). Fisheries bycatch alone however continues to deplete the population by 3.28-4.16 individuals annually; more than 54 times the sustainable level or PBR (Slooten 2014).

For the past three years, the IWC Scientific Committee (IWC SC) has issued increasingly urgent recommendations about the need for the immediate implementation of effective conservation measures for

Maui's dolphins. At its May 2014 meeting, the IWC SC emphasized that the additional fisheries restrictions introduced by New Zealand in 2012 and 2013 "*fall significantly short of those previously recommended (IWC, 2013a; 2014c)*". The Committee reiterated "*its extreme concern about the continued decline of such a small population as the human-induced death of even one dolphin would increase the extinction risk for this subspecies. It also reiterates that rather than seeking further scientific evidence it is of highest priority to take immediate management actions that will eliminate bycatch of Maui's dolphins. This includes full closures of any fisheries within the range of Maui's dolphins that are known to pose a risk of bycatch of small cetaceans (i.e. set net and trawl fisheries).*" IWC 2015. The Committee added that "*Ensuring full protection of Maui's dolphins in all areas throughout their habitat, together with an ample buffer zone, would minimise the risk of bycatch and maximise the chances of population increase.*" The Committee noted "*that the current range of Maui's dolphins comprises the area from Maunganui Bluff in the north to Whanganui in the south, offshore to 20 nautical miles and including harbours. This range reflects all available sightings and strandings data for Maui's and Hector's dolphins along the West Coast of the North Island. The Committee notes that data from Hector's dolphins off the South Island, with most sightings in waters less than 100 m deep and less than 20 nm offshore support our understanding of the offshore distribution of Maui's dolphins and the recommendation that within this defined area, fishing methods other than set nets and trawling should be used.*"

This paper presents quantitative estimates of Maui's dolphin abundance based on population data provided by Hamner et al (2012), as well as bycatch mortality estimates by Currey et al. (2012) and Slooten (2014). It provides projected timelines for short and long-term population recovery or decline to the projected functional extinction (< 3 breeding females) of Maui's dolphins under current protection levels, and in the absence of human-induced mortality. It also briefly describes the recent rise of fossil fuel exploration and production developments in or near Maui's dolphin habitat, as these were not in place when the panel of experts carried out its quantitative risk assessment in 2012 (Currey et al. 2012).

MATERIALS AND METHODS

Hamner et al.'s (2012) 2010/11 population estimate of 55 individuals (CL 48, 69) aged one year and older was used as a starting point to model population size over time. Webster (2008) identified the proportion of calves (0-1 year old) in Hector's dolphins to be 8 %, which was used to obtain a total abundance estimate for 2010/11.

Changes in Maui's dolphin abundance were assessed for four scenarios: 1. Max population growth (1.8%, Slooten & Lad 1991), 2. Zero human-induced mortality, and to simulate potential Allee effect or the ramifications of adverse environmental conditions 3. 50% maximum population growth (9%), and 4. Zero population growth.

Annual fisheries mortality prior to the 2012/13 extensions was based on 5.27 individuals per year (Currey et al. 2012) or (9.4% *per annum*). For the subsequent years, Maui's dolphin fisheries mortality was calculated by conservatively applying Slooten's (2014) 3.28 and 4.16 dolphin deaths *per annum* as a percentage of the remaining abundance estimate (5.6% and 7.1% of the population in any given year). Numbers in brackets show the range of results based on the upper and lower confidence limits from Hamner (2012).

RESULTS

Adding the proportion of calves (0-1 year old) of 8 % (Webster 2008) to Hamner et al.'s (2012) estimate of 55 individuals aged one year and older provides an overall abundance estimate of 59 Maui's dolphins in 2010/11 and a corresponding number of 15 breeding females. Estimated Maui's dolphin abundance and the number of mature females in the population for 2014/15 and 2019/20 under annual rates of fishing related mortality of 5.6 and 7.1 % (see Slooten 2014) are presented in Table 1. These two levels of fishing mortality represent uncertainty about the distribution of Maui's dolphin bycatch through their habitat, in particular the level of

continuing bycatch in the northern part of their range (for more information, see Slooten 2014).

Table 1 Maui's dolphin population size and the corresponding number of breeding females in 2014/15 and 2019/20 for four management scenarios: Four scenarios are shown: 1. Maximum population growth (1.8%), 2. Fifty percent maximum population growth (0.9%), 3. Zero population growth, 4. Zero human-induced mortality. The numbers in brackets show the range of results based on the upper and lower confidence limits from Hamner (2012).

Estimated Maui's dolphin abundance for 2014/15 and 2019/20				
	2014/15		2019/20	
	Population size	Mature Females	Population size	Mature Females
Annual fisheries related mortality rate: 5.6%				
Maximum population growth (1.8%)	47 (41-59)	12 (10-15)	38 (34-49)	10 (8-12)
50% max population growth (0.9%)	45 (39-57)	11 (10-14)	35 (31-45)	9 (8-11)
Zero population growth	43 (38-55)	11 (9-14)	32 (28-41)	8 (7-10)
Annual fisheries related mortality rate: 7.1%				
Maximum population growth (1.8%)	46 (41-58)	12 (10-15)	35 (31-45)	9 (8-11)
50% max population growth (0.9%)	43 (38-55)	11 (10-14)	32 (28-40)	8 (7-10)
Zero population growth	42 (37-53)	10 (9-13)	29 (25-37)	7 (6-9)
Zero anthropogenic mortality				
Maximum population growth (1.8%)	63 (56-80)	16 (14-20)	69 (61-87)	17 (15-22)

In 2014, the IWC recommended a substantial extension to the protected area for Maui's dolphins, from the current 19% to 86% of Maui's dolphin habitat. In addition, the IWC re-emphasized that there is ample scientific evidence to support this management action and further research is not a priority because there already is a comprehensive body of scientific evidence to support this management recommendation. No additional protection has been implemented since then. Instead, the New Zealand government has started to develop five year Maui's dolphin research plan (Currey & Lundquist 2015)., I therefore provide abundance estimates for 2019/20 to coincide with the time when this research programme would be completed.

Depending on the level of annual removal through bycatch (5.6% or 7.1%) and different population development scenarios (zero growth, 50% max. growth, max. growth), current Maui's dolphin population size is estimated at 42 - 47 (10 - 12 breeding females). Even under the most optimistic conditions of maximum population growth, the estimated total population size and the corresponding number of breeding females has decreased significantly since 2010/11: from 59 to 47 (annual removal of 5.6%) and 46 (annual removal of 7.1%), and from 15 mature females to 12.

Under current fisheries protection and depending on the level of annual removal through bycatch (5.6% or 7.1%), Maui's dolphin abundance is likely to decline to an estimated 32-35 individuals and just 7-10 breeding females by 2019/20. If human-induced mortality had been reduced to zero in 2010/11, Maui's dolphin numbers could have grown to an estimated 63 individuals (16 mature females) today and rise to 69, including 17 mature females, by 2019/20.

Timelines for Maui’s dolphin population decline based on annual bycatch mortality rates of 5.6% and 7.1% are presented in Table 2. Provided current level of fisheries protection remain the same, Maui’s dolphins could become functionally extinct (3 mature females or less) as early as 2029/30. Even under the most optimistic scenario, Maui’s dolphins are predicted to decline to this threshold in 32 years (by 2047/48).

Table 2 Timelines for estimated Maui’s dolphin population decline to functional extinction (3 mature females or less) from 2014/15 and for three scenarios: 1. Maximum population growth at 1.8 %, 1. Half maximum population growth at 0.9 %, 3. Zero population growth, The numbers in brackets show the number of years to functional extinction, based on the upper and lower confidence limits from Hamner (2012).

	Rate of estimated annual population decline to 3 mature females					
	Pre 2012, 2013 protection extensions for gillnetting		Post 2012, 2013 protection extensions for gillnetting			
Population growth scenarios	9.4%		5.6%		7.1%	
Maximum population growth (1.8%)	2029/30	15 (13-18)	2047/48	32 (28-38)	2036/37	22 (20-27)
50% max population growth (0.9%)	2027/28	13 (11-15)	2039/40	25 (22-30)	2032/33	18 (16-22)
Zero population growth	2025/26	11 (10-13)	2034/35	20 (18-24)	2029/30	15 (14-19)

Under maximum population growth and with human impact at zero, Maui’s dolphin population recovery to 250 mature individuals is estimated to take 87 years (74-94).

DISCUSSION

Hector's and Maui’s dolphins are amongst the best-studied marine mammal taxa, with an extensive body of peer-reviewed scientific literature describing their distribution, abundance, population structure and demography. Over a period of more than three decades, scientists have provided an exceptionally strong scientific basis for managing fisheries to prevent their ongoing decline. The IWC Scientific Committee (IWC 2013, 2014, 2015) and the IUCN (2012) have concluded that prohibiting gillnet and trawl fisheries across Maui’s dolphin habitat is necessary to avoid their extinction and affect recovery. The IWC SC has urged New Zealand over three consecutive years to implement immediate fisheries protection measures to address Maui’s dolphin decline by banning gillnet and trawl fisheries across their habitat. The IUCN (2012) and the Society for Marine Mammalogy (2013 a-c) have issued similar recommendations. In 2014, the IWC SC noted that “*the current management situation falls short of that required to reverse the Maui’s dolphin decline*”, and stated “*that ensuring full protection of Maui’s dolphins in all areas throughout their habitat, together with an ample buffer zone, would minimise the risk of bycatch and maximise the chances of population increase*”.

When Maui’s dolphins were discussed at the 65th Meeting of the IWC in Slovenia in 2014, the New Zealand stated that it had imposed restrictions on set net and trawl net fishing, was using fisheries observers and would continue to advocate for Maui’s and Hector’s dolphins. While New Zealand did not dispute the Scientific Committee’s findings, management also had to consider other factors. The history of Maui’s dolphin population decline tragically illustrates the consequences of divorcing population management from science. Maui’s dolphin numbers continue to decline because a unanimous and strong, science-based conservation message is

not translated into management actions.

The IWC Scientific Committee (IWC 2013) recognised that the loss of even one Maui's dolphin can have devastating consequences on the population. The results presented in this paper highlight the extreme urgency of the IWC SC's repeated call for habitat-wide fisheries protection. Maui's dolphins are subject to an annual fisheries related mortality of 5.6% and 7.1%, slightly down from 9.4% in 2012/13. Unless management measures that reduce fisheries mortality to zero are implemented as a matter of urgency, the current population of an estimated 42-47 individuals (10-12 breeding females) is expected to decline to 29-38 individuals and 7-10 breeding females by 2019/20, while the New Zealand Department of Conservation and Ministry for Primary Industries carry out a five year Maui's dolphin research programme (Currey and Lundquist 2015). If current protection levels persist, Maui's dolphins could face extinction in just 15 years.

Restoring this subspecies to healthy numbers levels will be protracted and requires genuine commitment. Even under the optimistic assumption of maximum population growth (1.8%) recovery to 250 mature individuals - the population size required for reclassification from Critically Endangered to Endangered under the IUCN Red List of Threatened Species (IUCN 2001) would take almost 90 years. Furthermore, the small population of Hector's dolphins on the north coast of New Zealand's South Island, which has the potential act as a source population in the recovery of Maui's dolphins, is currently entirely unprotected, thus further weakens the dolphins' long-term survival prospects.

To successfully protect this sub-species bycatch risk must be reduced to zero. This can only be achieved by extending existing fishing closures for gillnets and trawling to cover the entire habitat of the Maui's dolphins offshore to the 100 meter depth contour, including harbours. Only a very small fraction of the income from New Zealand fisheries originates from inshore fishery (WDC 2014). Affected fishermen could be transitioned to alternative livelihoods or sustainable, selective fishing methods that do not impact on Maui's or Hector's dolphins or other protected species.

The example of the Baiji has shown that small dolphin populations can disappear very quickly. Although 40 Baiji survived in 1998, not a single individual could be found in 2006, despite an extensive survey. Unless New Zealand implements science-based conservation measures for Maui's dolphins immediately, the world's smallest and rarest marine dolphin will follow the Baiji into extinction.

Threats other than fisheries

In 2012, a government appointed Panel of Experts was asked to estimate the level of Maui's dolphin mortality due to human activities for the period between 2012 and 2017. The panel agreed that 95.5% of Maui's dolphin mortality is caused by fishing, while the remaining 4.5% were ascribed to other causes, such as mining, oil exploration, disease, pollution and boat strikes etc. (Currey et al. 2012). Since the panel carried out its assessment, a widespread expansion of fossil fuel exploration and extraction in or adjacent to Maui's dolphin habitat has taken place (Figure 1). These activities directly and indirectly threaten Maui's dolphins through increased noise, including seismic testing, pollution, ship strikes and the loss and degradation of habitat and food supplies, stress and displacement. A growing number of oil wells, together with increased levels of offshore storage and offloading of oil to shuttle tankers, further intensifies these risks and suggests that this cluster of threats may have become much more significant than when the panel made its initial assessment.

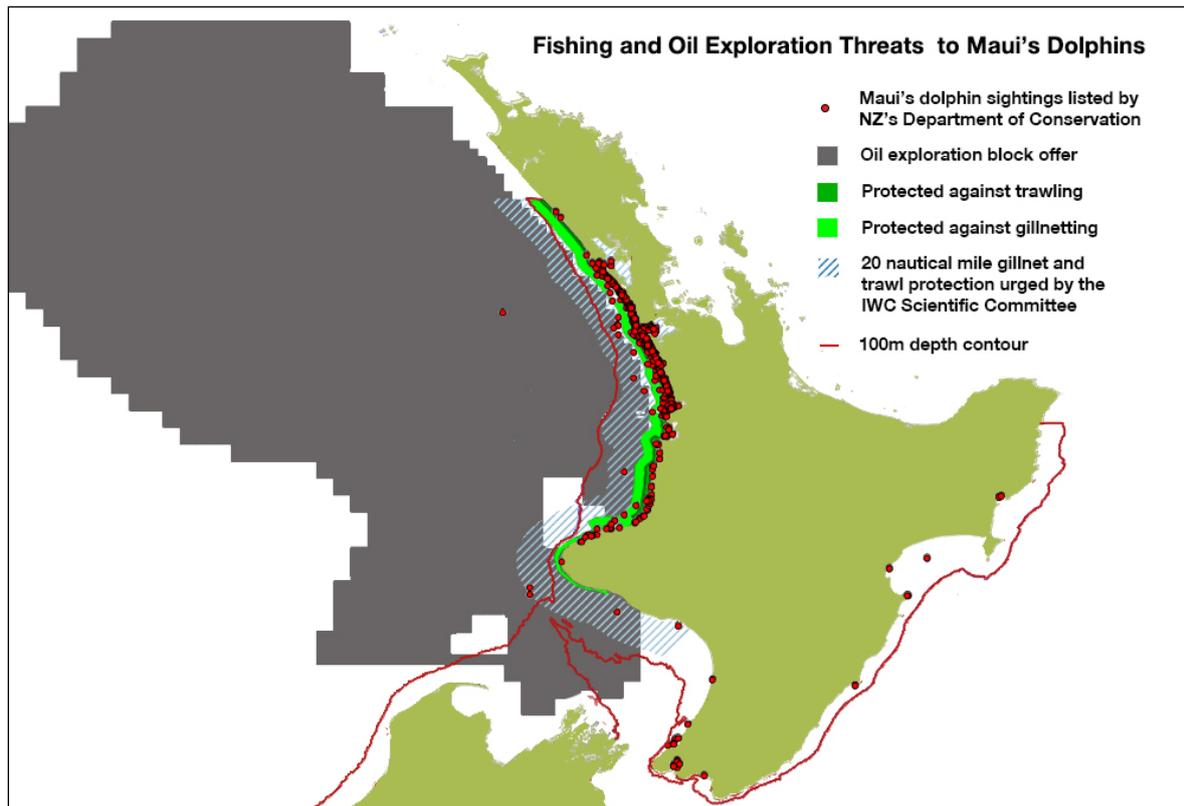


Figure 1 Fossil fuel exploration blocks (grey), fisheries protection zones (light and dark green) Maui's dolphin sightings in the context of Maui's dolphin habitat as described by the 100 m depth contour (red line). The pale blue hatched area shows the 20 nm offshore limit for trawl and gillnet fishing restrictions that were recommended by the IWC SC in 2014.

It is not only the “oil itself that may impact on the dolphins, but many aspects of an oil spill response will have direct or indirect effects on the population, eg, the use of dispersants to clean up the oil, increased vessel activity in the area, the use of sonar for tracking lost cargo etc.” (Currey et al. 2012). The fact that New Zealand's ability to deal with offshore oil spills is weak due to a lack of specialist equipment and resources exacerbates the risks associated with offshore oil spills. The potential consequences of oil spills as a result of activities in by Austrian firm OMV in the Maari oil field development off the west coast on New Zealand's North Island is shown in Figure 2. The sample trajectory of the spill forms part of the company's risk assessment report and indicates how spills could penetrate deeply into Maui's dolphin habitat within 72 hours. The programme also threatens recently discovered foraging grounds of Blue whales.

Besides the actual production of oil, the search for fossil fuels through seismic airgun surveys is associated with a host of potential harmful effects. Noise from a single seismic airgun survey can blanket an area of over 300,000 km², raising background noise levels 100-fold (20 dB), continuously for weeks or months (IWC 2005, IWC 2007). Seismic airgun surveys are loud enough to penetrate hundreds of kilometres into the ocean floor, even after passing through thousands of meters of ocean. Noise, especially of the intensity of seismic airgun surveys, represents an ecosystem-wide impact, affecting marine life from scallops, squid, crab, through fish to whales and dolphins. According to Weilgart (2013), at least 37 marine species have been shown to be affected by seismic surveys. Research documents animals moving over 70 km away from important habitat, stress responses, interference with reproduction and feeding, obliteration of essential signals, reduction in species diversity, and preventing endangered species from recovering. Fisheries catch rates too have been reduced up to 80%, and fish abundances have dramatically plummeted even 30 km away from seismic surveys (see Weilgart 2013 for a review). The International Whaling Commission's Scientific Committee noted “...repeated and persistent acoustic insults [over] a large area...should be considered enough to cause population level impacts.” (IWC 2005; Weilgart 2013). The effects of seismic airgun surveys on Maui's dolphins are discussed

in Annex I .

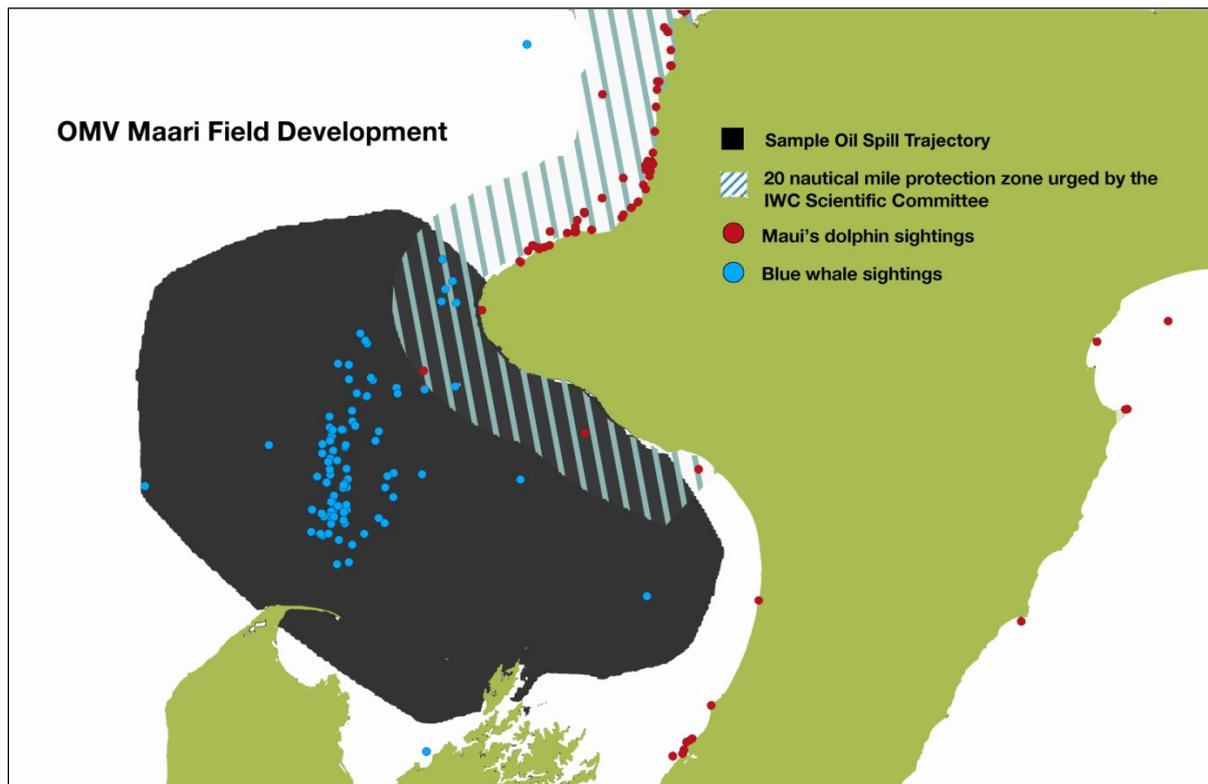


Figure 2 New Zealand's Environmental Protection Agency (EPA) has granted an application by Austrian firm OMV to drill up to seven new oil wells adjacent to the home of Maui's dolphins. Endangered blue whales also live in this area and use it as a feeding ground. The sample oil spill depicted forms part of OMV's risk assessment report.

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APPENDIX I

Seismic Airgun Surveys and their possible impact on Maui's dolphins

For offshore exploration, the oil and gas industry typically relies on arrays of airguns, which are towed behind ships and release intense impulses of compressed air into the water about once every 10-12 seconds. A large seismic airgun array can produce effective peak pressures of sound higher than those of virtually any other man-made source save explosives (NRC 2003), and although airguns are vertically oriented within the water column, horizontal propagation is so significant as to make them, even under present use, one of the leading contributors to low-frequency ambient noise thousands of miles from any given survey (Nieukirk et al. 2004) The high-intensity pulses produced by airguns can cause a range of impacts on marine mammals, fish, and other marine life, including broad habitat displacement, disruption of vital behaviors essential to foraging and breeding, loss of biological diversity, and, in some circumstances, injuries and mortalities (Hildebrand 2007).

Consistent with their large acoustic footprint, most of these impacts are felt on an extraordinarily wide geographic scale – especially on endangered baleen whales, whose vocalizations and acoustic sensitivities overlap with the enormous low-frequency energy that airguns put in the water. For example, a single seismic survey has been shown to cause endangered fin and humpback whales to stop vocalizing – a behavior essential to breeding and foraging – over an area at least 100,000 square nautical miles in size, and can cause baleen whales to abandon habitat over the same scale (Clark & Gagnon 2006, 2010; MacLeod et al. 2006)

Similarly, airgun noise can also mask the calls of vocalizing baleen whales over vast distances, substantially compromising their ability to communicate, feed, find mates, and engage in other vital behavior (Clark et al. 2009a). The intermittency of airgun pulses hardly mitigates this effect since their acoustic energy spreads over time and can sound virtually continuous at distances from the array (Weilgart 2010). Masking of natural sounds begins when received levels rise above ambient noise at relevant frequencies (Clark et al. 2009 a, b, see also Castellote 2010).

Airguns are known to affect a broad range of other marine mammal species. For example, sperm whale foraging appears to decline significantly on exposure to even moderate levels of airgun noise, with potentially serious long-term consequences (Miller et al. 2009) and harbor porpoises have been seen to engage in strong avoidance responses fifty miles from an array (Bain & Williams 2006). Seismic surveys have been implicated in the long-term loss of marine mammal biodiversity off the coast of Brazil (Parente et al. 2007).

Airgun surveys also have important consequences for the health of fisheries. For example, airguns have been shown to dramatically depress catch rates of various commercial species (by 40-80%) over thousands of square kilometers around a single array (Engås 1996; Skalski et al. 1992). Several studies indicate that airgun noise can kill or decrease the viability of fish eggs and larvae (Booman et al. 1996; Dalen & Knutsen 1973, Kostyuchenko 1973)

The mitigation measures used in New Zealand rely heavily on ship-based visual monitoring. However, it is well established that real-time visual shipboard monitoring is difficult for all marine mammal and sea turtle species, especially at night and during high sea states and fog, and particularly difficult for small cetaceans. For example, it has been estimated that in anything stronger than a light breeze, only one in fifty beaked whales surfacing in the direct track line of a ship would be sighted; as the distance approaches 1 kilometer, that number drops to zero (Barlow & Gisiner 2006).

The U.S. Navy estimated that, overall, the visual monitoring system it developed for real-time monitoring around a slow-moving, low-frequency source vessel would have only a 9 percent probability of citing marine mammal species (U.S. Department of the Navy 2001)

Maintaining a narrow safety zone used in New Zealand around a vessel would do virtually nothing to prevent

the vast majority of impacts occurring more than a short distance away (Parsons et al. 2009)

Conversely, time and place restrictions designed to protect high-value habitat are a critical means to reduce the potential impacts of noise and disturbance, including noise from oil and gas exploration. Indeed, there is scientific consensus that such restrictions are the most effective available means of reducing impacts, having been endorsed by, among others, the U.S. National Oceanic and Atmospheric Administration, the Helsinki Convention (OSPAR) and other intergovernmental bodies, and several expert workshops and papers (see, e.g., Lubchenco 2010; Agardy et al. 2007; Dolman et al. 2009; OSPAR 2012; CBD 2012). It is consistent with this consensus that Maui's dolphin habitat should be closed to seismic exploration, with an effective buffer zone to reduce impacts from exploration occurring in surrounding waters.

New technology represents a promising means of reducing the environmental footprint of seismic exploration. Industry experts and biologists participating in a September 2009 workshop on airgun alternatives reached the following conclusions: that airguns produce a great deal of "waste" noise and generate peak levels substantially higher than needed for offshore exploration; that a number of quieter technologies are either available now for commercial use or can be made available within the next few years (Weilgart 2009, Spence et al. 2007). Certainly seismic exploration should not even be considered for Maui's dolphin habitat until such new technologies, which have the potential to reduce environmental conflict, are available.