

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

Direct economic losses of oil spills in populated and remote locations within New Zealand

A thesis presented in partial fulfilment of the requirements for the
degree of

Doctor of Philosophy
In
Veterinary Science

At Massey University, Palmerston North, Manawatu
New Zealand.

Alexandra L. Egan

2023

Supervisors:

B. Louise Chilvers (School of Veterinary Science, Massey University, Manawatu, NZ)

Sue Cassells (School of Economics & Finance, Massey University, Manawatu, NZ)

Abstract

New Zealand is an island nation with an extensive coastline, leading to very high use of its coastal marine environment for recreational activities, tourism, and fishing. Because of this, pollution events such as oil spills, can negatively impact coastal activities, and therefore both the economic gains and the welfare of those who utilise it. Pollution events associated with the marine environment are likely to impact direct use values of recreation, tourism, and fisheries. This research aimed to estimate the direct costs associated with oil spills in populated and remote marine locations within New Zealand.

To represent a populated area, the Coastal Bay of Plenty (from Mount Maunganui to Maketu), New Zealand, was selected. This area was the site of the *MV Rena* oil spill in 2011, which is still considered New Zealand's largest oil spill. For this area an estimation of direct use losses was obtained by looking at the pre- and post- spill values for fisheries and tourism in the short term, as well as including the clean-up and restoration costs. Additionally, surveys were conducted along this stretch of beach, which was the most impacted by the *MV Rena* oil spill, to estimate the loss in recreational value using combined revealed and stated preference techniques of the travel cost and contingent behaviour methods.

Fiordland National Park, specifically Milford Sound, SW South Island New Zealand, was chosen as the second site to represent a remote location within New Zealand. Similarly, the combined techniques of travel cost and contingent behaviour surveys were carried out here to estimate the recreational value of the area, and the potential loss in the event of an oil spill occurring in Milford Sound. This survey differed from the Coastal Bay of Plenty survey to account for the unique nature of this site. Additionally, I estimated the probable impacts of an oil spill to the tourism and fishing industries, as well as the possible clean-up costs based on various likely lengths of an oil spill response.

The findings from this research contribute to the limited direct economic studies done on oil spills globally, but particularly in New Zealand and the South Pacific. The direct costs associated with the *MV Rena* can be estimated conservatively at NZD (2021) 99.06-115.38 million (low end not including accommodation), and potential direct costs in a remote area such as Milford Sound can be estimated at a minimum of NZD (2021) 140.235-770.177 million using pre-COVID visitor numbers (low end not including accommodation). It is important to understand the various costs that may be associated with past and future oil spills within New Zealand due to its relatively small economy, and the value that the coastal environment has to its people. Estimating these losses can help inform New Zealand coastal

and marine policies, ensuring that as a country New Zealand is suitably and adequately prepared in the event of an oil spill occurring again, therefore minimising not only the economic consequences, but the environmental damages as well.

Acknowledgements

I would like to first thank my supervisors, B. Louise Chilvers and Sue Cassells, for without their never-ending support and encouragement, this journey would not have been possible. You have both pushed me to grow as a researcher, as well as a person, and I will forever be thankful for my time spent in this program. To John Rolfe, who endured countless emails from me over the years of my random thoughts and questions, and always responded with respect and kindness.

Thank you to Geoffrey Kerr and Peter Clough, who provided me feedback on my surveys to make sure that all necessary information was collected, and that they were fitting for a New Zealand context. To all those who helped me with surveying, as it ended up being a much larger and challenging aspect than anticipated: Louise, Wyatt, Jesse, Department of Conservation (Te Anau), Real Journeys Te Anau, and Mount Maunganui Beachside Holiday Park. To Massey University, for awarding me the Massey Doctoral Scholarship in order to help support myself throughout this journey. To the School of Veterinary Science, for awarding me Postgrad funding in order to undertake the field work necessary for this research.

To the various organisations that provided me with the necessary information needed to conduct this research: Maritime New Zealand, namely Mike Hudson and Greg Meikle, Fisheries New Zealand (MPI), Ministry for Business, Innovation and Employment (MBIE), Haylee Preston from Milford Sound Tourism, and Malcolm Lawson from CRA8 Rock Lobster Industry Assn Inc.

And lastly, to my family, whom without their love and support, I never would have been able to complete this research during a pandemic on the other side of the world from them. The past nearly four years have been incredibly challenging, and I truly could not have done it without you.

This research was deemed low risk and received human ethics approval for the Massey University Human Ethics Committee (4000023029 / 2020).

Table of Contents

FIGURES.....	VIII
TABLES.....	IX
EQUATIONS.....	XI
ABBREVIATIONS.....	XII
CHAPTER 1: INTRODUCTION.....	1
CHAPTER 2: LITERATURE REVIEW.....	6
2.1 OIL AND THE MARINE ENVIRONMENT	7
2.2 HISTORY OF MAJOR MARINE OIL SPILLS	8
2.3 LEGISLATION AND POLICIES REGARDING OIL SPILLS	11
2.4 OIL SPILL RESPONSE	13
2.5 OIL AND ITS' ECOLOGICAL CONSEQUENCES	16
2.6 ECOSYSTEM SERVICES AND VALUING THE ENVIRONMENT	19
2.6.1 <i>Direct and Indirect Use Values</i>	22
2.6.2 <i>Non-use Values</i>	23
2.6.3 <i>The Travel Cost Method for Valuing Outdoor Recreation</i>	24
2.6.4 <i>Considerations While Using the Travel Cost Method</i>	27
2.6.4.1 Truncation, Endogenous Stratification, and Overdispersion.....	27
2.6.4.2 Multi-purpose or Multi-destination Trips.....	28
2.6.4.3 Opportunity Cost of Time.....	29
2.6.4.4 Treatment of Substitute Sites.....	30
2.6.5 <i>Combined Travel Cost and Contingent Behaviour for Recreational Values</i>	30
2.7 THE ECONOMICS OF OIL SPILLS.....	32
2.8 NEW ZEALAND MARINE OIL SPILLS.....	34
2.8.1 <i>The MV Rena Oil Spill is the Most Recent and Largest NZ Response to Date</i>	35
CHAPTER 3: METHODOLOGY.....	38
3.1 SITE SELECTION	39
3.2 CLEAN-UP COSTS	41
3.3 FISHERIES	42
3.4 TOURISM	44
3.5 WILDLIFE & ENVIRONMENT	45
3.6 RECREATIONAL VALUE – SURVEY DESIGN	45
3.6.1 <i>Cost of Travel</i>	47
3.6.2 <i>Demand Shifters</i>	47
3.6.3 <i>Other Survey Information</i>	48
3.6.4 <i>Key Considerations for Both Sites</i>	49
3.6.5 <i>Contingent Behaviour</i>	50
3.6.6 <i>Data Cleaning</i>	52
3.6.7 <i>General Equations</i>	53
3.6.8 <i>Model Specification</i>	54
3.6.9 <i>Regression Analysis</i>	56
3.6.10 <i>Consumer Surplus</i>	57
3.6.11 <i>Pooled Regression</i>	58
CHAPTER 4: DOES SIZE MATTER? THE DIRECT ECONOMIC COSTS ASSOCIATED WITH THE MV RENA.....	60
4.1 INTRODUCTION.....	61
4.2 CONTEXT.....	63
4.3 METHODS AND DATA.....	65

4.3.1	<i>Study Area</i>	65
4.3.2	<i>Clean-up Costs</i>	66
4.3.3	<i>Commercial Fisheries</i>	67
4.3.4	<i>Tourism</i>	68
4.4	RESULTS.....	69
4.4.1	<i>Direct Clean-up Costs</i>	69
4.4.2	<i>Losses to Commercial Fisheries</i>	71
4.4.3	<i>Losses to Tourism</i>	76
4.4.4	<i>Other Costs</i>	78
	4.4.4.1 <i>Impacts to Wildlife</i>	78
	4.4.4.2 <i>Restoration Costs</i>	78
4.5	DISCUSSION.....	79
4.6	CONCLUSION.....	81

CHAPTER 5: POTENTIAL CHANGES IN THE RECREATIONAL USE VALUE FOR COASTAL BAY OF PLENTY, NEW ZEALAND DUE TO OIL SPILLS: A COMBINED APPROACH OF THE TRAVEL COST AND CONTINGENT BEHAVIOUR METHODS ...82

5.1	INTRODUCTION.....	83
5.2	METHOD.....	86
	5.2.1 <i>Study Site</i>	86
	5.2.2 <i>Travel Cost Method</i>	88
	5.2.3 <i>Data Collection</i>	90
5.3	RESULTS.....	93
	5.3.1 <i>Travel Cost Model Results</i>	93
	5.3.2 <i>Contingent Behaviour Results</i>	97
5.4	DISCUSSION.....	98
5.5	CONCLUSION.....	100

CHAPTER 6: RECREATIONAL IMPACTS OF AN OIL SPILL IN A WORLD HERITAGE AREA: A COMBINED TRAVEL COST AND CONTINGENT BEHAVIOUR METHOD APPROACH.....102

6.1	INTRODUCTION.....	103
6.2	METHODS.....	105
	6.2.1 <i>Study Site</i>	105
	6.2.2 <i>Travel Cost for Valuing Recreation</i>	107
	6.2.3 <i>Incorporating Contingent Behaviour</i>	109
	6.2.4 <i>Data Collection</i>	110
6.3	RESULTS.....	112
	6.3.1 <i>Descriptive Statistics</i>	112
	6.3.2 <i>Travel Cost Model Results</i>	115
	6.3.3 <i>Contingent Behaviour Results</i>	117
6.4	DISCUSSION.....	118
6.5	CONCLUSIONS.....	120

CHAPTER 7: EXPECTED DIRECT COSTS OF AN OIL SPILL IN A UNESCO WORLD HERITAGE AREA IN NEW ZEALAND122

7.1	INTRODUCTION.....	123
7.2	METHODS.....	124
	7.2.1 <i>Study Area</i>	124
	7.2.2 <i>Hypothetical Oil Spill Scenario</i>	126
	7.2.3 <i>Estimating Clean-up Costs</i>	127
	7.2.4 <i>Estimating Costs to Fisheries</i>	128
	7.2.5 <i>Estimating Costs to Tourism</i>	129
	7.2.6 <i>Estimating Costs to Recreation</i>	131

7.2.7	<i>Oiled Wildlife Response Priorities</i>	131
7.3	RESULTS	131
7.3.1	<i>Estimating Clean-up Costs</i>	131
7.3.2	<i>Estimating Costs to Fisheries</i>	134
7.3.3	<i>Estimating Costs to Tourism</i>	135
7.3.4	<i>Estimating Costs to Recreation</i>	138
7.3.5	<i>Oiled Wildlife Response Priorities</i>	139
7.3.6	<i>Total costs</i>	141
7.4	DISCUSSION	142
7.5	CONCLUSION	145
CHAPTER 8: DISCUSSION AND CONCLUSION		147
8.1	SUMMARY OF FINDINGS	148
8.2	LIMITATIONS OF RESEARCH	150
8.3	RESULTS COMPARED TO INTERNATIONAL STUDIES	151
8.4	FUTURE OF TOURISM AND RECREATION IN NEW ZEALAND	153
8.5	FACTORS THAT MAY AFFECT MARINE OIL SPILLS IN NEW ZEALAND IN THE FUTURE	155
8.6	INTERNATIONAL AND NEW ZEALAND POLICIES IN RELATION TO RESPONSE AND COMPENSATION OF MARINE OIL SPILLS	156
8.7	FUTURE RESEARCH	158
8.8	CONCLUSION	159
REFERENCES		161
APPENDIX		184
A	: SURVEYS	184
	<i>A1: Coastal Bay of Plenty Survey</i>	184
	<i>A2: Fiordland National Park Survey</i>	190
B	: TABLES	195
	<i>B1: Descriptive Statistics - Coastal Bay of Plenty</i>	195
	<i>B2: Descriptive Statistics – Fiordland National Park</i>	199
	<i>B3: Sociodemographic Relationships with Travel Cost - Coastal Bay of Plenty</i>	203
	<i>B4: Sociodemographic Relationships with Travel Cost – Fiordland National Park</i>	204
	<i>B5: Summary of consumer surplus (CS, per person/trip) results from studies looking at coastal recreation using the individual travel cost method (ITCM), sometimes combined with contingent behaviour (CB)</i>	205
	<i>B6: Summary of consumer surplus (CS, per person/trip) results from similar studies using the individual travel cost method (ITCM)</i>	207
	<i>B7: Landings (kg) and Port Landing Value (PLV) (NZD 2019) for FMA5 and SA032 for years 2015 to 2019. The percent of FMA5 that SA032 is for each year is presented to demonstrate that it is not a statistically significant commercial fishing area for the management area.</i>	208
C	: STATEMENTS OF CONTRIBUTION	209

Figures

Figure 1: The direct and indirect economic effects of an oil spill.....	1
Figure 2: IPIECA Three Tiered Response.....	14
Figure 3: What constitutes the total economic value, demonstrated in a marine context.	21
Figure 4: Simplistic graphical representation of the TCM model.....	25
Figure 5: Demonstrates the shift in a basic demand function for complementary and substitute goods.....	28
Figure 6: Map of the two sites selected for research, Mount Maunganui to Maketu for the stretch of beach impacts by the MV Rena (represents populated area), and Milford Sound in Fiordland National Park (represents remote area).....	40
Figure 7: Map showing New Zealand FMA1 fishing area with inset showing area of interest (Tauranga), the location of <i>MV Rena</i> grounding, the 3 nm exclusion area surrounding the wreck, the stretch of beach between Mt. Maunganui and Maketu that was closed to the public from 13 October to 16 November due to oil contamination along the shoreline, and the statistical fishing area 009 (SA009).	64
Figure 8: Landings and port landing values for SA009 and FMA1. Catch is presented in kg (millions). Port landing values (PLValue) are presented in NZD 2011 prices and represent approximately how much the estimated catch would have been worth at port that year.	73
Figure 9: Domestic and international visitor expenditure in Tauranga. Estimated spending presented in NZD 2011	77
Figure 10: Map showing the Coastal Bay of Plenty (CBoP) study site. The site is ~25km of coastline from Mount Maunganui to Maketu in the Bay of Plenty region on the east coast of New Zealand’s north island.....	84
Figure 11: Photo from the top of Mount Maunganui (top), and an entrance near Moturiki Island (bottom).	87
Figure 12: Map of New Zealand regions where Coastal Bay of Plenty survey respondents identified their residence to be.	95
Figure 13: Location of study site, Fiordland National Park (45.4629°S, 167.5422°E). Te Anau is where survey data was collected.	103
Figure 14: Entrance to the fiord from the Tasman Ocean (top), and Bowen waterfall (bottom). Source: Photos by A. Egan.....	106
Figure 15: Map of New Zealand regions where Fiordland National Park survey respondents identified their residence to be.	114
Figure 16: Map of New Zealand showing (inset) Fiordland National Park, Milford Sound and Te Anau. The larger map shows where Fiordland National Park is situated in New Zealand and the two fisheries areas SA032 and the crayfish catchment area CRA8.....	125
Figure 17: Estimated clean-up costs of an oil spill occurring in Milford Sound and the hypothetical <i>MV Rena</i> (C_{ei}), results using the Etkin (2000) model presented in NZD 2019.....	132
Figure 18: Total annual expenditure (NZD 2019) for domestic and international visitors as well as the total combined expenditure.	136
Figure 19: Visitor trends and approximate collected fees by Milford Sound Tourism Ltd. from 2015-2019.....	137

Tables

Table 1: The different social costs associated with an oil spill, and which ones fall within the scope of this thesis.....	13
Table 2: Type of habitat and general recovery time. Recovery time is defined as the point at which the habitat is functioning normally. These recovery times are highly dependent on location, such as the arctic versus the tropics.....	17
Table 3: Kilometre rates for 2019-2020 income year (Inland Revenue, 2020).....	53
Table 4: Description of variables used in negative binomial regression.....	56
Table 5: Exclusion Zones. Various exclusion zones around Astrolabe Reef where the <i>MV Rena</i> ran aground and the dates they went into effect.....	65
Table 6: Description of cost categories.....	66
Table 7: Summary of the three data sources used to determine the Regional Tourism Estimates.....	69
Table 8: <i>MV Rena</i> response costs incurred by Maritime New Zealand. Costs (NZD 2011) incurred as of 29 January 2013, broken down by category.....	70
Table 9: Important species caught in SA009. Estimate catch is presented in kilograms (kg), and port landing values (PLValue) are presented in NZD 2011, for each fishing year. Ordered by largest estimated catch for 2006.....	75
Table 10: Monthly estimated catch for SA009.....	76
Table 11: Summary of estimated costs of the <i>MV Rena</i> oil spill. Other than clean-up costs, only short-term (2012 compared to 2011) effects will be considered.....	79
Table 12: Description of variables used in travel cost and contingent behaviour analysis.....	92
Table 13: Descriptive statistics for all the survey respondents (n=193) in the Coastal Bay of Plenty (CBoP) survey area. Sampling occurred over a two-week period in January/February 2021.....	93
Table 14: Respondents' top three reasons for visiting the Coastal Bay of Plenty (CBoP).....	96
Table 15: Truncated Negative Binomial results for the two travel cost models, both without (TCppT2) and with (TCAppT2) accommodation.....	97
Table 16: Contingent Behaviour scenario (CB) results, both individual negative binomial models and Panel Effects (PE) models presented.....	98
Table 17: Description of variables used in travel cost and contingent behaviour analysis for Fiordland National Park (FNP).....	112
Table 18: Descriptive statistics for survey respondents (n=351) in the Fiordland National Park (FNP) area. Sampling occurred over a two-week period in December 2020-January 2021.....	113
Table 19: Respondents top three reasons for visiting Fiordland National Park (FNP).....	115
Table 20: Truncated Negative Binomial results for the two travel cost models.....	116
Table 21: Pooled contingent behaviour results, combined NB panel model results.....	117
Table 22: Aggregate consumer surplus (AggCS) pre- and during-COVID visitor numbers, under the three different contingent behaviour oil spill scenarios.....	118
Table 23: Assumptions of oil spill scenarios made for estimating the clean-up and impact costs of an oil spill within Milford Sound, New Zealand.....	127
Table 24: Description of modifier factors for the Etkin calculations under the oil spill scenario.....	128
Table 25: Estimated equipment hire costs for different response length times for Fiordland National Park.....	133
Table 26: Possible range of losses to the crayfish industry due to port closures based on the port landing values.....	135

Table 27: Estimated losses of cruise ship fees collected by Environment Southland (ES) and Milford Sound Tourism Ltd. (MST).	138
Table 28: Potential losses for major companies that operate boat tourism and transport to Milford Sound from Te Anau and Queenstown.	138
Table 29: Wildlife found within the Milford Sound area identified as native or endemic, their New Zealand threat status, IUCN status, and whether they breed in Fiordland National Park (FNP).	140
Table 30: Estimated direct cost of an oil spill occurring in Milford Sound, Fiordland National Park.	142
Table 31: Selected New Zealand based studies using the travel cost method.....	150

Equations

Equation 1.....	42
Equation 2.....	53
Equation 3.....	53
Equation 4.....	54
Equation 5.....	54
Equation 6.....	55
Equation 7.....	55
Equation 8.....	55
Equation 9.....	58
Equation 10.....	89
Equation 11.....	89
Equation 12.....	108
Equation 13.....	108
Equation 14.....	128
Equation 15.....	132
Equation 16.....	132

Abbreviations

CB	Contingent Behaviour Method
CBoP	Coastal Bay of Plenty
CLC	Convention on Civil Liability for Oil Pollution Damage
CS	Consumer Surplus
CVM	Contingent Valuation Method
FNP	Fiordland National Park
HP	Hedonic Pricing Method
ICS	Incident Command Centre
IMO	International Maritime Organization
IOPC Fund	International Oil Pollution Compensation Funds
ITCM	Individual Travel Cost Method
IТОPF	International Tanker Owners Pollution Federation Limited
MARPOL	International Convention for the Prevention of Pollution from Ships
MD	Multi-destination
MNZ	Maritime New Zealand
MP	Multi-purpose
NB	Negative Binomial
NOAA	National Ocean and Atmospheric Administration
NOWRT	National Oiled Wildlife Response Team
OLS	Ordinary Least Squares
OPRC	International Convention on Oil Pollution Preparedness, Response, and Co-operation
PAH	Polycyclic Aromatic Hydrocarbons
PD	Poisson Distribution
RUM	Random Utility Model
TCM	Travel Cost Method
UNESCO	United Nations Educational, Scientific and Cultural Organization
WTP	Willingness to Pay
ZTCM	Zonal Travel Cost Method

Chapter 1: Introduction

The extraction, transportation, and consumption of petroleum are all anthropogenic activities that can lead to oil entering the marine environment. Once oil enters the environment, there are many factors that determine how it will interact with and affect the environment, such as the type of oil, weather, location, and time of year (National Research Council, 2003). Oil spills can have large negative impacts on not only the marine environment, but also on a variety of socio-economic activities (Figure 1). This means oil spills have the capability of disrupting the different values or gains that people derive from the marine environment.

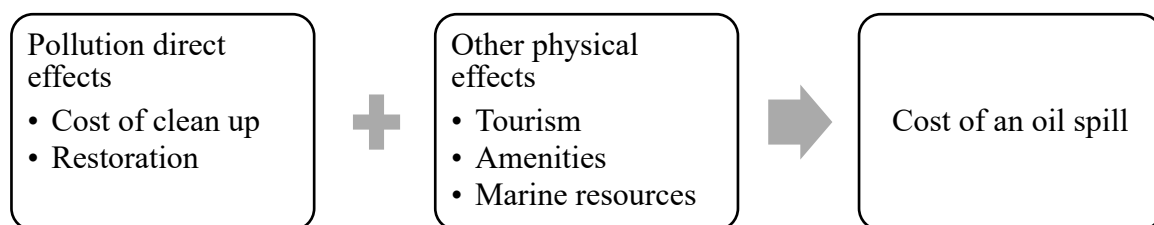


Figure 1: The direct and indirect economic effects of an oil spill.
Source: (Bonnieux & Rainelli, 1993)

According to the Millennium Ecosystem Assessment, ecosystem services are divided into four categories: provisioning, regulating, cultural, and supporting services (Millennium Ecosystem Assessment, 2005a). Provisioning services refer to food and freshwater, and cultural services encompass recreational, aesthetic, and cultural value gained from the environment; both services can be disrupted by an oil spill. Generally, oil spills are not usually considered capable of interrupting regulating and supporting services, since these refer to larger systems at work, such as climate regulation and nutrient production.

New Zealand's largest marine oil spill was from the *MV Rena*, which ran aground on Astrolabe Reef off the coast of Tauranga on 5th October 2011. It released approximately 350 tonnes of heavy fuel oil into the marine environment (Sievwright et al., 2019). Oil and debris washed ashore along the Tauranga coastline, as well as islands around the area. This resulted in a large clean-up effort, as well as an exclusion zone preventing fishing and recreational activities occurring near the wreck, being enforced by the Bay of Plenty Regional Harbourmaster (Northern, 2019). The *MV Rena* oil spill is still considered New Zealand's

worst marine environmental disaster. Globally, the *MV Rena* would be considered a small oil spill, but in a New Zealand context, this was a large oil spill that required a significant national response effort, because there were several releases of oil over a month and oil was released in high wildlife biodiversity and density areas. The environmental impacts of this oil spill have been well studied (Chilvers et al., 2015; de Lange et al., 2016; Dempsey et al., 2016; Hunter et al., 2019; Ross et al., 2016a; Ross et al., 2016b; Schiel et al., 2016b; Sievwright et al., 2019; Webby & Ling, 2016), however, there is little to no evidence that any socio-economic studies have been done.

In terms of total economic value of the marine environment, fishing, tourism, and recreation all fall under what are considered 'use' values (Remoundou et al., 2009). Comparatively, 'non-use' values refer to existence value, bequest value, quasi-option values, and 'warm glow' values (Remoundou et al., 2009). Simply put, these non-use values refer to the benefit received from knowing that an area exists, and that it is secured for future use by yourself and by others. It is straightforward to quantify the value that tourism and fisheries have towards the economy, given that they have market values. However, most of the outdoor recreation in New Zealand is free, as in there are no admission or entrance fees to go to the beach or enter a national park.

Throughout the oil spill literature, there are a few oil spills that have necessitated studies looking at the economic impacts, including but not limited to, the *Erika* 1999 France (Bonnieux & Rainelli, 2003), *Prestige* 2002 Spain (García-Negro et al., 2009; Garza et al., 2009; Suris-Regueiro et al., 2007), *Deepwater Horizon Oil Spill* 2011 Gulf of Mexico, USA (Alvarez et al., 2014; English et al., 2018), *Exxon Valdez* 1989 Alaska, USA (Carson & Hanemann, 1992; Cohen, 1993), the *Amoco Cadiz* 1978 France (Grigalunas et al., 1986) and the *Hebei Spirit* 2007 South Korea (Cheong, 2012). These studies tended to look primarily at impacts to fisheries or tourism (Cheong, 2012; Cohen, 1993; García-Negro et al., 2009; Grigalunas et al., 1986; Suris-Regueiro et al., 2007), with some investigating aspects of recreational losses, often fishing (Alvarez et al., 2014; Bonnieux & Rainelli, 2003; Carson & Hanemann, 1992; English et al., 2019). Throughout the literature, there have been little to no studies that performed a more comprehensive analysis to get a total estimate of the losses associated with oil spills.

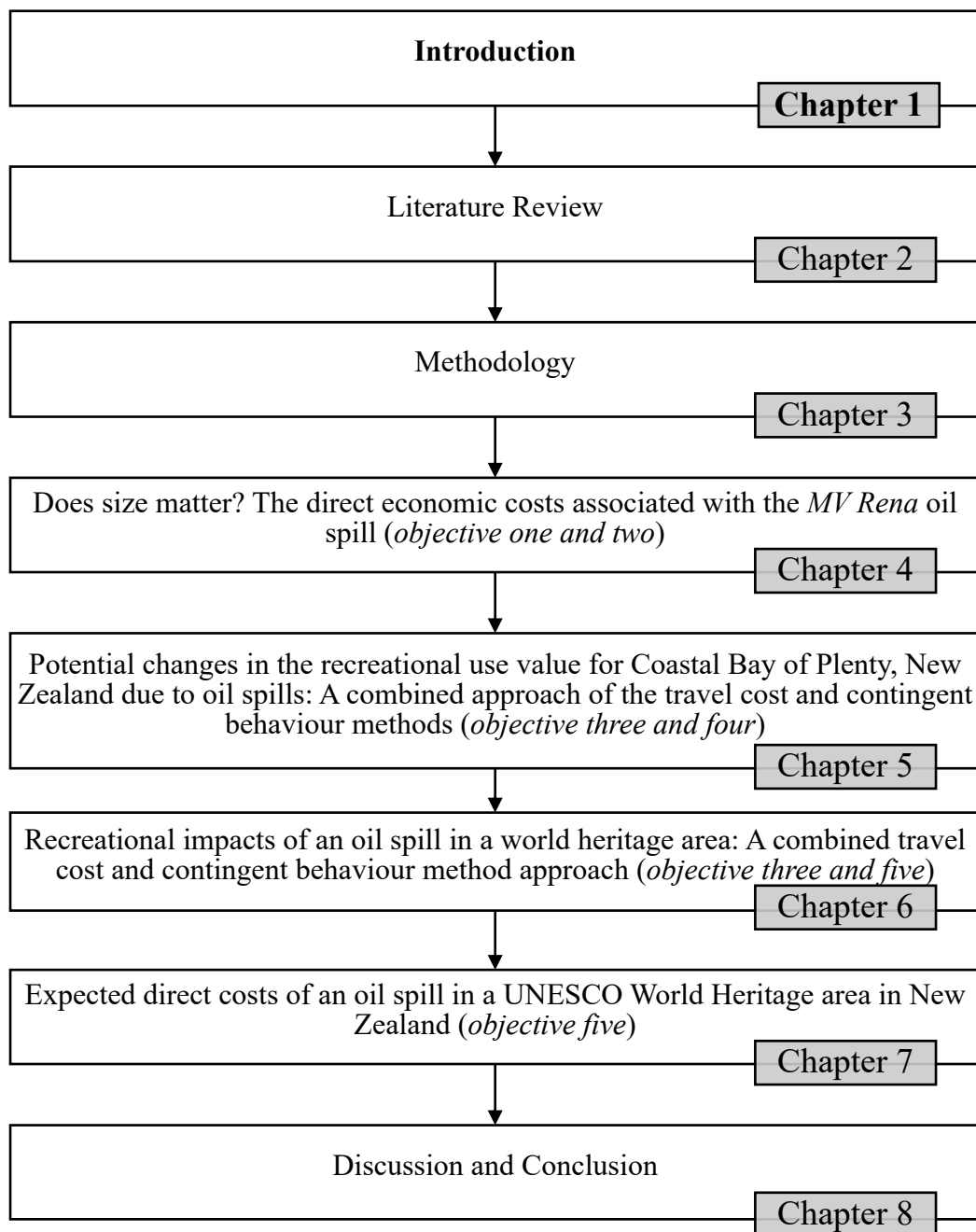
To date, most studies estimating the economic impacts of oil spills have focused on large oil spills that have already occurred. Little research has been done to estimate the potential direct economic impact of these smaller spills, and of an oil spill occurring in a

remote and pristine marine environment. How many coastal businesses there are, the extent of the commercial and recreational fisheries, the coastal tourism industry, and how easily accessible the site is, are important factors for determining the direct economic impact an oil spill will have on a community. These smaller scale oil spills can be economically impactful to the local communities.

The overall question to be addressed by this research is: what are the direct economic costs of oil spills within New Zealand's marine environment in populated and remote areas? This will be done by estimating the direct economic costs of New Zealand's worst marine oil spill, the *MV Rena* (which occurred in a populated area as it was entering New Zealand's busiest port (Port of Tauranga Limited, 2021a)), looking at the impacts to tourism, fisheries, recreation, and the clean-up costs that were associated with the spill. The findings will then be applied to a remote area, Milford Sound, Fiordland, to estimate the possible economic cost and consequences of a similar sized spill occurring. These results will allow New Zealand to have a greater understanding of the possible economics consequences of oil spills in our coastal waters, in order to help inform policy makers, so that they may make appropriate decisions regarding preparedness, prevention, and response policies. The specific research objectives of this thesis are to estimate:

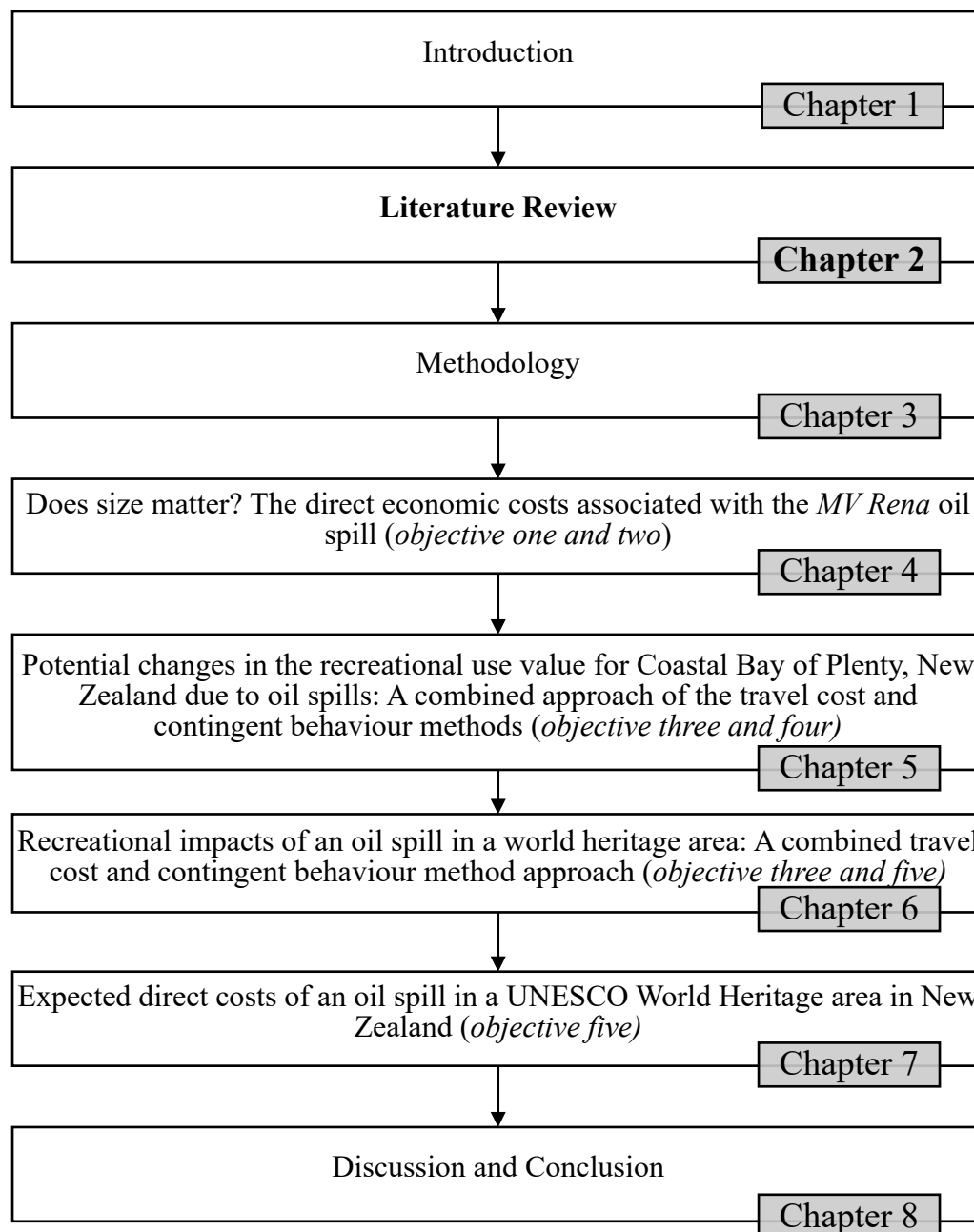
1. The direct economic impact of the *MV Rena* oil spill on the fishing industry. This will be done by analysing the change in landings prior to and after the oil spill, and their respective market prices.
2. The direct economic impacts of the *MV Rena* oil spill on the tourism industry within Tauranga. This will be done by analysing the change in spending of the tourism sectors within this territorial authority, with divisions between domestic and international spending.
3. The losses of recreational value of both a populated and remote area within New Zealand (Coastal Bay of Plenty and Milford Sound, Fiordland) due to oil spills. This will be done by carrying out on-site surveys at both locations and analysing the survey data using a combined approach of the travel cost method and contingent behaviour methods.
4. The total direct economic impacts of the *MV Rena* (fisheries, tourism, clean-up costs, and recreation), and come up with a final figure for the direct costs.
5. The potential direct economic costs of an oil spill occurring in Milford Sound, Fiordland (fisheries, tourism, clean-up costs, and recreation).

With the continuous expansion of the shipping and cruise ship industries, New Zealand's ports will continue to be under pressure. And though these industries have made safety improvements, accidents happen, as demonstrated by the past. For this reason, it is important to understand the potential impacts that an oil spill can have on the New Zealand economy, even at a local level. The *MV Rena* oil spill has well documented environmental effects, but what were the direct economic consequences? This is a clear gap in the knowledge and can add to the limited field of oil spill economic studies overall. In addition, to describing the direct economic consequences of the *MV Rena*, applying this knowledge to a remote area of New Zealand will allow us to consider the potential economic consequences of another spill occurring in a relatively pristine environment, and help inform those responsible for appropriate preparedness, management and policy recommendations. The outline of the remainder of this thesis and the objectives answered in each chapter is as follows:



At the beginning of each chapter, this figure will appear to demonstrate how the chapters are connected, with the **bolded** chapters representing the upcoming section. This thesis is written with publications, so each chapter will be comprised of its' own introduction, methodology, results, discussion and conclusion subsections. This will also lead to some repetition amongst chapters.

Chapter 2: Literature Review



This literature review will cover a wide range of topics that are relevant to this research. First, an overview of how oil enters and interacts with the marine environment will be described. This will be followed by a brief history of major marine oil spills, and important legislation and policies at both the international and domestic level. A New Zealand oil spill response will be described, followed by a discussion of the impact of oil on the environment. This will be followed by a discussion of ecosystem services, and various ways that one can value the environment. Studies that have looked at the economic impacts of various oil spills will then be considered. Lastly, marine oil spills in a New Zealand context will be described.

2.1 Oil and the Marine Environment

This section will describe how oil enters the environment both naturally and through anthropogenic means, general properties of various oils, and a global history of major marine oil spills. Oil enters the marine environment through two means, natural seepage, or human related activities. Natural seeps of oil and natural gas account for approximately half of the oil that enters the marine environment, and extraction and exploration activities typically correspond to these locations (WHOI, 2014). Fractures in the seafloor allow for crude oil to rise up slowly and enter the marine environment, allowing time for the ecosystem to adapt to the small changes that are occurring, so that there is little ecological effect (National Research Council, 2003; NOAA, 2018). Globally, these natural seeps are estimated to be contributing 600,000 tonnes of crude oil per year to the marine environment, with a range of 200,000 to 2,000,000 tonnes, and 40 percent of the world's total coming from the greater-Pacific area (National Research Council, 2003; Wilson et al., 1974). Typically, marine oil seeps occur in sedimentary rocks, or in metamorphic or igneous rocks which are closely associated with sediments (Wilson et al., 1974).

The extraction, transportation, and consumption of petroleum are all anthropogenic activities that can lead to oil entering the marine environment. According to the National Research Council (2003, p. 29), extraction, transportation, and consumption account for the remaining 3 percent, 12.5 percent and 37.5 percent of oil in the marine environment respectively. The extraction of oil includes platforms, operational discharges, and atmospheric deposition; transportation includes pipelines, tankers, trains, and trucks; consumption includes recreational marine vessels, commercial vessels, aircraft fuel, and land-based river runoff (National Research Council, 1985, 2003). These consumption-based accidents have been common enough throughout history, that a lot of research has been done to study their various impacts. These impacts include why these spills happens, what contributes to the severity of the spill, the environmental damages, and the socio-economic impacts.

The main physical properties of oil that will affect its behaviour and persistence in the marine environment, is its viscosity, specific gravity, distillation characteristics, pour point, and vapor pressure (ITOPF, 2011c). Viscosity is the measure of the oil's resistance to flow. Specific gravity will determine if an oil floats or sink when it enters the water, and most oils are less dense than water, which is why they tend to stay at the surface. Distillation characteristics refers to oils' volatility, or at what temperature the oil will begin to evaporate

(ITOPF, 2011c). The pour point is the opposite, in that it refers to the temperature at which an oil will condense and cease to flow (ITOPF, 2011c). Lastly, the vapor pressure simply refers to what pressure is needed in the environment for evaporation to occur (ITOPF, 2011c). With these various characteristics in mind, oil has been classified into four different types or groups.

According to NOAA (2019), there are four types, or groups, of oils. Type one is very light oils, such as jet fuels and gasoline. Type two is light oils, such as diesel, No.2 fuel oil, and light crudes. Type three is medium oils, which encompasses most crude oils. Type four is heavy oils, such as No.6 fuel oil, Bunker C, and other heavy crude oils. It is important to differentiate the different groups of oil, because the type of oil will determine its persistence and impact in the marine environment and therefore the best response to a particular spill.

What all of these oil types have in common, is that they are all composed principally of hydrocarbons, with polycyclic aromatic hydrocarbons (PAHs) being the most toxic towards the environment (National Research Council, 2003). The toxicity of PAHs is compounded by certain clean-up techniques, such as in-situ burning, and the natural breakdown through weathering. Generally, type one oils are the only non-persistent oil group, with types two, three, and four considered persistent and having greater visual impact in the marine environment if spilt.

Weathering is the term used for when oil enters the environment and natural processes begin to alter the physical and chemical state of the substance, such as spreading, evaporation, emulsification, dissolution, oxidation, dispersion, and biodegradation and sedimentation (ITOPF, 2011c; National Research Council, 2003; NOAA, 2019). Evaporation is considered to be the most important weathering process, since light crude oils and medium crude oils can lose up to 75 percent and 40 percent of their initial volume within the first few days of a spill, respectively (National Research Council, 2003), followed by dispersion. Temperature and weather play an important role in the weathering process, with higher temperatures leading to a higher rate of evaporation, and rougher seas with higher winds leading to faster rates of spreading and emulsification taking place. All other weathering processes depend heavily on the physical and chemical properties of the oil itself.

2.2 History of Major Marine Oil Spills

A large volume of oil accidentally released into the environment does not necessarily correspond to a substantial response effort or known negative environmental effects, as many of the largest tanker oil spills on record (as listed in ITOPF (2019) Oil Spill Tanker Statistics

technical paper), elicited little or no response due to being far offshore and not impacting the coastline. Therefore, many oil spills that are listed in the top 20 are not well known to the public. This section will discuss the major publicly visible oil spills that have elicited significant responses and therefore have become historically important, including being well studied in terms of the environmental and socio-economic effects. Though some of these spills result from large volumes of oil being released, many of the most devastating spills have spilt only a fraction of the oil spills located in the top 20. This section will be focused on well known, public oil spills that occurred from tankers, as they have been political motivators of change in response and legislation. Oil spills that have resulted from acts of war or on land will not be included.

Oil spills have occurred since oil exploration and consumption began; however, the world began to pay attention and keep a record after the *Torrey Canyon* spill, when the tanker ran aground near Cornwall, UK, on the 18 March 1967. Over the course of 12 days, this tanker spilt its entire 119,000 tonnes of crude oil into the ocean (and the tanker eventually split into two), killing numerous marine organisms, and over 25,000 seabirds (ITOPF, 2014; Wells, 2017). There were many methods used to try to contain and clean up the spill, such as burning the slick as well as an aerial bombardment, in hopes of activating further burning (ITOPF, 2014). What makes this oil spill so important, is that it was the first major offshore oil spill that used chemical dispersants. These dispersants were first generation, and instead of doing their job of dispersing the oil, they ended up amplifying the environmental damage (Wells, 2017). Because of this, dispersants still have a bad reputation.

Nonetheless, it is due to this spill's response, that many acts of legislature have been passed and organisations have been formed whose purpose is to study the effects and response to oil spills. These pieces of legislature and compensation funds include, but are not limited to, the International Convention on Civil Liability for Oil Pollution Damage 1969, and the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage 1971 (Rares, 2017). The organizations that have occurred as a direct result of this spill are the International Maritime Organization, UN Joint Group of Experts on the Scientific Aspects of Marine Pollution, and the International Tanker Owners Pollution Federation (Wells, 2017). The *Torrey Canyon* is still ranked the 7th largest tanker oil spill in the world (ITOPF, 2019).

The largest ship-sourced spill, by volume, ever recorded is the *Atlantic Empress*. On 19 July 1979, the *Atlantic Empress* collided with the *Aegean Captain* about 20 miles northeast of

the island of Tobago (Horn & Neal, 1981), spilling a total of 287,000 tonnes of crude oil (ITOPF, 2019). Though spilling a large amount of oil, the oil slick had completely dissipated by 5 August, with very little oil ever reaching the land, consequently having a small known environmental impact.

In contrast, the *Exxon Valdez*, which ran aground in Prince William Sound, Alaska on 24 March 1989, spilled 37,000 tonnes of heavy crude oil, affecting approximately 2100 kilometres of coastline (Heal et al., 2005b), and had devastating environmental and economic consequences. Over 30,000 oiled birds were collected within the affected area, but the estimates of total seabird mortality reached as high as 250,000 (Ballachey et al., 2014; Piatt et al., 1990). Over 20 killer whales, several thousand sea otters, and 300 harbour seals were oiled and died (Degange et al., 1994; Frost et al., 1999; Matkin et al., 1994; Shigenaka, 2014). Interestingly, before this spill, it was believed that cetaceans would avoid oil spills, thus minimizing their exposure to toxic substances. At the peak of the oiled wildlife response, there were an estimated 10,000 workers, 100 aircrafts and helicopters, and 1,000 vessels being used, with the clean-up lasting four years, at an estimated cost of \$2.1 billion USD (Shigenaka, 2014). The scale of this spill, response, and cost was unprecedented, but NOAA estimates that the clean-up itself only removed around 10 percent of the oil, with the vast majority of it being naturally weathered (Shigenaka, 2014). The *Exxon Valdez* currently ranks as the 36th largest tanker oil spill accident (ITOPF, 2019).

The *Erika* sank off the coast of Brittany, France on 12 December 1999, spilling around 20,000 tonnes of heavy oil. Though a small spill compared to the others mentioned, the type of oil and storm conditions caused an oil slick to form that covered approximately 400km of coastline, (Araújo et al., 2014; Bocquene et al., 2004). Over 70,000 oiled birds were found along the coast of the Bay of Biscay (Cadiou et al., 2004).

The *Prestige* suffered an accident off the Galician coast of Spain on 13 November 2002, eventually spilling 63,000 tonnes of heavy low-quality oil, reaching more than 1,300km of coastline (ITOPF, 2019; Loureiro & Loomis, 2013). This spill, also relatively small in terms of oil spilled, is the worst in Spanish waters, due to its vast environmental and economic consequences. According to García-Negro et al. (2009), there was a shellfish and fishing ban that affected 788km and 913.5km of coastline respectively. A decade later, the authors found that there was a clear decrease of 17.1 percent by analysing the fish and shellfish landings pre (with respect to 2001) and post spill, with losses of €38.40 million and €41.00 million in 2002 and 2003 respectively (Loureiro et al., 2006).

The *Hebei Spirit* collided with a crane barge in poor weather conditions on 7 December 2007 about 8km northwest of Taean, South Korea, resulting in approximately 11,000 tonnes of crude oil being released (ITOPF, 2019; Kim et al., 2017). This area is important for fisheries and mariculture, so the fishing bans that lasted until April 2008 and September 2008 (bans were lifted at different time for individual fisheries) and had sizable negative consequences for the economy. Interestingly, the tourism industry exhibited a quick surge, but then began to slowly decline (Cheong, 2012).

The *Sanchi* is the latest major oil spill, spilling 113,000 tonnes of condensate off the coast of Shanghai, China, ranking 9th on IOTPFs list (ITOPF, 2019). This spill is the only spill mentioned regarding non-persistent oil, meaning that it is of low density, low viscosity, and contains little PAHs as compared to crude oil. This type of spill is also not very common, so it's environmental and economic impacts are not well documented.

The *X-Press Pearl* caught on fire off the coast of Sri Lanka on the 20 May 2021, carrying 25 tonnes of nitric acid, 348 tonnes of oil, and an estimated 75 billion small plastic pellets known as nurdles (Smith, 2022). These plastic pellets will prove to have the worst environmental damage, in that it is estimate they will take up to 1,000 years to disintegrate (Smith, 2022).

Globally, the average number of major oil spills (>7000 tonnes) that occur per year from tankers is on a downward trend, with only 1.9 spills occurring per year on average from 2010-2018 (ITOPF, 2019). This is despite the growing trend in the marine transport of oil. The two main causes of tanker oil spills since the 1970s are groundings and allisions/collisions, which could be attributed to the continued improvements made in ship design, such as the double hull, improved navigation systems and global shipping tracking systems AIS.

2.3 Legislation and Policies Regarding Oil Spills

Before the *Torrey Canyon* oil spill, there was no international legislature or claims system in place. Now, there is an assortment of international policies in place aimed at marine pollution. The International Maritime Organization is responsible for managing the International Convention for the Prevention of Pollution from Ships, which was adopted in 1973. Annex I of this convention is specifically about the pollution of oil by ships in the marine environment. It is the legislature that is responsible for double hulls in tankers (International Maritime Organization, n.d.-a).

The International Convention on Oil Pollution Preparedness, Response and Co-operation was adopted in 1990, and it requires ships to carry a shipboard oil pollution emergency plan, report all incidents of pollution to be reported to coastal authorities, keep a stockpile of response equipment, as well as hold exercises that mimic an oil spill response (International Maritime Organization, n.d.-c).

The U.S. Oil Pollution Act of 1990 strengthened the US Environmental Protection Agency's ability to prevent and respond to oil spills. This is funded by taxing oil storage and shipping and is used for spills when the polluter is incapable of covering all costs (U.S. EPA, 2019). Financially, this made any parties deemed responsible for the spill, have to meet all clean-up costs; it also mandated that all oil spill contingency plans must include a section on the protection, rescue and rehabilitation of fish and wildlife resources (Henkel & Ziccardi, 2017).

The International Convention on Civil Liability for Oil Pollution Damage was adopted in 1969, and its overall goal is to ensure that sufficient compensation is available to persons who suffer oil pollution damage resulting from maritime casualties involving oil-carrying ships (International Maritime Organization, n.d.-b). Supplemental to the International Convention on Civil Liability for Oil Pollution Damage, is the International Oil Pollution Compensation Fund (IOPC Fund), which has two conventions, one in 1971, and the second in 1992. This fund is in place to cover claims of pollution damage that exceed the limit of the shipowner's liability (IOPC Funds, 2019). There are five types of pollution damage that are included under this fund, being property damage, cost of clean-up operations at sea and on shore, economic losses to fishers and mariculture, economic losses in the tourism sector, and costs for reinstatement of the environment. The social costs that are covered and not covered by the IOPC Fund are clearly represented in Table 1.

Table 1: The different social costs associated with an oil spill, and which ones fall within the scope of this thesis.

Within scope of thesis	Social Aspect	Cost	Economic Value	Compensated
Yes	Cleaning and restoration	Public	Marketed	Yes
Yes	Fisheries and related sectors	Private	Marketed	Yes
Yes	Tourism	Private	Marketed	Yes
Yes	Recreation	Private	Non-Marketed	No
No	Non-use or passive use	Public	Non-Marketed	No

Source: Adapted from Table 1 in Garza et al. (2009, p. 96).

In addition to these international conventions and regulations, New Zealand has implemented its own rules and regulations that monitor and regulate pollution in the marine environment. The Maritime Transport Act 1994 (Part 23, 24, 25, 26A) clearly outlines the plans, responses, and financial obligations to marine oil spills. Namely, it discusses the different levels of contingency planning and the process to getting a plan approved, the role of the National on Scene Commander, compensation to damaged or loss of property, domestic as well as international levels of compensation, as well as who pays for these plans and responses in the event of a spill (Ministry of Transport, 1994).

The Resource Management Act 1991, though regulating other forms of pollution, does not directly address oil spills, and diverts all legal rule and obligations to the Maritime Transport Act 1994 (RMA, p. 556, 330(4)) (Ministry for the Environment, 1991). According to Maritime New Zealand (2018), the act known as Marine Protection Rules from the Minister of Transport, is divided into parts, with Parts 130 (A, B, C), 131, and 132 relating to the planning and response to marine oil spills (Maritime New Zealand, n.d.-a).

2.4 Oil Spill Response

The International Petroleum Industry Environmental Conservation Association (IPIECA) recommends countries implement a three-tier organization structure to determine who is responsible for responding to a spill. Tiers one, two, and three represent local, regional or national, and international responsibility, respectively. Generally, the size of the spill determines whose responsibility it is (i.e., resources needed), however the location, season, oil type, and potential for negative consequences to resources, also determine what the most appropriate response is (IPIECA, 2015b). Figure 2 demonstrates the differences in response techniques based on the tiered system. Tanker incidents very frequently elicit a tier 3

response. This is usually due to the effects on wildlife, onshore oiling, as well as the size of the spill simply requiring more personnel and a wider range of expertise.

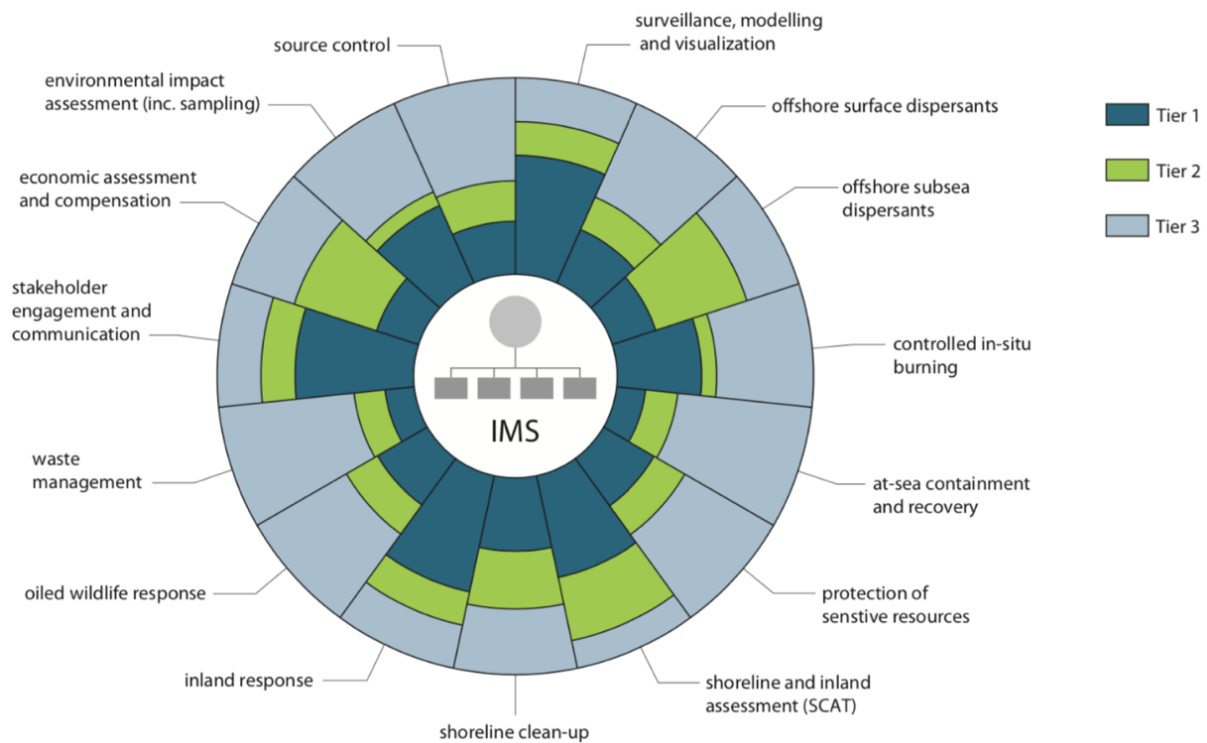


Figure 2: IPIECA Three-Tiered Response.
Source: IPIECA (2015c, p. 15).

Once a spill occurs, there are two commonly used response organizational structures, being either function-based or team-based. A function-based system is known as Incident Command System in the USA, Coordinated Incident Management Systems in New Zealand, and Australian Incident Management System in Australia. This system is purposely designed to bring together people from different backgrounds and organizations on short notice and have them work as members of a single structure (ITOPF, 2012a). This hierarchy has the commanding officer at the top, with four general groups reporting to them, these being operations, planning, logistics, and finance/administration; within these four groups, there are also various sub-groups. Smaller oil spills will often allow this system to be condensed, with people taking on multiple roles. A team-based structure is more commonly used for oil spills outside of the USA, with the strongest division being between at-sea responders versus on-shore responders, with support services located beneath these two groups (ITOPF, 2012a).

New Zealand operates using this three-tiered readiness and response approach for marine oil spills. According to Maritime New Zealand (2018), the industry or operator

responds in a Tier 1 incident, in which they must take immediate steps to control the spill and are required to notify the regional council or Maritime New Zealand (MNZ). In a Tier 2 response, the regional council that has the authority for the region where the spill took place will respond, working with the industry operator. A Tier 3 response, or a national response, is led by MNZ, when the spill is complex and exceeds the response capacity of the regional councils and operators' resources. If a spill is too large for the resources of MNZ, it becomes an international response. When this happens, various organizations would be notified, including, but not limited to, International Tanker Owners Pollution Federation, Australian Maritime Safety Authority, Oil Spill Response Limited and International Association of Independent Tanker Owners.

Clean-up techniques can be divided into two groups, at-sea containment and recovery, and on-shore clean-up. At-sea recovery and containment techniques generally fall into three categories: containment and recovery, in-situ burning, and dispersant application. Booms and skimmers are two widely used oil containment methods, with a few different types to choose from, depending on the environment where a spill occurs and the type of oil spilled (ITOPF, 2011d, 2012b).

Dispersants are designed to enhance the weathering process of dispersion, allowing the oil to diffuse throughout the water column. Due to the toxicity of the mixture of dispersants and oil to the marine flora and fauna, the use of dispersants is still widely debated. There are many factors that are considered before applying dispersants, such as depth of water, type of oil, amount of oil, sea conditions, as well as cost and potential effectiveness.

Another clean up technique for open water is in-situ burning, which is the controlled burning of the spilled oil's hydrocarbon vapours (IPIECA, 2016). Almost all oil types can burn, as long as the slick is thick enough; this technique is often applied to the oil collected with booms and skimmers. Though there are aesthetic and emissions concerns, since it primarily converts the hydrocarbons to carbon dioxide, it has the benefits of removing the oil rapidly and effectively, requires little equipment, and can be used in almost any habitat and on most oil types (IPIECA, 2016). However, in-situ burning is not practiced within New Zealand, due to a lack of equipment and technology.

In some instances, if time allows before oil reaches shore, before any cleaning of the oil begins, there is a beach pre-clean, where any debris that is on the shoreline, such as seaweed, logs, driftwood, etc., is removed so that there is less oily waste that needs to be removed once it reaches the shore. Once the oil reaches land, the shoreline clean-up techniques are divided

into three operational stages. Phase one is the recovery of oil that is floating beside the shoreline, and bulk and pooled oil onshore; phase two is the removal of moderate to heavy contamination, which primarily focuses on stranded oil, or oil that is now on the shore; finally, phase three is the treatment of lightly polluted sediments and removal of oil residues and stains (IPIECA, 2015a).

Throughout the response process, it is important to have realistic and attainable endpoints, or the point at which the clean-up process will be terminated. End point criteria differs for each spill and is heavily influenced by the location of the spill, as well as the different public and commercial pressures that exist for that environment (IPIECA, 2015a). According to IPIECA (2015a, p. 12), there are a few questions that should be considered when deciding whether or not to continue a cleaning process, but all of them agree that if continuing this effort will result in more harm than good, then it is time to stop the response. This includes potential economic, environmental, and aesthetic damages.

IPIECA (2017) identifies seven key overarching principles for the organization of a wildlife response: health and safety of responders, triage, euthanasia, documentation, facilities, communications, and response team organization. It is imperative to know how a spill response will be structured before it occurs. All these principles are pre-planned and important for making a wildlife response run smoothly and should be outlined within a contingency plan. It has the potential to be a very public, and expensive part of an oil spill response.

2.5 Oil and its' Ecological Consequences

One factor that determines the impact an oil spill can have on a coastal environment is the composition of the shoreline. The Environmental Sensitivity Index allows for a quick glance as to how susceptible certain shorelines are to negative impacts from an oil spill, with exposed rocky shores and cliff being the least sensitive, and marshes, swamps, and mangroves being the most sensitive (IPIECA et al., 2012). The more sensitive environments will take longer to recover, or return to their normal ecosystem function, after a spill occurs (Table 2).

Table 2: Type of habitat and general recovery time. Recovery time is defined as the point at which the habitat is functioning normally. These recovery times are highly dependent on location, such as the arctic versus the tropics.

Habitat	Recovery Period
Sand beaches	1 – 2 years
Exposed Rocky Shores	1 – 3 years
Sheltered Rocky Shores	1 – 5 years
Saltmarsh	3 – 5 years
Mangroves	10 years and greater

Source: Adapted from ITOPF (2011b).

Shigenaka (2014) reported that the *Exxon Valdez* oil spill had long lasting effects, with the intertidal zone showing signs of a strong recovery by 1997, almost 10 years after the spill occurred. Generally, there are three criteria are considered to determine a shorelines environmental sensitivity index, which is the substrate grain size and slope, exposure to wave and tidal energy, and general biological productivity and sensitivity (IPIECA et al., 2012). These characteristics will dictate the capacity of oil penetration and movement on the shore, as well as the natural persistence time of the oil. However, overall, the effect of an oil spill is very location dependent. Oil will behave differently in temperate versus arctic environments, since temperature plays a key role in how the oil weathers (Committee on Responding to Oil Spills in the U.S. Arctic Marine Environment et al., 2014).

The most common way of measuring the long-term toxic effects of an oil spill for marine species is by looking at the effect of PAHs. Various laboratory studies look at the impacts of different invertebrates encountering oil and its toxic compounds (Cho et al., 2011; Hatch & Burton, 1999; Overmans et al., 2018), as well as similar studies regarding fish (Carls et al., 2008; Hansen et al., 2019; Langanen et al., 2017; Olsvik et al., 2011), with some of these studies emphasizing that weathered oil could be more toxic than the originally spilt version. According to Yender et al. (2002), oysters, mussels, clams, scallops, as well as shallow water lobsters, crabs and shrimp are all at a high risk of exposure if a spill were to occur, particularly as they are not able to metabolize oil, unlike fish, reptiles, birds and mammals. Because of this perceived vulnerability, molluscs are commonly used as an indicator species in an oil spill, since they are filter feeders who process large amounts of water, they are at risk of ingesting dispersed oil droplets and particles that are within the water column (White & Molloy, 2001).

PAH levels in *Protothaca staminea* (Littleneck clams) returned to baseline levels within their tissues after the *Exxon Valdez*, baseline referring to levels in clams not found

within the oiling sites around 4 years after the spill (Shigenaka, 2014). In addition to the PAH levels, the study also looks at the community abundance and how it changed after the oil spill, finding that the abundance of species was similar to control sites within six years. Similarly, Bocquene et al. (2004) looked at the PAH levels within the tissues of *Mytilus edulis* (Common mussel) following the *Erika* oil spill and found that there were no immediate impacts and no massive acute mortality, with the contaminant returning to baseline levels by April 2001.

Sediment contamination is closely related to the continued contamination of invertebrates that burrow, for as long as the sediment is contaminated, the animals that reside in that environment will continue to be contaminated as well (Klerks et al., 2018); shallow water fish are also known to become contaminated through sediment (Hjermann et al., 2007). The impact to fish stocks is dependent on the weather conditions, time of year, extent of the spill, developmental stage of the fish, the distribution of spawning sites, and oceanic conditions at the time of spill (Hjermann et al., 2007). It should be noted that it is not common for entire fish stocks to be disrupted from an oil spill.

Marine mammals have also demonstrated to be susceptible to oil spills. Though the Gulf of Mexico was experiencing a mass mortality event beginning the month before the Deepwater Horizon oil spill, however this oil spill contributed to an increase in mortalities of cetaceans in the year following the spill in the areas that experienced oiling, as well as an increased prevalence of illness in the populations of bottlenose dolphins (Graham et al., 2017; Schwacke et al., 2014). The Exxon Valdez oil spill was estimated to contribute to over a thousand *Enhydra lutris* (sea otter) deaths, 300 *Phoca vitulina* (harbour seals), and over 20 *Orcinus orca* (killer whales) with inhalation of the vapours and eating contaminated food being the main suspected causes for the deaths of Killer Whales (Ballachey et al., 2014; Exxon Valdez Oil Spill Trustee Council, 2014; Frost et al., 1999; Matkin et al., 1994). Of the 421 sea otter carcasses that were collected post-spill, only seven percent had no oil on their pelage (Garshelis, 1997).

The Exxon Valdez oil spill has had extensive long-term studies done on the animal populations that were affected by the spill, and there are a few instances where the environment has not recovered. According to the Exxon Valdez Oil Spill Trustee Council (2014), there are four animals that are considered 'not recovering', the *Clupea pallasii* (Pacific Herring), *Cephus columba* (Pigeon Guillemots), *Brachyramphus marmoratus* (Marbled Murrelets), and the *Orcinus orca* (Killer Whale-AT1 population). As a result of

these sizeable collection of long-term studies that have been done about the Exxon Valdez, our knowledge of the potential effects of chronic exposure to oil toxins is more comprehensive.

2.6 Ecosystem Services and Valuing the Environment

This section will begin with a general overview of what ecosystem services are, and how they apply to marine oil spills. This is followed by a review of the literature regarding direct and indirect use values, followed by a brief description of non-use values and the various ways to measure them. Finally, the travel cost method (TCM) and contingent behaviour method literature will be examined, including their efficacy and short comings.

Ecosystem function refers to the processes that take place within an ecosystem as a result of the many interactions between plants, animals, and other organisms with each other, as well as with their environment (Heal et al., 2005a). The various structures and functions found within ecosystems also provide a range of goods and services to humans, that have value. Ecosystem services is the term used to describe these many benefits that people gain from different ecosystems. The Millennium Ecosystem Assessment (Millennium Ecosystem Assessment, 2005a) divides these services into four function-based categories, provisioning (for example: food, fresh water, timber), regulating (climate, flood, disease regulation), cultural (aesthetic, spiritual, recreational, educational), and supporting services (nutrient cycling, soil formation, primary production). All the categories are linked to different elements of human well-being, such as security, health, good social relations, and basic material for a good life. Oil spills are inherently tied into provisioning, and cultural services, in the sense that they affect the local food source and aesthetic/recreational activities. While they could impact supporting and regulating services, these services operate on a global scale, making it difficult for a single spill event to negatively impact them. It is worth noting that the Millennium Ecosystem Assessment is an anthropocentric value system, and that there are eco-centric value systems that have emerged. However, since this thesis does not analyse the problem from an eco-centric point of view, these will not be elaborated upon.

The theory of value in economics is based on the capability of a good or service to meet human needs and wants, or to improve the well-being or utility of individuals (Freeman et al., 2014). In terms of valuing the environment, it is widely accepted that there are two different categories needed to estimate total economic value, these are use and non-use values, as demonstrated in Figure 3 (Pearce, Markandya and Barbier, 1989). Use values are definitive benefits that can be physically observed and measured and is further divided into direct use

and indirect use values. For the coastal environment, direct use values include industries such as fisheries, tourism, recreation, and local culture. Local culture may refer to altruistic values, and the contribution to welfare or well-being of a particular group of people or society (Kenter et al., 2015). Indirect use values are also referred to as ecosystem services, encompassing services such as flood protection, and CO₂ sequestration (Remoundou et al., 2009). Non-use values include option values (future recreation values), existence values (satisfaction from knowing something exists), warm glow (moral satisfaction of contributing to the provision of marine ecosystem goods), and bequest values (satisfaction from providing future generations with the ecosystem benefits) (Remoundou et al., 2009). Of these non-use values, option values may be considered fluid, in that they can sometimes be classified as indirect use values (Clough & Bealing, 2018).

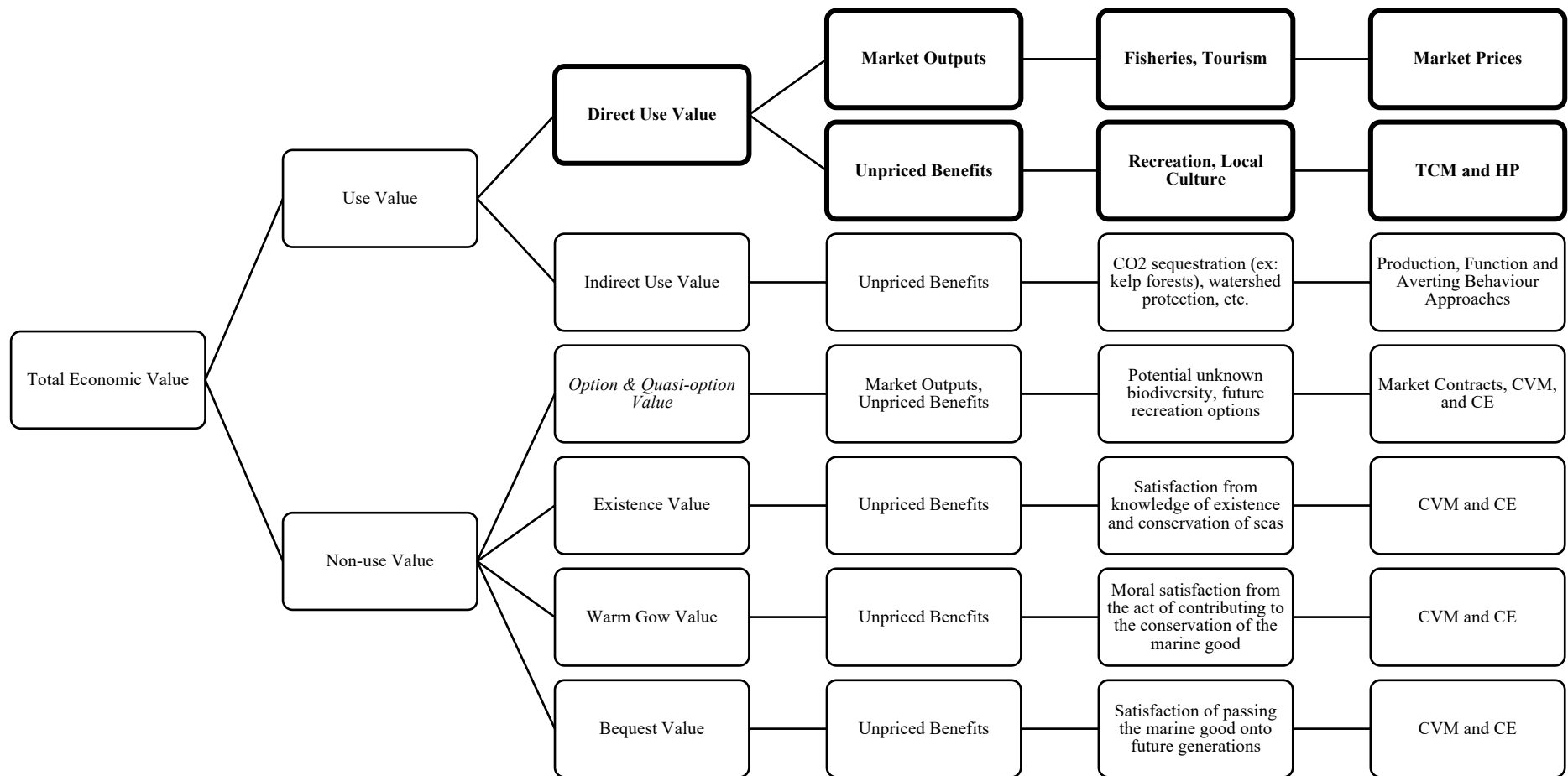


Figure 3: What constitutes the total economic value, demonstrated in a marine context.

Source: Adapted from Remoundou et al. (2009, p. 1042) and Clough and Bealing (2018).

Note: The **bolded** terms represent the focus of this research. TCM (Travel Cost Method), HP (Hedonic Pricing), CVM (Contingent Valuation Method), CE (Choice Experiments).

Methods for valuing the environment can be divided into two broad categories, revealed preference and stated preference techniques, with the major difference being that the latter gets its data from people's responses to a hypothetical situation, rather than observing real world choices being made (Freeman et al., 2014). These measured environmental values have become accepted for use in cost-benefit analyses, with many policies throughout Europe and the United States increasing support for these non-use value approaches, despite some continued debates regarding the methods (Alban et al., 2006; Börger et al., 2014a). What both different categories of methodologies have in common, is that they are both looking to quantify the willingness to pay to use a resource.

2.6.1 Direct and Indirect Use Values

Direct use values with unpriced benefits, such as recreation and local culture, have been more widely studied in a marine context using travel cost methods (TCM), with research in areas ranging from marine protected areas (Alban et al., 2006; Chae et al., 2012; Prayaga et al., 2010), to wetlands (Mahlatini et al., 2018; Wang et al., 2019), and beaches (Deacon & Kolstad, 2000; Pascoe, 2019; Windle & Rolfe, 2013; Zhang et al., 2015). An unpriced benefit refers to activities or goods that can have a monetary value but are not represented directly in the market.

For a market good, the consumer surplus (CS), or the difference between what someone is willing to pay minus what they actually pay, is derived from the demand curve (Kuosmanen et al., 2004). However, when dealing with non-market goods, specific valuation techniques are needed to construct a demand curve in order to derive the CS (Voltaire et al., 2017). The TCM looks at people's willingness to pay to visit a resource, as a function of how much they paid to get there (Clough & Bealing, 2018), and has become known as a strong technique to measure non-market values of environmental recreation. The TCM has also been extensively used to measure terrestrial based recreation, such as for forests or national parks (Amirnejad & Jahanifar, 2018; Borzykowski et al., 2017; Mayer & Woltering, 2018; Mendelsohn et al., 1992; Pak & Türker, 2006; Tardieu & Tuffery, 2019; Wan-Yu et al., 2019; Zandi et al., 2018).

Though not commonly used in the context of marine resources, it is worth briefly mentioning another way to measure indirect use values, using the hedonic pricing method. The hedonic pricing method, commonly used in relation to housing prices, attempts to relate the price of a market good to its underlying characteristics, such as its proximity to a particular park or amenity (Clough & Bealing, 2018). To use this method to value recreation

requires a large dataset of property values, and the capability to control other influential variables. Because property values are the main variable, this method is also only applicable in an urban context, since a remote area that is not near a residential or urban area would be valued incorrectly (Clough & Bealing, 2018).

Both the TCM and hedonic pricing method, are considered revealed preference methods, in which one observes the behaviours of individuals who are frequenting a specific site. Fisheries and tourism are commonly valued by direct market techniques, or their market prices, i.e., how much tourists spend, and jobs generated by the industry, and values of a fish multiplied by the amount caught (Barnes-Mauthe et al., 2013; Klein et al., 2004; Laurila-Pant et al., 2015). Fisheries and tourism are of particular interest within the literature, due to their direct tie to human activities and well-being. Within a New Zealand context, using only these direct market techniques would give an incomplete, or a lower bound estimate, of the value of the environment, due to the fact that New Zealand has many areas of environmental significance that you do not have to pay to access (Clough & Bealing, 2018).

2.6.2 Non-use Values

Since Arrow et al. (1993), non-use values have been heavily incorporated into the literature, providing methods that are commonly used to address values that do not have a market (Brouwer et al., 2016; Loureiro et al., 2009; Voke et al., 2013). Non-use values are estimated through stated preference methods, such as contingent valuation techniques and choice experiments. Both methods use a hypothetical scenario to determine someone's willingness to pay (WTP) to protect a resource, for example. These techniques can be applied to a broader population than those who currently use a site (Clough & Bealing, 2018).

To examine the non-use values of marine protected areas, Brouwer et al. (2016) used a contingent valuation method in order to determine a household's willingness to pay to protect a remote area in the Netherlands. Over the summer of 2006, the authors interviewed six hundred visitors face to face at eleven different beaches, with a response rate of 65 percent; as well as sending out a mail survey randomly to seven thousand Dutch households, with a response rate of 17 percent. Three different protection scenarios were used. One representing the status quo, the second placed strict control on fishing, shipping, sand extraction and gas drilling within the MPA, and the third was a complete ban on these activities (Brouwer et al., 2016). They found that even though it was remote, people knew what they were paying for, and that the mail survey respondents were willing to pay €56.5-€109.9, and the interviewed respondents were willing to pay €80.1-€168.8 to protect that area. In another study Bhat

(2003) used contingent valuation in addition to the TCM to determine the value of installing a new marine reserve in the Florida Keys, USA, and found that it could potentially produce US\$547 million in annual benefits. When using these methods to try to value a part of the environment, it is important that the way respondents are presented with information is clear and concise, especially if respondents are unfamiliar with the good, otherwise the WTP will not be accurately represented (Barkmann et al., 2008; Börger et al., 2018; Huff, 2016). This is particularly true in the instances of marine protected areas, or places that the public might not necessarily interact with or see regularly.

Contingent Behaviour (CB) is another type of stated preference technique. It differs from contingent valuation in that it generally is not asking what one would be WTP but is eliciting behavioural changes the respondent would make regarding a hypothetical situation regarding environmental quality (Lankia et al., 2019). It is commonly used by asking for a change in visitation rates (Kipperberg et al., 2019) under different environmental quality scenarios. CB may also improve the efficiency of the estimation of recreational benefits (Huang, 2017). Most commonly, it is combined with a revealed preference technique, such as TCM, in order to assess environmental quality changes or changes in site access (Alberini & Longo, 2006; Englin & Cameron, 1996; Huang, 2017; Lankia et al., 2019; Prayaga et al., 2010; Rolfe & Dyack, 2011). It may also be applied in a specific policy driven context, such as investigating the impacts of offshore windfarms (Kipperberg et al., 2019; Parsons et al., 2020; Voltaire & Koutchade, 2020), land and sea mining (Folkersen et al., 2018; Kosenius & Horne, 2016), and new walking trails (Hynes & Greene, 2016).

2.6.3 The Travel Cost Method for Valuing Outdoor Recreation

Natural resources are commonly used for recreation activities, and often are not valued through a direct marketplace, meaning that they are free to access, or of very low cost (Freeman et al., 2014; Kleppe & Jensen, 2018). And as discussed earlier, the benefits gained from utilizing these recreational areas are not observed directly through the market. Clawson and Knetsch (1963) identified five clear phases of the recreation experience: planning or anticipation, travel to the recreation site, on-site experiences, travel back to origin, and recollection of the experience. These divisions make estimating the recreational demand more manageable, with the TCM clearly stemming from the second phase. Outdoor recreation is unique, in that it involves three kinds of coin: dollars, time, and travel, emphasizing that the cost must be for the whole recreation experience, not just the cost of admission or direct spending (Clawson & Knetsch, 2011).

The initial idea of using travel costs as a means of estimating a demand curve for recreation, is believed to have originated in a letter written by Harold Hotelling to the United States Parks Service in 1947 (Bowker et al., 2005; Clawson & Knetsch, 2011; Graves, 2013; Phaneuf & Smith, 2005), in which he described that the value of access to a recreation site, or what people are WTP in order to conserve or protect a given area, can be assumed through the costs associated with getting to the site (Huff, 2016; Phaneuf & Smith, 2005). It is well adapted for areas such as national parks and wildlife reserves, when considering the recreational benefits of the site (Huff, 2016). The information that is linked with the visitors to the site, i.e., the time and cost it takes to get there, is commonly extracted through interviews via questionnaires, and using a regression analysis allows one to derive the total CS for a recreational place (Amirnejad & Jahanifar, 2018). Figure 4 shows that the CS is the measure of non-market benefits to the recreational user and is the difference between what the user would be WTP, and what they are required to pay (Pascoe, 2019; Voltaire et al., 2017). This value can be calculated through the negative reciprocal of the cost coefficient in a count-data regression model (Loomis et al., 2008; Mingie, 2011).

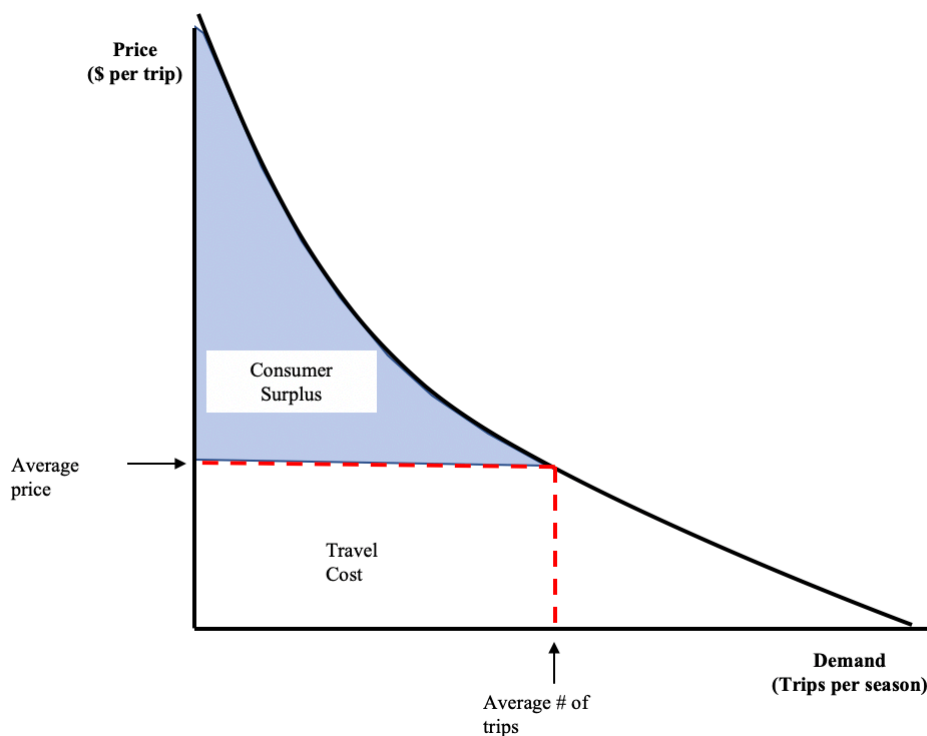


Figure 4: Simplistic graphical representation of the TCM model.
 Source: Adapted from (Blaine et al., 2015; Sohngen et al., 1999).

The TCM can be divided into three subsets, the zonal travel cost method (ZTCM), the individual travel cost method (ITCM), and the random utility model (RUM) (Torres-Ortega et al., 2018). The former of the three methods was the earliest developed, however recent studies tend to focus primarily on the ITCM, which derives results at the household or individual level (Martínez-Espiñeira & Amoako-Tuffour, 2009; Phaneuf & Smith, 2005). ITCM is considered to be the more accurate way of measuring the consumer surplus of recreation demand, since it uses the individual visitors' results in the statistical analysis (Zandi et al., 2018).

However, with recent advancements in geographical information software, ZTCM has seen a resurgence (Fleming & Cook, 2008; Han et al., 2013), but this is primarily due to the less extensive data collection and analysis that is required (Marini Govigli et al., 2019). Nevertheless, it is popular amongst valuations of emblematic sites, which are usually visited by the majority of people only once or a few times (Fleming & Bowden, 2009; Han et al., 2013; Poor & Smith, 2004; Torres-Ortega et al., 2018; Voltaire et al., 2017). A constraint for ZTCM, is that you are assuming a homogenous population within your defined geographic zones, which is not necessarily the case (Bhat et al., 1998). The defined zones are also determined by the author and vary within the research. The main concern being whether the zones accurately represent the sampled population (Marini Govigli et al., 2019).

The Random Utility Model (RUM) combines a TCM and a contingent valuation to determine the number of trips to a specific site among a set of different possibilities (Torres-Ortega et al., 2018). More specifically, it looks to determine how a few attributes of several sites affect a visitors' decision process and allows measuring these characteristics, deriving a utility function (Bell, 2002; Torres-Ortega et al., 2018). The RUM presumes that an individual will choose a single site over all possible substitutes, to maximize their utility, and is the most data intensive and intricate of the TCM (Wang et al., 2020). A slight variation of the RUM model is the Kuhn-Tucker model, which allows for the characterization of the occurrence of corner solutions (Phaneuf et al., 2000). Corner solutions refer to being able to account for those individuals who always will, or always will not utilize a recreation site, no matter the situation. According to von Haefen and Phaneuf (2005), this model is better suited for seasonal recreation demand and multiple site analysis than a discrete choice approach.

2.6.4 Considerations While Using the Travel Cost Method

Throughout the literature, there are a few commonly criticised practical difficulties regarding valuing recreational and environmental sites using the TCM. Blaine et al. (2015) and Graves (2013) identifies:

- Truncation, endogenous stratification, and overdispersion.
- How to deal with multipurpose and multi-destination trips.
- Opportunity cost of visiting the recreation site.
- Treatment of substitute sites.

Since TCM has been around since the 1960s, there have been many studies done to try and correct these issues. Sampling traditionally has occurred at the recreation site; therefore, these are discussed in turn now.

2.6.4.1 Truncation, Endogenous Stratification, and Overdispersion

On-site surveys can lead to two potential biases: truncation and endogenous stratification. Truncation refers to there being no ‘zeros’ in the data since everyone interviewed has been to the recreation site at least once, while the endogenous stratification bias results from the fact that people who frequent the site are more likely to be sampled than those who do not visit regularly (Blaine et al., 2015; Pascoe, 2019; Shaw, 1988). Truncation can be observed at both ends of the scale. The lower end is that there cannot be negative visits, and the upper end is that abnormally far distances have been travelled to get to the site, or excessive visits are observed (Blaine et al., 2015). However, these biases can be corrected for and will be discussed further in Chapter 3: Methodology (Bhat et al., 1998; Blaine et al., 2015; Borzykowski et al., 2017; Bowker et al., 2005; Englin & Shonkwiler, 1995).

Overdispersion is a frequent problem encountered throughout the TCM because few people make many trips, and many people make few trips. This leads to the variation of the dependent variable within the demand function to be larger than the mean (Martínez-Espiñeira et al., 2008). These authors wanted to see if there was a significant impact on the welfare estimate by comparing onsite sampling results (which exhibits overdispersion and truncation) to household survey results (data from Loomis (2003)), using negative binomial specifications with and without correcting for truncation and endogenous stratification (Martínez-Espiñeira et al., 2008). Their results showed that using negative binomial specifications, the simultaneous correction for truncation and endogenous stratification does bring the benefit measured from US\$46.71 to US\$19.95 for the on-site sampling, much

closer to the estimate that was obtained from the household surveys of US\$22.01. This shows that though on-site sampling can give exaggerated results, there are ways of correcting it that bring it closer to other survey methods.

2.6.4.2 Multi-purpose or Multi-destination Trips

It was originally thought that the TCM inherently assumes that all travel costs involved are exclusive to attain admittance to the single recreation site (Parsons & Wilson, 1997; Smith & Kopp, 1980), however this is not always the case, and often trips are focused on more than one destination, particularly for remote areas and for people who are on holiday for an extended period of time (Martínez-Espiñeira & Amoako-Tuffour, 2009). Parsons and Wilson (1997) suggested that these multi-destination trips can fall into two categories. Incidental consumption refers to trips that are being taken primarily for the purpose of visiting the selected recreation site, but allow for some other side trips, and therefore shift the function as any complementary good does on a demand model (Jiang, 2015) (Figure 5). Joint consumption refers to trips taken for dual purposes, in that if either purpose was lost, the whole trip would be forfeit (Parsons & Wilson, 1997).

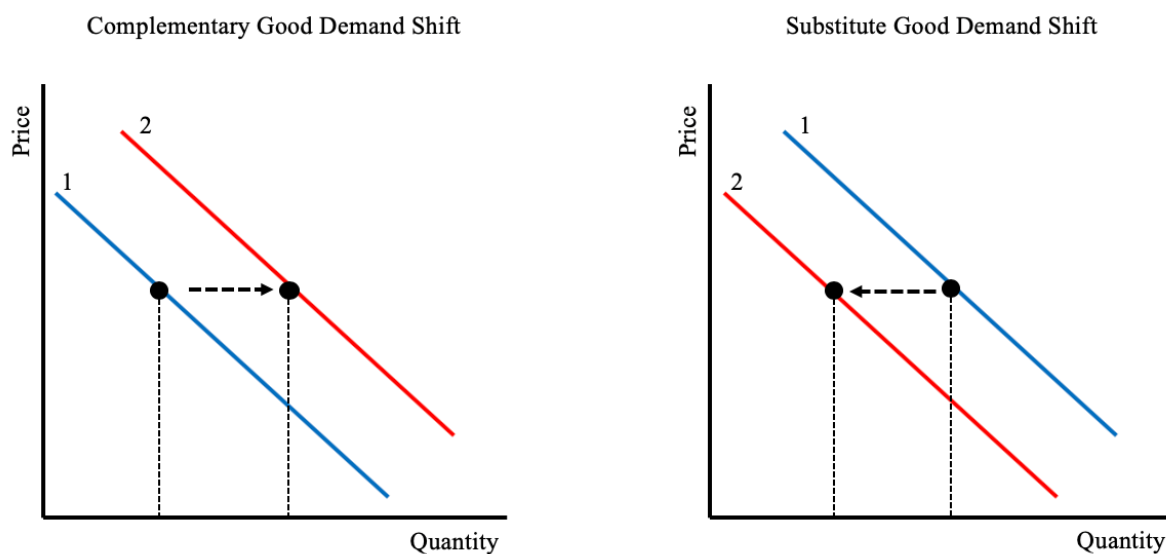


Figure 5: Demonstrates the shift in a basic demand function for complementary and substitute goods.

Source: Living Economics (n.d.).

Kuosmanen et al. (2004) suggest that the approaches that have been put forward to help deal with multi-destination trips fall into three broad categories: 1) to ignore them (either by exclusion or treating them as single destination visitors); 2) correcting multi-destination trip bias (usually by taking a proportion of the total attributed cost); or 3) multi-destination and

single destination trips separately. Excluding multi-destination trips will generally lead to an underestimation of the consumer surplus by as much as 50 percent, in turn underestimating the total value of the recreation site (Kuosmanen et al., 2004; Loomis et al., 2000; Martínez-Espiñeira & Amoako-Tuffour, 2009). Using ordinal ranking and weighting techniques based on satisfaction of visited destinations after they have completed their trip will yield different results than eliciting the visitors pre-trip consumption decisions, which is the main value one wants to gather (Kuosmanen et al., 2004; Martínez-Espiñeira & Amoako-Tuffour, 2009; Voltaire et al., 2017). It is worth noting that the zonal travel cost model is not currently capable of incorporating multi-destination/ multi-purpose (Huff, 2016).

2.6.4.3 Opportunity Cost of Time

How to measure and incorporate the opportunity cost of time while visiting the recreation site is still debated in the literature (Amoako-Tuffour & Martínez-Espiñeira, 2012; Zawacki et al., 2000). The assumption is that visiting a site suggests that one is foregoing not only income, but the opportunity of using that time in another way (Amoako-Tuffour & Martínez-Espiñeira, 2012). Early on, it was common to combine contingent valuation, or discrete choice model questions with the TCM method (Adamowicz et al., 1994; Álvarez-Farizo et al., 2001; Czajkowski et al., 2016; Englin & Cameron, 1996). However, more recently it is common to use a fraction of the wage rate, usually at a rate of 33 percent, but can range from $\frac{1}{4}$ to $\frac{1}{2}$ the wage rate (Amoako-Tuffour & Martínez-Espiñeira, 2012; Bhat et al., 1998; Blaine et al., 2015; Czajkowski et al., 2016; Englin & Shonkwiler, 1995; English et al., 2018; Mayer & Woltering, 2018). It is important to note that this is only relevant for those visitors who work full time. For example, visitors who are retired do not lose out on any potentially earned money, but their time still has value. A different opportunity cost is recommended for those who fall into this category, such as a lower fraction (Blaine et al., 2015). Travel time may also have a consumptive value, which is likely to be the case when traveling to national parks, UNESCO sites, and other natural wonders, given that most visitors are likely to derive some benefits enroute (Amoako-Tuffour & Martínez-Espiñeira, 2012). It has also been theorized that the opportunity cost of time should be able to be different for visitors based on their preferences (Czajkowski et al., 2016; Kleppe & Jensen, 2018).

2.6.4.4 Treatment of Substitute Sites

How to measure and determine substitute sites also deserves consideration. Generally, the RUM model deals with substitute recreation sites explicitly (Randall, 1994). Rosenthal (1987) wanted to determine how much CS estimates are affected by the treatment of substitute recreation sites, omitting substitute sites, including substitute sites, and a discrete choice handling with substitute prices. As suspected, omitting substitute sites yields higher CS values per person. However, according to Willis (1991), the inclusion of substitute sites did not significantly reduce WTP in a TCM model combined with contingent valuation questions, furthering that there is no one way to treat substitute sites. It is difficult to determine appropriate substitute sites and their respective prices, often resulting in substitutes being omitted (Kleppe & Jensen, 2018; Rosenthal, 1987).

Though this method has its challenges, there are various ways to correct/overcome them through statistical or sampling means. It is still generally accepted as being the best method for collecting data to determine the un-priced benefits of recreation.

2.6.5 Combined Travel Cost and Contingent Behaviour for Recreational Values

Recent studies suggest that combining the TCM and CB allows one to estimate the potential impacts that specific scenarios or situations may have on recreational values, with statistically significant findings. For example, some authors have attempted to identify the welfare impacts that offshore windfarms may have on recreationalists. Kipperberg et al. (2019) aimed to determine the potential effects of an offshore wind farm on beach and outdoor recreation on the south-west coast of Norway. It was found to decrease the CS for outdoor and beach recreation by 21% and 42% respectively when analysed by the random effects negative binomial. Similarly, Voltaire and Koutchade (2020) investigated four varying densities and distances of offshore windfarms from the beaches of Catalonia, Spain, revealing welfare reductions ranging from 3.17-64.44% for residents, and 4.86-50.15% for visitors.

Rolfe and Dyack (2011) estimated the reduction in CS of beach recreation in Coorong, Australia due to reductions in accessibility of the site. It was found to have a recreational value of AUD 242.08 per adult/year. Combining the CB data with the TCM information, and analysing it using the random effects negative binomial, was indicative of a marginal value of at least AUD 17.20 per person, for each one percent change in access. CB has been applied to estimate the effects of varying fishing conditions or prices have on CS (Englin & Cameron, 1996; Prayaga et al., 2010).

Previous studies that have investigated the impacts of different levels of water quality on the behaviour of visitors to recreation sites, have confirmed either that better quality will increase the welfare estimate, and or that worse water quality will decrease it. Bhat (2003) investigated the impacts on CS for not only improving water quality, but also fish abundance and coral quality in the Florida Keys, USA. The CS based on current conditions was found to be USD 2924, increasing to USD 5233, USD 5918, USD 6004 for improving fish abundance, improving water quality and coral quality, in that order.

Lankia et al. (2019) investigated the effects of intermediate, good, and poor water quality on swimming trips (both fresh and marine swimming) in Finland, with divisions between mode of transport: car drivers and walkers/cyclists. For current water quality, the CS was €16.1 for drivers and €6.8 for walkers/cyclists. Combining the CB data with the TC resulted in an intermediate water quality yield a CS of €16.4 and €6.5, a CS of €22.1 and €7.3 for good water quality, and poor water quality demonstrated a CS of €9.0 and €4.9 for drivers and walkers/cyclists, respectively. It should be noted that this study did not have any CB questions regarding future visitation rates in their estimations.

Similarly, Börger et al. (2021) estimated the value of blue space (water-based sites accessible to people) across Europe and found that for the adult population surveyed there was value of €631bn per year. Including the effects of water quality, an increase of quality was found to have total annual value of €41.89bn, whereas decreasing water quality was found to have an annual loss of €130.79bn. Water quality for this study was based on levels of bacteria. The welfare effects to possible changes in water quality due to climate change and eutrophication in the Baltic Sea area were investigated by Bertram et al. (2020). Four different scenarios were considered, and of the scenarios that looked at worse environmental conditions or different levels of facilities, there was a negative change in CS ranging from €219-536 billion compared to current conditions.

The possible impacts of improving ecosystem services have also recently been considered. Mäntymaa et al. (2021) used this combined approach to estimate the value of recreational ecosystem services within an urban park in Finland. Improvements of three types of services provided by the urban park were considered, being the restoration of brown trout populations, increased number of happenings or visits, and a restaurant on site. Separately, these services demonstrated increased visits between 14 and 21 percent, and all services combined increased visits by 66 percent, representing an increased value of approximately €75.7 million.

2.7 The Economics of Oil Spills

This section will describe various economic studies that have been conducted regarding marine oil spills. Most of the studies discussed will be from tanker accidents, rather than other types of marine oil spills.

There are different factors that determine how much an oil spill, and its response will cost, including the type of oil, weather and sea conditions, time of year, amount and rate spilled, physical, economic and biological characteristics of the spill location, and the effectiveness of the clean-up (White & Molloy, 2003). With the technical factors in mind, Liu and Wirtz (2006), divided the costs into five categories that can be associated with an oil spill. These are environmental damages, socio-economic losses, removal of the oil, research, and other costs; each of these categories comprising use and non-use values that could be analysed. To date, research has focused primarily on the environmental damages and the socio-economic damages caused by oil spill events.

Since the *Exxon Valdez* oil spill, a lot of studies have used the contingent valuation method in order to try to understand the non-use values temporarily lost to an oil spill. Carson et al. (1992) was the first major study to discuss these non-monetary values lost. It was an extensive survey that included all 50 states of the USA, went through multiple testing rounds, and asked survey respondents what they would be WTP to prevent another large oil spill from happening again in Prince William Sound. It was estimated that the median household willingness to pay for the proposed management plan was a one-time tax payment of \$31USD, and once multiplied by the number of USA households resulted in a damage estimate of \$2.8 billion USD, a conservative estimate (Carson et al., 1992, 2003). This study prompted the NOAA to review the relevance and methodology of contingent valuation in estimating passive-use values. It was decided that survey designs needed to be: (1) conservative, (2) use willingness to pay instead of willingness to accept, (3) the valuation questions should be in the form of a referendum, (4) adequate information must be provided to respondents so that they can make an informed decision, (5) provide respondents with environmental alternatives, (6) photographs must be used carefully, (7) the survey must only take place once enough time has passed, (8) a 'no answer' must be included for the referendum vote, and (9) respondents should be asked follow up questions to their answers (Arrow et al., 1993). WTP differs from willingness to accept in that the WTP is the amount one would be willing to offer to pay for a good, and willingness to accept is the minimum

amount one would be willing to accept to forgo a good or service (Martín-Fernández et al., 2010).

The conditional acceptance of this method led to many more studies being done for the passive or non-use lost values of oil spills, including studies done for the *Prestige* (Loureiro & Loomis, 2013; Loureiro et al., 2009; Loureiro et al., 2006), and for *Erika* (Bonnieux & Rainelli, 2003). There is still debate as to how reliable these values are, and therefore they are currently not incorporated into claims. Kim et al. (2017) tried to overcome the challenge of the contingent valuation method by performing a habitat equivalency analysis for the *Hebei Spirit* oil spill, similar to the Natural Resource Damage Assessment that is practiced in the United States today, which is predominantly based on restoration cost, but also requires physical, biological, and economic data. Focusing on the injured fisheries, the base case cost of restoration for 10 years was a total of US\$119.4 million at a 5.5 percent discount rate. Economic losses of recreation have been described for a few oil spills, and commonly look at the loss of recreation days due to beach closures, fishing bans, etc. (Bonnieux & Rainelli, 2003; Carson & Hanemann, 1992; Court et al., 2017; English et al., 2018; Garza et al., 2009). These studies commonly combine the travel cost method, being household or individual, with the contingent valuation method.

The *BP Deepwater Horizon* oil spill (20 April 2010) is the largest oil spill to have ever occurred in U.S. waters, spilling more than 440,000 tonnes of oil throughout the Gulf of Mexico, affecting more than 2100km of coastline across multiple states (English et al., 2018), which included popular beaches and fishing sites. English et al. (2018) conducted an extensive travel cost study consisting of local (6 states located along the Gulf of Mexico) and national populations, using a combination of phone, mail and in person surveys, with over 40,000 responses. Once fully compounded for the years 2010 to July 2015, the primary study of damage estimates for the studied shoreline activity was USD 520 million (USD 2015). A similar study by Court et al. (2017) looked at the impact of *BP Deepwater Horizon* oil spill in Northwest Florida by analysing the cost of cancelled recreation trips to the region by conducting household surveys in 13 different states. It was found that 1.88 million visitors' trips were cancelled to the area, resulting in an economic loss of USD 1.30 billion (USD 2011). Alvarez et al. (2014) used RUM to value the changes of a natural resource's quality that occur over a large region. Specifically, the authors looked at recreational anglers in the Southeast US, consisting of seven different states, and varying recreational fishing modes. Their estimate of losses by recreational users ranges between USD 459 and USD 711 million.

Similarly, Wang et al. (2020) used the Kuhn-Tucker model to estimate the recreational welfare losses of closed sites in Louisiana in relation to the *BP Deepwater Horizon* oil spill. Their results suggested an aggregate welfare loss ranging from USD 0.66 million to USD 2.33 million depending on the site.

Effects on fisheries and tourism are more widely studied in relation to oil spills, since these values are tangible, and have a direct impact on the regional or local economy where the oil spill occurred, since seafood contamination can often cause short term closures of fisheries. Comparing pre and post spill landing trends and harvest volume are the most common method used to determine the effect a spill has had on a local fishing industry (Cohen, 1995; Depellegrin & Blažauskas, 2013; García-Negro et al., 2009; Garza-Gil et al., 2006a; Hill & Bryan, 1997; Loureiro et al., 2006; McCrea-Strub & Pauly, 2011; Pan et al., 2015; Sumaila et al., 2012; Suris-Regueiro et al., 2007). The negative effects experienced can be attributed to declines in certain fish populations due to mortalities but are primarily due to the industry closures that often results from an oil spill (Moller et al., 1999). It is largely agreed that an oil spill will have negative economic effects on the local fishing economy, however whether these effects will be long or short term is dependent on multiple factors, such as whether spawning occurs in that area, whether the oil is persistent and whether there is any damage to fishing gear (Alford et al., 2015; ITOPF, 2011a). Adult free-swimming fish of commercial importance rarely suffer long term damages from an oil spill, largely due to how quickly oil concentrations decline within the water column (ITOPF, 2011a). These economic impacts to tourism and fisheries are important to understand because the IOPC Fund will reimburse these private costs (Table 1), as long as proof is provided by the affected individuals (Garza et al., 2009).

2.8 New Zealand Marine Oil Spills

According to Maritime New Zealand (n.d.-c), there have been seven significant marine oil spills in New Zealand since records began.

- The *Don Wong* grounding in October 1998, was a Korean fishing vessel that ran aground off Stewart Island, spilling 400 tonnes of automotive oil into the ocean.
- The *MV Rotoma* created an oil slick 6km long, by discharging 7 tonnes of oily sludge off the Tutukākā coast in 1999.
- The *Seafresh 1* sank off the Chatham Islands in March 2000, spilling 60 tonnes of diesel into the ocean.

- The *Jody F Millennium* broke away from the dock in Gisborne, spilling 25 tonnes of fuel oil in February 2002.
- The *Tai Ping* ran aground near the entrance to Bluff Harbour in October 2002 but was able to re-float and ended up not spilling any fuel.
- The *Oyang 70* sank near the Bounties Islands in April 2010, however little information is available regarding this spill, and it was not responded to.
- The *MV Rena* sank off the coast of Tauranga, spilling 350 tonnes in October 2011.

A Tier 3 oil response was declared for the *Tai Ping*, *Jody F Millennium* and the *MV Rena*.

2.8.1 The *MV Rena* Oil Spill is the Most Recent and Largest NZ Response to Date

On the morning of 5 October 2011, the container ship *MV Rena* was on its way from Napier to Tauranga, when it struck Astrolabe Reef (Ōtāiti). The *Rena* was carrying 1,368 containers, and 1,733 tonnes of heavy fuel oil at the time of the incident (Maritime New Zealand, n.d.-b; Ministry for the Environment, 2011). That same evening, an oil leak was detected, and the salvage team began work on 9 October attempting to get as much oil off the ship as they could, but bad weather and equipment breakdowns slowed the process. The situation worsened when a storm came the night of 11 October, releasing an estimated 350 tonnes of oil into the ocean, and an additional 5-10 tonnes the night of 22 October (Maritime New Zealand, n.d.-b), with much of this spilt oil washing up on the shore along the Bay of Plenty coast. Overall, around 1,300 tonnes of heavy fuel oil were recovered from the ship by 15 November 2011. By 26 December 2011, 341 of the containers that were on board had successfully been removed. However, mid-January 2012 the *MV Rena* separated into two pieces, and of the remaining 830 containers, an additional 200-300 were lost overboard (Maritime New Zealand, n.d.-b).

Maritime New Zealand (MNZ) is the government agency responsible for the oil response, being responsible for clean-up on the water as well as on the coast. Part of MNZ response included the National Oiled Wildlife Response Team, which is led by Wildbase, Massey University. The wildlife response during the *Rena* rehabilitated a total of 383 birds (Sievwright et al., 2019), and processed over 2000 dead birds from 49 species, with 67 percent of the carcasses showing signs of oiling (Hunter et al., 2019; Ministry for the Environment, 2011).

The amount of oil that was ultimately released was considerably less than other oil spills globally, partly because the *Rena* was a container vessel rather than a tanker, and that the oil removal response was swift (Schiel et al., 2016b). However, the grounding of the *MV*

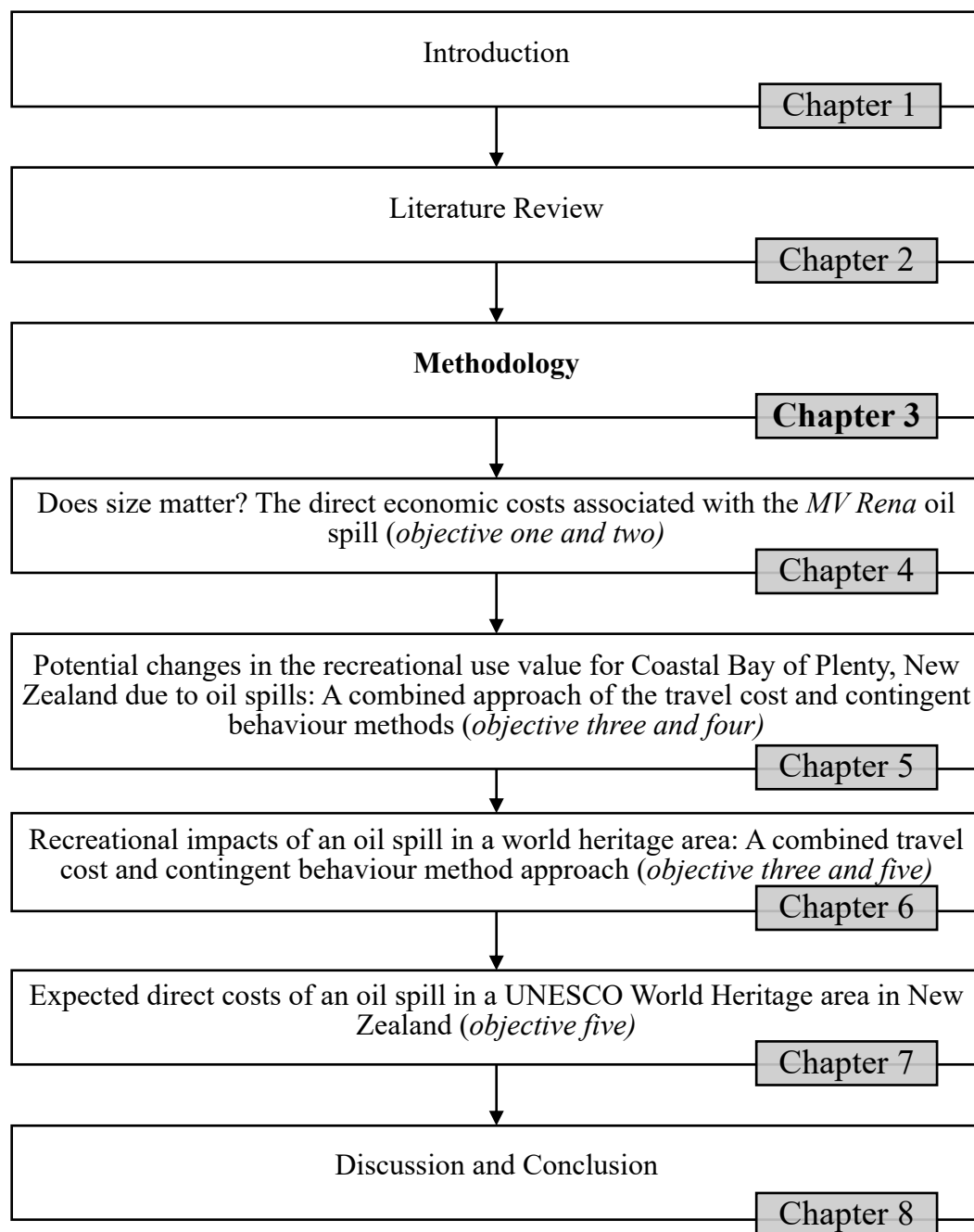
Rena is New Zealand's worst marine environmental disaster. Numerous studies were conducted to attempt to understand the ecological effects that were caused by the grounding of the *MV Rena*, with a special edition of the New Zealand Journal of Marine and Freshwater Research being dedicated to this topic (Volume 50, Issue 1, 2016).

In order to determine the effect on the benthic biota in the area, Ross et al. (2016b) collected the species *Paphies subtriangulata* (Tuatua, Surf Clam) a total of 14 times between October 2011 and June 2014 in multiple locations around the affected coastline, beginning two days after the grounding, to obtain a baseline concentration. The authors hoped that this species would be acceptable and comparable to other bivalves that have previously been used to test for contaminant levels due to oil spills, in addition to this bivalve being an important food source for the area. By analysing the PAH levels in this species, the authors discovered that there were relatively high concentrations of PAHs for the weeks following the spill, though the decrease in concentrations was just as rapid, returning to baseline concentrations within 6 months (Ross et al., 2016b). It should be noted that there is no pre-*MV Rena* data on the PAH concentrations for this species since the baseline concentrations were taken from right before oil came ashore, so the authors are unsure whether the somewhat high levels were there before the spill.

The contamination of sediments was also widely studied. Ross et al. (2016a) was able to collect sediment samples beginning in June 2013, attempting to trace the PAHs and other contaminants up the trophic food chain, at Astrolabe Reef, Mōtītī Island, and the control location, Tuhua (Mayor Island). At the time of publication 5 years after the incident, it was determined that there was persistent chemical contamination of Astrolabe Reef. In contrast, there was little evidence to suggest that Mōtītī Island, which was covered in debris from the spill, had any lasting contamination effects (Ross et al., 2016a). In a similar study, de Lange et al. (2016) took sediment cores from 12 different sites along the coast of the Bay of Plenty, and though they did not find any visible oil, PAHs that matched the oil fingerprint from the *MV Rena* were found in 11 of the 12 sites, with higher concentrations in the low tide/intertidal zone versus the high tide. Schiel et al. (2016b) surveyed eight of the largest accessible rocky reefs in the area, analysing the distribution of oil contamination, and the different ecological communities that were found at these sites. The authors discovered that though there was localized contamination, it had an insignificant ecological impact, with effects not being detectable after one year.

As demonstrated in this literature review, there is a clear gap in the literature regarding the economic research done around small/medium sized oil spills. This thesis aims to fill this gap, by looking at the direct costs associated with the *MV Rena* oil spill, and a hypothetical oil spill in Milford Sound, Fiordland National Park. The methodologies used to do this will be covered in the following Chapter 3: Methodology.

Chapter 3: Methodology



The following chapter will discuss the primary methodologies used in the data chapters. First, the two separate sites that were chosen for this research, Coastal Bay of Plenty, and Fiordland National Park, will be described. These two sites represent (1) a populated area within New Zealand where the country's largest marine oil spill occurred, and (2) a remote area within New Zealand that would prove to be logistically difficult in a response and have potentially large economic consequences. The methods used for clean-up costs, fisheries, and tourism

are described, and will be repeated in brief in Chapter 4: Does size matter? The direct economic costs associated with the *MV Rena*, and Chapter 7: Expected direct costs of an oil spill in a UNESCO World Heritage area in New Zealand. The methodology covered for valuing recreation, will be repeated in brief in Chapter 5: Potential changes in the recreational use value for Coastal Bay of Plenty, New Zealand due to oil spills: A combined approach of the travel cost and contingent behaviour methods and Chapter 6: Recreational impacts of an oil spill in a world heritage area: A combined travel cost and contingent behaviour method approach. Due to the nature of this thesis with publication, there will be repetition of the methodologies amongst chapters.

3.1 Site Selection

Tauranga is in the Bay of Plenty on the east coast of the North Island, New Zealand (37° 32.446 S, 176° 25.625 E). It is the 5th most populated city with over 150,000 residents and has the fastest growing population within the country (Statistics New Zealand, 2021a). The Port of Tauranga is the largest port in New Zealand, and as of 2017, was handling 37 percent of all shipping containers into the country (Port of Tauranga Limited, 2021b). This area is also home to a large cruise ship industry. For the fiscal year ending June 2019, a total of 116 cruise ships visited the port, an increase of 39.8 percent from the previous year (Port of Tauranga Limited, 2021b). The large amount of shipping and cruise activity puts the Tauranga shoreline at high risk of an oil spill occurring (Bermingham, 2015).

The Bay of Plenty marine area is a large, sheltered coastline, with long stretches of white sandy beaches, large marinas, and various islands that can be visited along its coast. This makes it a popular tourist destination for both domestic and international visitors. It also is the location of New Zealand's largest marine oil spill. On 5 October 2011, at 2.20 am the container ship *MV Rena* was traveling from Napier to Tauranga, when it ran aground on Astrolabe Reef (Otāiti), approximately 10 nautical miles off the coast of Tauranga. The *MV Rena* ultimately released 360 tonnes of heavy fuel oil. In this research, when Coastal Bay of Plenty (CBoP) it is referring to the stretch of beach from Mount Maunganui to Maketu (Figure 6).



Figure 6: Map of the two sites selected for research, Mount Maunganui to Maketu for the stretch of beach impacts by the MV Rena (represents populated area), and Milford Sound in Fiordland National Park (represents remote area).

Fiordland National Park is located on the West Coast of the South Island of New Zealand (Figure 16). It is one of the four national parks that make up the UNESCO World Heritage site Te Wāipounamu (UNESCO, 2004). Fiordland National Park is the largest national park in New Zealand, with a land area of over 40,000 ha, and is known for its natural flora, and diverse and abundant unique wildlife (DOC, 2017a). The distinctive land characteristics are matched by an equally rare aquatic environment. The freshwater that flows into the fiords from the numerous rivers and streams is stained with tannin and obscures the marine water beneath it at times up to a 10 m depth of freshwater (DOC, 2017a).

Fiordland National Park is comprised of many sounds, with the most well-known and most accessible being Milford Sound (Figure 6). Milford Sound is the most northerly sound in the National Park and receives as many as 500,000 visitors a year, making it the main area for tourism in Fiordland National Park (Fiordland Marine Guardians, 2017). Along the northern side of the sound is the Piopiotahi Marine Reserve, which is one of the most popular dive spots within Fiordland National Park (Fiordland Marine Guardians, 2017). Milford Sound is reachable by road; however, it is 120km from the nearest town Te Anau via a 1.2km one-way tunnel, making it approximately a 2-hour drive (Statistics New Zealand, 2021b). Milford Sound is 270km and 290km from either of the closest cities, Invercargill or Queenstown respectively.

3.2 Clean-up Costs

Data on the total *MV Rena* clean-up costs incurred by the New Zealand government as of 29 January 2013 are publicly available through The Treasury of New Zealand. A request filed with MNZ through the Official Information Act 1982 provided a breakdown of the costs incurred to MNZ during the response to the *MV Rena* oil spill. A request for information was also filed with Bay of Plenty Regional Council for their remaining costs associated with the *MV Rena* oil spill.

To estimate the possible clean-up costs of an oil spill occurring in Milford Sound, assumptions must be made. A hypothetical oil spill scenario was determined that (1) spilled approximately 350 tonnes of heavy fuel oil in the summer season (the amount of oil released by the *MV Rena*), and (2) had varying oil spill response times of 3-, 6-, and 12-weeks. Using the clean-up cost breakdown from the *MV Rena*, assumptions and modifications will be made to estimate the costs associated with a spill occurring in Milford Sound, Fiordland National Park.

The clean-up costs that are discussed in relation to this aforementioned oil spill in New Zealand will then be compared with results using Etkin (2000) proposed algorithm which is based on the cumulative averages of past spills (Equation 1). This algorithm uses the response cost (C_u) per unit (i) for the specified scenario, which is calculated using the cost per unit spilled for the scenario (C_{li}), the type of oil (t_i), how widely the shoreline is oiled (o_i), the main clean up mode (m_i) and the spill size modifier factor (s_i). The C_{li} is estimated using a regional multiplier (r_i), a modifier for where the spill occurred in relative to the coast (l_i), and the general cost per unit in nation (C_n). However, the actual per unit cost of the *MV Rena* was used for this variable, since it is the most recent and important spill to be compared to the scenario put forward. The estimated total response cost (C_{ei}) for this specified scenario is calculated by multiplying the C_{ui} and a specified spill amount for the scenario (A_i). A regional multiplier (r_i) is included in the Fiordland estimate, to account for the remoteness of the site. This is usually determined by considering factors such as the location of the site or if the wage rate is higher in that nation (Etkin, 2000).

$$C_{ui} = C_{li}t_i o_i m_i s_i \quad \text{where} \quad C_{li} = r_i l_i C_n \quad \text{and} \quad C_{ei} = C_{ui} A_i \quad \text{Equation 1}$$

The current daily hire rates from Maritime New Zealand for the equipment that would be needed for an oil spill in this area will also be discussed. An estimate of what equipment would be needed was determined based on consultation with a senior oil spill response technician from Maritime New Zealand, Marine Pollution Response Services.

3.3 Fisheries

The direct cost to fisheries is the loss of fish revenue, while the area around the oil spill was unable to be fished. Only the losses of port landings will be considered. For the *MV Rena* direct fishery costs to be estimated, data were collected through Fisheries Science and Information within the New Zealand Ministry for Primary Industries (MPI) under the confidentiality deed between MPI and Massey University. The estimated catch landings (kg) for Fishery Management Area 1 (FMA1) represents the greater fishing area where the *MV Rena* oil spill occurred. All reported fish catches were requested, as well as their corresponding yearly port price greenweight value. The greenweight refers to the weight of the entire fish, not necessarily the meatweight at market. For species that are measured in meatweight (such as scallops) and individuals (such as oysters and certain finfish), this data was also ask for. Fisheries data is documented from October to September, so for example,

2006 is from October 2005 to September 2006. The port prices are managed by the Fisheries (Cost Recovery) Rules 2001 (Cartwright, 2016). A voluntary survey is conducted with those who are permitted to sell the fish, where they can submit the landed price (port price) that they received for the fish. Specific parties, such as fisheries managers, use these recorded port prices to set deemed values. Deemed values are the prices that one would have to pay if their annual catch is greater than their entitlement. This information combined with the catch landings allow a Port Landing Value (PLV) to be calculated by multiplying the two. The data collected for FMA1 is further broken down into smaller statistical areas within the whole FMA1, with the specific statistical area where the spill occurred, SA009, also being investigated. Following Loureiro et al. (2006), landings, and the corresponding vessel port prices will be used together to estimate the impact to the local commercial fishery, based on pre and post *MV Rena* catch data and value estimates.

For the hypothetical Fiordland National Park (FNP) fishery losses, the same information and procedure was done for the relevant fishery management area, FMA5, and the statistical area, SA032, to see the current trends in landings and PLV. However, this data alone does not represent all the possible direct fishery losses. There is very little fishing that occurs within Milford Sound, but what is landed at the port is important, given it would most likely be closed during the response period for an oil spill. Therefore, the loss of value to the fishing industry were the Milford Sound Port to be closed for a length of time (3-,6-,12-weeks) due to an oil spill focuses on the catch that is landed at the port, namely the crayfish (also referred to as lobster) of the CRA8 fishery area. The CRA8 fishery provided approximations regarding the monthly number of tonnes of crayfish landed at the Milford Sound Port. Although there may be some overlap among values between CRA8 and SA032, based on a discussion with a delegate from CRA8 (Chief Executive Officer, 2021), the fishing area expands beyond the immediate statistical area, SA032. Crayfish are particularly important since it must be landed live and has a high PLV. After an oil spill, these ships would be able to enter/return to the port but would not be able to leave until the response slowed enough that it was safe and clean enough to do so. Furthermore, as the only access to Milford Sound is through a 1.2km one-way tunnel, which is likely to be inaccessible to all travel except response equipment and personnel, even if fishing vessels are returning to port, they would not be able to be resupplied, or unload live fish.

3.4 Tourism

The direct costs to tourism will be estimated using pre- and post-spill spending for domestic and international visitors alike. Tourism spending data for the potential losses due to the *MV Rena* were collected from the yearly Regional Tourism Estimates (RTEs) from the Ministry for Business, Innovation, and Employment, with records for the area only beginning in 2009, year ending in March. The RTEs provide absolute dollar estimates of tourism expenditure at the regional level for stakeholders. The RTEs are derived from three data sources, the Regional Tourism Indicators, the International Visitor Survey, and Statistics NZ's Tourism Satellite Account. The time period of 2009-2013 was investigated, in order to compare pre- and post-spill spending habits of visitors to the area. This allows assumptions to be made around the impact of the *MV Rena* oil spill to the tourism of the Tauranga area.

The tourism estimates for Milford Sound, Fiordland require a larger scope due to the unique tourism makeup of the area. Fees are collected by Milford Sound Tourism Ltd. for each individual travelling on a tourist vessel that leaves from Milford port. By looking at the amount charged per person, and the number of visitors who utilize the tourism boat trips over the scenario's timeframe, possible losses can be estimated. Fees that are collected by Environment Southland based on the tonnage of the cruise ships that wish to enter the Fiords are also estimated. Unfortunately, the long-term monthly visitation rates of these two categories were not obtainable, so only the most recent year of 2019 will be used to produce loss estimates.

Another common form of tourism/transportation are the buses that run from Queenstown and Te Anau to Milford Sound. Some of these services are strictly transportation, whereas other tickets will include boat/kayaking tours in Milford Sound. The ticket prices that include a tour of some kind, also include the fee that is collected by Milford Sound Tourism Ltd. at the port, so this will be deducted from the estimates to avoid overlap. Three companies will be considered; these companies were selected since there is the publicly available ticket prices, they operate consistently throughout the year, and are featured prominently on tourism websites. Assuming that there is one bus operated for each company every day, that each bus has approximately 30-50 seats, and that in the summer season 70-100 percent of the seats on the buses are taken, losses will be estimated. While there are different ticket prices for adults and children, only the adult ticket prices will be included in this estimate.

For the cruise options that do not include transport, four companies will be included for analysis. Though there are more options, these were the companies listed prominently on tourism websites as well, and some of these overlap with the previous ones. Assuming that there are two cruises operated for each company every day (except for those that said otherwise), that each boat holds approximately 100 people (except where explicitly stated otherwise), and that in the summer season 70-100 percent of the spots on the cruises are taken, losses will be estimated. The fees collected from Milford Sound Tourism Ltd. are included in all ticket prices, so this will also be removed to reduce overlap. Like the bus prices, there are different ticket prices for adults and children, however only the adult ticket prices will be included in this estimate. Some cruises run more frequently over the holiday season, but this will not be considered since there will already be overlap between the bus prices that include a cruise tour.

It is assumed that there would be a decrease in spending in the event of an oil spill, in that people would no longer wish to visit that area. It is also important to note that CBoP and FNP have a different visitor structure, in that CBoP is a popular destination amongst domestic travellers, and FNP has a high international visitor rate.

3.5 Wildlife & Environment

For the wildlife and environmental *MV Rena* impacts, the cost of the wildlife response as provided by MNZ will be described. As for the environmental effects, a review of the literature to date is provided in 2.8.1. For Chapter 7: Expected direct costs of an oil spill in a UNESCO World Heritage area in New Zealand, the possible impacts to wildlife and the environment will also be considered. To estimate the possible impacts of an oil spill on wildlife, one first must ascertain which species are at risk. This includes finding information about what types of wildlife is found in the area, their abundance and year-round occupancy, including whether they breed in the area. From a wildlife response viewpoint, it is also important to have the New Zealand and International Union for the Conservation of Nature (IUCN) conservation / threat status, to set priorities in the event of a response occurring. The unique characteristics of the environment will also be discussed, and the potential effects of oil contamination, based on the literature for similar wildlife.

3.6 Recreational Value – Survey Design

Tauranga, Bay of Plenty, New Zealand and Fiordland, Southland, New Zealand, are two sites with little in common. Tauranga represents a populated area on the northeast coast

of the North Island of New Zealand and is the location of the country's largest port and international freight gateway (Port of Tauranga Limited, 2021b). Whereas Fiordland represents remote, unpopulated fiords extensively covered in native forest which is an UNESCO World Heritage site in the southwest of the South Island. Generally, Tauranga receives more domestic visitors yearly, and Fiordland receives more international visitors. This leads to more repeat visitors to Tauranga, versus people who might only visit Fiordland once, or a few times. Because of the expected differences in demographic and repeat visitations, two separate surveys have been designed to capture information needed for the ITCM analysis. As stated earlier, ZTCM is more commonly used for emblematic sites, such as UNESCO World Heritage sites, whereas ITCM is more appropriate for sites that are visited frequently. However, only ITCM analysis will be performed, combined with a set of contingent behaviour questions, to illicit a change in visitation behaviour in the event of an oil spill. This was chosen based on previous studies using a combined approach (Hynes & Greene, 2016; Kipperberg et al., 2019; Rolfe & Dyack, 2011), that ITCM is more accurate because of its use of individual information (Zandi et al., 2018), and to make the results comparable between FNP and Coastal Bay of Plenty (CBoP).

Survey design was influenced by the TCM literature, with the main influences being Martínez-Espiñeira and Amoako-Tuffour (2009), Fleming and Bowden (2009), and Jiang (2015). These represent TCM studies done using TCM for UNESCO sites, as well as within a New Zealand context.

Since one of the main objectives of this thesis is to determine the total use values lost to the *MV Rena* oil spill, the questions for Tauranga have been modelled off of the impacted coastal sites, as well as being combined with the destinations that Bay of Plenty Tourism recommend on their website. The survey for Milford Sound, Fiordland will have different answers for activities and motives for visiting to accommodate the site, but the same questions will be asked. Though the questions have changed, the survey stays true to the literature and the kinds of questions that need to be asked to gather the necessary data to conduct a thorough analysis.

The survey designs were originally intended to be for both domestic and international visitors, but due to COVID-19 (2020-2022) and the border restrictions (New Zealand was closed to all international visitors), the decision was made to not include international visitors. Generally, New Zealand has a high incidence of international visitors, so all the results provided in this thesis will be lower-bound, but relevant to the world of COVID-19

that is currently being experienced. Though this will result in estimates being significantly lower than anticipated, it will provide us a national perspective of how New Zealand residents value these two recreational areas within their country. This is anticipated to be more prevalent in the Fiordland results, in that Fiordland is usually high in international tourist activity (Great South, 2019a), whereas Tauranga is a popular travel destination for New Zealand residents (Ministry of Business Innovation and Employment, 2021). The surveys were sent out to two New Zealand experts to help develop the contingent behaviour questions and clarify the wording of the other questions for a New Zealand audience.

3.6.1 Cost of Travel

Both surveys asked respondents about their current visit to the site including expenditure. These expenses can be divided into three categories: direct cost of travel, cost of time, and other expenses; all these factors together contribute to the travel cost.

Direct travel expenses refer to the round-trip costs from the respondent's permanent residence, including the mode of transportation and accommodation. To calculate the cost of transit, respondents were asked what mode of transportation used (personal vehicle, plane, cruise ship, bus, etc.), as well as their postal code. If a personal vehicle/rental car was used, the type of vehicle and what kind of power used (petrol, electric, etc), was asked for. The distance and costs associated with traveling to the site can then be estimated. This is a common way to calculate travel costs within the literature (Jiang, 2015; Loomis & Santiago, 2011; Loomis et al., 2008; Marini Govigli et al., 2019; Martínez-Espiñeira & Amoako-Tuffour, 2009; Matthew et al., 2019), rather than asking the respondents to estimate how much their journey cost. This information is followed by asking the respondent their 'travel party size,' since it is common for people traveling together (such as a couple or family) to share expenses. This allows the calculation of the appropriate per-person travel cost.

The issues and methods regarding measurement of the cost of time were discussed earlier in Chapter 2: Literature Review. For the purposes of this study, I decided to not include the opportunity cost of travel time. This is because it has been found to not substantially bias consumer surplus estimates when it is excluded (Voltaire et al., 2017), but has been shown to decrease the statistical precision when included (Kipperberg et al., 2019).

3.6.2 Demand Shifters

Within a travel cost survey, it is necessary to include various demographic variables that are commonly viewed as demand shifters. These factors are believed to impact the

demand model in addition to travel cost. Generally, the agreed upon list of factors to be included are income, education level, gender, household composition, age, and employment status (Börger et al., 2021; Kipperberg et al., 2019; Pokki et al., 2020; Zhang et al., 2015).

For income, it was necessary to collect both annual household income (disposable income) and annual personal income, before tax (Jiang, 2015). Some studies have demonstrated a positive correlation between income and recreation trips in Canada (Amoako-Tuffour & Martínez-Espiñeira, 2012), United States (Bin et al., 2005), and Australia (Windle & Rolfe, 2013; Zhang et al., 2015); while others have shown little to no impact on the demand for trips for the United States (Englin & Shonkwiler, 1995; Loomis, 2003; Loomis et al., 2000; Sohngen et al., 1999), demonstrating that it can produce both a negative or positive influence. Whether or not a respondent is employed determines how much available time one can undertake recreation activities. Generally, those who do not work full time are able to take more trips to a recreation site (Jiang, 2015), irrespective of earnings, due to more available time.

Education has been observed to have both a negative and a positive relationship with beach visitation. While measuring the beach recreation value of Benin (West Africa), Houngbeme et al. (2020) found a negative relationship between tertiary education and beach visits. The same negative relationship was also found in Australia (Zhang et al., 2015), United States (Landry et al., 2016) and Brazil (Shrestha et al., 2002). This is contrasted by other studies where a higher education level showed a positive relationship to beach visitation in Taiwan (Windle & Rolfe, 2013) and Australia (Windle & Rolfe, 2013). It is also theorized that the possibility of collinearity between education and income may exclude independent estimation of these variables (Amoako-Tuffour & Martínez-Espiñeira, 2012).

Within the literature, gender, age, and household composition are not consistently found to be either positive or negative. It was expected in this study that due to New Zealand's unique sociodemographic characteristics (such as four weeks annual leave, and the value that is placed on outdoor recreation as a society), that the demand shifters initially included would not be significant. The results of the coefficients associated with the travel costs and demand shifters can be found in Appendix B3/B4 but will not be discussed further.

3.6.3 Other Survey Information

Respondents were asked what primary motivation of their trip to the recreation site, the level of influence the site had on their reason for taking their trip, as well as at which point in their journey, they decided to visit the recreation site. This will determine if the recreation

site was the primary reason for traveling, or an incidental stop, allowing the appropriate portion of travel costs to be used. This stems from the initial theory of travel cost, that all costs are exclusive to the site and nothing else (Loomis et al., 2000), which is not necessarily the case.

Respondents were also asked about the site's level of influence in taking the current trip at all. This was based on a zero-to-five-point scale, with zero representing no influence, and five representing extremely influential. This is supporting information regarding one's decision to make a trip to demonstrate the sites importance when there are multiple destinations. This can also be used as weighting factor for travel cost as demonstrated by Martínez-Espiñeira and Amoako-Tuffour (2009).

Following good survey practice, a map was provided on the front of each survey showing the location of the specific site. A link and QR code to the survey online (which uses the software Qualtrics) was also provided on the front informational page of the paper survey, for those who preferred to complete the survey online rather than in person. The full version of both surveys may be found in Appendix A.

3.6.4 Key Considerations for Both Sites

The continuous stretch of beach being considered in the Tauranga area (Mount Maunganui to Papamoa and through to Maketu, Figure 6), is in a very populated area in New Zealand, with many people living at or very close to the beach. Because of this high incidence of residents, it was decided that they would need to be accounted for, by including additional questions and choices within the survey. Drawing on previous studies that investigate resident's preferences (Fleming & Cook, 2008; Windle & Rolfe, 2013), it was decided to include additional travel modes, such as biking and walking. To differentiate between the locals/residents in the immediate area, if a respondent lives within 20km of the site, they were then asked exactly how far. This was done to separate the potential large number of visitors who would all have the same postal code, allowing for a more detailed analysis.

Fiordland National Park is a particularly remote site, which leads to its own set of statistical issues. I anticipated that most respondents will have only visited the site once or twice over the course of a few years, leading to low variation in annual visitation rates. For this reason, it was decided to extend their previous trip recall to a 5-year period. Travel modes were divided by 'long' and 'short' haul (long haul referring to the travel mode use for most of the distance from personal residence, short haul referring to the travel mode used

within the area of the site), asking what their principal travel mode to Fiordland was, and what was their principal travel mode within Fiordland. These modes may differ, but not necessarily. Phrasing the question in this way allows to once again account for the complexities that occur in itineraries while traveling to remote sites but keeping it as simple as possible for the respondent.

3.6.5 Contingent Behaviour

Contingent Behaviour (CB) is one of the stated preference techniques that one can use for the valuation of non-market goods. It particularly lends itself to being combined with TCM, as it can be used to look at changes in visitation rates in the event of a change in site quality. This can be a preferred alternative to asking a respondent what they would be willing to pay to prevent an event from occurring (Alberini & Longo, 2006; Englin & Cameron, 1996; Kipperberg et al., 2019; Kleppe & Jensen, 2018; Lankia et al., 2019; Parsons et al., 2020; Prayaga et al., 2010; Rolfe & Dyack, 2011).

For each survey, three CB questions were asked regarding a respondent's theoretical behaviour if an oil spill was to occur. This was repeated for scenarios of varying levels of environmental damage at the recreation site. Preceding the questions, a short description of the general situation/accident was provided.

For the Tauranga survey, there were two separate sets of CB questions, differentiating slightly to account for the large number of locals/residents, and visitors. The first CB question for Tauranga visitors is:

For the next four questions, I want you to think about what you would do if conditions were different in Coastal Bay of Plenty. **Remember that Coastal Bay of Plenty here refers to the stretch of beach that includes Mt. Maunganui, Papamoa, and Maketu.**

Imagine that an oil spill occurred from a shipping accident off the coast of Tauranga. For the following scenarios that range from low to high impacts, please identify how poorer water quality would affect your visit behaviour.

1. Water quality is slightly worse than current conditions, with occasional traces of oil. You can still access the entire beach, but enter the water at your own risk.



- A) Would you still have visited the following sites on this trip?
- a. Bay of Plenty Region Yes No
- b. Coastal Bay of Plenty Yes No
- B) How many times would you visit the Coastal Bay of Plenty in the next two years, if there had been an oil spill?
- Most Days (5 out of 7)
- Most Weekends
- Once a month
- About 5 times a year
- About 2-4 times a year
- Once a year
- Only once in two years
- Zero – no visits
- C) If you would not come to the Coastal Bay of Plenty, would you stay home or visit elsewhere?
- Stay Home Visit Elsewhere

The CB question varied slightly for locals/residents; in that they already live in the Bay of Plenty region. The full survey can be found in Appendix A1. This survey also included a scope question, which stated:

“Now imagine that oil has washed up along the entire coast of the Bay of Plenty region, and none of the beaches are swimmable and all the beaches are only accessible above the high tide line. Would you stay home, or would you visit another region?”

Respondents were able to choose between two responses, being that they would have stayed home, or visited elsewhere. These potential changes in visitation behaviour are able to be pooled with the existing behaviour observed by the travel cost method, allowing a count data model to be estimated (Rolfe & Dyack, 2011).

The first CB question for the Fiordland National Park is similar to the Coastal Bay of Plenty CB question, but with visitation rates that are more appropriate to the site. The third contingent behaviour question for the FNP survey can be found below as an example.

For the next four questions, I want you to think about what you would do if water quality conditions were different to now.

Imagine that an oil spill occurred from a cruise ship in Milford Sound. For the following scenarios that range from low to high impacts, please identify how the poorer water quality would affect your visit behaviour.

1. Water quality is considerably worse than current conditions, with remnants of oil along the shore. No recreational activities allowed, just viewing from land.



A) Would you still have visited on this trip?

- | | | | | |
|----------------------------|-----------------------|-----|-----------------------|----|
| a. Milford Sound | <input type="radio"/> | Yes | <input type="radio"/> | No |
| b. Fiordland National Park | <input type="radio"/> | Yes | <input type="radio"/> | No |
| c. Southland Region | <input type="radio"/> | Yes | <input type="radio"/> | No |

B) How many times would you visit Fiordland in the next five years, if there had been an oil spill in Milford Sound?

- 00 01 02 03 04 05+

C) If you would not come to Fiordland, would you have stayed home or visited elsewhere?

- Stayed Home Visited Elsewhere

The full survey can be found in Appendix A2.

3.6.6 Data Cleaning

All raw data were collected from the surveys was entered into excel exactly as respondents answered the questions. From here, the midpoint of the range selected for household and personal incomes replaced the range selected; the same approach was also used for the age groups. For missing household and personal incomes, as well as age groups, the average of all respondents was used to complete the data. This was deemed appropriate since there was a low amount of missing data points for these fields.

The Coastal Bay of Plenty trips were corrected for endogenous stratification by subtracting one from the reported past trip count. This was not done for the Fiordland National Park data, since looking at the responses it was concluded that respondents did not

include their current trip in their past trip count. Why this is done is discussed further in section 3.6.8.

3.6.7 General Equations

A single site demand function for the individual travel cost method, according to Martínez-Espiñeira and Amoako-Tuffour (2009), can be generally represented by:

$$Y_i = f(TC_i, S_i, D_i, I_i) \quad \text{Equation 2}$$

Where Y_i represents the per person trip demand (for individual, i), TC_i is the travel cost, S_i is cost of the substitute site, D_i is demographic characteristics of the respondent, and I_i is the measure of income. In Equation 2, TC_i is given by:

$$TC_i = 2 \times \left(\frac{DI_i \times C_i}{P_i} \right) \quad \text{Equation 3}$$

Where DI_i is the one-way distance in kilometres (km) from the respondent's permanent residence to the site, C_i is the cost per km for the type of vehicle used, and P_i is the average number of people per group. The cost/km is determined on a yearly basis by the Inland Revenue Department of the New Zealand government. These rates are typically used by businesses claiming kilometre costs for vehicles used for work. The kilometre rates for the 2019-2020 year will be used (Table 3). These combined variables are multiplied by two to generate the round-trip costs.

Table 3: Kilometre rates for 2019-2020 income year (Inland Revenue, 2020).

Vehicle Type	Tier One	Tier Two
Petrol and Diesel	82 cents	28 cents
Petrol Hybrid	82 cents	17 cents
Electric	82 cents	9 cents

Note: Tier One is used for the business portion of the first 14,000 km travelled by a single vehicle in a year and includes operating costs, whereas the Tier Two rate is for running costs only for any travel over 14,000 kms a year.

Though both the Tier One and Tier Two costs were calculated, only the Tier Two will be used in the analysis. These values were selected because recreational uses are most likely

not factoring in the costs of running a vehicle other than gas mileage in their decision to take a trip.

It is difficult to ask respondents to recall the individual costs of the multiple trips that were made to the recreation site. Therefore, assumptions were made in that all the trips reported over the past two years would have consisted of the current group size and current costs associated with it. For those who had combined travel modes, the round-trip average price of flights (Air New Zealand), buses (Intercity), and ferry costs (Inter Islander) were used for their specific travel itinerary.

3.6.8 Model Specification

When the travel cost method was first introduced, it was generally modelled using Ordinary Least Squares (OLS) regression, or linear regression techniques (Du Preez et al., 2012). However, over time it has become more common to use a count data models or a generalized linear model. Within recreation demand analysis, the Poisson Distributions (PD) regression is the most common tool used (Chae et al., 2012; Du Preez et al., 2012; Loomis, 2006; Voltaire et al., 2017; Zawacki et al., 2000), as provided by Hellerstein and Mendelsohn (1993). The advantage of using a PD regression model is that it aligns with the count data features of recreation visits (Zhang et al., 2015). A general PD regression model can be represented by (Loomis, 2006; Westfall & Arias, 2020, p. 364):

$$p(y|x; \theta) = \frac{e^{-\lambda(x;\theta)} \{\lambda(x; \theta)\}^y}{y!} \quad \text{Equation 4}$$

This represents a particular distribution $p(y)$, where y signifies discrete integer values, λ is the mean (expected number of trips), and θ is a set of non-price parameters, such as demographic parameters. Where:

$$\lambda(x; \theta) = \exp(\beta_0 + \beta_1 x \dots) \quad \text{Equation 5}$$

represents the mean of the distribution $Y|X=x$, and $\theta = \beta_0, \beta_1 \dots$ etc. Unlike usual regression models, for a PD regression the mean and the variance are equal, eliminating the need for a σ^2 (Westfall & Arias, 2020). This leads the expected demand function to have a semi-log form represented by (Loomis, 2006):

$$\lambda(x; \theta) = t \exp(\beta_0 + \beta_1 TC + \beta_2 X_2 + \beta_3 X_3 + \dots + \beta_n X_n) \quad \text{Equation 6}$$

Where t represents a function of time, β_n represents the regression coefficients of variables X_n and TC is the travel cost per person.

When overdispersion is present in the data, the Negative Binomial (NB) regression, a more generalized version of the PD regression, is preferred. This relaxes the assumption that the variance must equal the mean, allowing for overdispersion, as well as allowing for the nature of data being truncated at '0' and an integer (Amoako-Tuffour & Martínez-Espiñeira, 2012; Borzykowski et al., 2017; Englin & Shonkwiler, 1995; Hounbeme et al., 2020; Landry et al., 2016; Martínez-Espiñeira et al., 2008; Mingie, 2011; Shrestha et al., 2002; Wan-Yu et al., 2019; Whitehead et al., 2018; Windle & Rolfe, 2013; Zhang et al., 2015). Thus, the variance is allowed to be greater than the mean, a problem commonly observed in TC data. This may occur when there are multiple visitation rates for many different levels of the travel cost of the trip (Prayaga et al., 2010). This is commonly obtained by introducing an additional variable, commonly referred to as α , reflecting the overlooked heterogeneity that the PD regression does not capture (Amoako-Tuffour & Martínez-Espiñeira, 2012), also referred to as the dispersion parameter. A general NB regression model is provided by Loomis et al. (1991) and NCSS (2020):

$$P \lambda(x; \theta, \alpha) = \left(\frac{\Gamma(y_i + \alpha^{-1})}{\Gamma(y_i + 1)\Gamma(\alpha^{-1})} \right) \cdot \left(\frac{1}{1 + \alpha\lambda} \right)^{\alpha^{-1}} \cdot \left(\frac{\alpha\lambda}{1 + \alpha\lambda} \right)^{y_i} \quad \text{Equation 7}$$

Where Γ is the gamma probability density function for $\lambda(x; \theta)$, the mean of the distribution is represented by λ per y_i unit of exposure, and $(1 + \alpha\lambda)$ is the variance. As α approaches zero, the distribution becomes better fit to a PD regression. This leads to the demand function being represented by:

$$\lambda(x; \theta, \alpha) = \exp(\ln(t_i)) + (\beta_0 + \beta_1 TC + \beta_2 X_2 + \dots + \beta_n X_n) \quad \text{Equation 8}$$

Where t represents the time of exposure, and β_n are the regression coefficients of the X_n variables. The regression coefficients for both the PD and NB regressions are estimated using the maximum likelihood method. Between the PD and NB regressions, it can be assumed that the NB will better fit travel cost data, however, one does not know until the

level of overdispersion present in the data is observed. Based on my data, the NB regression model, with a zero truncated specification was used.

In order to correct for endogenous stratification that commonly occurs when conducting on-site sampling, many researchers apply the Englin Correction (Englin & Shonkwiler, 1995), by subtracting one visit from the number of visits that a respondent has made to that site, which is the dependent variable (Amoako-Tuffour & Martínez-Espiñeira, 2012; Bin et al., 2005; Blaine et al., 2015; Kleppe & Jensen, 2018; Landry et al., 2016; Loomis, 2003; Prayaga et al., 2010; Refsdal & Lohaugen, 2016). However, in using count data models such as PD and NB regressions, correcting for endogenous stratification may also be done by using zero-truncated NB/PD regressions (Martínez-Espiñeira & Amoako-Tuffour, 2008; Rolfe & Dyack, 2011; Shrestha et al., 2002; Wan-Yu et al., 2019), in which the visitation rate it is truncated at zero, since there cannot be a negative number of visits. The Englin Correction was used for the Coastal Bay of Plenty data since the trips were not truncated at zero, and a negative binomial regression truncated at zero was used for the Fiordland National Park data.

3.6.9 Regression Analysis

A description of the variables used for the regression model are found below in Table 4. The data was then modelled using the Negbin2 function, in NLogit6® software. The CBoP data was truncated at 206, whereas the FNP data was truncated at zero. These differ because of the different nature of visitations to the site.

Table 4: Description of variables used in negative binomial regression.

Variables	Definition	Expected Sign
Age	Age of respondent	(+/-)
EducD	Education Level (1 = Tertiary and above, 0 = all else)	(+/-)
Gender	Gender (female/other = 0, male = 1)	(+/-)
AnnualHIncome	Annual Household income	(+)
Trips	Trip count for the respondent over the past 2 or 5 years	
TripsES	Trip count for the respondent over the time frame minus 1	
TCppT2	Travel Cost per person – round trip	(-)
TCApT2	Travel Cost per person – round trip, with accommodation	(-)
EmployD	Employment status (1 = Full time, 0 = all else)	
CBLevel	CBLevel code for panel data (0=past trips, 1=future trips)	
TripCB1	Panel data future trips reported for CB level 1 question	
TripCB2	Panel data future trips reported for CB level 2 question	
TripCB3	Panel data future trips reported for CB level 3 question	

Confidence intervals were calculated using a bootstrap method, specifically the Krinsky-Robb process. This generates a multivariate normal distribution, using the mean and covariance matrix of the estimated coefficients (Chiew, 2015). The non-symmetric confidence intervals that are obtained with this method are recommended where their standard errors may not be normally distributed, such as double bounded contingent valuation questions, or asymmetric willingness to pay estimates with reference points (Hensher et al., 2015; Krinsky & Robb, 1986). One thousand draws were taken from this distribution, in turn calculating a willingness to pay for each draw. By sorting these one thousand estimates from smallest to largest, the lower 2.5 and upper 2.5 percentile can be given by the values corresponding to the 25 and 975 values (Chiew, 2015). An example CBoP code can be found below:

```
NEGBIN;Lhs=TRIPES;Rhs=ONE, TCPPT2;Model=NB2;Limit=206;Truncation$
Matrix;bu=b;vu=varb$
matrix;se=sqrt(vu)$
Matrix;sn=rndm(1000,2)$
matrix;snse=sn*se$
matrix;aaa=[1000|1]$
matrix;aaa1=aaa'$
matrix;mbetas=bu*aaa1$
matrix;mbeta1=mbetas'$
matrix;list;y=snse + mbeta1$
```

and for FNP:

```
NEGBIN;Lhs=TRIPS;Rhs=ONE, TCPPT2;Model=NB2;Limit=0;Truncation$
Matrix;bu=b;vu=varb$
matrix;se=sqrt(vu)$
Matrix;sn=rndm(1000,2)$
matrix;snse=sn*se$
matrix;aaa=[1000|1]$
matrix;aaa1=aaa'$
matrix;mbetas=bu*aaa1$
matrix;mbeta1=mbetas'$
matrix;list;y=snse + mbeta1$
```

3.6.10 Consumer Surplus

The consumer surplus (CS) is the difference between what one is willing to pay and what one actually pays for a service; allowing you to derive the net benefits received in this

case from an environmental recreation site (Zhang et al., 2015). Count data models adopt a semi-log functional form (Lankia et al., 2019), allowing the CS per trip to be defined as the inverse of the travel cost coefficient, β_{TC} (Houngbeme et al., 2020; Kleppe & Jensen, 2018; Loomis et al., 2000; Prayaga et al., 2010; Zawacki et al., 2000; Zhang et al., 2015).

$$CS = -\frac{1}{\beta_{TC}} \quad \text{Equation 9}$$

If correcting for multi-purpose/multi-destination trips (MP/D), there are two options. You can either correct the TC before calculating the CS (Martínez-Espiñeira & Amoako-Tuffour, 2009), or you can adjust the CS after the fact (Voltaire et al., 2017). It should be noted that there are some who believe that MP/D trips should simply be ignored, since they may lead to an overestimated of CS for these trip types (Common et al., 1999). Conversely, there is evidence to suggest that ignoring them can lead to an underestimate of the recreational value of a site (Loomis et al., 2000; Martínez-Espiñeira & Amoako-Tuffour, 2009; Mendelsohn et al., 1992).

3.6.11 Pooled Regression

The travel cost data was then pooled with the contingent behaviour responses. The three different oil spill scenarios were analysed as separate models. All data remained the same (i.e., education level, travel costs, etc.) except the trip count, which was then changed to the respondents answer for future visitation rates if an oil spill were to occur. The data the represented the contingent behaviour data layered directly below the original data. A new variable, CBLevelx, was dummy coded (0=past trips, 1=future trips) to differentiate the responses that were past visit rates and new rates. The same Negbin2 model was performed three times to represent the three different levels of oil spills captured within the contingent behaviour questions. These results were then compared to the original travel cost model to estimate the consumer surplus loss for the three scenarios. An example of the CBoP code can be found below:

```
SETPANEL;Group=CBLevel;Pds=CB1$
NEGBIN;Lhs=TRIPCB1;Rhs=ONE,TCPPT2,CBLEVEL;Pds=2;Model=NB2;Limit=206;Tru
ncation$
Matrix;bu=b;vu=varb$
matrix;se=sqrt(vu)$
Matrix;sn=rndm(1000,3)$
```

```

matrix;snse=sn*se$
matrix;aaa=[1000|1]$
matrix;aaa1=aaa'$
matrix;mbetas=bu*aaa1$
matrix;mbeta1=mbetas'$
matrix;list;y=snse + mbeta1$

```

and for FNP:

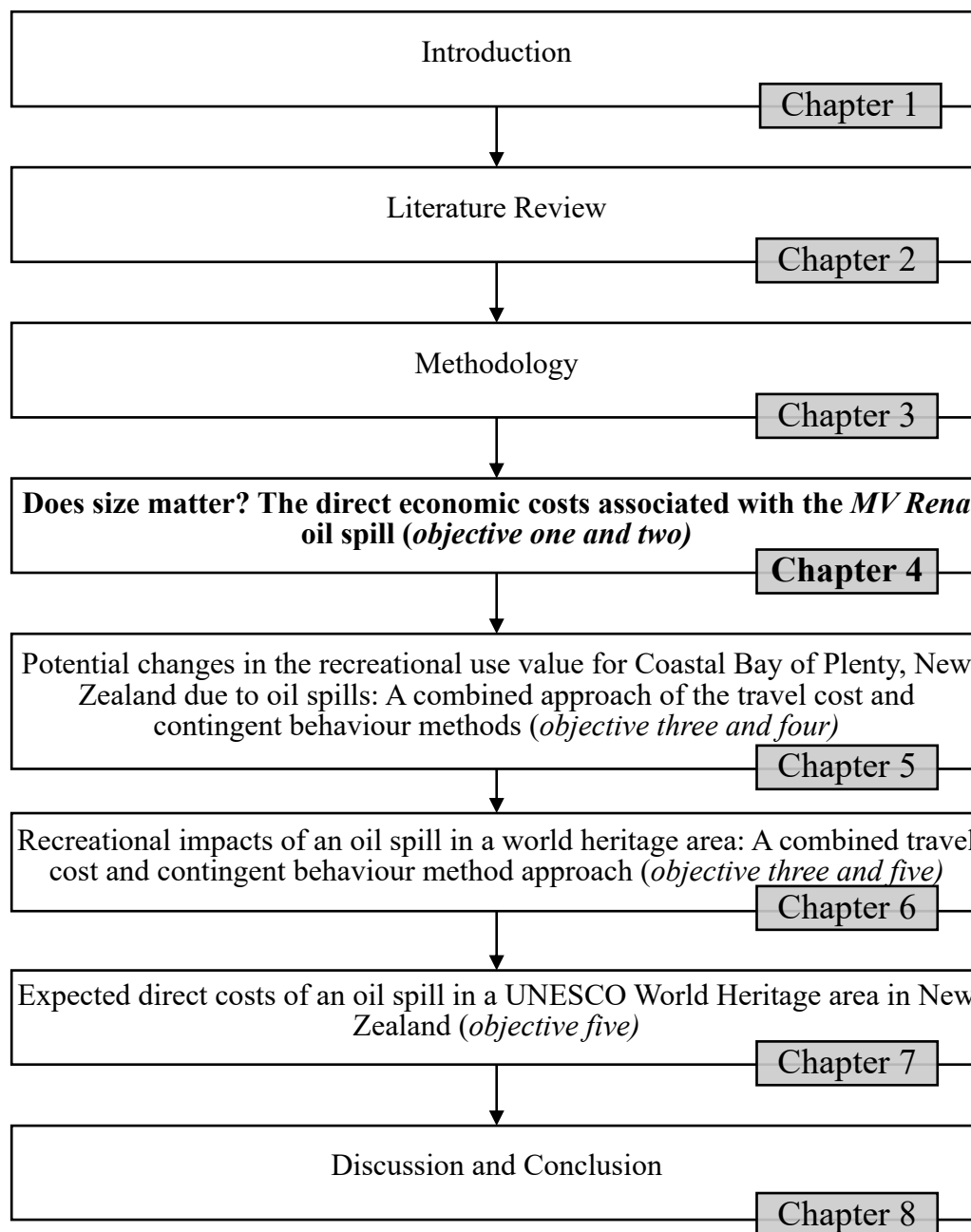
```

SETPANEL;Group=CBLevel;Pds=CB1$
NEGBIN;Lhs=TRIPCB1;Rhs=ONE, TCPPT2, CBLEVEL;Pds=2;Model=NB2;Limit=0;Trunc
ation$
Matrix;bu=b;vu=varb$
matrix;se=sqrt(vu)$
Matrix;sn=rndm(1000,3)$
matrix;snse=sn*se$
matrix;aaa=[1000|1]$
matrix;aaa1=aaa'$
matrix;mbetas=bu*aaa1$
matrix;mbeta1=mbetas'$
matrix;list;y=snse + mbeta1$

```

By combining the estimated losses from fisheries, tourism, recreation, and the clean-up costs associated with these two sites, the direct costs of the *MV Rena* and the hypothetical oil spill in FNP can be assessed. The next four chapters are written as papers (with Chapters 4 and 5 already published), so there will be some repetition throughout this thesis, particularly regarding methods.

Chapter 4: Does size matter? The direct economic costs associated with the *MV Rena*



The following chapter will estimate part of the direct losses to the *MV Rena* oil spill that in 2011. The response clean-up costs, and the direct losses to the fisheries and tourism industry will be considered. The relevant methodologies presented in this chapter are in brief since this chapter has been written and is published as a paper (Egan et al., 2021), but a further description may be found in Chapter 3: Methodology are 3.2, 3.3, 3.4, and 3.5.

Egan, A. L., Chilvers, B. L., & Cassells, S. (2021). Does size matter? The direct economic costs associated with the MV Rena oil spill. *Marine Pollution Bulletin*, 173, 112978. doi:<https://doi.org/10.1016/j.marpolbul.2021.112978>

4.1 Introduction

Marine oil spills can negatively impact people, environments, wildlife and economies, regardless of how much oil is spilled. They have the capability of disrupting socio-economic activities including the values or gains that people derive from the marine environment. There have been many significant oil spills around the world that impacted coastlines, with well documented economic effects. These include *Exxon Valdez* in 1992 (Carson & Hanemann, 1992), *Erika* in 1999 (Bonnieux & Rainelli, 2003), *Prestige* in 2002 (García-Negro et al., 2009; Garza-Gil et al., 2006a; Loureiro et al., 2006), *Hebei Spirit* in 2007 (Cheong, 2012; Kim et al., 2014), and the *Deepwater Horizon Well* in 2010 (Alvarez et al., 2014; English et al., 2018; McCrea-Strub & Pauly, 2011; Sarder et al., 2011). These spills clean-up costs range from approximately USD 108 million (*Prestige*) to over USD 65 billion (*Deepwater Horizon Oil Spill*). The shared characteristics of these oil spills is that they are all large events and exhibited extensive damaging effects on large areas of coastline environments, livelihoods, and economies where they occurred. There is limited literature regarding spills, that are small in global terms, however, demonstrating that they can still significantly affect a local economy that is largely reliant on its natural resources. An example of such a spill is the grounding on the *MV Rena* off the coast of New Zealand (Te Mauri Moana, 2013).

There are many different factors that determine how much an oil spill, and its response will cost, including the type of oil, weather and sea conditions, time of year, duration and amount spilled, physical, economic and biological characteristics of spill location, the size of the area oil spreads over, and the effectiveness of the clean-up (White & Molloy, 2003). These characteristics also influence the level of disruption for coastal activities, particularly within the tourism and fishing industries.

Various studies have investigated the impacts of large oil spills on fisheries and tourism (Bonnieux & Rainelli, 2003; Cheong, 2012; Cohen, 1995; Depellegrin & Blažauskas, 2013; García-Negro et al., 2009; Garza-Gil et al., 2006a; Grigalunas et al., 1986; Hill & Bryan, 1997; McCrea-Strub & Pauly, 2011; Ritchie et al., 2013; Suris-Regueiro et al., 2007). The majority of these studies observed immediate short-term losses. For fisheries in some

instances, negative ‘long-term’ costs were also reported when substantial fisheries die-offs and long lasting fishing bans were experienced (Loureiro et al., 2006). For tourism, large cancelation of tourist trips were also reported for areas where the spills occurred (English et al., 2018). Many of these oil spills affected large areas of coastlines impacting large economies, and millions of people. However, a small oil spill is still capable of having a disproportionately large impact on the local economy (Cirer-Costa, 2015).

Here I assess the direct costs of the oil spill caused by the *MV Rena* in Bay of Plenty, New Zealand in October 2011, including spill response costs and impacts to the tourism and fisheries sectors. Globally, the *MV Rena* would be considered a medium oil spill (ITOPF, 2020), however it had the potential of having sizeable economic consequences in New Zealand, as it was New Zealand’s largest recorded oil spill requiring a national response. Additionally, there were several releases of oil from the vessel over a period of a month. This is an area of high wildlife biodiversity and density (Chilvers & Battley, 2019). New Zealand prides itself on having pristine marine environments, in addition to the important cultural, recreational, and economic benefits that are commonly observed in its coastal waters (Schiel et al., 2016a).

To assess the direct costs of an oil spill, the environment, and the value of its services and products need to be valued and assessed. Millennium Ecosystem Assessment explicitly describes ecosystem services and their benefits, dividing ecosystem services into four categories: provisional, regulating, cultural, and supporting services (Millennium Ecosystem Assessment, 2005a). Provisioning and cultural services are the most likely to be impacted by an oil spill, given that these refer to food and fresh water, recreational, aesthetic, and cultural value gained from the environment (Millennium Ecosystem Assessment, 2005a). In terms of valuing the environment, it is widely accepted that there are two different categories needed to estimate the total economic value, these are use and non-use values. Use values are definitive benefits that can be physically observed and measured, and the category can be further divided into direct use and indirect use values. For the coastal environment, direct use values include industries such as fisheries, tourism, recreation, and local culture (Remoundou et al., 2009). Indirect use values refer to benefits derived from the environment such as flood protection and CO₂ sequestration (Remoundou et al., 2009). Non-use values refer to the value or benefit that one receives from knowing that the particular environment exists and can be used by themselves or others in the present and the future (Clough & Bealing, 2018; Remoundou et al., 2009).

In New Zealand, the service and primary industries represent 64.4 and 19.1 percent of the national gross domestic product (GDP), respectively (Statistics New Zealand, 2019b). Service industries include accommodation and food services, retail trade, wholesale trade, and various other service industries. Primary industries are comprised of agriculture, forestry, fishing and mining. When a community depends on coastal tourism and fishing, shoreline contamination from an oil spill, as well as beach closures, directly affect these industries where the oil spill occurred (Cheong, 2012; Ribeiro et al., 2020). Given that fisheries and tourism are essential components of the New Zealand economy, this chapter will specifically look at the direct costs associated with the *MV Rena* to the local commercial fishery, tourism industry, as well as the clean-up costs related to the oil spill response.

4.2 Context

On 5 October 2011, at 2.20 am the container ship *MV Rena* was traveling from Napier to Tauranga, when it ran aground at 17 knots on Astrolabe Reef (Otāiti), approximately 10 nautical miles off the coast of Tauranga (Figure 7). The *MV Rena* was carrying 1,368 containers and 1,733 tonnes of heavy fuel oil (HFO) (Ministry for the Environment, 2011). The immediate impact caused the ship to be stuck fast on the reef with an 11-degree list to port. Fears of ruptured fuel tanks meant this incident immediately elicited a national response led by the New Zealand government department Maritime New Zealand (MNZ). A national response is needed in New Zealand when the spill is complex and exceeds the response capacity of the regional councils and operators' resources. A response command centre, wildlife facility, assessment teams and equipment were deployed and operating from the day of the incident, 5 October.

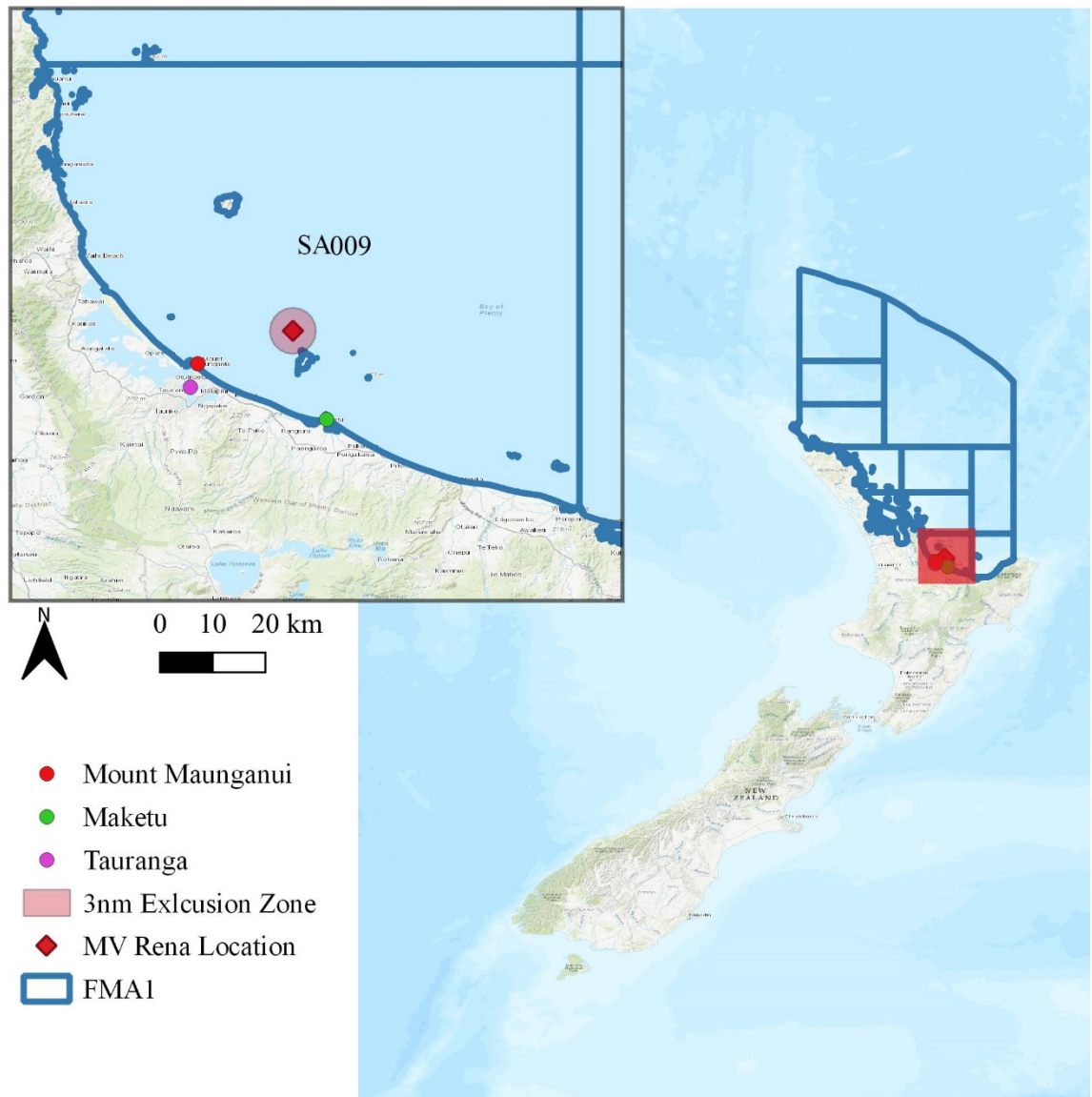


Figure 7: Map showing New Zealand FMA1 fishing area with inset showing area of interest (Tauranga), the location of *MV Rena* grounding, the 3 nm exclusion area surrounding the wreck, the stretch of beach between Mt. Maunganui and Maketu that was closed to the public from 13 October to 16 November due to oil contamination along the shoreline, and the statistical fishing area 009 (SA009).

Source: Statistical area boundaries sourced from Ministry of Fisheries (2020).

The first signs of extensive oil were seen in the form of oiled wildlife observed on the 6 October, and the first live oiled birds were captured and transferred to the wildlife facility on 7 October (Gartrell et al., 2019). The salvage operation began on 9 October, but inclement weather conditions and equipment issues slowed container recovery. The situation escalated on the night of 11 October, when a severe storm passed through, releasing an estimated 350 tonnes of HFO (de Lange et al., 2016), with an oil slick 5 kilometres long surrounding the

boat. An additional 5 to 10 tonnes of HFO was released on 22 of October. Oil first began reaching the coastline on 10 October, leading to restricted access to the beaches between Mt Maunganui and Maketu from 12 October to 16 November 2011 (Figure 7; (de Lange et al., 2016)). In addition to the oil released, the containers were carrying chemical and hazardous goods, that ended up being released into the marine environment as the containers were lost (Schiel et al., 2016a). Though there was no formal commercial fisheries closure, an exclusion zone of 3 nautical miles (5.5 kilometres) was placed around the wreck, and no ships or fishers were able to access this area, as shown in Table 5.

Table 5: Exclusion Zones. Various exclusion zones around Astrolabe Reef where the *MV Rena* ran aground and the dates they went into effect.

Date	Exclusion Zone Information
8 October 2011	0.4 nm around vessels working on clean-up
11 October 2011	1.5nm around Astrolabe Reef
21 November 2011	3nm around Astrolabe Reef
1 March 2012	2nm around Astrolabe Reef
6 January 2014	Three temporary points around Mōtītī Island at 500m each
14 January 2015	Points around Mōtītī Island reduced to 200m
5 April 2016	Current exclusion zone 2nm around Astrolabe Reef

Source: Heays (Personal Communication).

New Zealand has the New Zealand Oil Pollution Fund under the Maritime Transportation Act, that is funded by levies ships are required to pay when in New Zealand waters and is there as a reserve if a spiller is unknown or under insured for all of the costs associated with an event (Judd, 2014; Ministry of Transport, 1994). Internationally, the key legislation that New Zealand was a signatory to at the time of the *MV Rena*, was the 1976 Convention on the Limitation of Liability for Maritime Claims (LLMC); this essentially limits the liability of ship owners and related parties to pay for damages in relation to an oil spill (Judd, 2014). These two pieces of legislation are important when looking at overall direct costs of the *MV Rena* spill to NZ.

4.3 Methods and Data

4.3.1 Study Area

Tauranga is in the Bay of Plenty on the east coast of the North Island, New Zealand (37° 32.446 S, 176° 25.625 E, Figure 7). It is the 5th most populated city with over 140,000 residents and has the fastest growing population within the country (Statistics New Zealand, 2018). The Port of Tauranga is the largest port in New Zealand, and as of 2017, was handling

approximately 41 percent of New Zealand’s exports, 35 percent of New Zealand’s imports, and 37 percent of all shipping containers into the country (Port of Tauranga Limited, 2021b). The area is also home to a large cruise ship industry: for the fiscal year ending June 2019, a total of 116 cruise ships visited the port, an increase of 39.8 percent from the previous year (Port of Tauranga Limited, 2021b). This high level of shipping and cruise activity puts the Tauranga shoreline at high risk of an oil spill occurring again (Bermingham, 2015). In 2011, the Bay of Plenty region contributed approximately 5.5 percent of the New Zealand’s total GDP, making it New Zealand’s fifth most important economic region (Statistics New Zealand, 2019c).

The Bay of Plenty marine area is a large, sheltered coastline. With long stretches of white sandy beaches, large marinas, and various islands that can be visited along its coast, it is a popular tourist destination for both domestic and international visitors.

4.3.2 Clean-up Costs

Data on the total *MV Rena* clean-up costs incurred by the New Zealand government as of 29 January 2013 are publicly available through The Treasury of New Zealand. A request filed with MNZ through the Official Information Act 1982, provided a breakdown of the costs incurred to MNZ during the response to the *MV Rena* oil spill. Table 6 shows the categories of this cost breakdown, and what is included in each grouping. Salaries are included within Wildlife and Operations. A request for information was also filed with Bay of Plenty Regional Council for their remaining costs associated with the *MV Rena* oil spill.

Table 6: Description of cost categories.

Category	Includes
Boats/Aircraft	Hire of boats to causality site, tug and barge hire, monitoring of debris, shoreline and beaches, patrol of areas by helicopters and planes. In practice, most of the costs related to the provision of capacity for an on-water response.
Wildlife	Veterinarian and general wildlife care, including food, set up and operation of the wildlife centre, equipment and management by Massey Wildlife. Note that accommodation, travel and rental car costs have not been specifically identified.
Operations	Clean-up operations on 22 shoreline areas including beaches and rocky foreshore - equipment, health and safety, personnel protective equipment, cell phones, GPs, contractors, hire age, cameras, marine booms, Shore-line Clean-up and Assessment Technique (SCAT) work, spill control, costs associated with volunteers, planning.

Mōtītī Island	Operational costs specific to Mōtītī Island. A high level of consultation was required with the Islanders, both before the operation could commence and during the clean-up. Costs include catering, equipment, travel energy and accommodation.
Accommodation/Travel	Travel to/in Tauranga, accommodation in Tauranga, rental cars, taxis, fuel, mileage, meals, and laundry.
Waste Management	Trans Pacific Holdings and EnviroWaste costs for disposal of waste including oil spill clean-up, processing of oil and decontamination.
Salvage Oversight	Specialist support from London Offshore Consulting with respect to salvage operations. MNZ oversight provided by the Maritime Incident Response both in Wellington and Tauranga
Support Costs	Incident Command Centre, stationary, venue, telephone services, Information Technology services, furniture and fittings, office equipment, security, toilets and cleaning, financial services, some travel.
Media Costs	Communications and public relations, community engagement work, signs, photography, internet alerts and public announcements (e.g., beach closure)
Local Iwi (Māori) from the area	Iwi played a significant role in the examination of beaches; accordingly, this is an operation related cost. The cost includes liaison, consultation work and site monitoring.
RENA Overheads	Internal MNZ administrative, support and overheads allocated to the <i>RENA</i> cost centre to 30 June 2012
Marine Pollution Response Service (MPRS) equipment hire	MPRS have a stock of oil response equipment. This cost represents the rental value of MPRS equipment utilised during the response. Rates are internationally benchmarked. A lower rate was applied for equipment on standby.
July 2012 to September 2012 costs	All full year 12/13 costs have been budgeted in the <i>RENA</i> Non-oil Cost Centre
RENA Non-oil Response (RNOR)	The RNOR cost centre was created to manage the non-oil aspects of the response including, project management, investigations, prosecutions, negotiations, claim preparation, and salvage oversight in Tauranga
Salvage Oversight, Investigations, Prosecutions & Project Management	<i>RENA</i> Response Group was created in Jan 2012 to oversee the response
Internal Maritime New Zealand	Administrative, support and overheads allocated to the RNOR cost centre to 30 June 2012

Source: Maritime New Zealand (2019).

4.3.3 Commercial Fisheries

Data were collected through Fisheries Science and Information within the New Zealand Ministry for Primary Industries (MPI) under the confidentiality deed between MPI and Massey University. The estimated catch landings (kg) for Fishery Management Area 1 (FMA1), where the MV Rena oil spill occurred (Figure 7). I requested all reported fish

catches, as well as their respective yearly port price greenweight value. The green weight refers to the weight of the entire fish, not necessarily the meatweight at market. For species that are measured in meatweight (such as scallops) and individuals (such as oysters and certain finfish), this data was also requested. Fisheries data is recorded from October to September, so for example, 2006 is from October 2005 to September 2006. The port prices are managed by the Fisheries (Cost Recovery) Rules 2001 (Cartwright, 2016). A voluntary survey is sent out to licensed fish receivers, or those who are allowed to sell the fish, where they can enter the landed price (port price) that they received for the fish. This price is for a particular day and does not represent an average, and the fishing method is not recorded, even though certain fishing methods may result in a higher landed price. Certain parties, such as fisheries managers, use these recorded port prices to set deemed values. Deemed values are the prices that one would have to pay if their annual catch is higher than what they are entitled. The data collected for FMA1 is further broken down into smaller statistical areas within the whole FMA1, with the specific statistical area where the spill occurred, SA009, also being investigated. Following Loureiro et al. (2006), landings, and the corresponding vessel port prices will be used together to estimate the impact to the local commercial fishery, based on pre and post *MV Rena* catch data and value estimates.

4.3.4 Tourism

Tourism spending data were collected on the yearly Regional Tourism Estimates (RTEs) from the Ministry for Business, Innovation, and Employment, with records for the area only beginning in 2009, year ending in March. The RTEs provide absolute dollar estimates of tourism expenditure at the regional level for stakeholders. The RTEs are derived from three data sources, the Regional Tourism Indicators, the International Visitor Survey, and Statistics NZ's Tourism Satellite Account, which are described in Table 7.

Table 7: Summary of the three data sources used to determine the Regional Tourism Estimates.

Category	Includes
Regional Tourism Indicators (RTI)	<ul style="list-style-type: none"> • Launched by the Ministry in Dec 2012 • International RTI data comes from Paymark via Marketview, and Domestic RTI data comes from BNZ via Marketview • Comes from card transactions
International Visitor Survey	<ul style="list-style-type: none"> • Information on characteristics, behaviour and expenditure of international visitors
Statistics NZ's Tourism Satellite Account (TSA)	<ul style="list-style-type: none"> • Tourism expenditure by industry, separated into domestic and international visitor spending for each year ending in March • This is used as margin totals for deriving the RTEs by industry

Source: Ministry of Business Innovation and Employment (2013).

Iterative Proportional Fitting, more commonly known as the raking technique, is then used to derive the RTEs (Ministry of Business Innovation and Employment, 2013). Though assumptions are made, this is a robust source of information that is used for planning and decision making at the regional level. Information can be divided by territorial authority and viewed for total expenditure, as well as being separated into domestic and international spending. The data are divided into 8 categories: (1) food and beverage serving services (2) other passenger transport (3) other tourism products (4) retail sales-other (5) accommodation services (6) cultural, recreation, and gambling services (7) retail sales-alcohol, food, and beverages (8) retail sales-fuel and other automotive products.

4.4 Results

4.4.1 Direct Clean-up Costs

The *MV Rena* released approximately 350 tonnes of HFO, which on the world scale is considered a small oil spill (ITOPF, 2020). However, the response resulted in a significant cost to a number of governmental sectors, particularly when compared with the amount of oil spilled. According to The Treasury (2013), the total costs incurred as of 29 January 2013 was \$46,891 million. Within this total incurred by various governmental agencies, MNZ led the response effort and incurred \$36 million of the total costs, as shown in Table 8.

Table 8: *MV Rena* response costs incurred by Maritime New Zealand. Costs (NZD 2011) incurred as of 29 January 2013, broken down by category.

	Category	Costs (NZD 2011)
Rena Oil Response	Operations	14,456,976
	Wildlife	4,111,838
	Boats/Aircraft	3,526,195
	Accommodation/Travel	2,258,371
	Support Costs	1,951,439
	Waste Management	1,792,824
	Marine Pollution Response Service equipment hire	1,654,512
	<i>RENA</i> Overheads	1,076,000
	Salvage Oversight	415,901
	Media Costs	261,452
	Mōtītī Island	175,545
	Local Iwi	138,307
	July 2012 to September 2012 costs	38,717
	TOTAL RENA OIL RESPONSE COSTS	31,780,643
Non-oil Rena Response	Salvage Oversight, Investigations, Prosecutions & Project Management	3,789,974
	Internal Maritime New Zealand	696,000
	TOTAL RENA NON-OIL RESPONSE	4,485,974
	TOTAL MARITIME NEW ZEALAND COSTS (OIL+NON-OIL)	36,266,617

Source: Maritime New Zealand (2019).

The two sectors that included salary costs were the costliest sectors, with oil clean-up ‘Operations’ being the costliest aspect of the response, followed by ‘Wildlife’ response. ‘Operations’ includes the clean-up efforts of 22 shoreline areas, personal protective equipment, various electronic equipment and shoreline assessment work (Maritime New Zealand, 2019), ‘Wildlife’ response consisted of monitoring, capture, transport, removal or oil and veterinarian care of wildlife, including the rehabilitation of 383 little blue penguins and the pre-emptive capture of 60 NZ dotterels that were kept between one and three months (Gartrell et al. 2013; 2019), and the species identification and necropsies of dead oiled wildlife (Hunter et al. 2019). Salaries from these two sectors alone totalled \$14.077 million. These costs provided by MNZ do not include the salvage operations or restoration costs regarding the oil spill.

Operation “Beach Clean” was established under MNZ to train, enlist, and dispatch volunteers under their operations (Lockwood et al., 2016). Throughout the response, there

were 8,000 registered volunteers, who logged around 24,000 hours of volunteer effort (Fraser et al., 2012; Murdoch, 2013). A crude estimate of the cost of volunteers can be provided by multiplying the minimum wage in 2011 (\$13.00 for an adult, (Employment New Zealand, 2020)) by the number of logged volunteer hours. This leads to a rough estimate of NZD 312,000. Unfortunately, there is no information regarding professions of the volunteers for a more accurate estimate. Even so, without the volunteers, the clean-up of the shoreline may have taken longer, and had a higher cost if only specialists were used and logged the same amount of hours.

The Bay of Plenty Regional Council reported a net total cost of NZD 91,380 related to the oil response (Bay of Plenty Regional Council, 2019). The remainder of the direct response costs are divided among 16 other governmental agencies and special interest organizations.

Salvage costs are not being considered, since the operation lasted years, and ultimately it was decided that the wreck would remain where it sank. It is important to note though, that the *MV Rena* oil spill is considered to have one of the most expensive salvage operations to date, costing over NZD 660 million (Schiel et al., 2016a). Salvage costs were high due to various factors, such as no appropriate sized salvage vessels in New Zealand, inclement weather from the start of the operation, leading to many containers being lost and washing up along the shoreline of New Zealand that had to be recovered. Salvage costs are not included in this overall cost assessment, since the shipping company pays for salvage operations, and is not an expense to the New Zealand society.

4.4.2 Losses to Commercial Fisheries

Oil spills can impact commercial fisheries through toxic effects on fish stocks, physical contamination, and by disrupting business activities (ITOPF, 2011a). No two oil spills have the same effect on commercial fisheries due to the complex nature of fish stocks. Generally, it is thought that pelagic fish are not affected by oil toxicity, due to their high mobility within the water column (ITOPF, 2011a); however, if spawning is occurring or fish are in their larvae states, they are more susceptible to toxicity effects (Carls et al., 2008; Hansen et al., 2019). Losses to fisheries are also commonly observed due to a disturbance of normal fishing activities by the presence of oil, and extent of clean-up operations (OPOL & Oil & Gas UK, 2012). The commercial fishery where the *MV Rena* oil spill occurred is biologically diverse, with over 90 species having a port landing value.

A restriction was placed on the consumption of shellfish, seaweeds, crabs, and Kina (sea urchins, *Evechinus chloroticus*) due to trace oil contaminants being detected and was not lifted until December 2011 (Toi Te Ora Public Health, 2011). It is important to note that there was no reported contamination above consumption guidelines for fish or any die-offs observed (McLean, 2018), and that the restrictions were instead an additional safety measure. Because of these factors, I look only at the short-term direct losses from the disruption of normal fishing due to the exclusion zones and salvage operation.

The area where the *MV Rena* ran aground, as well as coastal Bay of Plenty, is a popular area for recreational fishing, as well as containing a small commercial fishery. Recreational fishing data is only collected onboard commercial vessels and are not collected in another capacity in New Zealand, so cannot be included in the overall costs. Bay of Plenty Harbourmaster declared an initial exclusion zone for all ships of 1.5 nautical miles around the wreck on the 5 October (centred on 37° 32.446 S, 176° 25.625 E) (Buell, Personal Communication), which was increased to 3nm on the 21 November (Heays, Personal Communication). Though this was not an official fishing ban, no vessels were able to access this area during this time, except for those related to the response.

By using the reported port prices and estimated catch (kg) of all the fish caught in FMA1 and the corresponding statistical area in which the wreck occurred (SA009), the economic losses to the local commercial fishery can be estimated. It should be noted that this does not include the export value of the fishery or any multiplier effects resulting from the processing of seafood, spending by the fishers in the local economy, of that catch price received. Figure 8 shows the yearly change in landings and port landing value for SA009 and FMA1 from October 2005 (2006) to September 2013.

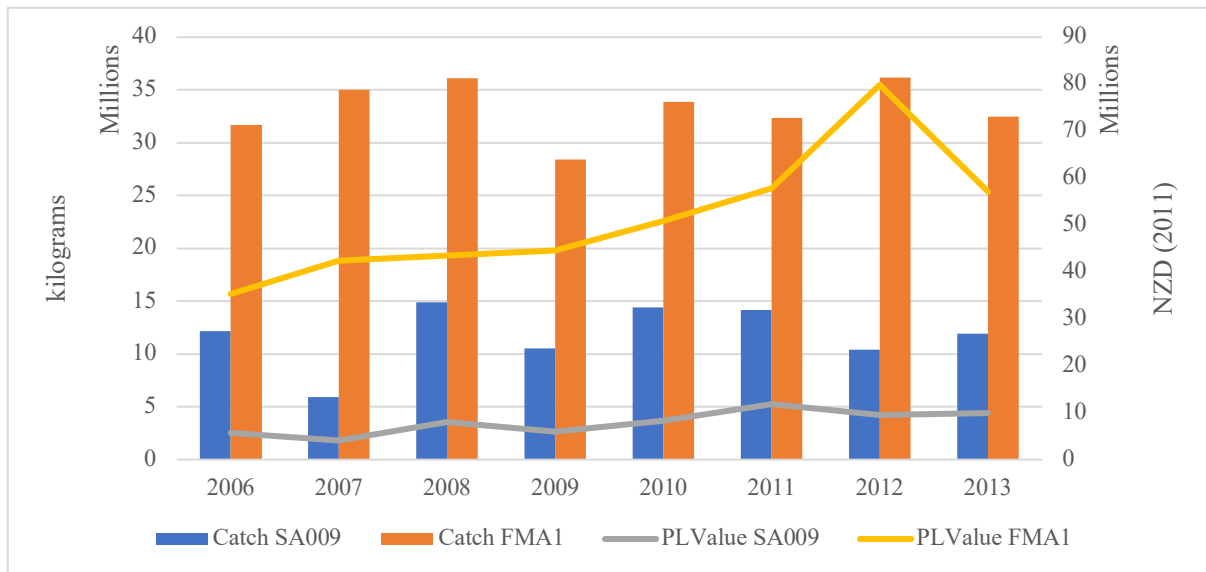


Figure 8: Landings and port landing values for SA009 and FMA1. Catch is presented in kg (millions). Port landing values (PLValue) are presented in NZD 2011 prices and represent approximately how much the estimated catch would have been worth at port that year¹. Source: Fisheries New Zealand (2020b).

One species (*Pecten novaezelandiae*) measured in meatweight not greenweight. Certain finfish are measured as individuals; for those that did not have a corresponding greenweight, the average weight for an individual was used, and multiplied by the number of individuals caught. This was the case for a small number of cells. Looking at percentage change of total landings and port landing value for SA009 2011-2012, there is a decrease of 26.6 percent and 20.5 percent respectively, representing a decrease estimated at NZD 2,266,017. The percentage change of total landings and port landing value for FMA1 2011-2012 shows that there is an increase of 11.7 percent and an increase of 35.9 percent respectively, representing an estimated increase of NZD 22,046,141.

According to Fisheries New Zealand (2020a), the notable commercial species in the Bay of Plenty area are snapper (*Pagrus auratus*), John dory (*Zeus faber*), terakihi (*Nemadactylus macropterus*, *Nemadactylus sp.*), gurnard (*Chelidonichthys kumu*), trevally (*Pseudocaranx georgianus*), mackerels (*Scomber australasicus*, *Trachurus declivis*, *Trachurus murphyi*, *Trachurus novaezelandiae*), kahawai (*Arripis trutta*, *Arripis xylabion*), and skipjack tuna (*Katsuwonus pelamis*). This refers to the quantity caught and does not

¹ Fishing year begins Oct 1, ends Sept 30. Years represent where most fishing months occur (i.e., 2012 = 1 Oct 2011 to 30 Sept 2012). There are 11 species that have a fishing year of April 1-March 31; these species were considered in the same Oct-Nov format, given that they were not consistently caught throughout the years, and the value would have changed overall results.

mean that they necessarily have a high port value per kilogram. The yearly landings for these species for SA009 are provided in Table 9. Looking only at these species, there was a decrease of 3,631,372 kg, representing a loss of NZD 1,438,288 from 2011-2012. Again, when considering all species recorded as estimated catch (kg) with a port price for 2011-2012, there was a decrease of 3,766,592 kg, representing a loss of NZD 2,266,017. Of the 80 species that were caught, 39 showed a decrease in estimated catch for 2011 to 2012, with 18 of these species decreasing by over 50 percent. Furthermore, when looking at the monthly estimated catch for SA009, as demonstrated in Table 10, the losses observed in October 2011 account for the majority (90.9 percent) of the difference compared to the previous year. While there are always fluctuations within fisheries over time, it would appear that after this oil spill, the immediate local commercial fishery (estimated catch within SA009) losses were observed for the October 2011 to September 2012 fishing season.

Table 9: Important species caught in SA009. Estimate catch is presented in kilograms (kg), and port landing values (PLValue) are presented in NZD 2011, for each fishing year. Ordered by largest estimated catch for 2006.

Common Name	Species		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Jack mackerel	Trachurus (declivis, murphyi, novaezelandiae)	kg	8,497,461	3,370,645	7,614,093	7,712,728	8,308,371	7,033,167	6,562,566	6,345,977	8,560,167	7,960,907
		PLValue	1,128,913	447,281	1,042,362	1,128,754	1,303,167	1,660,266	1,837,518	1,741,179	2,668,890	2,540,764
Blue mackerel	Scomber australasicus	kg	1,107,123	586,613	2,459,184	831,536	3,651,213	4,286,402	1,171,764	1,087,781	1,559,696	4,368,438
		PLValue	330,940	175,147	757,485	273,813	1,288,558	1,770,752	492,141	451,246	714,583	2,048,765
Snapper	Pagrus auratus	kg	549,941	346,870	451,079	362,430	413,894	498,103	452,540	426,217	491,942	584,100
		PLValue	1,790,002	1,431,290	1,984,338	1,703,954	2,085,528	2,728,911	2,611,153	2,479,524	3,082,398	3,733,787
Skipjack tuna	Katsuwonus pelamis	kg	501,845	402,014	2,726,311	172,097	570,832	399,331	514,146	2,525,122	1,128,755	1,137,846
		PLValue	283,354	226,724	1,585,757	107,042	380,523	200,317	272,497	1,346,787	1,861,788	585,875
Kahawai	Arripis (trutta, xylabion)	kg	409,529	467,891	563,981	540,132	489,724	446,705	512,482	474,373	499,442	524,321
		PLValue	146,219	87,595	108,926	113,631	110,419	333,926	399,736	379,514	457,102	491,223
Trevally	Pseudocaranx georgianus	kg	321,138	137,656	306,421	194,634	197,354	465,811	360,299	296,194	699,931	462,170
		PLValue	383,977	164,401	377,539	300,868	326,962	815,539	677,361	585,098	1,339,928	905,694
Tarakihi	Nemadactylus (macropterus, sp.)	kg	189,684	124,596	164,878	185,455	217,536	203,475	185,086	142,419	124,422	101,761
		PLValue	315,001	206,672	259,750	508,898	639,758	752,514	716,283	541,564	494,291	413,827
Gurnard	Chelidonichthys kumu	kg	73,331	49,301	68,773	77,798	98,877	99,601	57,259	68,188	56,402	50,762
		PLValue	105,947	66,371	109,485	132,359	180,290	242,958	156,890	183,082	148,055	136,402
John Dory	Zeus faber	kg	26,322	20,987	22,291	21,494	28,222	36,320	21,402	29,256	18,593	18,453
		PLValue	107,531	93,607	122,637	126,418	177,892	247,565	150,881	202,113	131,483	133,578
Total		kg	11,676,374	5,506,573	14,377,011	10,098,303	13,976,022	13,468,914	9,837,542	11,395,525	13,139,350	15,208,758
		PLValue	4,591,887	2,899,088	6,348,279	4,395,737	6,493,097	8,752,747	7,314,459	7,910,107	10,898,519	10,989,914

Source: Fisheries New Zealand (2020b, 2020d).

Table 10: Monthly estimated catch for SA009.

	2005	2006	2007	2008	2009	2010	2011	2012	2013
Jan		884,872	376,522	1,995,327	143,286	341,189	456,610	968,493	926,787
Feb		139,105	911,722	2,225,723	196,512	1,381,008	507,188	234,415	1,635,405
Mar		644,168	432,617	183,360	123,473	988,291	404,447	722,069	1,332,675
Apr		505,071	759,465	164,385	104,139	963,958	209,175	140,324	506,248
May		609,559	507,649	670,014	312,264	1,684,610	929,903	959,669	568,486
Jun		1,510,542	268,976	1,607,443	399,258	393,937	1,149,918	1,968,447	1,129,254
Jul		1,211,009	459,935	1,534,223	1,318,666	1,665,240	1,906,606	1,327,136	1,408,907
Aug		1,773,776	85,619	381,628	479,174	868,023	393,449	532,453	756,280
Sep		636,652	731,282	2,336,239	1,540,566	882,201	1,681,677	708,892	1,033,540
Oct	2,049,165	236,851	431,669	2,157,193	3,089,819	3,519,633	94,846	120,626	740,654
Nov	1,352,231	393,417	2,630,695	1,611,158	366,297	2,055,411	1,679,429	1,972,142	3,148,061
Dec	829,686	753,816	761,655	2,130,635	1,813,379	953,448	1,064,698	511,873	1,860,963

Source: Fisheries New Zealand (2020d).

Note: All values are presented in kilograms. Monthly breakdown of total yearly estimated catch shown in Figure 8. Indicated values correspond to the year of the *MV Rena* oil spill.

In 2012, a large increase real port landing value was observed. This is not expected to have occurred due to the *MV Rena*, given that it only affects a small part of a large commercial fishery. The cumulative port price for all species increased by NZD 2011 10.4/kg from 2011 to 2012, however this alone does not explain the large spike in port landing value observed in FMA1. It is more likely that this is due to an increased fishing effort overall, or with species with a higher landing value.

4.4.3 Losses to Tourism

The 25km stretch of beach from Mt Maunganui to Maketu (shown in Figure 7) was closed to the public from 13 October, until 16 November (Lundy, 2011; NZHerald, 2011), and according to the Tourism Bay of Plenty manager at the time, there were 168,000 less visitors from October 2011 to October 2012 compared to the previous year (Radio New Zealand, 2012). With this reported drop in visitors to the area, a decrease is expected in the amount of visitor spending that occurred after the *MV Rena* oil spill. Contamination of a coastal area is known to interfere with many activities, such as boating, diving, and bathing (OPOL & Oil & Gas UK, 2012). According to the Ministry of Business Innovation and Employment (2015), the Bay of Plenty represented approximately 3% of New Zealand's tourism expenditure, with Tauranga representing 82% of that. The change in expenditure (in millions), for domestic and international visitors in Tauranga City according to the Bay of Plenty RTO is shown in Figure 9. Given the oil spill occurred in October 2011, the expected impacts would be visible for 2011-2012, and potentially 2012-2013.

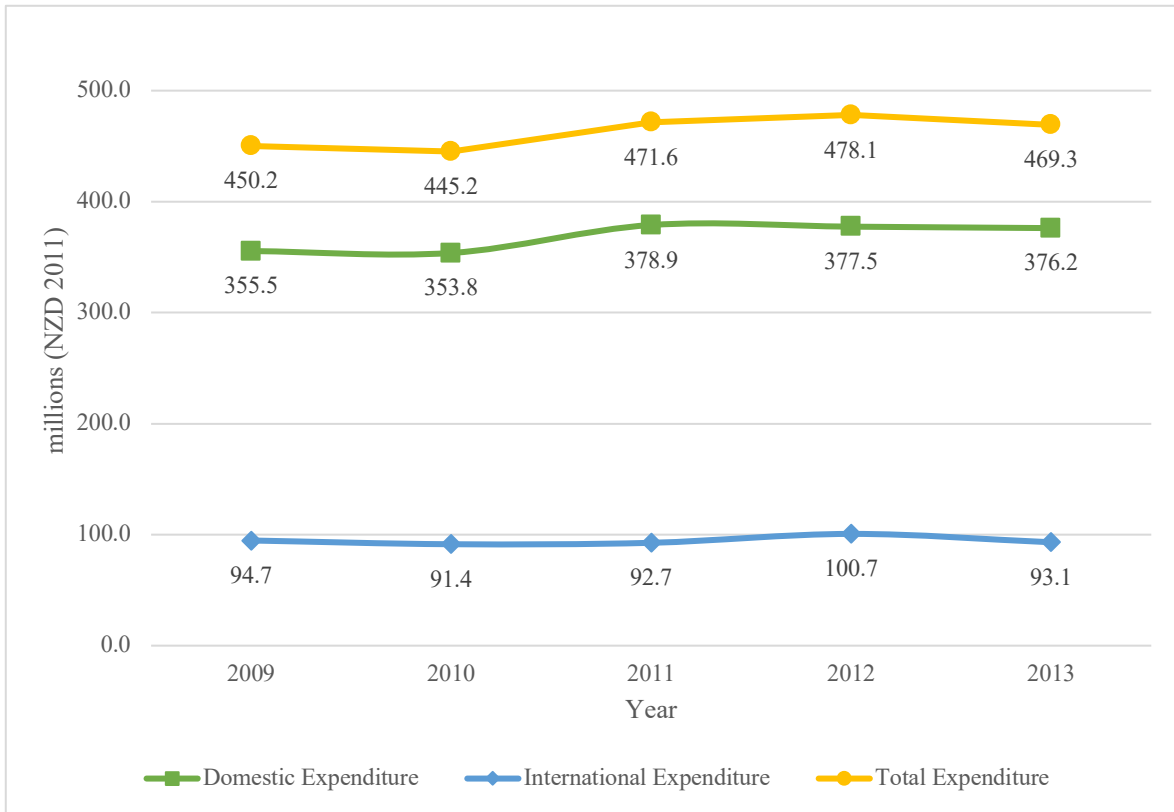


Figure 9: Domestic and international visitor expenditure in Tauranga. Estimated spending presented in NZD 2011

Source: Ministry of Business Innovation and Employment (2015).

The *MV Rena* response and salvage continued through the popular summer tourism months. Moreover, the tourism industry in Tauranga is comprised mostly of domestic visitors, so it is to be expected that there would be a negative change in domestic visitor spending. From March 2011- February 2012, there was an overall decrease of NZD 1.5 million for domestic visitor spending, and an increase of NZD 8.0 million for international visitor spending. From March 2012 to February 2013, there was a decrease of NZD 1.3 million for domestic visitor spending, and a decrease of NZD 7.5 million for international visitor spending, when compared to the previous year (Figure 9). This large increase in international visitor expenditure followed by a large decrease from 2012-2013, may be attributed to the large influx of international personnel who were in the area for the response and salvage operations (McLean, 2018). It may also be attributed to individuals choosing to visit the Tauranga area because of the oil spill, a phenomenon that has been observed previously (Loureiro et al., 2006). The occupancy rate (including both domestic and international visitors) suggests that there was an increase in spending in the short term, given that there was an increase of 5,457 when comparing the summer season of 2010 to 2011, and

then a decrease of 9,061 from summer 2011 to 2012 (Statistics New Zealand, 2019d). In December 2011, Tourism Bay of Plenty launched a rebranding campaign to encourage visitors to come to the area. However, this campaign lacked the funding to be a major national campaign, and they looked to the local businesses to promote their message as well (Piriority One, 2011). However, based on the domestic tourism expenditure data, it may not have increased, but it may have helped minimize the economic impacts.

4.4.4 Other Costs

4.4.4.1 Impacts to Wildlife

On 5 October 2011, the wildlife response commenced, led by MNZ, which includes New Zealand's National Oiled Wildlife Response Team led by Wildbase, Massey University (Gartrell et al., 2019; Hunter et al., 2019), and the first little blue penguin (*Eudyptula minor*) were captured and brought to the wildlife facility on the 7th of October. When estimating an oil spills impact on wildlife, it is necessary to collect both alive and dead animals that are found within the spill area (Heubeck et al., 2003; Hunter et al., 2019). Overall, 428 live seabirds were taken to the oiled wildlife facility, and 2063 bird carcasses from 49 species were processed, with 1376 (67 percent) of these being oiled (Gartrell et al., 2019; Hunter et al., 2019). It is important to take the time to collect the carcasses to get a complete impression of the impacts to wildlife for an oil spill impact assessment (Heubeck et al., 2003). It is difficult to estimate the economic value of the wildlife lost due to this oil spill, with no market values or previous studies existing for these seabirds on this side of the world. However, it is possible but is outside the scope of this research.

4.4.4.2 Restoration Costs

The MV *Rena* Long-Term Environmental Recovery Plan's main goal is to restore the affected environment to its pre-*Rena* state, as far as it is practical to do so (Ministry for the Environment, 2011). It is governed by various agencies, including members of the central government, local Māori/Iwi leaders, and local government. Much of the information that was used to show how the Bay of Plenty environment was coping with the oil spill was conducted by Waikato University, with the main report detailing the findings titled "Rena Environmental Recovery Monitoring Programme 2011/2013" (Te Mauri Moana, 2013). The plan was in force until June 2015, with \$2.42 million being provided by the New Zealand Government (Finlayson, 2014).

4.5 Discussion

Oil spills are capable of having significant direct and indirect economic effects on the communities and countries where they occur. The level of disruption to the fishing and tourism industries are directly connected to the same factors that determine how much an oil spill response will cost, such as the time of year, location, and how effective the oil spill response is (White & Molloy, 2003). Using the secondary data that is recorded by the New Zealand local and national government agencies, it is possible to estimate the short-term direct economic costs the *MV Rena* oil spill had on New Zealand and Bay of Plenty region. A summary of these costs is provided in Table 11.

Table 11: Summary of estimated costs of the *MV Rena* oil spill. Other than clean-up costs, only short-term (2012 compared to 2011) effects will be considered.

	Actual	Estimate
<i>Clean-up Costs</i>		
Total	46,891,000	
MNZ	36,266,617	
BoPRC	91,380	
Other	10,623,003	
Volunteer		312,000
<i>Commercial Fisheries</i>		
SA009		2,266,017
<i>Tourism Expenditure - Tauranga</i>		
Domestic Visitors		1,500,000
International Visitors		- 8,000,000
<i>Restoration Costs</i>		
	2,420,000	
<i>Estimated Net Losses</i>		
Total	45,479,017	

The costs associated with the clean-up of the oil are sizeable considering the small amount of oil that was released. The clean-up costs were exacerbated by the long response time, due to oil being released over the course of several weeks. Since at the time of the *MV Rena* oil spill, New Zealand only enacted the 1976 Convention on the Limitation of Liability for Maritime Claims (LLMC) and was therefore only eligible for \$11,030,110 in compensation claims (Judd, 2014). There is little information regarding the breakdown of these legal claims as the court records are sealed. As well as this claim, the clean-up response costs were reimbursed for \$27.6 million (Judd, 2014).

Commercial fishing and tourism are two industries that commonly have sizeable negative impacts due to oil spills. Most large oil spills result in long commercial fishing closures, where no fishing is allowed to occur for an entire fishery, not just what is immediately located around the wreck. The *Erika* 1999 oil spill contaminated approximately 450km of coastline, resulting in fishery and shellfish closures lasting between two and 18 months (Loureiro et al., 2006). The total costs associated with the *Erika* spill accounted for 0.13 percent of France's GDP at the time, and 2.50 percent of the local economy of Brittany (Deere-Jones, 2016). The *Prestige* 2002 oil spill resulted in a fishing closure ranging from two to eight months along the coast of Spain, Portugal, and France, represented a net loss of approximately €63.08 million (Loureiro et al., 2006). Overall, the costs associated with the spill represented approximately 1.57 percent of the total GDP of Galician economy.

The *MV Rena* is a different situation, in that there was no official fishing ban, but there was an exclusion zone placed around the wreck which was located on a productive reef. This appears to be an important fishing location within the area, with the majority of losses observed for SA009 occurring in October 2011 the time of grounding. Total SA009 landings were already on a downward trend, decreasing by 1.9 percent from 2010-2011. For this reason, it is difficult to conclude that the additional decrease in landings is only caused by the *MV Rena* oil spill. Since there was no official fishing ban in place, a decrease in landings could be attributed to a decreased fishing effort in the area, in order to protect ships and gear from being contaminated by the oil. The losses observed in the tourism sector are observed for domestic visitors, and a surge in international visitors, a trend observed for other oil spills (Cheong, 2012; Garza et al., 2009; Loureiro et al., 2006).

The total costs associated with the *MV Rena* represent approximately 0.42 percent of the Bay of Plenty GDP. Although this seems small, the amount of oil spilled only represents 1.13 percent of that from the *Erika* and 0.56 percent of that from the *Prestige*. One issue with comparing the losses of the spill to the GDP is that all expenses are for goods and services, which by definition add to the GDP, even though clean-up costs and impacts due to an oil spill reduce overall welfare for an area (Kubiszewski, 2019). The comparison to GDP is to demonstrate the relative scale of these oil spills to the economies of the regions where they occur. Although the *MV Rena* was a small oil spill with a relatively small direct cost, it had an impact on the local economy comparative to those of the larger spills.

It is important to bear in mind that the values provided are likely to be minimum estimates, based on the best available data. This analysis does not include multiplier effects,

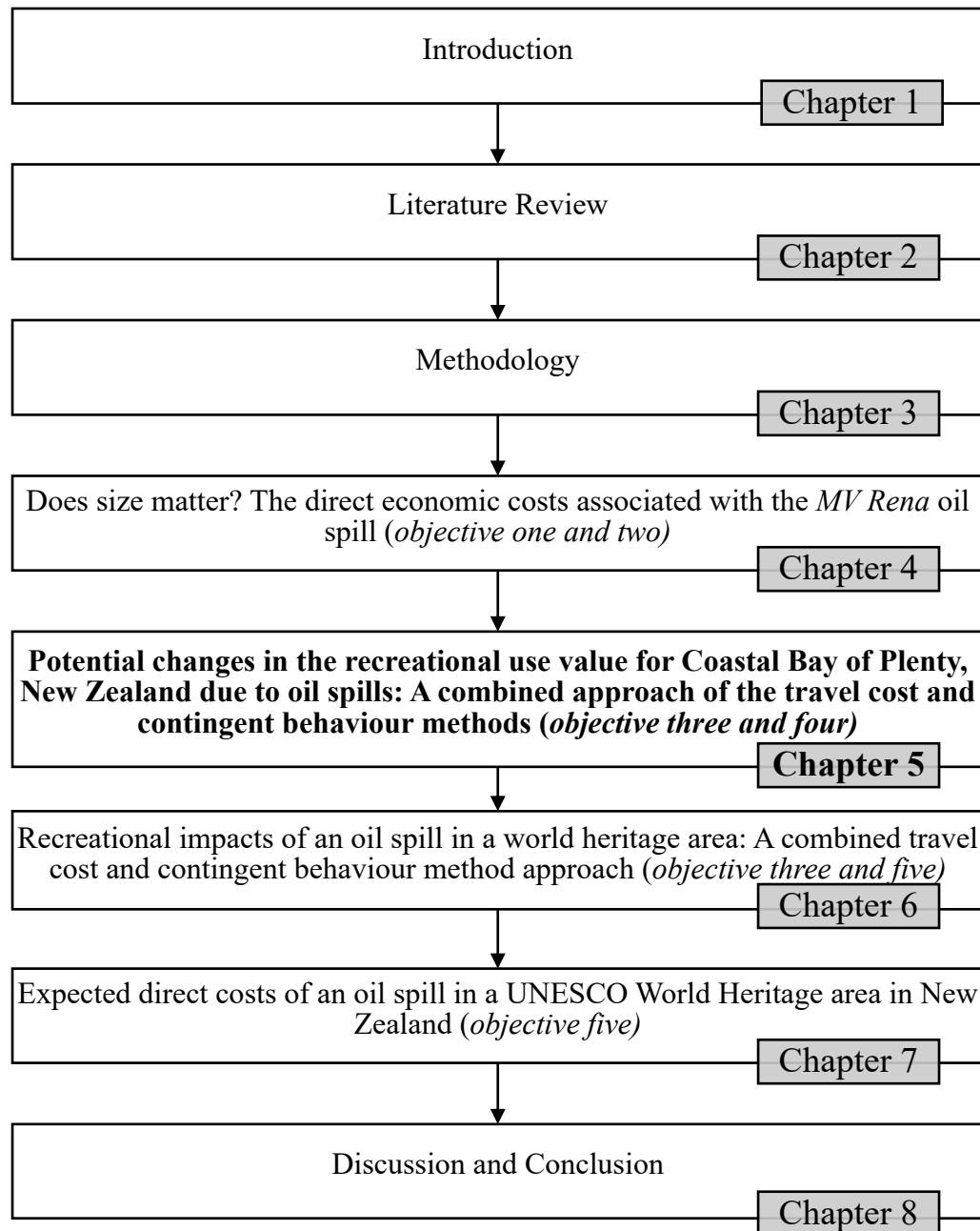
such as the potential impacts to employment within the tourism and fishing industry through processing and exporting processes, or any potential additional costs or saving due to a change in fishing effort. Losses to indigenous harvests, recreational fishing and shellfish harvesting, and non-financial benefits are also not considered.

4.6 Conclusion

In this chapter, I assessed the direct economic costs of the *MV Rena* oil spill to New Zealand by looking at the clean-up costs, commercial fishing and tourism industries. Tourism and commercial fishing contribute to New Zealand's two most important sectors, in terms of GDP, the primary and service industries. To my knowledge, this is the first attempt to estimate the wider economic losses due to the oil spill and one of only a few papers that looks at the direct clean-up costs, not as a function of the claims reimbursed through the IOPC Fund. Unfortunately, at the time of the *MV Rena*, New Zealand had not ratified the IOPC Supplementary Fund, and therefore was unable to claim anything above the allotted amount of the 1976 LLMC (Judd, 2014).

I acknowledge that this study is likely a minimum of loss estimates and does not reflect natural resources damaged and the non-use values lost, though I anticipate that they would be significant. However, these direct economic costs are important to understand in order to weigh the benefits and costs of different preparedness and preventative plans for oil spill response within New Zealand, such as the price of levies and maritime safety measures. The area of Tauranga is still considered high risk for another oil spill occurring (Bermingham, 2015; Chilvers & Battley, 2019), making the need to study the economic consequences from this previous oil spill critical to the greater understanding of how future oil spills may affect New Zealand coastal waters. Future research could be undertaken determining the unpriced benefits lost, such as those to coastal recreation, and the loss of non-use values associated with the oil spill. Similarly, understanding costs of oil spills for other areas of New Zealand, particularly remote, limited population areas where response costs are likely to be higher, to understand needs and costs of different preparedness and preventative plans.

Chapter 5: Potential changes in the recreational use value for Coastal Bay of Plenty, New Zealand due to oil spills: A combined approach of the travel cost and contingent behaviour methods



The following chapter investigates the recreational value of a stretch of beach that was heavily oiled by the *MV Rena* oil spill (from Mount Maunganui to Maketu in the Bay of Plenty Region). First, a recreational value will be estimated using the individual travel cost method. Secondly, contingent behaviour questions regarding different levels of an oil spill will be incorporated to estimate the recreational losses due to the *MV Rena*. There will be

some repetition of the methodology described in Chapter 3: 3.6 Recreational Value – Survey Design since this chapter was written and is published as a paper (Egan et al., 2022).

Egan, A. L., Rolfe, J., Cassells, S., & Chilvers, B. L. (2022). Potential changes in the recreational use value for Coastal Bay of Plenty, New Zealand due to oil spills: A combined approach of the travel cost and contingent behaviour methods. *Ocean & Coastal Management*, 228, 106306. doi:<https://doi.org/10.1016/j.ocecoaman.2022.106306>

5.1 Introduction

Coastal recreation is a popular pastime for New Zealanders, with an estimated 3.5 million people visiting beaches every year out of a population of just over 5 million (Statistics New Zealand, 2022; Water Safety New Zealand, 2021). This is not surprising given that New Zealand is an island nation and has the 10th longest coastline in the world, measuring over 14,000 kilometres (Bell & Gibb, 1996). Beaches contribute to human well-being through different ecosystem services, namely spiritual, aesthetic, recreational values, and supporting biodiversity (Millennium Ecosystem Assessment, 2005b). The degradation of these coastal marine environments, such as worsening water quality, has been shown to have negative economic impacts to these ecosystem services (Börger et al., 2021; Lankia et al., 2019). There are studies that have looked at the change in water quality on recreational values using the combined approach of travel cost and contingent behaviour methods. Lankia et al. (2019) investigated the effects of good, intermediate, and poor water quality (based on visibility) on swimming trips in Finland. For current water quality, the CS was €16.1 for car drivers, and combining the contingent behaviour data with the travel cost resulted in a CS of €22.1 for good water quality, €16.4 for intermediate water quality, and €9.0 for poor water quality. Börger et al. (2021) found a consumer surplus of €41.32 for travel cost model, and when incorporating improved water quality estimated €129.25 per adult/year, and worse water quality estimated €403.57 lost per adult/year (based on bathing quality). Though these recent studies employed the methodology used in this study, both were conducted in Europe, and there are limited studies of this nature regarding New Zealand coastal recreational values.

An oil spill is an example of an event that could negatively affect the environment, as well as the recreational value of a site, at least in the short term. Through the Bunker Convention and International Oil Pollution Compensation Fund, impacts to tourism and

fisheries, as well as clean-up and restoration costs, are able to be claimed for reimbursement. However, losses to recreational use are not currently covered under any of these treaties.

The Bay of Plenty coast, North Island, New Zealand (Figure 10) is a popular destination for domestic and international tourists alike, and is unique in comparison to the rest of New Zealand in that over 80 percent of the visitors are residents of New Zealand (Tourism Bay of Plenty, 2015). According to Surf Life Saving NZ (2022) who take headcounts along this stretch of beach, an estimated 641,683 visitors utilized the beach from Mount Maunganui to Maketu from Labour Day through to Easter in 2022.

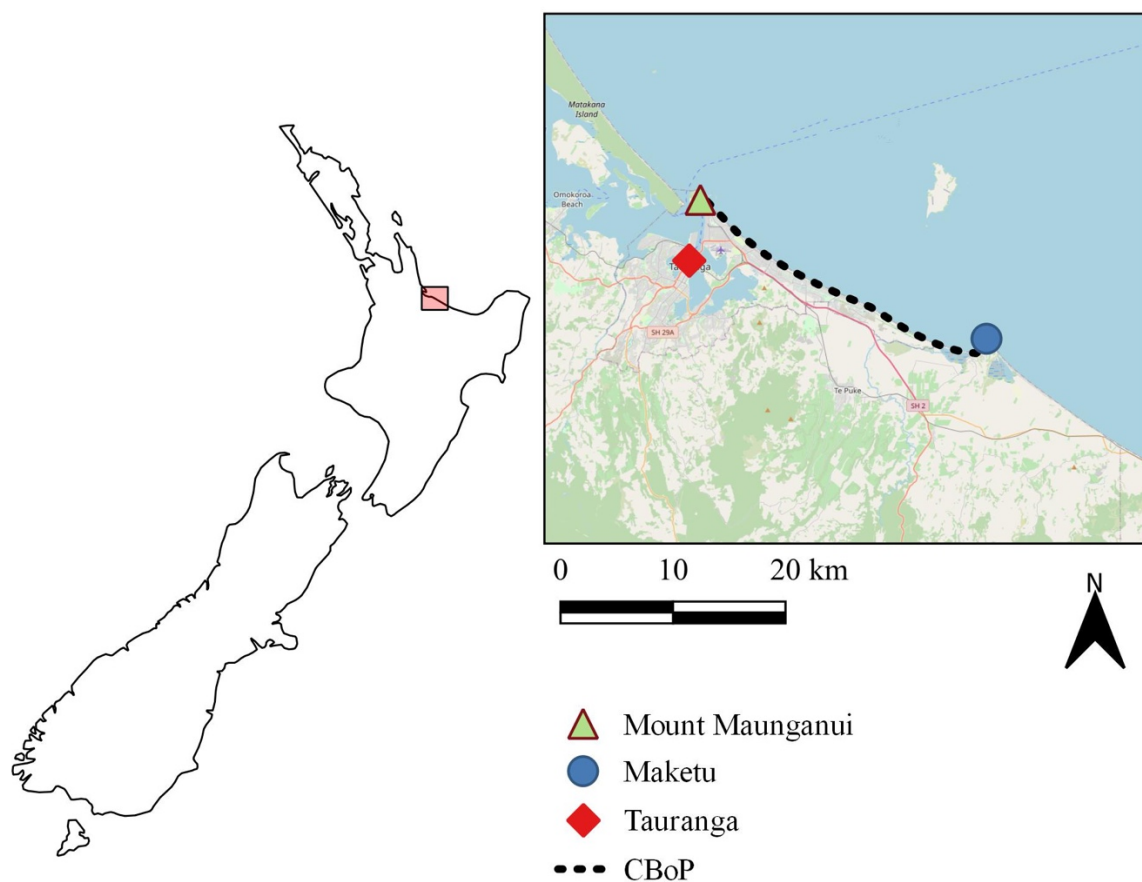


Figure 10: Map showing the Coastal Bay of Plenty (CBoP) study site. The site is ~25km of coastline from Mount Maunganui to Maketu in the Bay of Plenty region on the east coast of New Zealand's north island.

According to the Ministry of Business Innovation and Employment (2021), domestic tourism spends for the fiscal year ending June 2021 for the area of the Tauranga territorial authority was NZD (2021) 507 million, accounting for around 4.5 percent of the country's total domestic tourism spend. The Port of Tauranga (with Mount Maunganui at its entrance) is the largest port in New Zealand (Port of Tauranga Limited, 2021b), handling over 1,300 ships a year with a total of 15 berths, over one million in container volume (using a measure

of twenty-foot equivalent units, TEU), and has a quay length of 2.8km. Though most of these ships are container/cargo vessels, cruise ships also play an important role. Prior to COVID-19, the port handled 116 cruise ships throughout the summer season from 2018-2019 (Port of Tauranga Limited, 2022). The volume and frequency of ships, both cargo and cruise ships, through this area demonstrates the need to understand the economic impacts if coastal recreation in this area were to be negatively affected by a natural or anthropogenic disaster, and consequently how this relates to the New Zealand policies for preparedness for marine oil spills. This is demonstrated by the Bermingham (2015) report that undertook a marine oil spill risk assessment, finding that this area has a 'very high' risk of having severe consequences if an oil spill occurred near the shoreline (for more information regarding this, please refer to the report). According to Maritime New Zealand (n.d.-c), there have been seven significant marine oil spills in New Zealand, the most recent being the *MV Rena* which ran aground in October 2011, oiling the stretch of beach from Mount Maunganui to Maketu.

There are a few key pieces of legislation that aim to protect and control activities in New Zealand's coastal environment: The Resource Management Act, Marine and Coastal Area Act 2011, and the New Zealand Coastal Policy Statement 2010 (Environment Foundation, 2022). The 2010 review of the Marine and Coastal Area Act led to a nation-wide protection of surf breaks (Edwards & Stephenson, 2013; Orchard, 2020), however other specific recreational activities did not receive the same attention. Additional national pieces of legislation regarding marine pollution are the Maritime Transport Act and the Exclusive Economic Zone and Continental Shelf Amendment Act 2013 (Maritime New Zealand, 2021).

This study has two main objectives, first to estimate the recreational value of a stretch of beach in the Bay of Plenty region using the travel cost method, and secondly to estimate the sensitivity of the recreational value in the event of one of three different size oil spills impacting this coastline. Many of the recreation-based studies in New Zealand focused on recreational fishing (Kerr & Latham, 2011; Marsh & Schischka, 2008; Muller et al., 2018), national parks (Kerr et al., 1986; Woodfield & Cowie, 1977), forests (Dhakal et al., 2012), and freshwater systems (Harris & Meister, 1981; Omwenga, 1995). There are few, if any, studies that have investigated the value of coastal recreation in New Zealand, and none that have valued sensitivity to oil spills.

The research was undertaken by carrying out on-site surveys of the users of the beach, eliciting the data needed to apply the travel cost method, followed by contingent behaviour questions. All those surveyed were currently residing in New Zealand, due to the border

being closed from COVID-19. The consumer surplus per person per visit will first be determined, and then future expected visits under the different oil spill scenarios will be incorporated to estimate each corresponding recreational loss. This also allows us to estimate the recreational loss that may have been observed for the *MV Rena* oil spill that occurred in this area in 2011 (Börger et al., 2021; Voltaire & Koutchade, 2020) and is further described in the next section.

5.2 Method

5.2.1 Study Site

The stretch of beach from Mount Maunganui to Maketu was selected to undertake surveys for this study as it represents the stretch of coastline that was most affected by the *MV Rena* oil spill (Figure 10). The *MV Rena* ran aground on Astrolabe Reef directly off the coast of Tauranga on 5 October 2011, eventually releasing around 360 tonnes of heavy fuel as well as various other hazardous materials (Sievwright et al., 2019). This area is an important destination for domestic tourists, as well as being frequented by international tourists through the cruise ship industry (100% Pure New Zealand, 2018; Tourism Bay of Plenty, 2015). Part of this stretch of beach at Mount Maunganui (Figure 11) is considered one of the best beaches in New Zealand (Sivertsen, 2021).



Figure 11: Photo from the top of Mount Maunganui (top), and an entrance near Moturiki Island (bottom).

Source: Photos by Alexandra L. Egan.

5.2.2 Travel Cost Method

Throughout the past few decades, the recreational benefits derived from coastal/marine and other outdoor recreation have been estimated using the revealed preference travel cost method (TCM) (Bin et al., 2005; Castellini et al., 2009; Fleming & Cook, 2008; Houngebeme et al., 2020). The aim of TCM is to estimate the physical and social benefits that are generated by outdoor recreation into monetary terms (Zhang et al., 2015). The zonal travel cost (ZTCM) and individual travel cost (ITCM) are two variations of this method that may be used. The ZTCM groups respondents into zones, and then estimates the travel costs (TC) over the zonal population (Fleming & Cook, 2008). The ITCM estimates the TC from the individual visits made by each visitor and is the preferred method of the two (Anciaes, 2021; Bhat, 2003; Houngebeme et al., 2020). This method uses differences in travel costs by individual users of a site to estimate a demand curve, allowing the consumer surplus to be calculated. It is generally accepted that the ZTCM is more appropriate when there are lower individual visitation rates, and the ITCM is more suitable when there are high individual visitation rates (Rolfe & Dyack, 2011).

When the TCM was first introduced, it was generally modelled using ordinary least squares regression, or linear regression techniques (Dhakal et al., 2012; Du Preez et al., 2012; Hanley & Ruffell, 1992; Shaw, 1988). However, over time it has become common place to use count data models. Within recreation demand analysis, the Poisson Distribution (PD) regression is the most common tool used (Chae et al., 2012; Du Preez et al., 2012; Loomis, 2006; Voltaire et al., 2017; Zawacki et al., 2000), as provided by Hellerstein and Mendelsohn (1993). The benefit of using a PD regression model is that it aligns with the count data qualities of recreation visits (Zhang et al., 2015).

When overdispersion is present in the data, the Negative Binomial (NB) regression, a more generalized form of the PD regression, is preferred. It relaxes the assumption that the variance must equal the mean, allowing for overdispersion, as well as acknowledging the nature of data being an integer and truncated at '0' (Amoako-Tuffour & Martínez-Espiñeira, 2012; Borzykowski et al., 2017; Englin & Shonkwiler, 1995; Houngebeme et al., 2020; Landry et al., 2016; Martínez-Espiñeira et al., 2008; Shrestha et al., 2002; Windle & Rolfe, 2013; Zhang et al., 2015). Thus, the variance is allowed to be greater than the mean, a problem frequently observed in TC data. This may occur when there are several visitation rates for many different levels of the TC of the trip (Prayaga et al., 2010). This is commonly obtained by introducing an additional variable, commonly referred to as α , reflecting the

overlooked heterogeneity that the PD regression does not capture (Amoako-Tuffour & Martínez-Espiñeira, 2012).

Endogenous stratification is an issue that occurs with on-site sampling, in that one is most likely to survey people who visit more often. It is usually corrected for by subtracting one visit from the number of visits that the respondent has reported (Blaine et al., 2015; Englin & Shonkwiler, 1995; Landry et al., 2016). This is commonly referred to as the Englin correction. A general NB regression can be modelled as (NCSS, 2020):

$$P \lambda(x; \theta, \alpha) = \left(\frac{\Gamma(y_i + \alpha^{-1})}{\Gamma(y_i + 1)\Gamma(\alpha^{-1})} \right) \cdot \left(\frac{1}{1 + \alpha\lambda} \right)^{\alpha^{-1}} \cdot \left(\frac{\alpha\lambda}{1 + \alpha\lambda} \right)^{y_i} \quad \text{Equation 10}$$

Where Γ is the gamma probability density function for $\lambda(x; \theta)$, the mean of the distribution is represented by λ per y_i unit of exposure, and $(1 + \alpha\lambda)$ represents the variance. As α approaches zero, the distribution becomes better fit to a PD regression. This leads to the demand function being represented by:

$$\lambda(x; \theta, \alpha) = \exp(\ln(t_i)) + (\beta_0 + \beta_1 TC + \beta_2 X_2 + \dots + \beta_n X_n) \quad \text{Equation 11}$$

Where t represents the time of exposure, and β_n are the regression coefficients of the X_n variables. The regression coefficients for both the PD and NB regressions are estimated using the maximum likelihood method. Between the PD and NB regression, it can be assumed that the NB will better fit travel cost data, however, one doesn't know until the level of overdispersion present in the data is observed.

An individual's consumer surplus (CS) is the difference between what one is willing to pay for a good/service and what one actually pays for it. Summing these to obtain the overall CS allows you to estimate the net benefits received from an environmental recreation site (Zhang et al., 2015). Since count data models adopt a semi-log functional form (Lankia et al., 2019), they allow the CS per trip to be defined as the inverse of the travel cost coefficient (Houngbeme et al., 2020; Prayaga et al., 2010; Zhang et al., 2015).

A single site model is most common as described above; however, this does not allow one to estimate the change to recreational value based on site quality (Lankia et al., 2019). Random Utility Models are an alternative approach to the single site model (Alvarez et al., 2014; Efimova, 2019), but they require that alternative sites be defined, and this is generally

difficult to do. The contingent behaviour (CB) method, a stated preference technique, may be combined with the TCM instead of utilizing one of the multi-site methodologies (Lankia et al., 2019). This combined approach has been used to see the effects on recreation of windfarms (Kipperberg et al., 2019; Voltaire & Koutchade, 2020), water quality (Anciaes, 2021; Börger et al., 2021), changes in water activities (Lankia et al., 2019; Prayaga et al., 2010; Wang et al., 2020), and the presence of marine reserves (Bhat, 2003).

5.2.3 Data Collection

Data were collected by surveying the current users of the stretch of beach from Mount Maunganui to Maketu over the course of two weeks in January/February 2021. This research was considered low risk by Massey University (4000023029), and no incentives were provided to respondents. Beach goers were approached at random and asked to confirm that they were over 18 years of age, and a survey was administered for one per travelling group sharing expenses. When approached, visitors were not informed that this survey would be in relation to a pollution event, to help minimize response bias, and not attract respondents who would be more inclined to complete the survey for this reason. The target population was users of this stretch of beach, and by surveying on each day of the week it would be reasonably representative of the beach going population. For those who preferred to not complete the survey in person, they were provided with an online code and encouraged to complete at a time convenient to them. This research took place during COVID-19; therefore, a negligible number of international visitors (those not currently residing in New Zealand) were expected to be present. This was especially true in New Zealand, since the borders were closed to all international visitors.

The direct travel expenses were calculated using the round-trip costs from the respondent's permanent residence, which was identified via postal code, including the mode of transportation, and accommodation costs during the visit. To calculate the cost of transit, respondents were asked what type of transportation was used (personal vehicle, plane, cruise ship, bus, etc.). If a personal vehicle/rental car was used, the type of vehicle and what kind of power (petrol, electric, etc) used, was asked for. The distance and costs associated with traveling to the site can then be estimated based on the cost of running a vehicle (Inland Revenue, 2020). Inland Revenue distinguishes between two methods of calculating running costs. "Tier one" includes fuel costs and the fixed costs of running a vehicle (such as the cost of registration, maintenance etc.) while the "Tier two" approach considers only fuel costs. "Tier two" running costs for a vehicle were selected over "Tier one" as recreational users are

most likely to factor in fuel costs only, in their decision to take a trip or visit a site (Inland Revenue, 2020). This is a common way to calculate travel costs within the literature (Loomis & Santiago, 2011; Marini Govigli et al., 2019; Martínez-Espiñeira & Amoako-Tuffour, 2009; Matthew et al., 2019), rather than asking the respondents to estimate how much their journey cost. For those who took a plane or another form of transportation, the average cost of tickets 6 weeks out from their departure location was used.

Given the large number of people who live near/on this stretch of beach, additional travel modes such as walking, and biking were included. If the respondent lived within 20km to the beach, they were asked exactly how close, to have greater differentiation in travel distances. This information was followed by asking the respondent their 'travel party size,' since it is common for people traveling together (such as a couple or family) to share expenses. This allows the calculation of the appropriate per-person travel cost. Sociodemographic information was also collected, such as their education level, gender, employment status, annual household income, and age. The NB model was chosen to accommodate overdispersion in the data set, including the Englin correction for endogenous stratification (Amoako-Tuffour & Martínez-Espiñeira, 2012; Englin & Shonkwiler, 1995; Prayaga et al., 2010).

Respondents were also asked whether their future visitation behaviour would change under three different environmental quality scenarios. Specifically, the questions inquired as to how their future behaviour regarding visits to the beach would change with varying degrees of oil appearing along the coastal waters and beach and the potential restrictions the oil would have on their ability to undertake recreational activities. Prior to the questions being asked, a description of an oil spill incident was depicted. With each contingent behaviour question, icons were provided to visually describe which activities would no longer be possible within the study area. CB scenario one was a small oil spill, CB scenario two was a moderate oil spill, and CB scenario three was a major oil spill. Below are the three scenarios presented.

CB scenario one: Water quality is slightly worse than current conditions, with occasional traces of oil. You can still access the entire beach but enter the water at your own risk.



CB scenario two: Water quality is worse than current conditions, with many traces of oil. You are able to access the beach; however, you are unable to enter the water.



CB scenario three: Water quality is considerably worse than current conditions, with remnants of oil across the beach. Swimming and other marine activities are prohibited, and the beach is only accessible above the high tide line.



After each scenario, the respondent was asked whether they would have still visited this site, and the Bay of Plenty region on the current trip. Then, the respondent was asked how many times they would visit the Coastal Bay of Plenty in the next two years, if there had been an oil spill, and if they did not come, whether they would stay home or visit somewhere else.

Data cleaning was executed, removing future visit rates that did not make logical sense. This data was then pooled with the past trip data set and allows one to estimate the change in benefits received by the recreationist (Rolfe & Dyack, 2011). An NB model, as well as a pooled model using both NB combined with a Panel Model with Group Effects was used for this panel data set. A description of variables used in the analysis can be found in Table 12. The full survey can be found in Appendix A1.

Table 12: Description of variables used in travel cost and contingent behaviour analysis.

Variable	Description
Trips	Trips to CBoP reported by respondent over the past 2 years
TCppT2	Travel cost per person per trip
TCAppT2	Travel cost per person per trip + accommodation
CBLevel	Dummy code for pooled data, 0=past trips, 1=CB1, 2=CB2, 3=CB3
CB1	Future trips (2 years) under CB scenario one
CB2	Future trips (2 years) under CB scenario two
CB3	Future trips (2 years) under CB scenario three

5.3 Results

5.3.1 Travel Cost Model Results

Of the 434 beachgoers approached, there were 193 useable responses (in that the respondents answered all questions used in this analysis and logically made sense (Lankia et al., 2019)), yielding a response rate of 44.5 percent. Just over half of the respondents were male (53.4 percent), 30.6 percent were in the 30-45 age bracket, and had a mean travelling group size of 3.1 persons. Of the 193 responses, 39.0 percent were locals/residents. Roughly 54.4 percent of respondents were employed full time, and 54.4 percent held a bachelor's degree or higher. Approximately 83.0 percent decided to visit the CBoP prior to leaving their home, signifying this stretch of beach's importance in the decision of respondents to take the trip. The level of influence that the CBoP site had on visitors' decision to take a trip also indicated the value of the site to this decision, with 53.9 percent of respondents rating it a 5 (out of a scale of 0-5, with 5 being the most influence). Descriptive statistics for the survey respondents are provided in Table 13 (further descriptive statistics provided in Appendix B1).

Table 13: Descriptive statistics for all the survey respondents (n=193) in the Coastal Bay of Plenty (CBoP) survey area. Sampling occurred over a two-week period in January/February 2021.

	Mean	SD
Past Trips to CBoP – past two years	129.18	196.38
Group Size	3.10	2.22
Percentage locals	38.86%	
Age	41.86	14.29
18-29	26.94%	
30-45	30.57%	
46-64	29.53%	
65+	10.36%	
Did not answer	2.59%	
Days - in CBoP	3.85	8.29
Days – total trip	7.67	28.37
Travel cost pp	\$41.04	\$115.46
Travel cost pp with accommodation	\$989.17	\$1947.94
Gender – female	46.63%	
Decided on visiting CBoP before leaving home	82.90%	
This was their first visit to CBoP	7.77%	
Education		
Some High School	6.22%	
High School Graduate	14.51%	
High School Equivalent	3.63%	
Tertiary/Trade Certificate	12.47%	
Bachelors/University Degree	38.86%	

Postgraduate Qualification	15.54%	
Other	6.74%	
Did not answer	1.04%	
Employment Status		
Full Time	54.40%	
Part Time	16.06%	
Retired	7.77%	
Student	5.70%	
Unemployed	7.25%	
Self-Employed	7.77%	
Did not answer	1.04%	
Annual Household Income		
Less than \$45,000	17.10%	
\$45,001 - \$60,000	7.25%	
\$60,001 - \$80,000	10.88%	
\$80,001 - \$100,000	12.95%	
\$100,001 - \$120,000	6.74%	
\$120,001 - \$140,000	8.81%	
\$140,001 - \$160,000	6.22%	
\$160,001 - \$180,000	5.18%	
\$180,001 - \$200,000	7.77%	
More than \$200,000	10.88%	
Did not answer	6.22%	
Level of Influence CBoP had on decision to make the trip		
Zero	2.07%	
One	3.11%	
Two	3.63%	
Three	11.40%	
Four	24.35%	
Five	53.89%	
Did not answer	1.55%	

A large percentage of respondents, approximately 43.0 percent, were from the Bay of Plenty region, with Auckland being the second most common region of residence for those visiting CBoP, as shown in Figure 12.

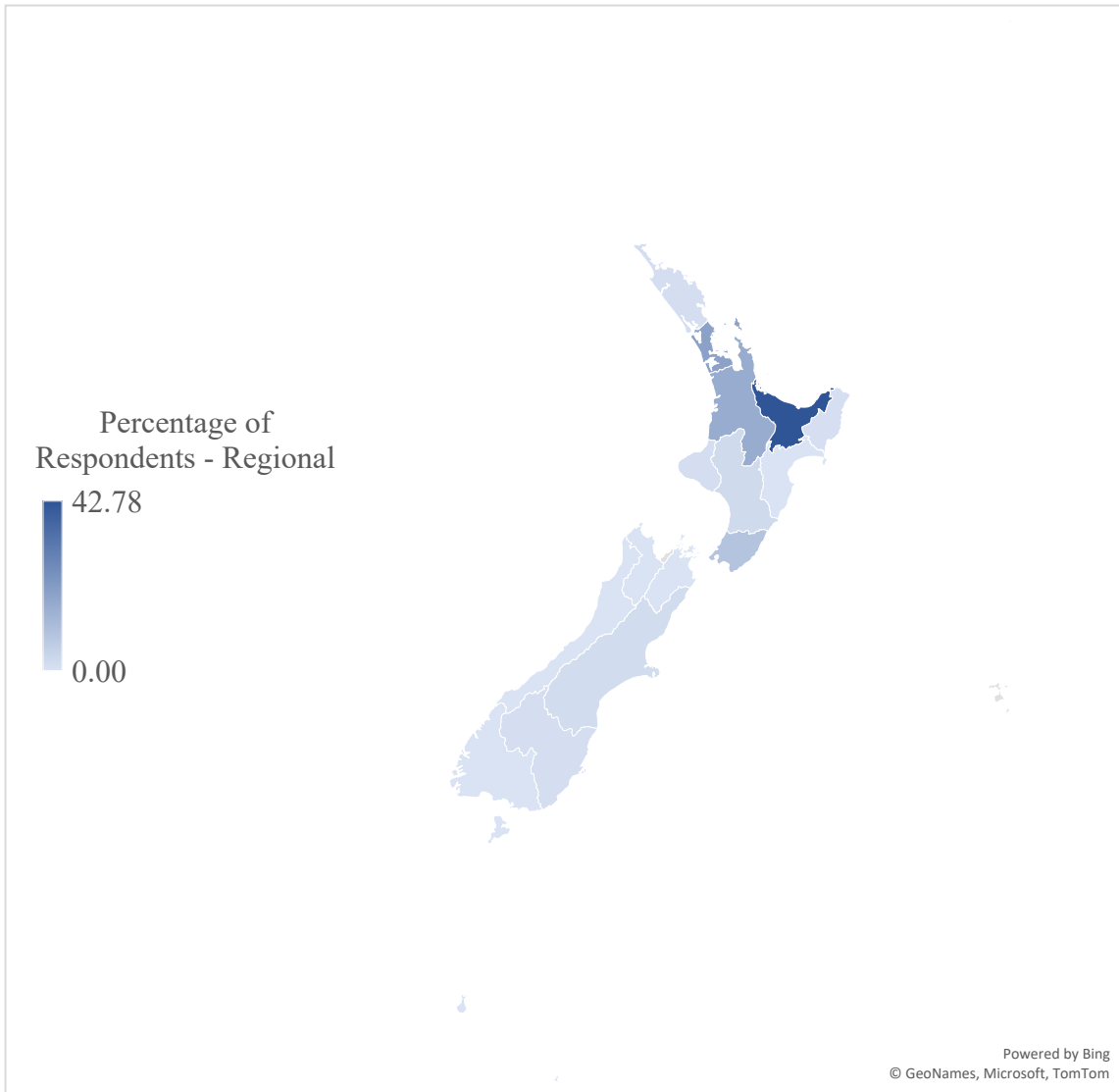


Figure 12: Map of New Zealand regions where Coastal Bay of Plenty survey respondents identified their residence to be.

Respondents were also asked what their top three reasons for visiting the CBoP were. Approximately half of respondents listed their number one reason for visiting the area was to go to this stretch of beach from Mount Maunganui to Maketu, followed by swimming and the scenery. The most common responses identified under ‘other’ were to visit family/friends, surfing, and to relax. This reinforces the importance of the beach and marine activities in respondents’ decision to visit this area/take a trip. A further breakdown of these rankings is found in Table 14.

Table 14: Respondents' top three reasons for visiting the Coastal Bay of Plenty (CBoP).

Primary Reason for Visiting CBoP	Reason 1	Reason 2	Reason 3
Beaches	47.15%	18.65%	11.40%
Swimming	14.51%	30.57%	6.74%
Boating/Kayaking	0.00%	1.55%	2.07%
Scenery	5.70%	13.99%	30.57%
Marine Activities	1.04%	1.55%	3.11%
Walk/hiking/tramping	8.29%	13.47%	12.95%
Camping	0.00%	1.55%	2.07%
Shopping	0.00%	2.59%	3.63%
Restaurants	0.52%	3.11%	11.40%
Day trip elsewhere	0.00%	0.00%	1.55%
Wildlife	0.00%	0.52%	0.52%
Other	21.76%	9.84%	9.84%
Selected Multiple	0.52%	0.00%	0.00%
Did not answer	0.52%	2.59%	4.15%

Note: The two most common reasons for the 'other' category were family and surfing. Reason 1 other (16.2% family, 18.9% surfing), reason 2 other (23.8% family, 23.8% surfing), reason 3 other (5.0% family, 10.0% surfing).

Negative binomial (NB) regression models were performed on all observations (193), and then again with outliers removed, reducing the number of observations to 188. However, there was little variation between these two sets of data for the truncated models, so all observations were used for the travel cost analysis. It was decided not to split the observations between locals and visitors, due to the lower number of surveys for locals. Due in part to the large number of respondents who visit the site multiple times a week, resulting in many respondents having around 200 visits over two years, truncation was manually set to 206, which had the best fit for the model when trialling different levels. The model was first estimated including demand shifters, such as education, employment status, household income, gender, and age. However, none of these variables were significant, and for this reason are not included in the final analysis (results can be found in Appendix B3). Interaction effects between age and gender were also considered but were found to be non-significant and are not reported on. The results for the NB model using travel costs with and without accommodation can be found in Table 15, with the CS per person/trip.

Table 15: Truncated Negative Binomial results for the two travel cost models, both without (TCppT2) and with (TCApT2) accommodation.

	TCppT2		TCApT2	
	NT	T	NT	T
Log likelihood function	-967.2474	-377.0253	-958.1300	-375.9469
AIC	10.054	3.938	9.96	3.927
Constant	4.96431***	3.07724	5.00045***	5.99004***
Alpha	3.24797***	13.0315	2.98237***	0.58562
Coefficient	-.00516***	-.00740	-.00275***	-.00825***
CS per person/trip	\$193.80	\$135.14	\$363.64	\$121.21
Lower CI (2.5%)	\$156.94	\$7.86	\$316.09	\$89.54
Upper CI (2.5%)	\$243.65	-\$9.47	\$431.57	\$180.35

Note: ***, **, * ==> Significance at 1%, 5%, 10% level, respectively. NT=Not Truncated, T=Truncated.

In both cases (with and without accommodation costs), the truncated model outperformed the non-truncated model. Alpha is greater than zero across all four models, confirming that the NB is a better fit than a Poisson model. The travel cost (including accommodation) performed better than the model excluding accommodation, so will be the focus of the results that are discussed further. The travel cost coefficient was found to be significant at the one percent level for TCApT2. This indicates that visitors are factoring in the accommodation and travel cost of their trip, rather than just the travel components. The CS per person per trip was found to be NZD 121.21 (NZD 89.54-180.35). Assuming the estimate of 641,683 annual visitors to this area (Surf Life Saving NZ, 2022), the annual recreational value of the CBoP can be estimated at NZD 77.78 million (NZD 57.56-115.73 million).

5.3.2 Contingent Behaviour Results

The contingent valuation experiment assessed the impact of an oil spill on this stretch of coast for future recreation visits, relative to the average number of past trips in the last two years (138.4). The average number of future trips to the beach in the next two years per person decreased with each increase in oil level 100.1 for CB1, 68.6 for CB2, and 49.0 for CB3. The dependent variable for the NB model was CBs1, 2 and 3, representing the future trips with varying degrees of activities being inaccessible. The Pooled model introduced the variable CBLevel, which was coded to represent the CB scenario the response corresponded to (see Table 12). The responses for each level were stacked to create the pooled data set. The results for all CB models can be found in Table 16.

Table 16: Contingent Behaviour scenario (CB) results, both individual negative binomial models and Panel Effects (PE) models presented.

	NB Model			Pooled	
	CB1	CB2	CB3	Pooled (NB)	Pooled (PE)
Observations	188	186	188	736	736
Log likelihood function	-288.5951	-202.2740	-147.3707	-3161.2445	-1933.1337
AIC	3.102	2.207	1.6	8.601	5.261
Constant	-1.53326	5.78677***	5.70416***	5.10664***	-.68899***
Alpha	1097.42	0.6224	0.63837	3.69993***	-
TCApT2 Coefficient	-.03362***	-.10176***	-.23257***	-.00393***	-.00170***
CBLevel Coefficient	-	-	-	-.36365***	-.23347***
CS per person/trip	\$29.74	\$9.83	\$4.30	-	-
Lower CI (2.5%)	\$17.22	\$6.53	\$3.10	-	-
Upper CI (2.5%)	\$121.63	\$21.49	\$6.58	-	-
CS per change in spill intensity	-	-	-	-\$92.51	-\$137.34

Note: ***, ** and * indicate significances at the 1%, 5% and 10% levels, respectively.

The NB models for each CB scenario all had highly significant travel cost coefficients, demonstrating the influence of oil spills on future visitation rates. For each level decrease in accessibility to the beach and its activities, there was a CS loss of NZD 91.47 (for CB1), 111.38 (CB2), and 116.91 (CB3) per person per trip. This leads to an estimate of annual recreational losses (assuming 641,683 visitors annually) of NZD 58.70 million, NZD 71.47 million, and NZD 75.02 million for CB scenarios one, two and three respectively. The pooled model also had highly significant travel cost and CBLevel coefficients. This model showed a reduced value of NZD 92.51 per person/trip for a one unit increase in oil level for the pooled NB model, and NZD 137.34 per person/trip for the pooled panel model.

5.4 Discussion

With coastal recreation being such a popular past time amongst New Zealanders, it's important to understand the potential losses in recreational value that may occur if people could no longer access it and enjoy their coastal activities. The study site of the beach from Mount Maunganui to Maketu in the Bay of Plenty was chosen since this is where New Zealand's largest marine oil spill occurred in 2011, limiting people's access to this stretch of beach. To my knowledge, this is one of the first studies using this combination of revealed and state preference techniques for coastal recreation in New Zealand.

Using the ITCM to estimate the recreational value of the stretch of beach from Mount Maunganui to Maketu (Figure 10), the CS per person for a single visit was estimated to be NZD 121.21, including both locals to the area and travellers from further away. The travel cost coefficient is negative and significant at the one percent level, confirming that the higher the travel cost, the less visits one will make. The CS here is generally higher than in much of the literature since many studies do not include accommodation costs. Examples include USD 16.95-21.73 for a beach visit in Ecuador (Zambrano-Monserrate et al., 2018), and AUD 19.47 for Gold Coast, Australia (Zhang et al., 2015). However, for studies that do include accommodation, the CS (using travel costs inclusive of accommodation) is similar. Windle and Rolfe (2013) found for overnight visitors specifically, their CS ranged from AUD 212.63-234.14 when visiting beaches in Brisbane, Australia. Similarly, for those visiting the Coorong in Australia, the CS was found to be AUD 242.08 (AUD 186.–7 - 328.41) (Rolfe & Dyack, 2011)(see Appendix B5 for further details on these and other studies). Another explanation as to why this CS is higher is the higher percentage of visitors from further away (61.0 percent) as compared to locals (39.0 percent), leading to higher travel costs, and less frequent visits. Though none of the explanatory variables were significant, it is expected that this may be due to the relatively small sample size.

The contingent behaviour models showed that even the lowest amount of oil being present on the beach, would impact the number of visits over the next two years, reducing these and the CS per person/visit from NZD 121.21 to NZD 29.74. Looking at the pooled panel model results shows that a decrease in value of NZD 92.51 is attached to each increase in oil level/loss of coastal activities in this area. Minimum annual recreational use losses for this area are estimated at NZD 58.70 million based on the estimate of 641,683 visitors (Surf Life Saving NZ, 2022). Garza et al. (2009) estimated the indirect losses associated with the *Prestige* oil spill in Spain, with losses to recreation being estimated around EUR 86.9 representing 3.8 percent of the total indirect estimation. To put this in perspective, the *Prestige* leaked around 77,000 tons of heavy fuel oil and impacted approximately 1,000 kilometres of Spain's coastline. The *MV Rena* impacted approximately 25 kilometres of beach and leaked 360 tons of heavy fuel oil, and the estimated losses represents approximately 0.62-0.79 percent of the current GDP of the Bay of Plenty region.

This stretch of beach was most impacted by the *MV Rena* spill, allowing these contingent behaviour scenarios to be used as a range for possible recreational losses from the *MV Rena*. Up until this point, only direct market values and environmental impacts

associated with this oil spill have been studied. Though there are likely wellbeing impacts due to this spill, only the losses to direct use values will be considered. Including the direct market losses associated with fisheries, tourism, restoration, and clean-up costs from Chapter 4: Does size matter? The direct economic costs associated with the *MV Rena* (NZD (2011) 45,479,017), the direct use losses associated with the *MV Rena* can be estimated between NZD (2011) 111.62-130.01 million, representing 1.04-1.21 percent of the area's GDP in 2011, when potential recreational losses are included. In addition, there may be other wellbeing losses that have not been considered.

From a policy perspective, the effects that oil spills have on a community need to be considered. The Port of Tauranga has been consistently expanding, handling around 590,000 TEUs in 2011 increasing to 1.2 million TEUs in 2021 (Port of Tauranga Limited, 2021a, 2021b), increasing the likelihood of another oil spill in the future. Based on the results presented in this study, an oil spill in this area has been estimated to decrease the welfare of visitors by 75-96 percent for a year (or NZD (2021) 58.70-75.02 million). This estimate only considers the perceived oil level on the beach, and its impacts to various marine based recreational activities. This does not factor in if the oil spill response and salvage operations take a long time, or how long the beach may be closed to the public, and therefore should be considered a lower bound estimate. This estimate also does not include the physical environmental impacts, impacts to physical sites and cultural aspects for NZ Māori/local iwi (New Zealand's First nations people), impacts to the wellbeing of visitors/residents, and the spiritual and non-use values associated with this area.

The potential estimated losses presented in this chapter from the *MV Rena* oil spill demonstrate that New Zealand needs to be fully prepared for when another incident like this occurs, in order to minimize the possible economic and environmental damages. This would include: (a) investing in equipment and training of oil response staff to mobilize responses quickly and efficiently and (b) making sure there is a sufficient supply of response equipment not only at major ports, but at various locations around the coast of New Zealand. Investing in preparedness for all aspects of an oil spill response will lessen possible damages and potentially save money and overall losses long-term.

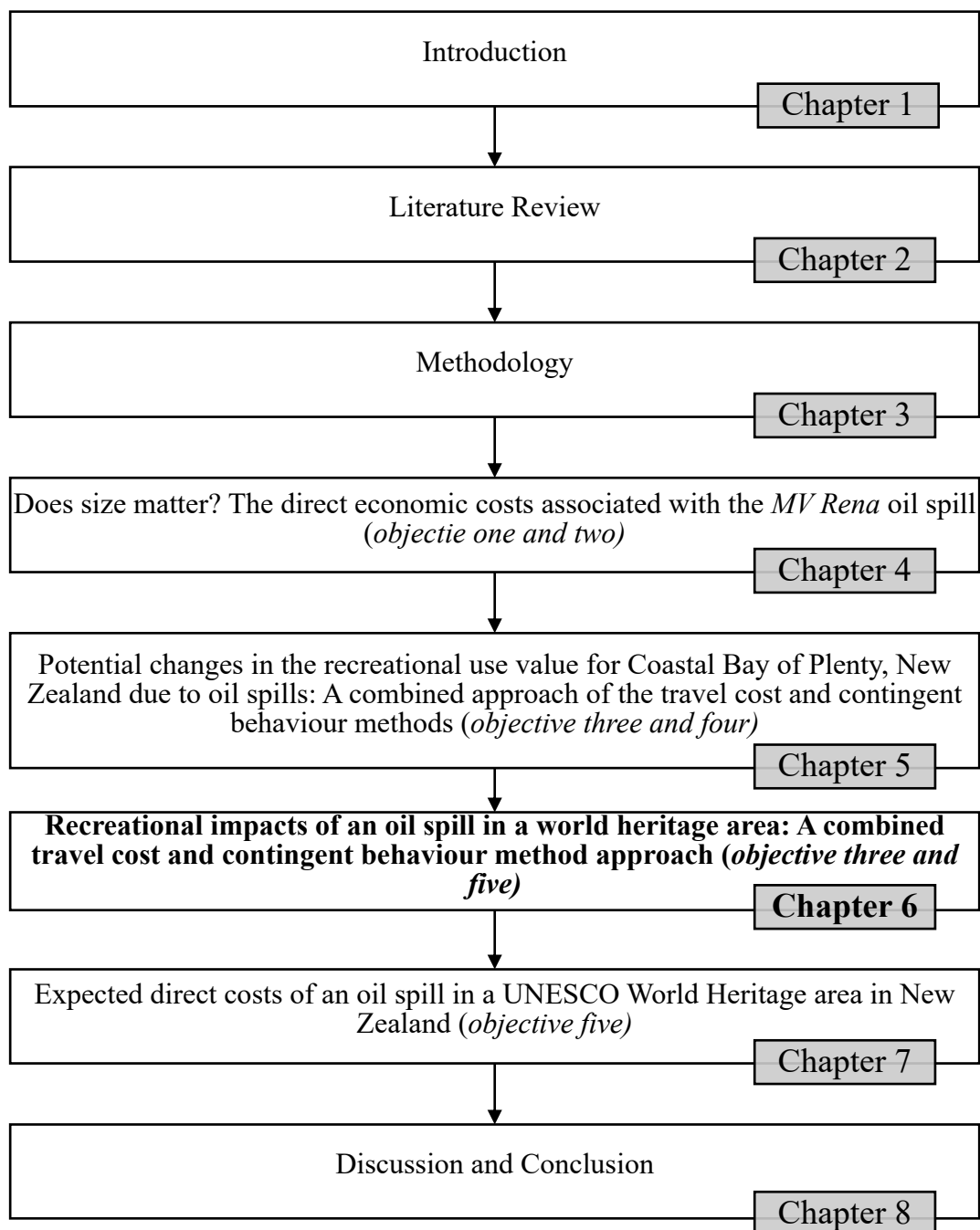
5.5 Conclusion

Overall, this research demonstrates that the recreational value of the Coastal Bay of Plenty (from Mount Maunganui to Maketu) is sensitive to an oil spill occurring. These estimates should be considered conservative, due to the absence of international visitors

being surveyed, locals being underrepresented, and there being no record of how many visits this stretch of beach receives annually. The *MV Rena* had direct use market losses of around NZD 45 million, and including recreation leads to potential direct use losses of NZD (2011) 111.62-130.01 million. Recreational losses potentially account for 59.25-65.02 percent of direct use losses from this oil spill, demonstrating the importance of coastal recreation for this area, and should be factored into future policy discussions. Due to the continually increasing shipping and cruise industry in this area, it is important to understand the potential economic impacts that an oil spill may have in this area, so that marine based policies can be properly informed. Though New Zealand is now a signatory to other treaties that would have allowed higher reimbursement from the *MV Rena* oil spill, it is important to weigh the overall costs and benefits to society of these expanding industries. This research has shown that there are other costs associated with oil spills other than clean-up costs that should be factored into policy and preparedness decisions. By investing in New Zealand's training, equipment, and other aspects of preparedness for an oil spill, a response will not only become more efficient, but minimise the possible costs and damage associated with it.

Further research should be conducted looking at only locals in order to capture their priorities and values. Based on the interactions the surveyor had with the respondents, it is clear that many feel strongly that their coastline should be protected, with several indicating that if a major oil spill occurred again, they would consider moving away from the area. This demonstrates that conducting a similar study with only those who live in the area may produce different results. It would also be worth investigating the passive use values (knowing it is there for use without necessarily using it, or knowing it is available for future generations) associated with this area. It would also be worth using hedonic pricing to capture the loss to real estate values within this area, similar to analysis in relation to the BP oil spill (Winkler & Gordon, 2013). A study focusing on the views of the Māori/local iwi regarding this past oil spill as well as potential future ones is also recommended. These potential studies would provide an even more comprehensive view of the costs associated with oil spills in New Zealand's coastal waters.

Chapter 6: Recreational impacts of an oil spill in a world heritage area: A combined travel cost and contingent behaviour method approach



The following chapter investigates the recreational value of Fiordland National Park, located on the Southwest of New Zealand's South Island. First, a recreational value will be estimating using the individual travel cost method. Secondly, contingent behaviour questions regarding different levels of an oil spill will be incorporated to estimate the recreational losses due to an oil spill occurring in Milford Sound. There will be some repetition of the

methodology described in Chapter 3: 3.6 Recreational Value – Survey Design since this chapter was written as a paper.

6.1 Introduction

Nature based recreation is a common activity for New Zealanders and international visitors alike, and Fiordland National Park (45.4629°S, 167.5422°E) is one of its most popular places to do so. Due to its unique landscapes and biodiversity, it is regarded as one of New Zealand’s premier places for various outdoor recreation activities (DOC, 2007). It is known for its numerous waterfalls, its unique aquatic and terrestrial environments, as well as its many fiords (Fiordland Marine Guardians, 2017). Fiordland National Park is also a UNESCO world heritage site located in the far southwest of New Zealand (Figure 13).

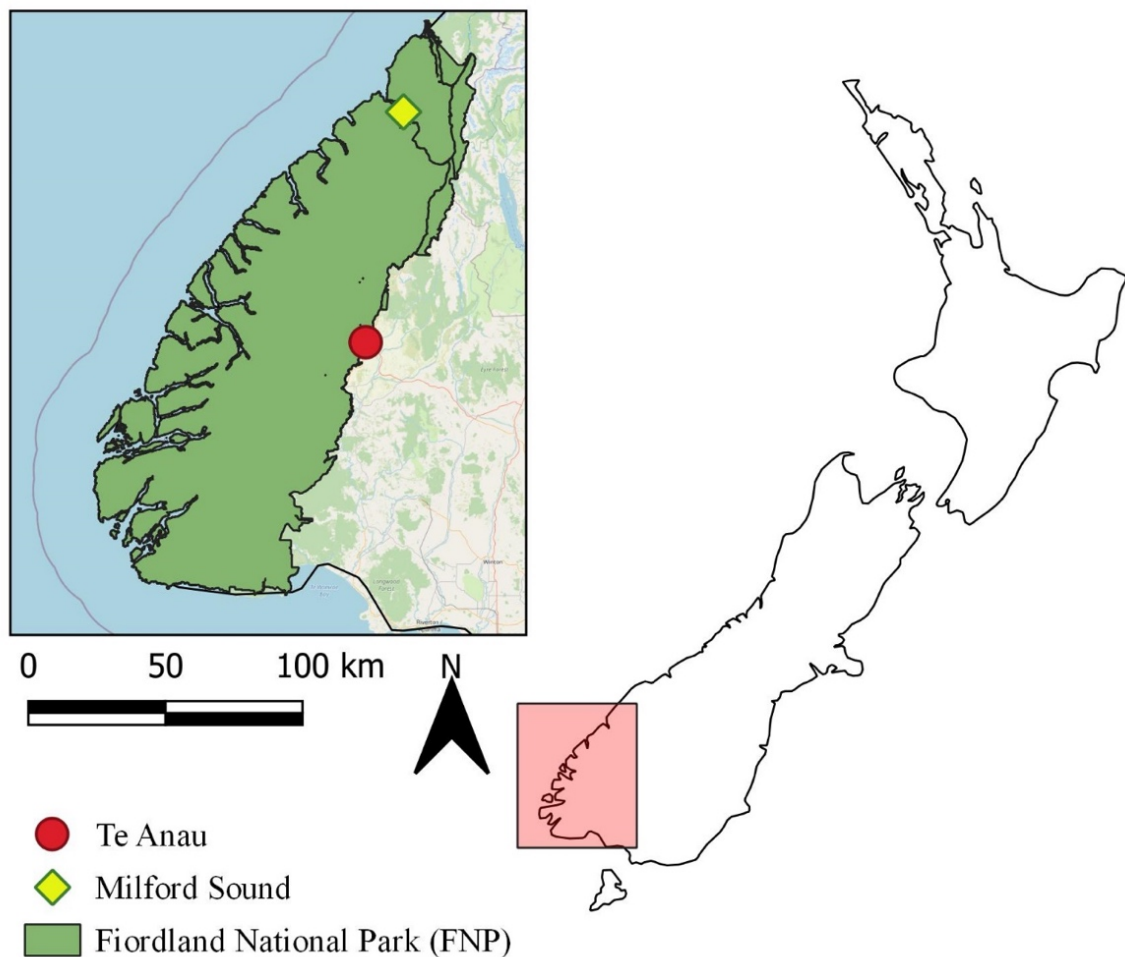


Figure 13: Location of study site, Fiordland National Park (45.4629°S, 167.5422°E). Te Anau is where survey data was collected.

One of the most visited areas within Fiordland National Park is Milford Sound (Figure 13). Prior to the COVID-19 pandemic, over 800,000 visitors went to Milford Sound annually,

with international visitors accounting for 83 percent of these visitors. In contrast, the visitor numbers during COVID (with closed borders to all international visitors from 20 March 2020 until 2 May 2022 (for 60 countries)) are estimated around 200,000 (CEO of Milford Sound Tourism, 2021; Stantec NZ Limited, 2021b). Milford Sound is the only fiord accessible by vehicle, leading to extensive daily recreational and scenic tours boating cruises and is commonly visited by 1000+ passenger cruise ships. This extensive use creates pressure on its environment, with many calling to limit visitor numbers and restrict the number of ships (McClure, 2021; Yardley, 2021).

There are two broad ways that people derive benefits from the environment, which are summarised in economic analysis into use and non-use value categories (Remoundou et al., 2009). Use values are more tangible and more easily valued, whereas non-use values, while not traded in the market, clearly still hold significance, and generally are measured using hypothetical situations with methods such as contingent valuation and choice experiments (Börger et al., 2014b; Brouwer et al., 2016). Recreation is a direct use activity; therefore, its value is considered a direct use value. For estimating direct use values, common methods are the hedonic pricing method and the travel cost method (TCM), which are both types of revealed preference techniques. The TCM is the most utilized tool for valuing environmental recreation, allowing the estimation of what visitors are willing to pay to use that good/service. Contingent Behaviour (CB) is a type of stated preference technique and is generally used to elicit behavioural changes regarding a hypothetical situation regarding environmental quality (Lankia et al., 2019). Most commonly, it is combined with a revealed preference technique, such as TCM, to assess these hypothetical environmental quality changes or changes in site access (Englin & Cameron, 1996; Huang, 2017; Lankia et al., 2019; Rolfe & Dyack, 2011).

The underlying goal of applying these non-market methods is to create a demand curve for the environmental good of interest in order to estimate the consumer surplus, which is the difference between what consumers are willing to pay for a good/service, and what they are actually paying (Blaine et al., 2015; Voltaire et al., 2017). A search of the New Zealand non-market valuation database (Lincoln University, n.d.) for recreation studies identified 24 previous studies that used TCM and an additional four studies that were choice based, or stated preference (Kerr, 2010; Lincoln University, n.d.). There have also been some studies done, predominantly by the Department of Conservation (DOC), that have investigated valuing recreation assets. Study areas include the West Coast of New Zealand (DOC, 2004),

Fiordland National Park (DOC, 2006a), and the Abel Tasman National Park and Queen Charlotte Track (DOC, 2005). However, all these studies focus on measures of economic impact, specifically the expenditure, economic value added and length of stay, and employment to the area (Clough, 2013), and hence are not relevant for estimating consumer surplus.

This study has two main objectives: first, to estimate the value of recreation for Fiordland National Park (using Milford Sound as a proxy for the park), by means of the TCM, and secondly, to pool revealed preference data with CB questions in order to estimate the change in welfare if an oil spill were to occur in Milford Sound. This was done by carrying out on-site surveys and interviewing people who were visiting Fiordland National Park. All those who were surveyed were currently residing in New Zealand, due to the borders being closed in response to COVID-19. The consumer surplus per person/visit will first be determined, and then the future expected visits over the next five years under different oil spill scenarios will be integrated to estimate the recreational losses. Given its UNESCO world heritage site status, popularity and the frequency of large and small passenger ships that visit Milford Sound, Fiordland National Park, the possible consequences of an oil spill occurring should be considered.

6.2 Methods

6.2.1 Study Site

New Zealand has three UNESCO World Heritage sites, with the first and largest being Te Wāhipounamu UNESCO World Heritage site, or Southwest New Zealand World Heritage site. Fiordland National Park (Figure 13) is a part of the Te Wāhipounamu UNESCO World Heritage site, which was established in December 1990 (UNESCO, 2004). Given the importance of this park for domestic and international travellers, receiving over three-quarters of a million visitors annually (DOC, 2006b; Milford Sound Tourism Ltd., 2019), it was selected for this study. For choosing the location where the oil spill scenarios would take place, Milford Sound (Figure 14) was the clear choice, since it is frequented by large cruise ships, fishing vessels, as well as other tour boats.

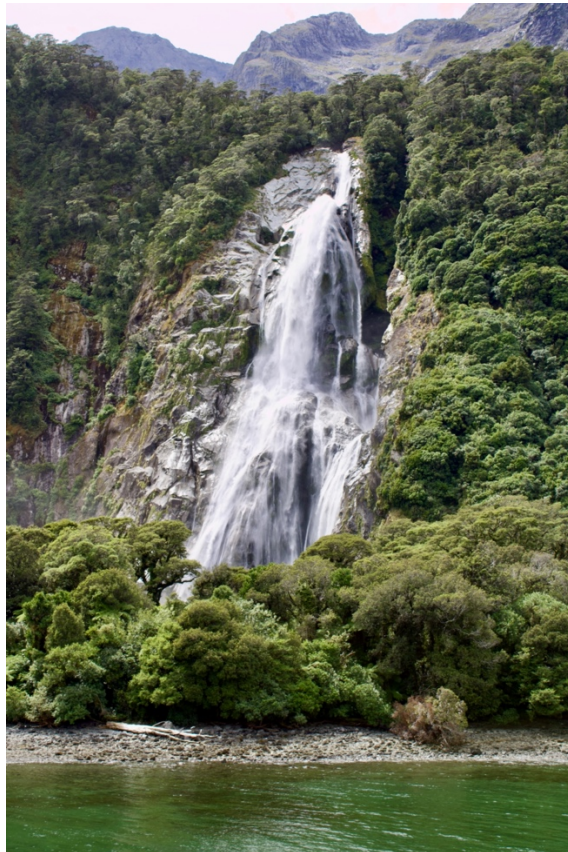


Figure 14: Entrance to the fiord from the Tasman Ocean (top), and Bowen waterfall (bottom).
Source: Photos by Alexandra L. Egan.

6.2.2 Travel Cost for Valuing Recreation

Recreation is an un-priced use good where there is no direct market to reveal prices for use. TCM is commonly used to value outdoor recreational activities and sites (Rolfe & Dyack, 2011), and is well adapted for national parks and wildlife sites (Huff, 2016). The information that is linked with the visitors to the site, such as the time and cost it takes to get there, allows one to derive the total consumer surplus for a recreational site (Amirnejad & Jahanifar, 2018).

Application of a TCM exercise is complicated because of issues such as the treatment of substitute sites, multi-purpose and multi-destination trips, and the measurement of travel and opportunity costs. How to deal with substitute sites is a long-standing issue within the TCM literature. Willis (1991) found that the inclusion of substitute sites did not significantly reduce the willingness to pay in a TCM model when contingent valuation questions were included. Some researchers chose to omit substitute sites due to the difficulties in determining them and their respective prices (Alberini & Longo, 2006; Kleppe & Jensen, 2018; Voltaire et al., 2017). Substitute sites were ultimately not included in this analysis due to the unique nature of the site and the difficulties in identifying suitable substitutes.

TCM inherently assumes that all travel costs involved are exclusive to the single recreation site (Parsons & Wilson, 1997; Smith & Kopp, 1980). This is not always the case with multi-purpose/multi-destination trips, which commonly occur when the area is remote and when people are on holiday for extended periods of time (Martínez-Espiñeira & Amoako-Tuffour, 2009). Kuosmanen et al. (2004) define three broad categories that have been applied in this case study. First, to ignore them, either by excluding these visitors from analysis or treating them as single destination visits. Second, apportioning the travel costs by taking a proportion of the total attributed cost to represent the site's share of the travel costs. Third, treat single destination and multipurpose/multi-destination trips separately. Given the attractions of the Fiordland National Park it was decided to treat all visitors for this case study as though they were single site destination visits, although information was collected about their trips for future research.

Travel costs can be assessed directly from records, estimated from visitor feedback, or modelled as a function of factors such as travel distance and mode of transport. For this study, it was chosen to use the travel distance, mode of transports, and costs associated with that transport to calculate the direct travel costs. Within the literature, the opportunity cost of travel time can be dealt with in a variety of ways, with no one way being universally agreed

upon. Probably the most used method is to use a fraction of the wage rate, ranging from ¼ to ½ (Amoako-Tuffour & Martínez-Espiñeira, 2012; Blaine et al., 2015; Mayer & Woltering, 2018). However, this only applies to those who work full time. It is also worth noting, that it has been theorized that the opportunity cost of time may have a consumptive value when visiting certain sites, such as UNESCO sites and other natural wonders (Amoako-Tuffour & Martínez-Espiñeira, 2012), in that the act of traveling to the site has additional benefits and may not necessarily be a cost. For these reasons the opportunity cost of travel time has not been included in this study.

On-site survey methods may lead to two types of potential biases, truncation and endogenous stratification. Researchers have adopted some ad hoc truncation measures to account for both upper and lower cases of extreme observations, such as removing observations with extremely large travel costs, or a very high number of reported visits (Blaine et al., 2015). Endogenous stratification, which is over-sampling of more frequent visitors, is commonly corrected with the Englin Correction, in which one is subtracted from the visit number (Blaine et al., 2015). Overdispersion, where there are several different travel costs recorded for each visit rate, typically requires that a negative binomial (NB) regression model instead of the Poisson regression model, since it allows for variation in the mean and variance (Blaine et al., 2015; Rolfe & Dyack, 2011). A general NB regression can be modelled as (NCSS, 2020):

$$P \lambda(x; \theta, \alpha) = \left(\frac{\Gamma(y_i + \alpha^{-1})}{\Gamma(y_i + 1)\Gamma(\alpha^{-1})} \right) \cdot \left(\frac{1}{1 + \alpha\lambda} \right)^{\alpha^{-1}} \cdot \left(\frac{\alpha\lambda}{1 + \alpha\lambda} \right)^{y_i} \quad \text{Equation 12}$$

Where Γ is the gamma probability density function for $\lambda(x; \theta)$, the mean of the distribution is represented by λ per y_i unit of exposure, and $(1 + \alpha\lambda)$ represents the variance. As α approaches zero, the distribution approximates a Poisson regression. This leads to the demand function being represented by:

$$\lambda(x; \theta, \alpha) = \exp(\ln(t_i)) + (\beta_0 + \beta_1 TC + \beta_2 X_2 + \dots + \beta_n X_n) \quad \text{Equation 13}$$

An individual's consumer surplus (CS) is the difference between what one is willing to pay for a good or service, and what one actually pays for it; so, summing these across visitors provides estimates of the benefits received from an environmental recreation site (Zhang et

al., 2015). Since count data models adopt a semi-log functional form (Lankia et al., 2019), they allow the consumer surplus per trip to be defined as the inverse of the travel cost coefficient (Houngbeme et al., 2020; Prayaga et al., 2010; Zhang et al., 2015).

There are two forms of the TCM. The Individual TCM (Alberini & Longo, 2006; Fonseca & Rebelo, 2010; Martínez-Espiñeira & Amoako-Tuffour, 2009; Matthew et al., 2019; Sinclair et al., 2020) and Zonal TCM (ZTCM) (Fleming & Cook, 2008; Han et al., 2013; Voltaire et al., 2017) have both been used when estimating the values of various UNESCO sites. The Individual and Zonal TCMs estimate the CS per individual, but the former produces results at the household or individual level, whereas the latter identifies average values within a given zone, assuming a homogenous population within them (Bhat et al., 1998; Marini Govigli et al., 2019; Martínez-Espiñeira & Amoako-Tuffour, 2009; Phaneuf & Smith, 2005).

Within New Zealand, Woodfield and Cowie (1977) specifically looked at estimating a Clawson demand function (which derives a demand curve for a recreation site and shows how visits change with different rates for admission (Smith, 1971)) for the Milford Track in Fiordland National Park, using the ZTCM with 12 defined zones within New Zealand. By means of ordinary least squares for analysis, the authors determined a consumer surplus per trip ranging from NZD 860,323 to NZD 3,179,981 (or NZD (2021) 107,932.06-398,945.39). This was used to inform management decisions regarding prices for rationing the tracks' services. It is expected that estimates will be significantly higher than this now, due to the increase in visitors to the area seen over the past decade.

6.2.3 Incorporating Contingent Behaviour

The contingent behaviour (CB) method, which is a stated preference technique, may be supplemented with the TCM, instead of utilizing one of the multi-site methodologies, to estimate a change in recreational value due to changes in the environment/environmental quality (Lankia et al., 2019). This combined approach has been used to see the effects on recreation of windfarms (Kipperberg et al., 2019; Voltaire & Koutchade, 2020), water quality (Anciaes, 2021; Börger et al., 2021), changes in water-based activities (Lankia et al., 2019; Prayaga et al., 2010; Wang et al., 2020), and the presence of marine reserves (Bhat, 2003). This case study applies this method in conjunction with the TCM. Three CB questions were asked regarding a respondent's theoretical behaviour if an oil spill was to occur. This was repeated for scenarios of varying levels of environmental damage at the recreation site.

Preceding the questions, a short description of the general situation/accident was provided. A further description will be provided in 6.2.4.

This chapter applies the NB regression model and the Englin correction to the travel cost data, allowing the current CS to be calculated per person per trip to derive an aggregate recreational value for the area. Applying the same modelling to the CB scenarios as a panel data set, allows for the change in CS to be estimated. This results in an estimation of the change in recreational value due to an oil spill occurring in Milford Sound.

6.2.4 Data Collection

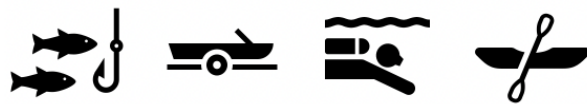
Data was collected on-site in Te Anau over the period of two weeks, from December 2020 to January 2021. This research was considered low risk by Massey University (4000023029), and the respondents were not provided with any incentives. Respondents were approached in two separate visitation areas, the Department of Conservation office in Te Anau, and Real Journeys visitor centre/i-Site (where visitors to the area can find information of things to do). Visitors were approached at random at these locations, and the respondent had to be over 18 years of age to participate. Surveys were limited to one per travelling group who were sharing expenses. If they did not want to take the survey in person, they were offered a link to complete it online at their convenience. This research took place during COVID-19, and due to the borders being closed to international visitors for two years and six weeks in New Zealand, a negligible number of international visitors were expected to be surveyed.

The direct travel expenses were modelled using the round-trip expenditures from the respondent's permanent dwelling, which was ascertained via the provided postal code, including the mode of transportation, and accommodation costs during the visit. To calculate the cost of transit, respondents were asked which type of transportation was used (personal vehicle, plane, cruise ship, bus, etc.). If a personal vehicle/rental car was used, the type of vehicle and what kind of power (petrol, electric, etc) used, was asked for. The travel cost variable was then calculated using the tier two costs provided by Inland Revenue (2020) for those who travelled by cars and the distance driven. Inland Revenue distinguishes between two methods of calculating running costs. "Tier one" includes fuel costs and the fixed costs of running a vehicle (such as the cost of registration, maintenance etc.) while the "Tier two" approach considers only fuel costs. "Tier two" running costs for a vehicle were selected over "Tier one" as recreational users are most likely to factor in fuel costs only in their decision to take a trip or visit a site (Inland Revenue, 2020). The average cost of flights (calculated for a

round trip, 6 weeks out from the travel, with one checked bag per person for Air New Zealand), and the cost of the InterIslander ferry was calculated for a round trip based on the traveling group description. The price of round-trip bus tickets was also included for the relevant respondents. Sociodemographic information was also collected, being their employment status, age, annual household and individual income, gender, and education level.

Survey respondents were asked whether their future visitation behaviour would change under three different environmental quality scenarios involving hypothetical oil spills in the future in Milford Sound. Prior to the questions being asked, a description of the consequences of the three levels of an oil spill incident were depicted. With each contingent behaviour question, icons were provided to visually describe which activities would no longer be possible within the study area. Scenario one represented a small oil spill, scenario two was moderate oil spill, and scenario three was major oil spill. Below are the scenarios that were presented.

CB scenario one. Water quality is slightly worse than current conditions, with occasional traces of oil. You can still access the sound, but conduct recreational activities at your own risk.



CB scenario two. Water quality is worse than current conditions, with many traces of oil. Activities are allowed on the water, but nothing below the water (no fishing, scuba, etc.).



CB scenario three. Water quality is considerably worse than current conditions, with remnants of oil along the shore. No recreational activities allowed, just viewing from land.



Following each scenario presented, the respondent was asked whether they would still have visited Milford Sound, Fiordland National Park, and the Southland region on this trip. This was followed by ‘how many times would you visit Fiordland in the next five years, if there had been an oil spill in Milford Sound?’, to estimate their future visit rates. Lastly,

respondents were asked, if they had not come to Fiordland would they have stayed home or visited elsewhere.

Data cleaning was executed, removing future visit rates that logically did not make sense. This led to 1272 observations instead of the original possible 1404. This data was then combined with the past trips to create a panel data set, allowing one to estimate the change in benefits received by the recreationist (Rolfe & Dyack, 2011). An NB model combined with a Panel Model with Group Effects was used for this panel data set. A description of variables used in the analysis are found in Table 17. The full survey is available upon request from author.

Table 17: Description of variables used in travel cost and contingent behaviour analysis for Fiordland National Park (FNP).

Variable	Description
Trips	Trips to FNP reported by respondent over the past 5 years
TCppT2	Travel cost per person per trip
TCAppT2	Travel cost per person per trip + accommodation
CBLevel	Dummy code for pooled data. Future trips (5 years) under CB scenario one, two and three 0=past trips, 1=CB scenario one, 2=CB scenario two, 3=CB scenario three

6.3 Results

6.3.1 Descriptive Statistics

Of the 460 visitors approached, there were 351 useable responses, yielding a response rate of 76.3 percent. Most of the respondents were female (61.5 percent), and of all of the respondents, 36.8 percent, were in the 46-54 age bracket. The mean travelling group size was 2.9 persons, and roughly 67.5 percent of respondents were employed full time. A bachelors/university degree and postgraduate qualification were the most common education levels held by respondents, at 39.9 percent and 28.8 percent respectively. Approximately 89.0 percent of respondents decided to visit Fiordland National Park prior to the start of their trip. The level of influence that Fiordland National Park had on respondents' decision to take their trip indicates the importance of this area as a destination, on a scale of 0-5 (with 5 being the most influence), 69.0 percent of respondents indicated a four or higher. Full descriptive statistics for the survey respondents can be found in Table 18 (further descriptive statistics provided in Appendix B2).

Table 18: Descriptive statistics for survey respondents (n=351) in the Fiordland National Park (FNP) area. Sampling occurred over a two-week period in December 2020-January 2021.

	Mean	SD
Past Trips to FNP – over 5 years	2.103	1.588
Group Size	2.940	2.241
Age	42.787	12.979
18-29	20.23%	
30-45	35.04%	
46-64	36.75%	
65+	5.70%	
Did not answer	2.28%	
Days - in FNP	6.773	22.376
Days – total trip	18.709	30.917
Travel cost pp	\$292.12	\$270.29
Travel cost pp with accommodation	\$1,065.44	\$1508.33
Gender – female	61.54%	
Decided on visiting FNP before leaving home	89.17%	
This was their first visit to FNP	36.75%	
Visited prior to 2016	48.43%	
Education		
Some High School	3.42%	
High School Graduate	5.70%	
High School Equivalent	3.42%	
Tertiary/Trade Certificate	15.38%	
Bachelors/University Degree	39.89%	
Postgraduate Qualification	28.77%	
Other	3.42%	
Did not answer	0.00%	
Employment Status		
Full Time	67.52%	
Part Time	0.28%	
Retired	3.42%	
Student	3.42%	
Unemployed	5.70%	
Did not answer/other	5.13%	
Annual Household Income	\$120,599.08	
Less than \$45,000	10.54%	
\$45,001 - \$60,000	6.27%	
\$60,001 - \$80,000	9.12%	
\$80,001 - \$100,000	15.67%	
\$100,001 - \$120,000	9.40%	
\$120,001 - \$140,000	5.98%	
\$140,001 - \$160,000	8.55%	
\$160,001 - \$180,000	5.41%	
\$180,001 - \$200,000	10.26%	
More than \$200,000	12.25%	

Did not answer	6.55%	
Level of Influence		
Zero	4.56%	
One	4.27%	
Two	6.27%	
Three	15.38%	
Four	23.65%	
Five	45.30%	
Did not answer	0.57%	

Respondents were dispersed throughout the country, with the most represented regions being Canterbury, Auckland, and Wellington (Figure 15).

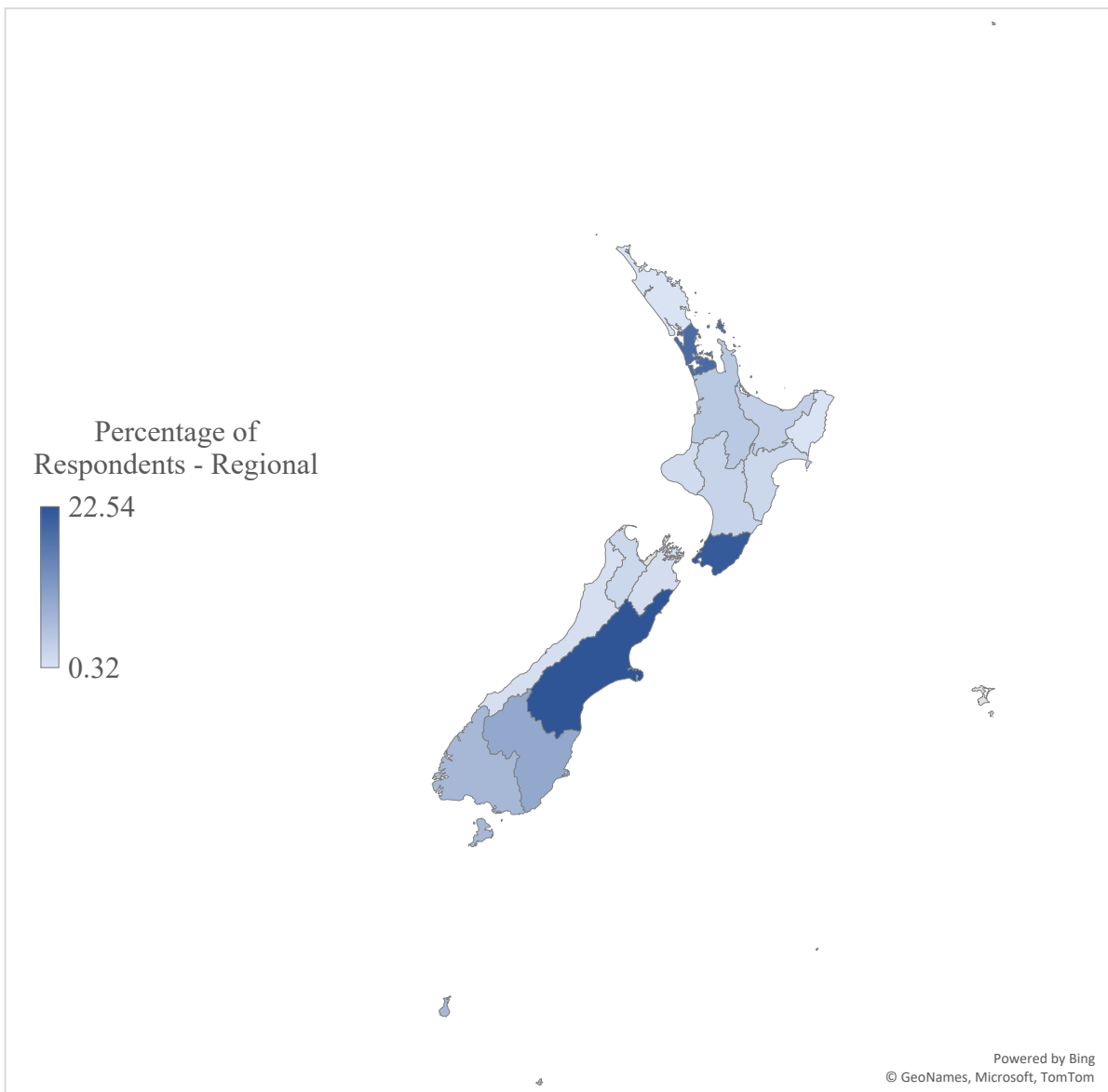


Figure 15: Map of New Zealand regions where Fiordland National Park survey respondents identified their residence to be.

Visitors were also asked what their top three reasons for visiting Fiordland National Park area were. The number one reason was for the scenery at nearly 60.0 percent, followed by walking/hiking/tramping at 26.5 percent. These two responses remained the two most selected second reasons, and wildlife and walk/hiking/tramping were the top two third reasons. A further breakdown of these ranking is found in Table 19.

Table 19: Respondents top three reasons for visiting Fiordland National Park (FNP).

Primary Reason for visiting FNP	Reason 1	Reason 2	Reason 3
Scenery	59.83%	22.51%	9.12%
Boating/kayaking	2.56%	7.12%	7.41%
Marine activities	0.85%	3.70%	3.99%
Walk/hiking/tramping	26.50%	22.79%	13.11%
Camping	1.42%	3.13%	6.27%
UNESCO world heritage site	0.28%	4.27%	5.98%
Wildlife	1.14%	17.66%	23.36%
Cycling	0.28%	0.85%	3.42%
Hunting	0.00%	0.28%	0.28%
Fishing	0.00%	1.42%	2.28%
Tours	1.99%	10.26%	10.83%
Other commercial charters	0.00%	0.00%	0.00%
Other	3.70%	1.42%	5.70%
Did not answer	1.42%	4.56%	8.26%

6.3.2 Travel Cost Model Results

The NB regression models were performed with all observations (351), with left truncation set to zero. The model was first estimated including the potential demand shifters of education, gender, employment status, annual household income, and age. However, none of these sociodemographic variables were significant, and therefore are not included in the results presented (results can be found in Appendix B4). The NB model results using travel costs with and without accommodation can be found in Table 20, with the CS per person/trip.

Table 20: Truncated Negative Binomial results for the two travel cost models.

	TCppT2		TCApT2	
	NT	T	NT	T
Log likelihood function	-507.7718	-251.11498	-512.43368	-253.02235
AIC	2.91	1.448	2.937	1.459
Constant	.46010***	1.09260***	.33166***	1.17508***
Alpha	1.12752***	.23344D-04	1.17076***	0.18643
Coefficient	-.00134***	-.00187***	-.00024***	-.00069***
CS	\$746.27	\$534.76	\$4,166.67	\$1,449.28
Lower CI (2.5%)	\$508.37	\$400.13	\$3,168.46	\$1,195.90
Upper CI (2.5%)	\$1,324.66	\$859.73	\$6,454.86	\$1,764.99
	Pre-COVID19		During-COVID19	
Aggregate CS	TCppT2-T	TACppT2-T	TCppT2-T	TACppT2-T
AggCS	\$427,808,000	\$1,159,424,000	\$106,952,000	\$289,856,000
Lower CI (2.5%)	\$320,104,000	\$956,720,000	\$80,026,000	\$239,180,000
Upper CI (2.5%)	\$687,784,000	\$1,411,992,000	\$171,946,000	\$352,998,000

Note: ***, ** and * indicate significances at the 1%, 5% and 10% levels, respectively. TCppT2=Travel cost per person per trip, TCApT2=Travel cost per person per trip + accommodation. NT=Not Truncated, T=Truncated. During-COVID19 borders were closed.

In both cases, the truncated model outperformed the non-truncated model for both travel costs with and without accommodation. The CS per person per trip without accommodation is NZD 534.76 (NZD 400.13-859.73), and with accommodation is NZD 1,449.28 (NZD 1,195.90-1,764.99), and both were significant at the one percent level. Visitors to Milford Sound are recorded monthly and are used here as an estimate for visitors to Fiordland National Park. Pre-covid, there were over 800,000 visitors to the area annually, however the past two years visitor numbers have been around 200,000 (Milford Sound Tourism Ltd., 2019). This leads to annual recreational value estimates ranging from NZD 427.8 million – NZD 1.6 billion pre-COVID19, and NZD 107.0 million – NZD 289.9 million during-COVID19 (predominately domestic visitors, or those currently residing in New Zealand with borders closed). It should be noted that both these estimates contain caveats, in that the ‘pre-COVID19’ estimates use international visitor numbers, but the individual CS estimated is not representative of international visitors; and ‘during-COVID19’ is a lower bound estimate, in that international visitors are also not captured, and the low visitor numbers are due to COVID19 being a unique situation.

6.3.3 Contingent Behaviour Results

The average number of potential trips reported per person decreased with each increase in oil level. The original average number of trips in the past 5 years was 1.5, followed by 1.2 for CB scenario one, 1.0 for CB scenario two, and 0.7 for CB scenario three. The dependent variable for these models was the reported past trips over 5 years, and future trips over the next 5 years under the CB scenarios one/two/three, representing the varying degrees of activities being inaccessible in Milford Sound. The results for the CB models can be found in Table 21.

Table 21: Pooled contingent behaviour results, combined NB panel model results.

	TCppT2-T	TCAppT2-T
	Pooled (NB)	Pooled (NB)
Observations	1272	1272
Log likelihood function	-1671.85534	-1685.3292
AIC	2.635	2.656
Constant	.53123***	.43126***
Alpha	.64461***	.65748***
TCppT2 Coefficient	-.00123***	-
TCAppT2 Coefficient	-	-.00022***
CBLevel Coefficient	-.20184***	-.20322***
CS per change in spill intensity	-\$164.10	-\$923.73

Note: ***, ** and * indicate significances at the 1%, 5% and 10% levels, respectively. -T = Truncated (for TCppT2 and TCAppT2).

The travel cost coefficients were found to be highly significant both with and without accommodation and had similar AICs. Each increase in oil showed a stepwise decrease in CS of NZD 164.10 and NZD 923.73 per person/trip without and with accommodation, respectively. The stepwise effects on the aggregate consumer surplus can be found in Table 22.

Table 22: Aggregate consumer surplus (AggCS) pre- and during-COVID visitor numbers, under the three different contingent behaviour oil spill scenarios.

	CB Scenario	TCppT2	TCAppT2
Pre-COVID19	Original CS	\$427,808,000	\$1,159,424,000
	CB1	\$296,528,000	\$420,440,000
	CB2	\$165,248,000	(\$318,544,000)
	CB3	\$33,968,000	(\$1,057,528,000)
During-COVID19	Original CS	\$106,952,000	\$289,856,000
	CB1	\$74,132,000	\$105,110,000
	CB2	\$41,312,000	(\$79,636,000)
	CB3	\$8,492,000	(\$264,382,000)

When calculating the aggregate consumer surplus without accommodation, there was a decrease of 30.7 percent, 61.4 percent, and 92.1 percent for CB1, CB2, and CB3 respectively, when compared to the original AggCS. When including accommodation, there was a 63.7 percent decrease from the original AggCS to CB1. However, the model became negative for CB2 and CB3, which may be due to the very small TCAppT2 coefficient, resulting in 127.5 percent and 191.2 percent reductions respectively. Pre- and During-COVID19 resulted in the same percentage change in consumer surplus estimations, since the only thing that changed was the number of visitors. It should be noted that the ‘During-COVID19’ estimate is not representative, since covid-19 was a unique situation, and international visitors are not captured.

6.4 Discussion

Fiordland National Park is an important destination in New Zealand for international and domestic visitors alike for recreational activities. Milford Sound was chosen as the specific site for the oil spill scenarios, since it is the most visited area within Fiordland National Park, is accessible by vehicles, and is frequented by both large and small passenger cruise ships. Using the ITCM to estimate the recreational value of Fiordland National Park (Figure 13), the CS per person for a single site visit was estimated to be NZD 534.76 and NZD 1,449.28 without and with accommodation; with both of the travel cost coefficients being significant at the one percent level. In a New Zealand context, a stretch of beach in the Bay of Plenty region showed a CS of NZD 121.21 when including accommodation costs (Chapter 5: Potential changes in the recreational use value for Coastal Bay of Plenty, New Zealand due to oil spills: A combined approach of the travel cost and contingent behaviour methods). It is expected that the CS values presented in this chapter for Fiordland National Park would be substantially higher, predominately due to the remoteness of this area is. It is

important to note that international visitors were not included in this study due to the New Zealand borders being closed during the pandemic.

These individual CS estimates for Fiordland National Park are generally higher than previous studies of similar sites, being world heritage sites or national parks, throughout the world. Within the United States the CS per person have been estimated at USD 8.00-19.26 for a UNESCO site, and USD 98.92 for a National Park (Bowker et al., 2005; Poor & Smith, 2004). Within Europe, the CS per person have been estimated at €27.16- €38.77 for a UNESCO site in Spain, and €136-€281 in France (Torres-Ortega et al., 2018; Voltaire et al., 2017). As demonstrated, these estimates are substantially smaller than the estimates provided in this chapter, and this is most likely due to the unique characteristics of this site. The township of Te Anau, the 'entry' to Fiordland National Park, is remote, with its nearest cities being Queenstown (171.2km) and Invercargill (154.5km), and travel to Milford Sound adds another 75km to those distances. Martínez-Espiñeira and Amoako-Tuffour (2009) studied a similarly remote UNESCO site in Canada, and estimated a recreational value of CAN\$ 1,135-2,528, which is similar to estimates presented here when including accommodation (see Appendix B6 for a further description of relevant studies).

The pooled panel contingent behaviour models demonstrated that each increase in oil spill level showed a stepwise decrease of NZD 164.10 and NZD 923.73 per person/trip without and with accommodation, respectively. This leads to minimum annual recreational losses to be estimated ranging from NZD 131.3-739.0 million using pre-COVID visitor numbers, and NZD 32.8-184.7 million using during-COVID visitor numbers based on whether or not accommodation was included. It is important to emphasise again that the during-COVID estimates are lower bound, and not representative. These potential losses are substantially larger than what was estimated for recreational losses in the Bay of Plenty region. Chapter 5: Potential changes in the recreational use value for Coastal Bay of Plenty, New Zealand due to oil spills: A combined approach of the travel cost and contingent behaviour methods estimated a stepwise decrease of NZD 92.51 for each increase of oil when including accommodation costs. These results demonstrate how people use and value the site and will affect how they respond to environmental changes/degradation. It is important to note that these estimates do not include the environmental impacts, the effects of wellbeing of visitors/residents, the spiritual and non-use values that are associated with this area, or the cultural aspects for NZ Māori/local iwi (New Zealand's First nations people).

Fortunately for the environment, but unfortunate for comparisons to this study, there are a very limited number of oil spills globally that have occurred that would be comparable to one taking place in Milford Sound, Fiordland National Park. This means these findings can help us to understand not only the economic implications for Fiordland National Park, but for the whole of the Southland region. The need to understand the possible consequences are further justified due to the large number of cruise and daily tour ships and visitors who frequent this area. The Fiordland Regional Tourism Organisation accounted for approximately 35.2 percent of visitor spend in 2019 for the Southland region (Great South, 2019b). And according to DOC (2017b), of an estimated 3.2 million international visitors to New Zealand, around 1.7 million visited national parks, with Fiordland National Park being the most frequented. Prior to the pandemic, tourism was New Zealand's largest export earnings, accounting 20.1 percent of total exports (Tourism Industry Aotearoa, 2021). Based on this, one can infer that the loss of Milford Sound as a destination in this region would have ripple impacts throughout this tourism area and for the whole of New Zealand. New Zealand's tourism and recreation is based on this notion of '100% pure New Zealand,' that it has a natural and pristine environment. Appropriate funding needs to be allocated to prevention and preparedness around oil spills, in hopes of being able to minimize the social, economic, and environmental damages.

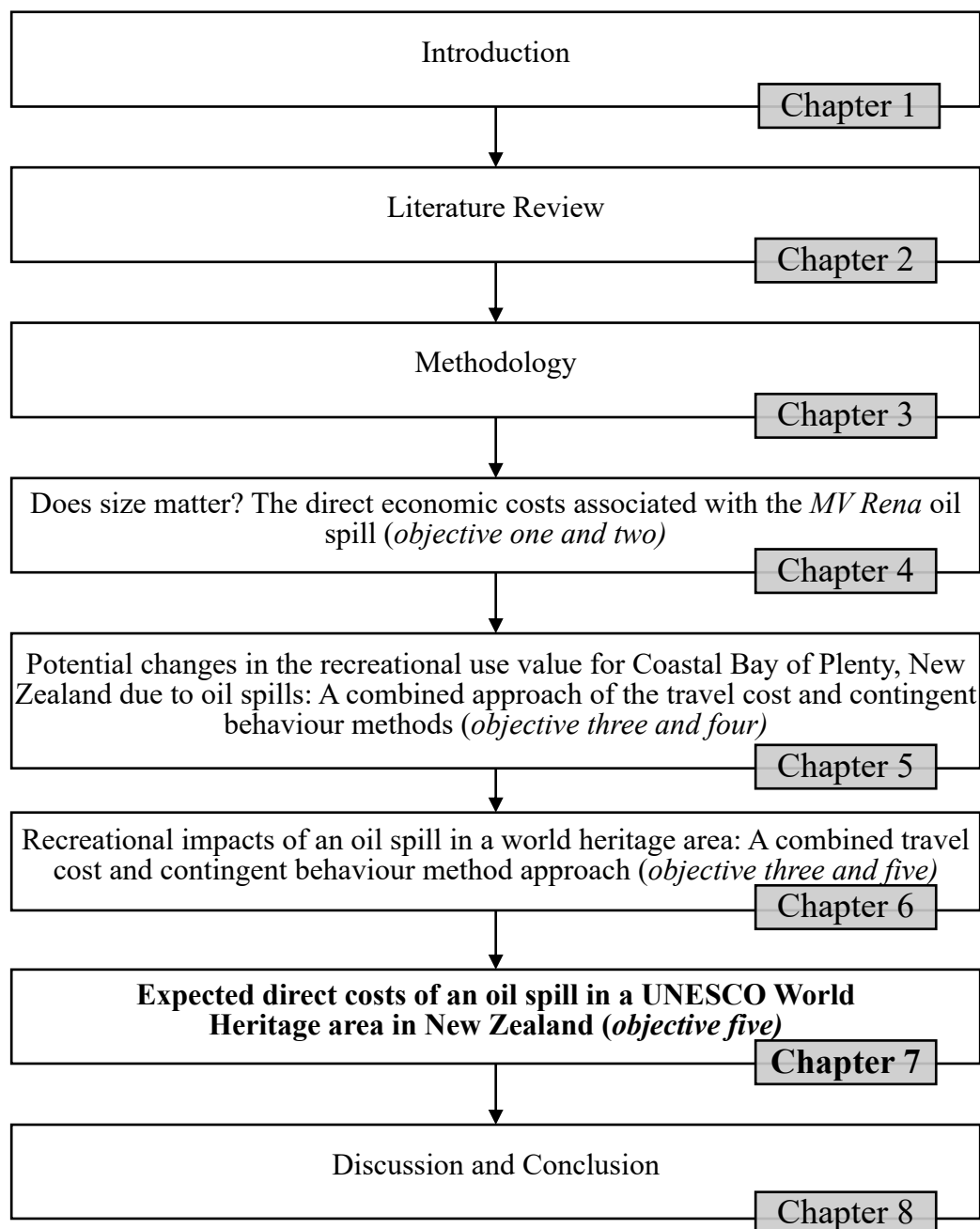
6.5 Conclusions

This research demonstrates that the recreational value of Fiordland National Park is sensitive to an oil spill occurring in Milford Sound. These figures should be regarded as conservative, due to no international visitors being surveyed, who traditionally represent the majority of visitors to this area. Potential annual recreational losses are estimated to be between NZD 131.3-393.8 million and NZD 739.0-2,217.0 million using pre-COVID visitation rates (without and with accommodation respectively), and NZD 32.8-98.5 million and NZD 184.7-554.2 million using during-COVID visitation rates (without and with accommodation respectively). These possible losses are important to understand, since losses to recreation are not currently able to be reimbursed by the various international treaties for oil spill "insurance" that New Zealand is signatory to (Chapter 5: Potential changes in the recreational use value for Coastal Bay of Plenty, New Zealand due to oil spills: A combined approach of the travel cost and contingent behaviour methods).

Further research should be conducting with international visitors, as this would more than likely affect the recreational value of Fiordland National Park. Additionally, it would be

interesting to see the impact Milford Sound/Fiordland National Park has on their decision to visit the South Island, or even New Zealand at all, and if they would still visit knowing they would not be able to access this area in the event of an oil spill. Additionally, research into the effects an oil spill may have on passive or non-use values (such as knowing this area is kept pristine, even though they might not utilize it) would be beneficial as a national study. Furthermore, research focusing on the views of the Māori/local iwi regarding oil spills in this area is also recommended. These suggestions are made based on the benefit of having a comprehensive view of the socioeconomic effects that an oil spill can have in this remote area so that New Zealand policies and response preparedness funding takes into full account the costs and losses an oil spill can have on New Zealand.

Chapter 7: Expected direct costs of an oil spill in a UNESCO World Heritage area in New Zealand



The following chapter aims to estimate the potential direct losses to fisheries and tourism industries in Fiordland National Park, if an oil spill were to occur in Milford Sound. Clean-up costs will also be considered as a measure of the cost of equipment. It will combine the estimated recreational losses under the hypothetical scenario as found in Chapter 6: Recreational impacts of an oil spill in a world heritage area: A combined travel cost and contingent behaviour method approach.

7.1 Introduction

UNESCO World Heritage sites can represent many things, such as culture, physical or living traditions, superlative natural beauty, major stages of earth's history, on-going ecological and biological processes, or contain significant natural habitats for the conservation of biological diversity (UNESCO, 2019). These areas are not only important to the people who reside in that country, but also hold significant value on an international level, with immense national and international pressure to prevent and effectively respond if a disaster were to occur. New Zealand has three World Heritage Sites, the first being Te Wāipounamu, which includes Fiordland National Park, southwest South Island, listed in 1990 for its Natural beauty. The listing of this UNESCO site makes it imperative that the potential impacts of natural and man-made disasters are considered within its management protocols, including those that may result from an oil spill, occurring in a remote, unique site like Fiordland National Park. Oil spills are capable of negatively affecting the people, environments, wildlife, and economies where the spill occurred, regardless of how much oil is spilled (Garza-Gil et al., 2006b; Loureiro et al., 2006; Smith et al., 2011).

There are several factors that determine the impact of an oil spill and its resultant economic, ecological, and social cost. Factors include the economic and biological characteristics of the area where the spill occurred, remoteness of the area, weather and time of year, duration and amount of oil spilled, type of oil, area the oil spreads and the effectiveness of the clean-up response (White & Molloy, 2003). The vast majority of economic based oil spill studies look at the effects of spills that have already occurred, with the spills generally large in scale (Carson et al., 2003; Cheong, 2012; English et al., 2018; García-Negro et al., 2009; Garza-Gil et al., 2006b; Loureiro et al., 2006; Sumaila et al., 2012). For many of these spills, thousands of tonnes of oil impacted long stretches of coastline and large economies. However, for small economies that are reliant on recreation and tourism, a small oil spill can have just as large, if not a disproportionately larger impact, to an area (Cirer-Costa, 2015).

To understand costs of a spill within an environment, the total economic value of the environment first needs to be understood, with it generally accepted that there are both use and non-use values (Rogers et al., 2019). Use values are definitive benefits that can be physically observed and measured, whereas non-use values refer to the value or benefit that one receives knowing that an environment can be used by themselves or others in the future, or simply knowing that it exists (Remoundou et al., 2009). Oil spills can affect both use and

non-use values, in that they directly affect fisheries, tourism, recreation, and may affect the aesthetic and attitudes towards the site if it is utilized by people (Loureiro et al., 2006).

The risk of an oil spill occurring along the coast of Fiordland is moderate, according to the risk assessment for the whole of New Zealand, completed by Bermingham (2015), with a spill within Fiordland most likely occurring from a fishing vessel or cruise ship. The report considered potential social, economic, and cultural affects, as well as potential impacts to habitats and wildlife of an oil spill in the Fiordland area. However, the report did not go into the specifics of how the rating was determined for each area. The Fiordland coastline is an area that has ever increasing tourist and recreational use; and given its World Heritage listing, uniqueness, remoteness, and high biodiversity (Chilvers & Battley 2019), it is an area I believe needed investigation to understand and estimate the potential costs and impacts an oil spill could incur.

New Zealand's largest marine oil spill was the *MV Rena*, in which the vessel ran aground on Astrolabe Reef (37.5603° S, 176.3962° E) off the coast of the Bay of Plenty in October 2011, spilling over 350 tonnes of heavy fuel oil. There was a total direct net estimated loss to New Zealand of 45,479,017 NZD, when looking at tourism, commercial fisheries, clean-up costs, and restoration projects (Chapter 4: Does size matter? The direct economic costs associated with the *MV Rena*). Drawing on the information learned from the *MV Rena* study, the potential direct economic losses from an oil spill occurring in Milford Sound (44.6414° S, 167.8974° E, Figure. 1), Fiordland National Park can be estimated. This research estimates the costs of an oil spill under three different hypothetical oil spill scenarios, representing a small, medium, and large-scale event. The volume of oil would be the same in each case, equivalent to the 350 tonnes of heavy fuel oil spilt at the *MV Rena*, however the difference between scale will be the length of the clean-up response, and in turn the amount of time everything associated with Milford Sound (access road, port, tourism business etc) would be closed. The possible clean-up costs, as well as losses to fisheries, tourism, recreation, and a possible wildlife response will be estimated.

7.2 Methods

7.2.1 Study Area

Fiordland National Park is in the southwest of the South Island, New Zealand (Figure 16). It is one of the four national parks that make up the UNESCO World Heritage site Te Wāipounamu, meeting criteria vii (contains unparalleled natural phenomena or areas of unique natural beauty and aesthetic importance), viii (exceptional example of major stages of

earth's history), ix (representative of ongoing ecological and biological processes in the evolution of both land and water plants and animals), and x (essential and significant habitats for in-situ conservation of biological diversity) (UNESCO, 2004). It has a land area of over 40,000 ha, and is recognized for its natural flora, and diverse and abundant unique wildlife (DOC, 2017a). The unique land characteristics are matched by an equally distinctive aquatic environment. The freshwater that pours into the fiords from the numerous rivers and streams is stained with tannin and blankets the marine water beneath it at times up to a 10 m depth of freshwater (DOC, 2017a). This significantly reduces the depth that light is able to penetrate and alters the temperature and dissolved oxygen profile of the water column allowing marine species that are usually found at great depths to thrive in much shallower water (DOC, 2017a).

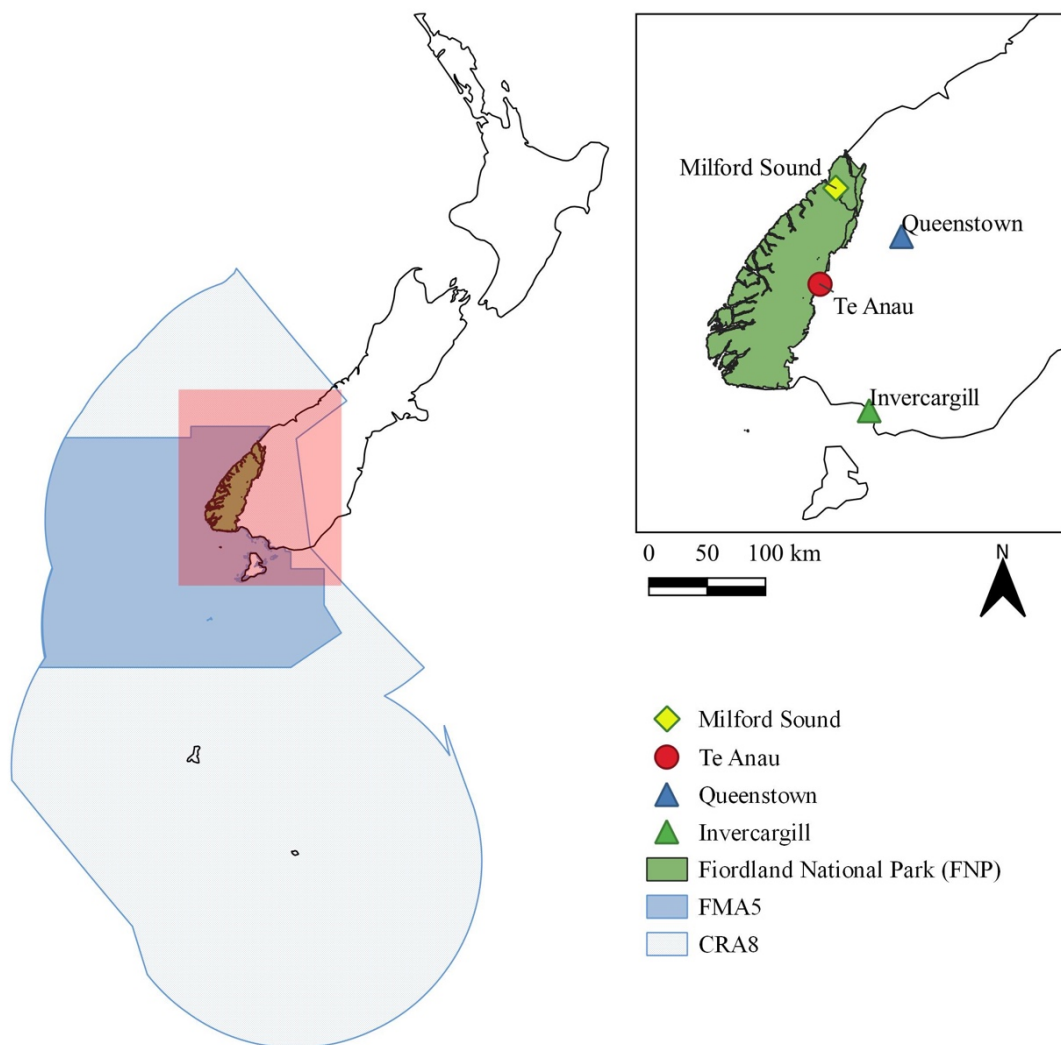


Figure 16: Map of New Zealand showing (inset) Fiordland National Park, Milford Sound and Te Anau. The larger map shows where Fiordland National Park is situated in New Zealand and the two fisheries areas SA032 and the crayfish catchment area CRA8.

Fiordland National Park is comprised of many sounds, with the most well-known and only one accessible by road being Milford Sound. Milford Sound is the most northerly sound in the National Park and received as many as 800,000 visitors a year pre-COVID, making it the main area for tourism in Fiordland National Park (Fiordland Marine Guardians, 2017; Milford Sound Tourism Ltd., 2019). Along the northern side of the sound is the Piopiotahi Marine Reserve, which is one of the most popular dive spots within Fiordland (Fiordland Marine Guardians, 2017). Milford Sound's Road accessibility is via a 120km rural road from the nearest town Te Anau (population 2760), and a 1.2km one-way tunnel, making it a 2-to-3-hour drive (Statistics New Zealand, 2021b). Milford Sound is 270km and 290km drive from either of the closest cities, Invercargill, or Queenstown respectively (Figure 16).

Countries' economies are often described in terms of their Gross Domestic Product (GDP), which for New Zealand is dominated by the service and primary industries, representing 64.4 and 19.1 percent, respectively (Statistics New Zealand, 2019b). Service industries include food services and accommodation, retail and wholesale trade, and various other service sectors. Primary industries consist of fishing, forestry, mining, and agriculture. Both service and primary industries are capable of being directly impacted by oil spills as seen from the *MV Rena* spill, New Zealand's largest marine oil spill accident. Southland is the southernmost district of mainland New Zealand and had a GDP of NZD 6,359 million in 2020 (Statistics New Zealand, 2021c) representing approximately 2 percent of New Zealand's total GDP. Fiordland National Park is a driving factor for people visiting the region, from a recreation and tourism standpoint, and according to Statistics New Zealand (2019a), Fiordland had the fifth most passengers by region in New Zealand visited in 2019 by cruise ships.

7.2.2 Hypothetical Oil Spill Scenario

Milford Sound was chosen as the site most likely to have an oil spill, since it receives the most visitors per year, including both large cruise ships and day touring vessels, since it is the only sound accessible directly by motor vehicle. Cruise ships would be the most likely scenario for a large oil spill occurring in the sound comparable to the *MV Rena* oil spill. Upon consultation with representatives of Maritime New Zealand (Senior Oil Spill Response Technician, 2021), it was considered that the scenario most likely to occur and cause a major oil spill was that of a cruise ship hitting a rock while entering Milford Sound causing oil to leak. A cruise ship would be forced to run aground at the head of Milford Sound, since it is no longer deemed a means of safe transport, therefore putting passengers at risk, and making

their rescue from the ship the priority. With this basic scenario in mind, a list of assumptions relating to the scenario are presented in Table 23.

Table 23: Assumptions of oil spill scenarios made for estimating the clean-up and impact costs of an oil spill within Milford Sound, New Zealand.

	Assumptions
Oil type	Heavy fuel oil (HFO)
Time of year	Summer – (December-March) Main season for cruise ships
Oil onboard	Heavy fuel oil tanks were 3/4 full before entering the sound and heated so were in a liquid state
Amount of oil spilled	350 tonnes (equivalent to <i>MV Rena</i> spill)
Milford Sound Road and port closure time scenarios	3 weeks, 6 weeks, and 12 weeks

While within Milford Sound, HFO is not allowed to be used as fuel, due to air pollution restrictions, however these ships will still have it on board since there are not limitations to use it elsewhere during their cruise around New Zealand, and it is likely to be continuously heated to be ready for use. This makes the scenario comparable to the approximate amount and type of oil leaked from the *MV Rena* (Chilvers et al., 2015).

7.2.3 Estimating Clean-up Costs

Using the clean-up cost breakdown from the *MV Rena* (Chapter 4: Does size matter? The direct economic costs associated with the *MV Rena*), assumptions and adjustments will be made to estimate the costs associated with a spill occurring in Milford Sound, Fiordland National Park. The *MV Rena* cost information was collected through Maritime New Zealand under the Official Information Act 1982 (Maritime New Zealand, 2019). For a full description and breakdown of the costs of the *MV Rena*, please refer to Chapter 4: section 4.3.2

The clean-up costs that are discussed in relation to this previous oil spill in New Zealand will then be compared with results using the Etkin (2000) proposed oil spill clean-up costing algorithm which is based on the cumulative averages of past spills. This algorithm uses the response cost (C_u) per unit (i) for the specified scenario, which is calculated using the cost per unit spilled for the scenario (C_{li}), the type of oil (t_i), how widely the shoreline is oiled (o_i), the main clean up mode (m_i) and the spill size modifier factor (s_i). The C_{li} is estimated using a regional multiplier (r_i), a modifier for where the spill occurred in relative to the coast (l_i), and the general cost per unit in nation (C_n). However, the actual per unit cost of the *MV*

Rena was used for this variable, since it is the most recent and important spill to be compared to the scenario put forward. The estimated total response cost (C_{ei}) for this specified scenario is calculated by multiplying the C_{ui} and a specified spill amount for the scenario (A_i). A regional multiplier (r_i) is included to account for the remoteness of the site, and possible higher wages in the area. This is usually determined by considering factors such as the location of the site or if the wage rate is higher in that nation (Etkin, 2000). A description of the modifiers used for each scenario can be found in Table 24.

$$C_{ui} = C_{li}t_i o_i m_i s_i \quad \text{Equation 14}$$

where $C_{li} = r_i l_i C_n$

$$C_{ei} = C_{ui} A_i$$

Table 24: Description of modifier factors for the Etkin calculations under the oil spill scenario.

Variable	MV Rena	FNP
t_i	0.71 (No. 6 fuel)	0.71 (No. 6 fuel)
o_i	0.61 (20-90km)	0.61 (20-90km)
m_i	0.92 (Mechanical)	1.89 (Manual)
s_i	0.27 (340-1,700 tonnes)	0.27 (340-1,700 tonnes)
r_i	1	3
l_i	1.46 (Nearshore)	1.46 (Nearshore)
C_n	NZD (2011) 133,974.29	NZD (2011) 133,974.29
A_i	350 tonnes	350 tonnes

Source: Etkin (2000).

The government organisation responsible for the clean-up of marine oil spills in New Zealand is Maritime New Zealand. The current daily hire rates from Maritime New Zealand for the equipment that would be needed for an oil spill in this area is included in estimates. An estimate of what equipment would be needed was determined based on consultation with a senior oil spill response technician from Maritime New Zealand, Marine Pollution Response Services.

7.2.4 Estimating Costs to Fisheries

Fisheries data to estimate a catch loss from an oil spill in Milford Sound were collected through Fisheries Science and Information within the Ministry for Primary Industries (MPI) under the confidentiality deed between MPI and Massey University. All reported estimated fish catches (kg) and yearly port prices for greenweight values were requested for Fishery

Management Area 5 (FMA5), where Fiordland resides (Figure 16; for further definitions on fisheries information please refer to Chapter 3: 3.3). FMA5 is further broken down into statistical areas, in which SA032 is the general statistical area with Milford Sound resides. Certain species have their own statistical areas, such Paua (*Haliotis iris*, *H. australis*), Crayfish (also referred to as lobster) (*Jasus edwardsii*), and Oysters (*Ostrea chilensis*). A baseline value for the previous year's landings was established (2015-2019), to determine the current trends of the fisheries for the area (see Chapter 4: Does size matter? The direct economic costs associated with the *MV Rena*). It should be noted that for some species (predominantly shellfish), their statistical area expands past SA032, so the values presented may be an over representation of the value to the statistical area.

Not all fish caught within the statistical area are physically landed at the port, therefore the loss of value to the fishing industry were the Milford Sound Port to be closed for a length of time due to an oil spill focuses on the catch that is landed at the port, namely the crayfish of the CRA8 fishery area. The CRA8 fishery provided estimates regarding the monthly number of tonnes of crayfish landed at the Milford Sound Port. In the event of an oil spill, crayfish fishing vessels would be able to enter/return to the port but would not be able to leave until the response slowed enough that it was safe and clean enough to do so. Additionally, as the only land access to Milford Sound is through a 1.2km one-way tunnel, the tunnel is likely to be closed to all traffic except response equipment and personnel, therefore even if fishing vessels are returning to port, they would not be able to be resupplied, or unload live fish.

7.2.5 Estimating Costs to Tourism

Tourism spending data to estimate the loss from an oil spill in Milford Sound were collected through the annual Regional Tourism Estimates (RTEs) from the Ministry for Business, Innovation and Employment. To establish a trend in the spending data between international and domestic tourism spending, the years 2015-2019 were used to allow for comparison with *MV Rena* and outside of impacts to tourism from COVID-19. For a further description of RTEs, refer Chapter 3: Tourism/Chapter 4: Does size matter? The direct economic costs associated with the *MV Rena*. The fees collected by Milford Sound Tourism Ltd. for each individual travelling on a tourist vessel leaving from Milford Port will also be considered, by calculating the amount charged per person, and the number of visitors who utilize the tourism boat trips over the scenario's timeframe. The fees collected by Environment Southland, based on the tonnage of the ships that wish to enter the Fiords, are

also estimated. Unfortunately, the long-term monthly visitation rates of these two categories were not available, so only the most recent year of 2019 will be used to produce loss estimates.

Another common form of tourism/transportation to Milford Sound are the buses that run from Queenstown to Milford Sound via Te Anau. Some of these services are strictly passenger transportation, whereas other packages will include boat/kayaking tours in Milford Sound. The ticket prices that include a tour within the Sound of some kind, also include the fee that is collected by Milford Sound Tourism Ltd. at the port, so this will be deducted from the estimates to avoid overlap. The companies that will be considered in the analysis for bus packages are Intercity, Great Sights, and Real Journeys. These were selected since they have publicly available ticket prices, operate consistently throughout the year, and are featured prominently on tourism websites. Assuming that there is one bus operated for each company every day conservatively (this is based on information available at time of research), that each bus has approximately 30-50 seats, and that in the summer season 70-100 percent of the seats on the buses are taken, losses will be estimated. Though there are different ticket prices for adults and children, only the adult ticket prices will be included in this estimate.

For the day cruise options on Milford Sound that do not include transport, Real Journeys, Mitre Peak Cruises, Cruise Milford Sound and Intercity were included for analysis. Though there are more options, these are the largest companies operating within Milford Sound and predominantly listed on tourism websites. Assuming that there are two cruises operated for each company every day (based on publicly available information at time of research), that each boat holds approximately 100 people, and that in the summer season 70-100 percent of the spots on the cruises are taken, losses will be estimated. The fees collected from Milford Sound Tourism Ltd. are included in all ticket prices, so this will also be deducted to reduce overlap. Like the bus prices, there are different ticket prices for adults and children, however only the adult ticket prices will be included in this estimate. Some cruises run more frequently over the holiday season, but this will not be considered since there will already be overlap between the bus prices that include a cruise tour.

It should be noted that the estimates of losses to the tourism industry in this area are expected to be minimum estimates, this is due to the information being collected during the time of the COVID pandemic, and therefore cannot accurately predict if the number of buses/cruises will increase permanently once borders are open and travel resumes.

7.2.6 Estimating Costs to Recreation

The possible recreational losses to an oil spill occurring in Milford Sound was previously estimated in Chapter 6: Recreational impacts of an oil spill in a world heritage area: A combined travel cost and contingent behaviour method approach. A combined revealed and stated preference technique (travel cost and contingent behaviour method respectively) was used and analysed using a negative binomial regression model truncated at zero. This allowed an estimation of the consumer surplus per person/visit, as well as the change in consumer surplus with each increase in oil.

7.2.7 Oiled Wildlife Response Priorities

To estimate the potential impacts of an oil spill on wildlife, one first must identify which species are at risk (Chilvers & Battley 2019, Chilvers 2021). This includes information such as the wildlife found in the area, their abundance and year-round occupancy, including whether they breed in the area. From a wildlife response perspective, it is also important to have the New Zealand and International Union for the Conservation of Nature (IUCN) conservation/threat status, to set priorities in the event of a response occurring. The unique aspects of the environment will also be discussed, and the potential consequences of oil contamination, based on the literature for similar organisms.

7.3 Results

7.3.1 Estimating Clean-up Costs

There are many factors that would determine the cost of clean-up, such as the quantity of oil spilled, the length of time of the response, weather conditions, and seawater properties. By using the Etkin (2000) algorithm, and substituting the cost per unit oil spilled, based on the actual cost of the *MV Rena* oil spill, an estimation of the clean-up costs for a similar size spill occurring in Milford Sound can be estimated (Figure 17).

Milford Sound is a remote location, and this is accentuated when considering the cost of clean-up of an oil spill in the Sound. This remoteness adds considerable time before response equipment and personnel can get to the location to respond, and additional costs of transport of equipment and personnel to the site. Accessibility of the site, and that most or all response staff will have to be based in Te Anau, means a drive of 120km/2 hours each way, each day for accommodation and food, as well as the equipment and supplies also need to be factored in. For these reasons a regional multiplier of three was used in the Etkin (2000) algorithm when calculating the hypothetical Milford Sound clean-up cost estimate. The

hypothetical Milford Sound and *MV Rena* clean-up costs estimates can be found in Equation 15 and Equation 16 respectively.

$$C_{ui} = (\$570,507.17)(0.71)(0.61)(1.89)(0.27) \quad \text{Equation 15}$$

where $C_{li} = (3)(1.46)(\$133,974.29)$

and $C_{ei} = (\$126,088.32)(350)$

$$C_{ei} = \text{NZD}(2011) 45,391,795.01$$

$$C_{ei} = \text{NZD}(2019) 41,407,352.88$$

$$C_{ui} = (\$190,169.06)(0.71)(0.61)(0.92)(0.27) \quad \text{Equation 16}$$

where $C_{li} = (1)(1.46)(\$133,974.29)$

and $C_{ei} = (\$20,458.77)(350)$

$$C_{ei} = \text{NZD}(2011) 7,365,158.98$$

$$C_{ei} = \text{NZD}(2019) 6,718,653.38$$

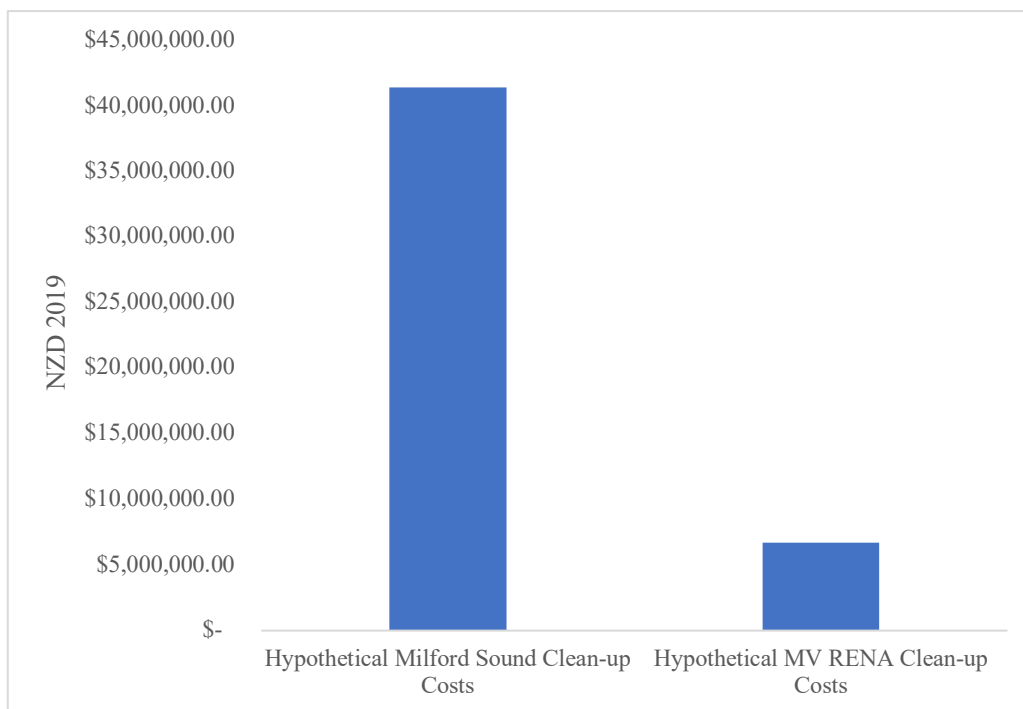


Figure 17: Estimated clean-up costs of an oil spill occurring in Milford Sound and the hypothetical *MV Rena* (C_{ei}), results using the Etkin (2000) model presented in NZD 2019.

The Etkin (2000) algorithm cost predictions are shown to indicate the predicted cost of an oil spill based on spills of a similar size. In both estimations, the actual cost per tonne of

the *MV Rena* oil spill clean-up is used, to see how the factors other than amount of oil spill impact the cost of clean-up. When compared to the likely clean-up costs calculated below it is clear this algorithm is a significant underestimate.

Based on the Maritime New Zealand daily hire rates for equipment, an estimate for equipment hire costs alone for a spill response in Milford Sound could range from NZD 1.476-5.905 million, as shown in Table 25.

Table 25: Estimated equipment hire costs for different response length times for Fiordland National Park.

Response Time	Estimated hire costs (including labour for equipment use (not general staffing), NZD 2019)
3 weeks	\$1.476 million
6 weeks	\$2.952 million
12 weeks	\$5.905 million

Source: Senior Oil Spill Response Technician (2021).

This hire costs reflect a variety of equipment, including but not limited to various types of booms, skimmers, on-water recovery vessels, land/sea cranes, and aerial observation equipment. This estimation does not include any security, fencing, personal protective equipment, general transport, decontamination equipment, administration costs, logistics, wildlife or command centre staff personnel, food, accommodation, and/or other miscellaneous items needed in a response. Based on the *MV Rena* equipment costs which were approximately NZD 1.6 million, as well as the unique characteristics of this site, further demonstrates that these are likely minimum estimates. It should be noted that it is unlikely that a response would only last 3 weeks given that it is expected to take at least 4 days for equipment to be transported to Milford Sound. This also does not reflect all the possible costs associated with a clean-up, since those are difficult to estimate. This is just for the specific clean-up equipment alone, that would most likely be used in this scenario. It is known that the *MV Rena* had other incurred costs associated with the clean-up, resulting in the response costing NZD 42 million (not including the wildlife response costs (Chapter 4: Does size matter? The direct economic costs associated with the *MV Rena*)). Based on the Etkin calculations, it is possible that an oil response cost in Milford Sound could cost as much as 6 times more than the *MV Rena*. The possible costs and implications of a wildlife response will be found in section 7.3.5 of this chapter.

7.3.2 Estimating Costs to Fisheries

The fishing area in which Milford Sound is located, represents a small portion of the landings (kg) and value of seafood landed for FMA5 (Appendix B7). According to Fisheries New Zealand (2020c), the Southland region is nationally significant commercially for oysters, blue cod (*Parapercis colias*), paua, and crayfish. All these species except for oysters are fished for in SA032 from within FMA5 (Figure 16). Most of the fishing does not occur directly within Milford Sound but around it, however a high proportion of the live crayfish catch is landed through the Milford Sound port. In 2019, these four significant species represented 17.3 percent of the landings, and 86.8 percent of the value for seafood landed in SA032 (with crayfish being the most important of these four species). None of New Zealand's previous oil spills have resulted in fisheries closures and given that a spill in Milford Sound would not impact a major fishing area it is also unlikely that the fisheries would close in this scenario either, just the port would close.

Though the direct fishing area is not significant, and a fishing ban is unlikely, Milford Sound port is an essential harbour for boats to unload their catch, especially for live crayfish, including boats that fish outside of SA032. This port is where roughly 29 percent of the total allowable commercial crayfish catch for Fiordland for FMA5 is landed live, every year. Based on the average value landed at this port from the 2015/16 to 2019/20 fishing year, the five most important months in order of size of catch landed are September, April, May, January, and October, averaging a value between NZD (2019) 2.21-4.4 million a month. Assuming December is the start of the summer season when increasing numbers of cruise ships would be passing through Milford Sound, one can estimate a range of losses within the port closure times that correspond to these summer months for live crayfish, as shown in Table 26. These ranges represent only a small fraction of the total cost to the industry, in that it does not consider the logistics of the export process, employment throughout the supply chain, and other multiplier effects.

Table 26: Possible range of losses to the crayfish industry due to port closures based on the port landing values.

Port Closure	Potential Losses to the Crayfish Industry (NZD 2019)
3 weeks	\$386,781 - \$2,101,786
6 weeks	\$2,488,567 - \$4,101,746
12 weeks	\$4,212,588 - \$6,644,810

Source: Chief Executive Officer (2021).

Note: The ranges reflect the time of year in which the scenario begins (for example, if the 3 weeks is in December compared to April).

It is unlikely that the boats that use Milford Sound port would not be able to go out for a full 12 weeks. However, once allowed out, it is equally unlikely that they would be allowed to come back until the response was finished. This will result in additional costs to the fisherman; they either must keep maintaining the catch out at sea, or they will have to incur additional costs to transport them to another port or have them helicoptered out.

7.3.3 Estimating Costs to Tourism

According to the annual RTEs, Fiordland accounts for approximately 37 percent of the tourism expenditure for the Southland region annually (Ministry of Business Innovation and Employment, 2020), demonstrating its importance for attracting visitors to the region. Figure 18 shows the total annual visitor spend for 2015-2019.

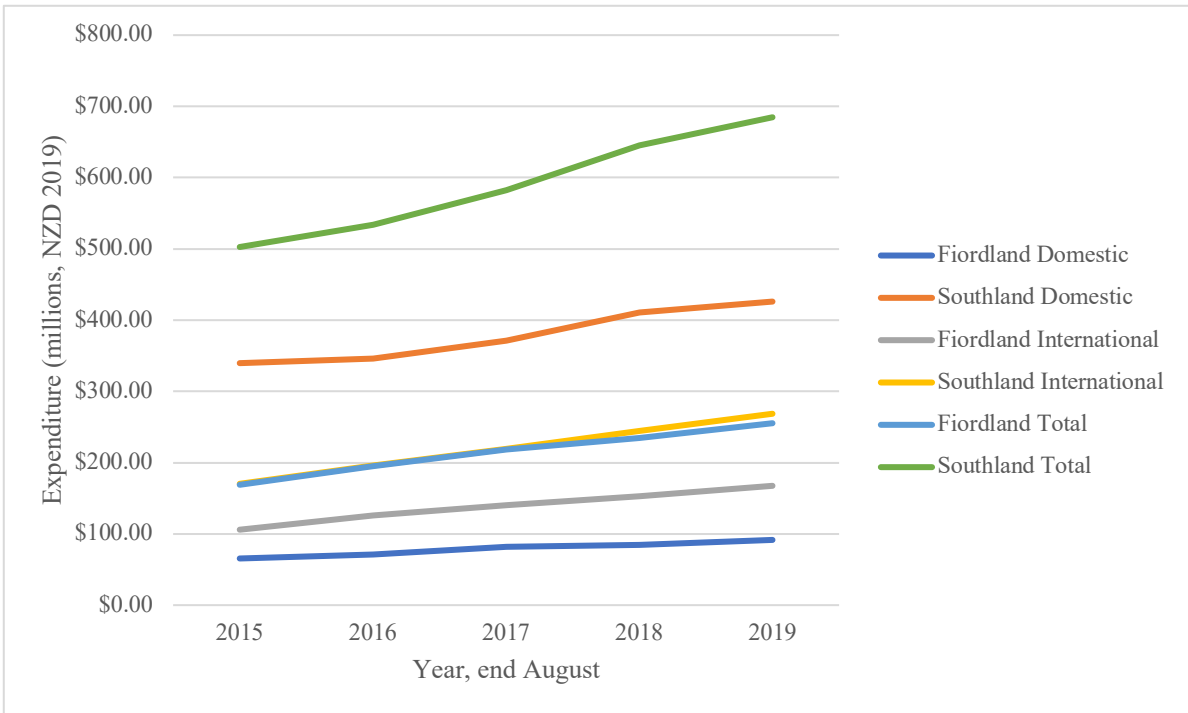


Figure 18: Total annual expenditure (NZD 2019) for domestic and international visitors as well as the total combined expenditure.

Source: Ministry of Business Innovation and Employment (2020).

The *MV Rena* led to a 0.04 percent decrease in domestic visitor spending, and an 8.7 percent increase in international visitor spending in the year following the oil spill (4.4.3). It is unclear but likely that the large immediate increase in international visitor spending was due to the international personnel involved in the clean-up and salvage response needed for the *MV Rena*. However, Fiordland National Park, Milford Sound has a different tourist profile compared to Coastal Bay of Plenty, so the effect of an oil spill on tourism in Milford Sound would be markedly different. There are several reasons for this, one being that Milford Sound is predominantly an international tourist market, whereas the Coastal Bay of Plenty visitor market comprises largely domestic visitors. The second reason being due to the remoteness of Milford Sound, it is likely that international visitors would no longer visit that area while there was an oil spill response or visible environmental effects.

Since this oil spill scenario happens in Milford Sound specifically, it's important to look at the effects on the tourism industry on port use and income. Prior to COVID-19, there was a charge of NZD 10.50 per adult for use of the port (children and tour guides are free of charge), and this is what the estimates will be based on. As demonstrated in Figure 19, the number of visitors to Milford Sound had been increasing over the 5 years to 2019, with an estimated NZD 8 million being collected in 2019. Based on the 2019 visitation numbers,

estimates can be made regarding the losses by Milford Sound Tourism Ltd. with the scenario closures of the port over the 3-, 6-, and 12-week time frames, as demonstrated in Table 27.

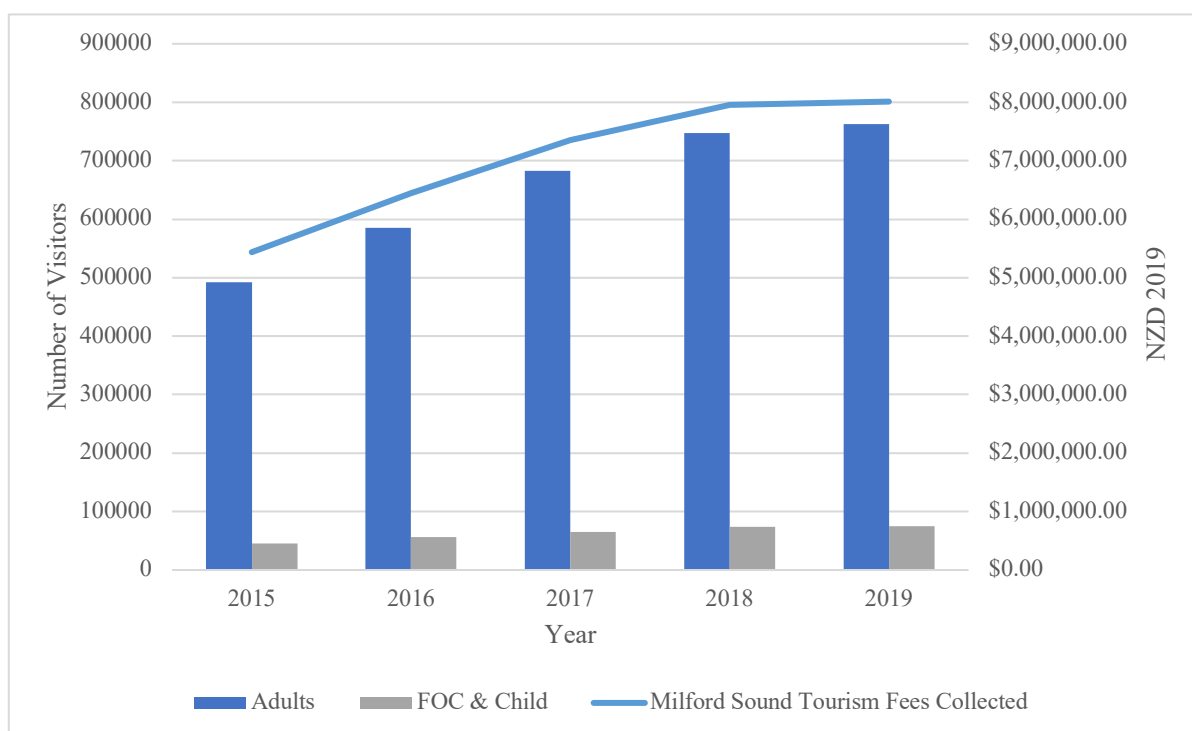


Figure 19: Visitor trends and approximate collected fees by Milford Sound Tourism Ltd. from 2015-2019.

Source: CEO of Milford Sound Tourism (2021); Milford Sound Tourism Ltd. (2019).

There are a rules controlling ships entering Fiordland sounds, including no more than two cruise ships may enter any fiord in one day, and visitation fees are collected from every cruise ship that enters the sounds (Environment Southland, 2021a). The fees that are collected currently run at a rate of the total gross tonnage of the ship x NZD 0.385 and increases every two years at the same level as the average consumer price index for the preceding two years (Environment Southland, 2021a). According to the New Zealand Cruise Association (2020), for the 2019-2020 season, 128 cruise ships were scheduled to enter Fiordland, with an average tonnage of 81,631. This would have generated a revenue of approximately NZD 4 million (without the end of season cancellations that occurred due to the COVID lockdown). Assuming the same three possible closure periods stated earlier, the estimated possible losses can be found in Table 27.

Table 27: Estimated losses of cruise ship fees collected by Environment Southland (ES) and Milford Sound Tourism Ltd. (MST).

Port Closure	Potential MST Losses (NZD 2019)	Potential ES Losses (NZD 2019)
3 weeks	\$1,076,334 - \$1,188,736	\$588,445 - \$971,120
6 weeks	\$1,988,910 - \$2,326,149	\$775,542 - \$1,702,445
12 weeks	\$2,444,788 - \$3,443,748	\$775,542 - \$2,425,272

Note: The estimates are based on the 2019/2020 cruise ship schedule and Milford Sound port visitor numbers, and the port fee charges collected by Milford Sound Tourism Ltd (MST) and gross tonnage weight charge from Environment Southland (ES).

Source: CEO of Milford Sound Tourism (2021), Milford Sound Tourism Ltd. (2019), Environment Southland (2021a)

The tourism and transportation options available from Te Anau and Queenstown that go to Milford Sound also stand to be negatively impacted by an oil spill occurring. Though there are peaks in visitation to Fiordland National Park across the year, the buses and Milford Sound cruises/excursions operate all year long, so it was assumed one trip per day, all year. For the companies who were clear regarding how frequently they operate, this was factored into the estimates. Looking at five different companies that were featured prominently on tourism websites, and assuming these companies operate at 70 to 100 percent capacity, the potential estimate losses can be found in Table 28.

Table 28: Potential losses for major companies that operate boat tourism and transport to Milford Sound from Te Anau and Queenstown.

Port Closure	Potential Losses for Milford Sound Tourism and Transport Companies (NZD 2019)	
	70 percent capacity	100 percent capacity
3 weeks	\$1,315,667	\$2,165,494
6 weeks	\$2,631,335	\$4,330,988
12 weeks	\$5,262,671	\$8,661,976

Sources: Cruise Milford Sound (2022); Great Sights (2022); Intercity (2022); Mitre Peak Cruises (2022); RealNZ (2022).

7.3.4 Estimating Costs to Recreation

The original consumer surplus per person/visit (with accommodation) was estimated at NZD1,449.28 (Chapter 6: Recreational impacts of an oil spill in a world heritage area: A combined travel cost and contingent behaviour method approach). By incorporating the contingent behaviour questions into the model, it was estimated that there was a decrease of NZD 923.73 for each stepwise increase of oil spilt to the consumer surplus. Based on the initial recreational values presented (NZD 427.80-1,159.42 million pre-COVID, and NZD 106.92-289.86 million during-COVID, with the lower end not including accommodation, and the higher end including accommodation costs), minimum annual recreational losses can be

estimated ranging from NZD 131.280-738.984 million (pre-COVID) and NZD 32.820-184.746 million (during-COVID) (excluding and including accommodation respectively).

7.3.5 Oiled Wildlife Response Priorities

It is difficult to say how much a wildlife response would cost in this area. There are several factors that would make it difficult, including but not limited to: remoteness of site, difficult terrain for capture of wildlife, limited lodging and supply stores, no available facility for treatment of wildlife, and difficulties associated with having to transport oiled wildlife the more than two hours to a facility. Additionally, in this scenario of a cruise ship incident, human life is the priority in the response, and it may therefore be days before a wildlife response could be initiated within the area. Due to these unknown factors, I will use the cost of the oiled wildlife response from the *MV Rena* as an indication of wildlife response costs in New Zealand from such an oil spill, which were NZD 4.112 million (4.4.1). The remainder of this section will have a brief discussion regarding what wildlife exists in the area, what the priorities would likely be, and what response options would be. In the event of an oil spill occurring in Milford Sound, there are certain species that would be of concern due to either their threat status, sheer numbers present and or difficulty in handling (fur seals). A list of these may be found in Table 29.

Table 29: Wildlife found within the Milford Sound area identified as native or endemic, their New Zealand threat status, IUCN status, and whether they breed in Fiordland National Park (FNP).

Scientific Name	Common Name	NZ Status ¹	NZ Threat Status ²	IUCN Conservation Status ³	Breed in FNP
<i>Antipathella fiordensis</i>	Black coral	E	RR	E	Yes
<i>Arctocephalus forsteri</i>	New Zealand fur seal	N	NT	LC	Yes
<i>Chroicocephalus novaehollandiae scopulinus</i>	Red billed gull	E	NE	LC	No
<i>Daption capense austral</i>	Snares Cape petrel	E	RR	NT	No
<i>Eudyptes pachyrhynchus</i>	Fiordland crested penguin	E	NV	E	Yes
<i>Eudyptula minor</i>	Little blue penguin	N	AR	LC	No
<i>Leucocarbo punctatus</i>	Spotted Shag	E	NT	LC	No
<i>Leucocarbo stewarti</i>	Stewart Island shag	E	NV	LC	No
<i>Leucocarbo sulcirostris</i>	Little Shag	E	AR	LC	No
<i>Leucocarbo varius</i>	Pied Shag	E	AR	LC	No
<i>Megadyptes antipodes</i>	Yellow-eyed penguin	E	NE	E	No
<i>Pachyptila desolata</i>	Antarctic Prion	N	AR	LC	No
<i>Pachyptila turtur</i>	Fairy prion	N	AR	LC	No
<i>Pachyptila vittate</i>	Broad-billed prion	N	AR	LC	No
<i>Pelagodroma marina</i>	White-faced storm petrel	N	AR	LC	No
<i>Pelecanoides urinatrix</i>	Common diving petrel	N	AR	LC	No
<i>Phoebetria palpebrata</i>	Light-mantled sooty albatross	N	AR	NT	No
<i>Procellaria westlandica</i>	Westland petrel	E	NC	E	No
<i>Puffinus carneipes</i>	Flesh-footed shearwater	N	NV	LC	No
<i>Puffinus griseus</i>	Sooty shearwater	N	AR	LC	Yes
<i>Sterna striata aucklandorn</i>	White-fronted tern	E	AR	LC	No
<i>Thalassarche bulleri</i>	Southern Bullers mollymawk	E	RR	NT	No
<i>Thalassarche salvini</i>	Salvin's mollymawk	E	NC	E	No

Sources: Birds New Zealand (2013); Department of Conservation (2021); Freeman et al. (2013); IUCN (2021); Robertson et al. (2016).

¹E=Endemic (only found and breeds in NZ), N=Native

²RR=Range restricted, NT=Not threatened, NE=Nationally endangered, NV=Nationally vulnerable, AR=At risk, NC=Nationally critical

³LC=Least concern, NT=Near threatened, E=Endangered

It is extremely likely that all birds found within the area will be responded to, and attempted to capture, clean and rehabilitate for release back into a cleaned environment, in

the event of an oil spill, with high mortalities likely if the *MV Rena* is anything to go by (Hunter et al. 2019). If animals can be rescued, there has been previous success in New Zealand regarding the oil-rehabilitation of seabirds for the *MV Rena* oil spill (Gartrell et al., 2019) where a survival rate to release of 87.1 percent was observed for species such as the little blue penguin. There was also success with the pre-emptive capture/release of New Zealand Dotterels (*Charadrius obscurus aquilonius*), which are a nationally vulnerable species considered extremely likely to die if oiled (Gartrell et al., 2013). There was a survival rate of 90 percent over two months in preventative captivity (Gartrell et al., 2013), establishing this technique a worthwhile way to prevent at risk species becoming oiled and the likely high mortality that could bring for such a species.

Using New Zealand threat status as a priority, it is likely that the Red Billed Gull, Fiordland Crested Penguin, Stewart Island Shag, Yellow-eyed Penguin, Westland Petrel, Flesh-footed Shearwater, Salvin's Mollymawk would be prioritized in a response (Table 6). Range restricted animals, though not endangered, would also likely be a high priority, namely Snares Cape Petrel and the Southern Buller's Mollymawk. One of these threatened species, the Fiordland Crested Penguin, would require a particular labour-intensive response. This is a large species, with adults weighing around four kilograms and a height of 60cm (Ellenberg, 2013), that has unique behavioural and distribution characteristics. Collecting and finding oiled Fiordland Crested Penguins would prove to be difficult, since they live in loose colonies in hard-to-reach habitats (Ellenberg, 2013). New Zealand has limited equipment or facilities to respond to marine mammals, which for Milford Sound would primarily be the New Zealand fur seal, given that there is a colony at the entrance to Milford Sound, and bottlenose dolphins (*Tursiops truncatus*) which are frequently found in sound. It is expected that the main response to help these animals, would be to prevent the animals from being oiled through hazing or deterrence, and ensure their habitat is cleaned quickly and efficiently.

7.3.6 Total costs

Total estimates associated with an oil spill in Milford Sound are given in Table 30.

Table 30: Estimated direct cost of an oil spill occurring in Milford Sound, Fiordland National Park.

Sector	Possible losses, NZD 2019 (millions)		
	3 weeks	6 weeks	12 weeks
Equipment hires for Clean-up (minimum)	\$1.476	\$2.952	\$5.905
Fisheries/Crayfish	\$0.387 - \$2.102	\$2.489 - \$4.102	\$4.213 - \$6.645
Tourism	\$2.980-\$4.325	\$5.396-\$8.359	\$8.484-\$14.531
Environment Southland Port Fees	\$0.588 - \$0.971	\$0.776 - \$1.702	\$0.776 - \$2.425
Milford Sound Tourism Port Fees	\$1.076 - \$1.189	\$1.989 - \$2.326	\$2.445 - \$3.444
Tourism and Transport	\$1.316 -\$2.165	\$2.631 - \$4.331	\$5.263 - \$8.662
Recreation	\$131.280-\$738.984 (pre-COVID)		
Wildlife & Environment	\$4.529		
Total Estimated Losses			
Pre-COVID	\$140.652-\$751.416	\$146.646-\$758.926	\$154.411-\$770.594

The total estimated losses labelled pre-covid are influenced by the visitors' numbers for recreation prior to the pandemic. The ranges within the time frames of 3-, 6-, and 12- weeks is determined by when the spill would occur within the summer months. This primarily has the greatest impact for the estimated direct losses to the fisheries/crayfish industry. Overall, the estimated losses are NZD (2019) 140.652-154.411 (when recreation estimate does not include accommodation), and NZD (2019) 751.416-770.594 (when recreation estimate does include accommodation).

7.4 Discussion

This chapter estimates the direct costs an oil spill may cause if it were to occur in Milford Sound, Fiordland, New Zealand. Oil spills can affect many different economic sectors, so the possible impacts of one occurring needs to be considered, especially when the area is a UNESCO World Heritage site which holds value in both the international and domestic realm. This chapter specifically looked at the potential clean-up costs, and the likely impacts to the fishing industries, tourism, recreation, and the wildlife/environment, associated with an oil spill in the area. This site was chosen due to its UNESCO World Heritage status and interest to international visitors, its remoteness, and the consideration and costs this remoteness would likely incur in a response, as a clear comparison with Bay of Plenty, New Zealand (a densely populated city area), where the *MV Rena* oil spill occurred.

The incurred cost estimates given in Table 30 ranging from NZD (2019) 140 to 770 million are for an oil response of varying time periods, and the ranges for costs to

fisheries/crayfish and tourism based on the possible months are included in the time frame of the spill over the summer period. During which summer months the scenarios occurred proved to be an important determining factor for the crayfish estimations, with April having the highest average cost if an oil spill was to impact that month. Unfortunately, the level of data used for the tourism sector would not allow a more specific temporal estimation, but it could be argued that an oil spill over the height of New Zealand summer, would lead to the most losses for this sector. The ranges for recreation are based on whether accommodation was included in the estimate (the lower end is without, and the higher end is with accommodation). Pre-COVID, visitor numbers were around 800,000 people annually (Milford Sound Tourism Ltd., 2019), leading to larger possible recreational losses, and in turn larger possible direct costs.

These direct cost estimates are considerably larger than the previous study regarding the direct costs associated with the *MV Rena* oil spill where estimates ranged from NZD (2019) 108.79-125.11 million (with recreation including accommodation costs). Prior to the COVID-19 pandemic, these losses can be conservatively valued at 2.09-2.29 percent of the GDP of the Southland Region, or as high as 11.18-11.46 percent. The possible clean-up costs using the Etkin (2000) algorithm (Figure 17) clearly underestimates the possible costs associated with an oil response, which has been demonstrated to be the case previously in New Zealand in relation to the *MV Rena* (Chapter 4: Does size matter? The direct economic costs associated with the *MV Rena*) and offshore oil drilling operation in what country (Oldham et al., 2020). Using a regional multiplier of three within the Etkin calculations brought the costs up to a similar cost seen for the *MV Rena* however given the logistical challenges of a response occurring in Fiordland, it is easily assumed that they will cost more and that the Etkin model significantly underestimates clean-up costs.

Internationally, there have been limited studies undertaken regarding direct costs associated with oil spills, their clean ups, and costs to regions. For the *Prestige* oil spill, which occurred off the coast of Spain, direct losses were estimated at €566.97 million (over two years, including recovery costs and other miscellaneous smaller costs, not including recreation), which represented approximately 1.57 percent of the GDP of the area where the spill occurred (Loureiro et al., 2006). Based on these figures, although the estimates presented in this study are lower compared to those of the *Prestige*, they represent a larger proportion of the GDP in Southland (minimum of 1.95-11.0 percent).

For the 2019-2020 summer season, new cruise ship restrictions were put in place by Environment Southland (the local regional council, similar to a state or territorial authority), allowing no more than two ships in any fiord or inlet at one time, in order to make the cruise ship industry more sustainable within Fiordland National Park (Bradley, 2019). Environment Southland and the New Zealand Cruise Ship Industry also have their own Deed of Agreement, which outlines a marine fee and the responsibilities of the ships that enter Southlands waters (Environment Southland, 2012). The tourism policies for Fiordland National Park are currently being debated. There is a push to limit or eliminate cruise ships within Milford Sound. The Stantec NZ Limited (2021b, p. 9) proposed the concept to “prohibit cruise ships from entering Milford Sound / Piopiotahi as they are causing visual impacts that are not in keeping with the beautiful natural setting and intent of the vision of the plan.” At this stage the document is a discussion document. Although this proposal would make the possibility of an oil spill occurring within Milford Sound less likely, eliminating cruise ships would have other regional impacts. The Regional Council expects to collect approximately NZD 2.8 million in fees from cruise ships wishing to utilize Fiordland’s waters (Environment Southland, 2021b), which would be greatly reduced if cruise ships were not allowed to enter Milford Sound. It is likely that if cruise ships were unable to enter Milford Sound, Doubtful and Dusky Sounds would experience a higher volume of cruise ships. These fiords are considered to be more remote, since they are either difficult or cannot be accessed by road, so if an oil spill were to occur here instead, it is likely that a spill response would come at a much higher cost, and result in a higher wildlife mortality. Oil spills in fjords from cruise ships have previously been reported in Norway within a UNESCO site (Iovine, 2009), with significant effects to the environment, however no economic analysis has been reported.

Because much of New Zealand’s coastline is remote, it is important to try to estimate the possible costs and implications of an oil spill occurring in this type of remote and pristine area. The possible short-term economic consequences of an oil spill occurring here would be greater than what was previously experienced during the 2011 *MV Rena* oil spill. Estimating the long-term costs would prove to be difficult, but it is likely that the perception of this area as being ‘untouched’ would no longer be the case. It can be assumed that there would be a permanent drop in visitors to the area, impacting the value added by tourism, as well as the overall recreational value of the area.

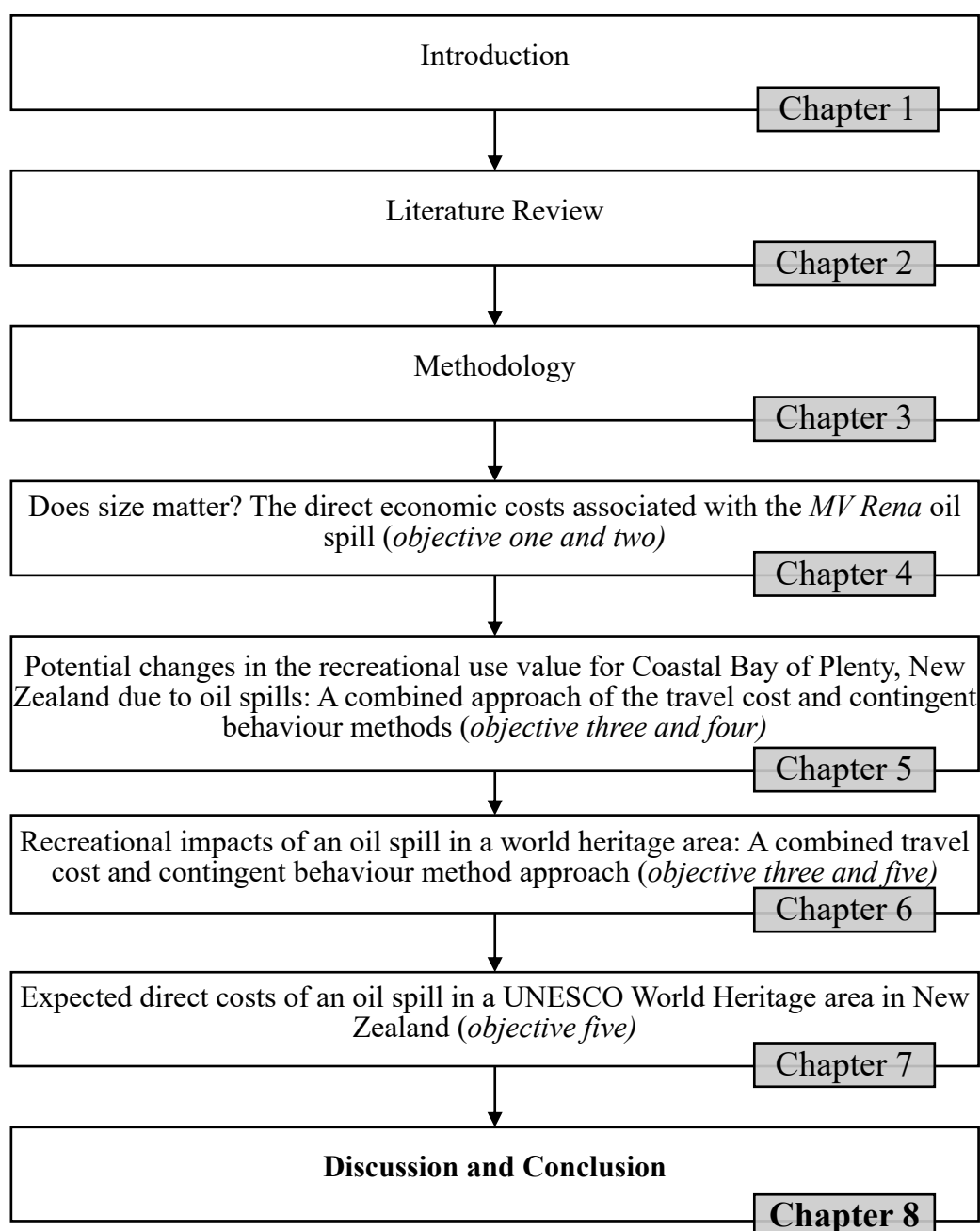
New Zealand has well-established oil response legalisation and government led response coordination, as shown during the *MV Rena* response. However, the results provided in this study show that the direct costs of oil spills within New Zealand can be a significantly higher cost in proportion to New Zealand's GDP than other countries, due to the small economy of New Zealand. This research shows that for remote areas such as Milford Sound this cost can be even more significant. New Zealand has an extensive coastline (15,000km) and thousands of offshore islands, all of which could be impacted by a ship-based oil spill and at least 50% of which could be considered remote. Given the remoteness of Milford Sound, it is important to have the appropriate domestic policies, be party to relevant international treaties, have fully operational response plans and trained personnel in place, so that there may be a quick and efficient response to minimize the economic and environmental damages that may result of an oil spill. This can be done by training oil spill response personnel in advance and having area specific response plans and equipment to enable the fastest response possible.

7.5 Conclusion

This chapter assesses the direct economic costs that may be associated with an oil spill occurring in Milford Sound, Fiordland National Park by looking at the possible clean-up costs, losses to recreation, commercial fishing, and tourism industries, as well as the expected priorities in a wildlife response. Prior to the COVID-19 pandemic, possible costs are estimated conservatively at NZD (2019) 140.24-153.99 depending on the length of response, with recreational losses accounting for 85.2-93.6 percent of the costs. To my knowledge, this is the first attempt at this kind of study for a possible ship-based oil spill direct cost assessment in New Zealand. I acknowledge this study does not reflect all possible losses due to an oil spill, since non-use/passive-use values were not investigated, and I anticipate that they would be significant, and more so with the inclusion of cultural, including indigenous / Iwi (Māori) impacts, which are outside the scope of this research. Nonetheless, the results presented here demonstrate the need for appropriate funding for oil spill preparedness and response policies. Further research should be conducted once international visitors are back in New Zealand, as this would likely increase the recreational losses. It is also recommended investigating the flow on or multiplier effects of these industries, to see the impacts that an oil spill occurring in Milford Sound would have at the highest level. These recommendations are made so that an even more appropriate view of the costs associated with oil spills in New

Zealand's coastal waters can be considered and the appropriate response legalisation, planning and preparedness be implemented.

Chapter 8: Discussion and Conclusion



The following chapter, which is this research's last, will demonstrate the connection between all previous chapters. It will first present a summary of findings, then the limitations of this research, and a discussion on the results presented here compared to international studies. It will then have a discussion regarding the future of tourism in New Zealand, factors that may affect or influence marine oil spills in New Zealand in the future, as well as international and

domestic policies in relation to response and compensation. Lastly, recommendation for future research and an overall conclusion will be provided.

8.1 Summary of Findings

Oil spills can have large negative impacts, not only on the marine environment, but also on a variety of socio-economic activities relating to them. Meaning, that oil spills have the capability of disrupting the different values or gains that people derive from the marine environment. As demonstrated by this thesis, some key industries that are affected by marine oil spills are commercial fishing and tourism, but the clean-up costs and impacts to recreation also need to be considered to get a comprehensive understanding of the direct costs oil spills can cause.

The *MV Rena* oil spill that occurred off the coast of the Bay of Plenty, New Zealand in 2011 has had little or no research undertaken investigating the economic consequences associated with the spill. Chapter 4: Does size matter? The direct economic costs associated with the *MV Rena* compared pre- and post-spill trends for commercial fisheries and tourism in the area, with losses to these sectors estimated. Fisheries demonstrated losses of around NZD (2011) 2.27 million. Interestingly, domestic tourism spending in the area saw a decrease of NZD (2011) 1.50 million, but international tourism spending showed an increase of NZD (2011) 8 million, suspected to be related to the complexity of the vessel's salvage and the international expertise needed in Tauranga to undertake the work. The total oil clean-up response costs for the *MV Rena* were estimated at NZD (2011) 46.89 million, with Maritime New Zealand fronting most of that cost at NZD (2011) 36.27 million, with volunteer costs estimated at an additional NZD (2011) 312,000. These costs are sizeable when the relatively small amount of oil that was released by the ship is considered. Additionally, restoration costs (or the costs of programs to try to bring the damaged environment back to a 'pre-spill' state) for the *MV Rena* were estimated at an additional NZD (2011) 2.42 million. For a true understanding of the cost of oil spills, it is not only the clean-up costs that need considering, therefore Chapter 5: Potential changes in the recreational use value for Coastal Bay of Plenty, New Zealand due to oil spills: A combined approach of the travel cost and contingent behaviour methods, estimated the value of potential losses to recreation for the stretch of beach from Mount Maunganui to Maketu, which was oiled during the *MV Rena* oil spill; losses were estimated ranging from NZD (2021) 58.70-75.02 million per year (low end representing CB1 (low amount of oiling on beach, minimal marine recreational activities impacted), high end representing CB3 (heavy oiling on the beach, all marine recreational

activities impacted)). Therefore overall, this put the total estimated direct costs from the *MV Rena* oil spill at NZD (2021) 99.06-115.38 million (NZD 2011 costs from Chap 3 converted to 2021 here for total cost estimate).

For this thesis, Milford Sound, Fiordland National Park was chosen to contrast the *MV Rena* spill, as a remote unpopulated area for a hypothetical oil spill and the differences in costs that may present. This is particularly important for New Zealand as there are long stretches of New Zealand's coast and offshore islands that are equally remote and unpopulated and oil spills from shipping and cruise ships could happen in many of these areas. New Zealand needs an understanding of just what that sort of spill may mean and cost.

Chapter 7: Expected direct costs of an oil spill in a UNESCO World Heritage area in New Zealand, used a similar methodology to that used to estimate the costs to the *MV Rena*, with trends for fisheries (namely the crayfish industry in this instance) and tourism for Milford Sound determined, and hypothetical losses estimated. The losses for the fisheries/crayfish industry could potentially range from NZD (2019) 0.387-6.645 million. Tourism losses can potentially range from NZD (2019) 2.98-14.53 million. The estimates for fisheries/crayfish and tourism are both heavily dependent on the month of summer in which the oil spill would occur. The equipment hire rates based on information obtained from Marine Pollution Response Services, Maritime New Zealand ranged from NZD (2019) 1.476-5.905 million. This does not include all expenses that would be needed, as demonstrated by comparison with the full breakdown of costs from the *MV Rena* oil spill (Chapter 4: Table 6). The cost of a wildlife response for Milford Sound is difficult to determine, so the costs associated with the *MV Rena* was used (NZD (2011) 4.112 million, equivalent to NZD (2019) 4.529 million).

Chapter 6: Recreational impacts of an oil spill in a world heritage area: A combined travel cost and contingent behaviour method approach estimated the potential recreational losses associated with an oil spill occurring in Milford Sound, which ranged from NZD (2021) 131.280-738.984 million annually over five years with the range dependant on whether or not accommodation was included in the estimates. This puts the total estimated direct costs associated with an oil spill occurring in Milford Sound at NZD (2021) 140.235-770.177 million. A selection of New Zealand based studies for a comparison of AggCS can be found in Table 31.

Table 31: Selected New Zealand based studies using the travel cost method.

Authors	Year	Location	Agg CS (NZD)
Dhakal, B., Yao, R. T., Turner, J. A., & Barnard, T.	2012	Whakarewarewa Forest, Rotorua	8 million
Kerr, G. N., & Greer, G.	2004	Rangitata River, Canterbury	1.8-4.5 million 1.4-3.7 million
Kerr, G. N., Sharp, B. M. H., & Gough, J. D.	1986	Mt Cook National Park, Canterbury	2.2 million
Woodfield, A., & Cowie, D.	1977	Milford Track, Fiordland National Park	860,323

When comparing the Fiordland National Park AggCS estimates to other TCM studies in New Zealand, they are in line with the research. Though they may look higher initially, the previous studies either focus on areas with lower visitor numbers or focus a specific activity within an area.

These overall findings provide critical cost estimates needed to understand, support and ensure the adoption of strong policies that focus on prevention and preparedness for marine oil spills response within New Zealand’s coastal environment. The estimated direct costs alone of a previous major oil spill, let alone the hypothetical cost of an oil spill in a remote area of New Zealand demonstrates the large economic consequences that are possible if oil spills occur.

8.2 Limitations of Research

This research was undertaken during the world COVID pandemic when New Zealand’s borders were closed with no international visitors, meaning recreational use values were restricted to New Zealand residents (so any internationals surveyed were already here/residing here and would not be considered international tourists). This means potential recreational use values would likely be even higher for an area like Milford Sound whose world heritage classification brings it significant numbers of international tourists annually (in non-pandemic years). However, the fact of no international visitors did make the recreational use estimates between the two locations more comparable using only New Zealand residents. Overall, the impact of the pandemic, makes the true potential cost of an oil spill for a place like Milford Sound a minimum within this thesis and this needs to be taken into consideration when considering the results and understanding the cost implications for potential policy implementation.

For any piece of research, a larger sample size is something always aimed for. Although the survey sample sizes in this thesis for both BOP and Fiordland were not small, larger numbers of surveys would have continued to give a clearer picture of true recreational costs/value lost. The numbers of surveys that were collected for in both areas showed good modelling fits (see the AICs and log likelihood functions).

This research only considered the direct use values, which does not provide all the possible costs/losses that may be associated with oil spills. Non-use values (existence, bequest, warm glow, and options/quasi-option values) were not investigated. This decision was made since the reliability of these values is still being debated in the literature (Alban et al., 2006; Börger et al., 2014a). However, this is an area of research that could be undertaken in the future.

8.3 Results Compared to International Studies

To my knowledge, there are no studies that have used this combined methodology of travel cost and contingent behaviour to estimate the losses/potential losses to recreation due to an oil spill. However, there are a multitude of studies that use travel costs to estimate the consumer surplus or recreational value of site, as well as incorporating contingent behaviour questions to estimate losses for different environmental change or degradation scenarios (Kipperberg et al., 2019; Lankia et al., 2019; Voltaire & Koutchade, 2020).

For the Coastal Bay of Plenty (the stretch of beach from Mount Maunganui to Maketu, alongside New Zealand's largest port), the consumer surplus (CS) per person for a single visit was estimated to be NZD (2021) 121.21, including both locals to the area and travellers from further away (all who still reside in New Zealand). The travel cost coefficient is negative and significant at the one percent level (-.00825***), which confirms that the higher the travel cost, the less visits one will make. The contingent behaviour models showed that even the lowest amount of oil being present on the beach, would impact the number of visits over the next two years, reducing these and the CS per person/visit from NZD (2021) 121.21 to NZD (2021) 29.74. Looking at the pooled panel model results show that a decrease in value of NZD (2021) 92.51 is attached to each increase in oil level/loss of coastal activities in this area. Minimum annual recreational use losses for this area are estimated at NZD (2021) 58.70 million based on the estimate of 641,683 visitors (Surf Life Saving NZ, 2022).

This CS per person/visit is higher than what is primarily demonstrated in the literature, since many studies do not include accommodation costs (such as USD 16.95-21.73 for a beach visit in Ecuador (Zambrano-Monserrate et al., 2018), and AUD 19.47 for Gold Coast,

Australia (Zhang et al., 2015)). For studies that do include accommodation within their travel cost estimates, the estimated CS is similar. For example, Windle and Rolfe (2013) found for overnight visitors specifically, that their CS ranged from AUD 212.63-234.14 when visiting beaches in Brisbane, Australia. Similarly, for those visiting the Coorong in Australia, the CS was found to be AUD 242.08 (AUD 186.7 - 328.41) (Rolfe & Dyack, 2011). Within the European Union, 14 countries were considered for a study that looked at improving and worsening water quality around various blue spaces. From an original CS estimate at €41.32 per person/visit, an improvement of water quality increased the CS to €129.25, whereas a decrease in water quality had an estimated loss of €403.57 per adult/year (Börger et al., 2021). In Norway, the change in CS for a proposed wind farm in two locations was investigated. One location showed a decrease in CS from NOK 78.45 to NOK 61.77, and the other NOK 134.89 to NOK 77.87 (Kipperberg et al., 2019).

For Fiordland National Park, the estimated CS estimated in Chapter 6: Recreational impacts of an oil spill in a world heritage area: A combined travel cost and contingent behaviour method approach of NZD (2021) 534.76 and NZD 1,449.29 (accommodation included in the latter), is generally higher than previous studies of similar sites, being world heritage sites or national parks, throughout the world. Within the United States the CS per person have been estimated at USD 8.00-19.26 for a UNESCO site, and USD 98.92 for a National Park (Bowker et al., 2005; Poor & Smith, 2004). Within Europe, the CS per person for UNESCO sites have been estimated at €27.16- €38.77 in Spain, €136-€281 in France, AMD 13,850-22,000 in Armenia (Alberini & Longo, 2006; Torres-Ortega et al., 2018; Voltaire et al., 2017), and £148.39 for a National Park in the United Kingdom (Voke et al., 2013). Martínez-Espiñeira and Amoako-Tuffour (2009) studied a similarly remote UNESCO site in Canada, and estimated a recreational value of CAN\$ 1,135-2,528, which is similar to the estimates here when including accommodation. The pooled panel contingent behaviour models demonstrated that each increase in oil spill level showed a stepwise decrease of NZD (2021) 164.10 and NZD (2021) 923.73 per person/trip without and with accommodation, respectively. This leads to minimum annual recreational losses estimated ranging from NZD (2021) 131.3-739.0 million using pre-COVID visitor numbers, and NZD (2021) 32.8-184.7 million using during-COVID visitor numbers based on whether accommodation was included. These potential losses are substantially larger than what was estimated for recreational losses in the Bay of Plenty region, especially when including accommodation.

For other oil spills that consider recreational losses, Garza et al. (2009) estimated the indirect losses associated with the *Prestige* oil spill in Spain, with losses to recreation being estimated around EUR 86.9 representing 3.8 percent of the total indirect estimation. To put this in perspective, the *Prestige* leaked around 77,000 tons of heavy fuel oil and impacted approximately 1,000 kilometres of Spain's coastline. The *MV Rena* impacted approximately 25 kilometres of beach and leaked 360 tons of heavy fuel oil, and the estimated recreational losses represents approximately 0.62-0.79 percent of the 2020 GDP of the Bay of Plenty region. Under a similar scenario for FNP in Chapter 7: Expected direct costs of an oil spill in a UNESCO World Heritage area in New Zealand, the estimated recreational losses represent 1.95-11 percent of the 2020 GDP of the Southland region.

It is estimated that 3.5 million New Zealanders visit the coastal areas/beaches every year, out of a population of just over 5 million (Water Safety New Zealand, 2021). Given how important all types of outdoor recreation are to New Zealanders, it makes sense that the CS estimated for both CBoP and FNP would be higher compared to international studies. In addition, New Zealand's cost of living is at a three-decade high, which may also have contributed to the generally CS that was estimated (Corlett, 2022).

8.4 Future of Tourism and Recreation in New Zealand

Prior to the COVID-19 pandemic, tourism represented 5.2 percent of New Zealand's gross national product (McClure, 2021; WorldData.info, 2022), with a record 996,000 tourists visiting New Zealand in 2020 (this includes the summer of 2019-2020 prior to the pandemic), of which 87% went to Milford Sound (McClure, 2021). Because of the value of tourism to New Zealand's economy, but also the damage it is seen or perceived to bring, there have been discussions about trying to 'reset' this sector in a post/during-covid world. The New Zealand tourism minister has indicated that there needs to be diversification of the economics of tourism for dependent towns, in order to make them more resilient for the future (McClure, 2021). The tourism minister went as far as to single out Milford Sound (Fiordland National Park), saying that it cannot go back to its pre-covid tourist numbers, as the natural environment here was under significant pressure from its 870,000 annual visitors (McClure, 2021). According to a report by the Ministry of Business Innovation and Employment (2019) prior to the covid-19 pandemic, international tourism was expected to reach around 5.1 million visitors by 2025, contributing around NZD 15 billion. With covid-19 changing the view on the New Zealand tourism sector, these gains are not expected to be

seen if less emphasis is expected to be on international tourism (assuming that the world returns to a 'pre-covid' travelling state).

Stantec NZ Limited (2021b) (which is an infrastructure/environmental/engineering consulting company) has put forth a comprehensive plan, for the future management of Milford Sound. One of their key recommendations, is limiting or eliminating all cruise ships from Milford Sound. This is a curious recommendation, considering cruise ships are already limited to two ships entering the fiord in a day (Environment Southland, 2021a). Chapter 6: Recreational impacts of an oil spill in a world heritage area: A combined travel cost and contingent behaviour method approach and Chapter 7: Expected direct costs of an oil spill in a UNESCO World Heritage area in New Zealand, demonstrated the potential consequences to the tourism industry and recreational losses to that area, with the assumption that a cruise ship would be the most likely source of a significant oil spill for Milford Sound. The total estimate losses to tourism range from NZD (2019) 2.98-14.53 million (range represents estimates of 70 to 100 percent occupancy), when looking at the port fees collected by Environment Southland (the local regional council), the port fees collected by Milford Sound Tourism, and the possible decreased capacity in the buses and boat tours that frequent Milford Sound. The losses to recreation showed a stepwise decrease in the consumer surplus per person of NZD (2019) 164.10 (without accommodation) and NZD (2019) 923.73 (including accommodation), which equates to minimum annual aggregate losses ranging from NZD (2019) 131.3-739.0 million over five years (using pre-covid visitor numbers).

The covid-19 pandemic also changed the way that New Zealander's felt about their outdoor environment. According to a report by Espiner et al. (2021, p. 6), "outdoor recreationists reported that, after the lockdown ended, they felt more appreciative of their outdoor recreation opportunities and for New Zealand's great outdoors. The events of 2020 also prompted many New Zealanders to consider the future of tourism in New Zealand. The outdoor recreationists' increased interest in travelling within New Zealand suggests that one enduring legacy of lockdown might be a renaissance for domestic tourism in New Zealand. Furthermore, outdoor recreationists generally felt that international tourism is important for New Zealand, but they noted concerns about the number of tourists and the impact that international tourism has on the natural and social environment in the recent past." Even though this study was unable to include international visitors within the analysis, this emerging position on tourism and recreation in New Zealand demonstrates that these results

which offer a domestic/national perspective are relevant, a should be included in the discussions for policies regarding coastal water use/protection.

8.5 Factors That May Affect Marine Oil Spills in New Zealand in the Future

New Zealand's only oil refinery was decommissioned in early April 2022, taking its last crude oil shipment in March of 2022 (Piper, 2022). It can be assumed that with the closure of this refinery more ships will be carrying petroleum products into and around the country as all petroleum products will now be made offshore and shipped in. This could potentially increase the risk of larger oil spills as more ships will be carrying not just the oil that is used to power the ships, but petroleum products being imported into the country.

According to a report done by Deloitte (2022), port activity is beginning to rebound to 2019 levels prior to the covid-19 pandemic. Auckland has seen an increase of five percent in import volume compared to 2019 levels, and the Port of Tauranga has returned to pre-pandemic export and import traffic levels (Deloitte, 2022). Though the shipping supply chain has been disrupted for reasons other than just the pandemic alone, shipping is vital for New Zealand's export and imports, which supports over 99 percent of their international trade by volume (Deloitte, 2022). The increasing volume of ships entering ports around New Zealand, also raises the chances that a significant marine oil spill could occur.

In 2018, the New Zealand government banned new permits for offshore oil exploration, but the 30-year permits that were already granted prior to this are still in effect (McKenzie, 2022). Currently, there is exploratory drilling off the coast of the Taranaki region on the west side of the North Island and in the Southern Basin, off the SE of the South Island. Oldham et al. (2020) indicated that an oil spill occurring from the drilling in the Taranaki area had a median total damage cost of USD (2020) 679 million, with a maximum value of around USD 1100 million using an integrated damage assessment model. Though this estimate is substantially higher than the estimates provided by this research, it is to be expected that there would be higher costs associated with an oil drilling accident.

As described earlier in this thesis (Chapter 7: Expected direct costs of an oil spill in a UNESCO World Heritage area in New Zealand), the hypothetical oil spill scenario in Milford Sound would most likely be caused by a cruise ship. As mentioned, the Stantec NZ Limited (2021b) report has suggested further limiting or eliminating cruise ships from entering Milford Sound. However, the risk of eliminating cruise ships from Milford Sound would be that more cruises are pushed towards the even more remote and inaccessible Dusky and Doubtful Sounds. If a spill was to occur in there sounds it is likely to increase the costs if an

oil spill significantly (financially and environmentally) as the inaccessibility of these fiords means response time, spill and response duration, and impacts will be significantly longer and higher. Beside this potential shift in threat location, in 2018, approximately 97.8 percent of visitors to Milford Sound utilized some form of a marine vessel for scenic tours, demonstrating the importance of the tour operators in the area, including the cruise ships (Stantec NZ Limited, 2021a). Though due to the pandemic there have not been any cruise ships travelling around New Zealand, early August 2022 the first one has returned, and numbers are expected to increase (Perry, 2022).

These changing factors around New Zealand means the potential for oil spills is likely to increase as the shipping industry continues to recover, more petroleum products are shipped around New Zealand and cruise ships return to our coastal waters. The economic consequences associated with oil spills, as presented in this research, add strength to consideration around policies that can help minimize future oil spills.

8.6 International and New Zealand Policies in Relation to Response and Compensation of Marine Oil Spills

New Zealand is signed up to multiple international conventions/policies that are relevant in the event of a marine oil spill. Regarding prevention and safety, New Zealand is party to MARPOL (73/78, and Annexes III/V), which regulates the discharges of various pollutants (Maritime New Zealand, 2021). For oil spill response, the International Convention on Oil Pollution Preparedness, Response and Co-operation 1990 (OPRC '90) is in effect, ensuring that New Zealand ships, operators of offshore units in New Zealand waters, and operators of seaports and oil handling facilities have spill response plans (Maritime New Zealand, 2021). In regard to compensation, New Zealand is party to these (ITOPF, 2018):

- Civil Liability Convention (CLC '92) – provides adequate compensation for those who suffer oil pollution damage, that resulted from maritime casualties involving oil-carrying ships (International Maritime Organization, n.d.-b).
- International Oil Pollution Compensation Funds (IOPC Fund) – financial compensation for oil pollution damage that occurs from spills from tankers (persistent oil) (IOPC Funds, 2022).
- Supplementary Fund Protocol – provides additional compensation for what is not covered by the IOPC Fund (IOPC Funds, 2022).

- Bunker Convention – make sure that there is enough and effective compensation to persons who suffered damage due to oil spills, when carried as fuel in ships’ bunkers (International Maritime Organization, 2019b).
- Convention on Limitation of Liability for Maritime Claims (LLMC) – sets the liability of owners of ships responsible for oil spills (International Maritime Organization, 2019a).

In addition to these international conventions, there are a few domestic policies that are of importance, being the:

- The Maritime Transport Act 1994 (Part 23, 24, 25, 26A) clearly outlines the plans, responses, and financial obligations to marine oil spills (Ministry of Transport, 1994).
- Resource Management Act 1991 - diverts all legal rule and obligations to the Maritime Transport Act 1994 (RMA, p. 556, 330(4)) (Ministry for the Environment, 1991).
- Oil Pollution Levy – rates to be paid by NZ and foreign vessels. Basis of calculation is either per gross ton of vessel, or per tonne of oil carried as cargo. Payments can be either per port/voyage or annually (Maritime New Zealand, 2022).

At the time of the *MV Rena* oil spill, New Zealand had only enacted the LLMC and was therefore only eligible for NZD (2011) 11,030,110 in compensation claims from the shipowners (Judd, 2014). Due to court records being sealed, there is little information regarding the breakdown of any legal claims for personal damage, if any were made through the CLC or IOPC Fund. The clean-up response costs for the *MV Rena* were ultimately reimbursed for NZD 27.6 million (Judd, 2014).

For the hypothetical oil spill scenario in Milford Sound, one can try to estimate how much New Zealand would be entitled to through the international conventions. It is important to keep in mind, that each convention targets a different aspect of damages, and therefore the total possible compensation is most likely not an accurate reflection of what would be reimbursed. Based on the international conventions listed above, the maximum possible compensation is SDR² 869.4 million (or NZD (2022) 1,767.2 million³). New Zealand now being signed on to the majority of relevant international conventions since the *MV Rena* oil

² SDR (Special Drawing Rights) – not an official currency, it is a potential claim using currencies of IMF (International Monetary Fund) members (US Dollar, Euro, Chinese Yuan, Japanese Yen, and the British Pound).

³ Based on a conversion rate of 1 NZD = 0.6533 USD (average 2022 conversion rate thus far).

spill clearly allows for possible higher compensation. However, there is a lot of information required to file a claim, and small businesses in New Zealand may not have the resources to go through the process to prove their losses due to an oil spill event. Regarding the cost of oil spill preparedness and response, it is essential that the oil pollution levy charges be enough to cover the possible costs of a response, and the results presented in this work add to the body of knowledge to better inform these levies.

8.7 Future Research

It is recommended that the non-use values associated with the *MV Rena* and hypothetical oil spills in New Zealand be investigated. These include existence, warm-glow, bequest, and option/quasi-option values. This will help provide a more comprehensive view of the total economic costs associated with oil spills in New Zealand, since these were outside the scope of this research. The cultural impacts to and involvement of the Māori/local iwi should also be investigated both economically and from a social perspective, with this type of research being a significant piece of stand-alone work. There has been two pieces of research regarding the impacts to the local Māori population, with only their involvement in the *MV Rena* response being considered (Anderson, 2012; Faau et al., 2017). In addition to the *MV Rena*, other coastal areas of importance to the Māori should be researched in regard to oil spills.

The environmental impacts of the *MV Rena* have previously been investigated (Dempsey et al., 2016; Schiel et al., 2016a), however a limitation of some studies is that there was no previous data available regarding toxin levels or were not conducted in real time (Ross et al., 2016a; Webby & Ling, 2016). It is recommended that studies begin to be conducted to uncover they baseline levels of oil toxins (such as PAHs) around areas of risk in New Zealand.

Consideration of other remote NZ locations should be considered. Though Milford Sound is remote, it is still accessible by land, and there are many other locations along the New Zealand coastline that are not accessible by vehicles (such as other fiords that are frequented by ships in Fiordland National Park). At the other end of the scale, more populated areas such as Auckland, which has significant commercial infrastructure around the port, should be considered for similar research.

8.8 Conclusion

The overall objective of research was to investigate the direct economic impacts of oil spills in a populated and remote location in New Zealand. The results of this research demonstrate that even small/medium sized oil spills are capable of having large consequences. The overall findings show that spills of this size are able to disrupt the commercial fishing and tourism industries, cost millions to clean-up, and have a recreational value that proved to be sensitive to oil being on the shoreline. It is important to note that there are a few key factors that make New Zealand more susceptible to economic consequences of these smaller sized spills. These are that in general New Zealand has a small economy on a world scale, New Zealanders have strong conservation views towards their outdoor/coastal environment and have a high economic dependence on primary industries.

From Chapter 4: Does size matter? The direct economic costs associated with the *MV Rena*, examined the clean-up costs, and the losses to fisheries and tourism in the area where the *MV Rena* ran aground, off the coast of the Bay of Plenty. This was achieved by looking at pre- and post-spill trends in these industries, as well as Official Information Requests from government agencies. The total estimated net losses were found to be NZD (2011) 45,479,017. From Chapter 5: Potential changes in the recreational use value for Coastal Bay of Plenty, New Zealand due to oil spills: A combined approach of the travel cost and contingent behaviour methods, surveyed users of the stretch of beach that was heavily oiled by the *MV Rena* oil spill (from Mount Maunganui to Maketu), in order to estimate the recreational value of this area using the travel cost method, as well as the losses due to an oil spill occurring by incorporating contingent behaviour questions. The CS per person/visit was estimated at NZD (2021) 121, with an aggregate CS estimated at NZD (2020) 77.78 million annually. The CS per person/visit decreased to NZD (2021) 29.74 under CB1, 9.83 under CB2, and 4.30 under CB3. This leads to annual losses ranging from NZD (2021) 58.70-75.02 million over two years. Combining the results from these two chapters, allow for an estimation of the total direct losses of the *MV Rena* at NZD (2021) 99.06-115.38 million.

From Chapter 6: Recreational impacts of an oil spill in a world heritage area: A combined travel cost and contingent behaviour method approach, surveyed the users of Fiordland National Park, allowing an estimation of the recreational value through means of the travel cost method, and incorporating contingent behaviour questions to estimate the losses in the event of varying sized oil spills. The CS per person/visit was estimated at NZD (2021) 534.76 and NZD (2021) 1,499.28, without and with accommodation included

respectively. This leads to an annual aggregate CS ranging from NZD (2021) 427.8-1,159.4 million based on pre-covid visitor numbers to the park. For each increase in oil level, there was a decrease of NZD (2021) 164.10 and NZD (2021) 923.73 per person, with and without accommodation respectively. This leads to a minimum estimated decrease of NZD (2021) 131.3-734.0 million in the annual recreational value. From Chapter 7: Expected direct costs of an oil spill in a UNESCO World Heritage area in New Zealand, investigated the hypothetical clean-up costs, and losses to fisheries and tourism in the event of an oil spill occurring in Milford Sound. The total direct losses estimated of an oil spill occurring in Milford Sound (including potential clean-up costs, losses to fisheries and tourism, as well as recreational losses) was estimated at NZD (2021) 140.235-770.177 million, a significantly larger estimate than total direct losses estimated from the *MV Rena*.

These estimates show it is imperative that New Zealand makes sure that all of its relevant domestic policies related to marine oil spills are up to date, guaranteeing that there will be adequate funds available in the event that another oil spill occurs, and that there is continued funding for the prevention and preparedness. This will allow New Zealand to respond quickly and effectively, limiting the potential impacts of an oil spill. New Zealand should also consider signing onto other relevant international conventions that it is currently not a part of. With shipping increasing around the coast and cruise ships returning, it is more relevant than ever that New Zealand takes action to be prepared, so that environmental and economic damages of oil spills can be minimized.

References

- 100% Pure New Zealand. (2018). Cruise Sector [Press release]. Retrieved from <https://www.tourismnewzealand.com/media/3359/cruise-sector-infographics-march-2018.pdf>
- Adamowicz, W., Louviere, J., & Williams, M. (1994). Combining Revealed and Stated Preference Methods for Valuing Environmental Amenities. *Journal of Environmental Economics and Management*, 26(3), 271-292. doi:<https://doi.org/10.1006/jeem.1994.1017>
- Alban, F., Appéré, G., & Boncoeur, J. (2006). Economic analysis of marine protected areas: a literature review. In *EMPAFISH Project* (pp. 51).
- Alberini, A., & Longo, A. (2006). Combining the Travel Cost and Contingent Behavior Methods to Value Cultural Heritage Sites: Evidence from Armenia. *Journal of Cultural Economics*, 30, 287-304. doi:10.1007/s10824-006-9020-9
- Alford, J. B., Peterson, M. S., & Green, C. C. (2015). *Impacts of oil spill disasters on marine habitats and fisheries in North America*: CRC Press.
- Alvarez, S., Larkin, S. L., Whitehead, J. C., & Haab, T. (2014). A revealed preference approach to valuing non-market recreational fishing losses from the Deepwater Horizon oil spill. *Journal of Environmental Management*, 145, 199-209. doi:<https://doi.org/10.1016/j.jenvman.2014.06.031>
- Álvarez-Farizo, B., Hanley, N., & Barberán, R. (2001). The Value of Leisure Time: A Contingent Rating Approach. *Journal of Environmental Planning and Management*, 44(5), 681-699. doi:10.1080/09640560120079975
- Amirnejad, H., & Jahanifar, K. (2018). Comparison of contingent valuation and travel cost method in estimating the recreational values of a forest park. *Journal of Environmental Science and Management*, 21, 36-44.
- Amoako-Tuffour, J., & Martínez-Espiñeira, R. (2012). Leisure and the Net Opportunity Cost of Travel Time in Recreation Demand Analysis: An Application to Gros Morne National Park. *Journal of Applied Economics*, 15(1), 25-49. doi:10.1016/S1514-0326(12)60002-6
- Anciaes, P. (2021). Revealed preference valuation of beach and river water quality in Wales. *Journal of Environmental Economics and Policy*. doi:10.1080/21606544.2020.1864778
- Anderson, J. (2012). *CV Rena - An Oil Spill Response Case Study*. Paper presented at the International Conference on Health, Safety and Environment in Oil and Gas Exploration and Production, Perth, Australia.
- Araújo, C. S. T. d., Hoshina, M. r. M., Silva, M. T. P., Roberto, M. M., Hara, R. V., & Marin-Morales, M. A. (2014). Oil Spills: Environmental Consequences and Recovery Strategies. In A. Clifton (Ed.), *Oil Spills: Environmental Issues, Prevention and Ecological Impacts* (pp. 87-119). Hauppauge, New York: Nova Science Publishers, Inc.
- Arrow, K., Solow, R., Portney, P., Leamer, E., Radner, R., & Schuman, H. (1993). *Report of the NOAA panel on Contingent Valuation* (Vol. 58).
- Ballachey, B. E., Bodkin, J. L., Esler, D. N., & Rice, S. D. (2014). Lessons from the 1989 Exxon Valdez oil spill: A biological perspective. In *Impacts of Oil Spill Disasters on Marine Habitats and Fisheries in North America* (pp. 181-197). Alaska, United States: Taylor & Francis.
- Barkmann, J., Glenk, K., Keil, A., Leemhuis, C., Dietrich, N., Gerold, G., & Marggraf, R. (2008). Confronting unfamiliarity with ecosystem functions: The case for an

- ecosystem service approach to environmental valuation with stated preference methods. *Ecological Economics*, 65(1), 48-62.
doi:<https://doi.org/10.1016/j.ecolecon.2007.12.002>
- Barnes-Mauthe, M., Oleson, K. L. L., & Zafindrasilivonona, B. (2013). The total economic value of small-scale fisheries with a characterization of post-landing trends: An application in Madagascar with global relevance. *Fisheries Research*, 147, 175-185.
doi:<https://doi.org/10.1016/j.fishres.2013.05.011>
- Bay of Plenty Regional Council. (2019). *Costs associated with the Rena*. (A3326079).
- Bell, F. W. (2002). Damage Assessment of the Tampa Bay Oil Spill: Travel Cost Method. In D. Letson & J. W. Milon (Eds.), *Florida Coastal Environmental Resources: A Guide to Economic Valuation and Impact Analysis* (pp. 53-62): Florida Sea Grant College Program.
- Bell, S., & Gibb, J. G. (1996). *Public Access To The New Zealand Coast: Guidelines For Determining Legal And Physical Constraints*. Retrieved from Wellington, NZ:
<https://www.doc.govt.nz/globalassets/documents/science-and-technical/docts10.pdf>
- Bermingham, G. (2015). *Marine Oil Spill Risk Assessment 2015: Prepared by Navigatus Consulting for Maritime New Zealand*. Navigatus Consulting Limited
- Bertram, C., Ahtiainen, H., Meyerhoff, J., Pakalnieta, K., Pouta, E., & Rehdanz, K. (2020). Contingent Behavior and Asymmetric Preferences for Baltic Sea Coastal Recreation. *Environmental and Resource Economics*, 75(1), 49-78. doi:10.1007/s10640-019-00388-x
- Bhat, G., Bergstrom, J., Teasley, R. J., Bowker, J. M., & Cordell, H. K. (1998). An ecoregional approach to the economic valuation of land- and water- based recreation in the United States. *Environmental Management*, 22(1), 69-77.
doi:10.1007/s002679900084
- Bhat, M. G. (2003). Application of non-market valuation to the Florida Keys marine reserve management. *Journal of Environmental Management*, 67(4), 315-325.
doi:[https://doi.org/10.1016/S0301-4797\(02\)00207-4](https://doi.org/10.1016/S0301-4797(02)00207-4)
- Bin, O., Landry, C., Ellis, C., & Vogelsong, H. (2005). Some Consumer Surplus Estimates for North Carolina Beaches. *Marine Resource Economics*, 20.
doi:10.1086/mre.20.2.42629466
- Birds New Zealand. (2013). NZ Birds Online. Retrieved from
<https://www.nzbirdsonline.org.nz/>
- Blaine, T. W., Lichtkoppler, F. R., Bader, T. J., Hartman, T. J., & Lucente, J. E. (2015). An examination of sources of sensitivity of consumer surplus estimates in travel cost models. *Journal of Environmental Management*, 151, 427-436.
doi:10.1016/j.jenvman.2014.12.033
- Bocquene, G., Chantereau, S., Clerendeau, C., Beausir, E., Menard, D., Raffin, B., . . . Narbonne, J.-F. (2004). *Biological effects of the "Erika" oil spill on the common mussel (Mytilus edulis)* (Vol. 17).
- Bonnieux, F., & Rainelli, P. (1993). Learning from the Amoco Cadiz oil spill: damage valuation and court's ruling. *Industrial & Environmental Crisis Quarterly*, 7, 169-188.
- Bonnieux, F., & Rainelli, P. (2003). Lost Recreation and Amenities: The Erika Spill Perspectives. *INRA*, 25.
- Börger, T., Beaumont, N. J., Pendleton, L., Boyle, K. J., Cooper, P., Fletcher, S., . . . Austen, M. C. (2014a). Incorporating ecosystem services in marine planning: The role of valuation. *Marine Policy*, 46, 161-170.
doi:<https://doi.org/10.1016/j.marpol.2014.01.019>

- Börger, T., Böhnke-Henrichs, A., Hattam, C., Piwowarczyk, J., Schasfoort, F., & Austen, M. C. (2018). The role of interdisciplinary collaboration for stated preference methods to value marine environmental goods and ecosystem services. *Estuarine, Coastal and Shelf Science*, 201, 140-151. doi:<https://doi.org/10.1016/j.ecss.2017.03.009>
- Börger, T., Campbell, D., White, M. P., Elliott, L. R., Fleming, L. E., Garrett, J. K., . . . Taylor, T. (2021). The value of blue-space recreation and perceived water quality across Europe: A contingent behaviour study. *Science of The Total Environment*, 771. doi:10.1016/j.scitotenv.2021.145597
- Börger, T., Hattam, C., Burdon, D., Atkins, J. P., & Austen, M. C. (2014b). Valuing conservation benefits of an offshore marine protected area. *Ecological Economics*, 108, 229-241. doi:<https://doi.org/10.1016/j.ecolecon.2014.10.006>
- Borzykowski, N., Baranzini, A., & Maradan, D. (2017). A travel cost assessment of the demand for recreation in Swiss forests. *Review of Agricultural, Food and Environmental Studies*, 1. doi:10.1007/s41130-017-0047-4
- Bowker, J. M., English, D., Bergstrom, J. C., & Starbuck, C. M. (2005). *Valuing National Forest Recreation Access: Using a Stratified On-Site Sample to Generate Values across Activities for a Nationally Pooled Sample*. Paper presented at the American Agricultural Economics Association Annual Meeting, Providence, Rhode Island.
- Bradley, G. (2019, 8 November). Cruise ship crackdown in Fiordland - how this affects Royal Caribbean. *NZ Herald*. Retrieved from https://www.nzherald.co.nz/business/news/article.cfm?c_id=3&objectid=12283360
- Brouwer, R., Brouwer, S., Eleveld, M. A., Verbraak, M., Wagtendonk, A. J., & van der Woerd, H. J. (2016). Public willingness to pay for alternative management regimes of remote marine protected areas in the North Sea. *Marine Policy*, 68, 195-204. doi:<https://doi.org/10.1016/j.marpol.2016.03.001>
- Buell, P. (Personal Communication, 10 February 2020). [Rena Exclusion Zones].
- Cadiou, B., Riffaut, L., McCoy, K., Cabelguen, J., Fortin, M., Gélinaud, G., . . . Bouludier, T. (2004). *Ecological impact of the "Erika" oil spill: Determination of the geographic origin of the affected common guillemots* (Vol. 17).
- Carls, M. G., Holland, L., Larsen, M., Collier, T. K., Scholz, N. L., & Incardona, J. P. (2008). Fish embryos are damaged by dissolved PAHs, not oil particles. *Aquatic Toxicology*, 88(2), 121-127. doi:<https://doi.org/10.1016/j.aquatox.2008.03.014>
- Carson, R. T., & Hanemann, W. M. (1992). *A Preliminary Economic Analysis of Recreational Fishing Losses Related to the Exxon Valdez*. Retrieved from <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.361.6859&rep=rep1&type=pdf>
- Carson, R. T., Mitchell, R. C., Hanemann, M., Kopp, R. J., Presser, S., & Ruud, P. A. (1992). *A Contingent Valuation Study of Lost Passive Use Values Resulting From the Exxon Valdez Oil Spill*. Retrieved from <https://ideas.repec.org/p/pramprapa/6984.html>
- Carson, R. T., Mitchell, R. C., Hanemann, M., Kopp, R. J., Presser, S., & Ruud, P. A. (2003). Contingent Valuation and Lost Passive Use: Damages from the Exxon Valdez Oil Spill. *Environmental and Resource Economics*, 25(3), 257-286. doi:10.1023/A:1024486702104
- Fisheries (Cost Recovery) Rules 2001, SR 2001/229 C.F.R. § 12 (2016).
- Castellini, A., Devenuto, L., & Ragazzoni, A. (2009). The marine environment as tourism-recreational resource. An economic assessment of the demand. *New Medit*, 8, 41-47.
- CEO of Milford Sound Tourism (Personal Communication, 2021, 9 November). [Inquiry to tourism in Milford Sound].

- Chae, D.-R., Wattage, P., & Pascoe, S. (2012). Recreational benefits from a marine protected area: A travel cost analysis of Lundy. *Tourism Management*, 33(4), 971-977. doi:<https://doi.org/10.1016/j.tourman.2011.10.008>
- Cheong, S.-M. (2012). Fishing and Tourism Impacts in the Aftermath of the Hebei-Spirit Oil Spill. *Journal of Coastal Research*, 28(6), 1648-1653. doi:10.2112/JCOASTRES-D-11-00079.1
- Chief Executive Officer (Personal Communication, 2021, 5 November). [Milford Sound].
- Chiew, W. L. E. (2015). *Confidence intervals for willingness-to-pay and beyond: a comparative analysis*. (Doctor of Philosophy). Cornell University, New York.
- Chilvers, B. L., & Battley, P. F. (2019). Species prioritization index for oiled wildlife response planning in New Zealand. *Marine Pollution Bulletin*, 149, 110529. doi:<https://doi.org/10.1016/j.marpolbul.2019.110529>
- Chilvers, B. L., Morgan, K. M., Finlayson, G., & Sievwright, K. A. (2015). Diving behaviour of wildlife impacted by an oil spill: A clean-up and rehabilitation success? *Marine Pollution Bulletin*, 100(1), 128-133. doi:<https://doi.org/10.1016/j.marpolbul.2015.09.019>
- Cho, S.-M., Lee, Y.-M., & Jeong, W.-G. (2011). Effect of Polycyclic Aromatic Hydrocarbon (PAH) on Shell Repair in the Pacific oyster, *Crassostrea gigas*. *The Korean Journal of Malacology*, 27(1), 35-42. Retrieved from <Go to ISI>://KJD:ART001540745
- Cirer-Costa, J. C. (2015). Tourism and its hypersensitivity to oil spills. *Marine Pollution Bulletin*, 91(1), 65-72. doi:<https://doi.org/10.1016/j.marpolbul.2014.12.027>
- Clawson, M., & Knetsch, J. L. (1963). Outdoor recreation research: some concepts and suggested areas of study. *Natural Resources Journal*, 3(2), 250-275. Retrieved from <http://www.jstor.org/stable/24879321>
- Clawson, M., & Knetsch, J. L. (2011). *Economics of Outdoor Recreation* (2nd ed. Vol. 3). New York: RFF Press.
- Clough, P. (2013). The value of ecosystem services for recreation. *Ecosystem services in New Zealand—conditions and trends*. Manaaki Whenua Press, Lincoln, New Zealand.
- Clough, P., & Bealing, M. (2018). *What's the use of non-use values?* Retrieved from Wellington, NZ: <https://www.treasury.govt.nz/sites/default/files/2018-08/LSF-whats-the-use-of-non-use-values.pdf>
- Cohen, M. J. (1993). Economic impact of an environmental accident: A time-series analysis of the Exxon Valdez oil spill in southcentral Alaska. *Sociological Spectrum*, 13(1), 35-63. doi:10.1080/02732173.1993.9982016
- Cohen, M. J. (1995). Technological Disasters And Natural-Resources Damage Assessment - An Evaluation Of The Exxon-Valdez Oil-Spill. *Land Economics*, 71(1), 65-82. doi:10.2307/3146759
- Committee on Responding to Oil Spills in the U.S. Arctic Marine Environment, Ocean Studies Board, Polar Research Board, Division on Earth and Life Studies, Marine Board, Transportation Research Board, & National Research Council. (2014). Report in brief. In *Responding to Oil Spills in the U.S. Arctic marine environment* (pp. 8).
- Common, M., Bull, T., & Stoeckl, N. (1999). The Travel Cost Method: an Empirical Investigation of Randall's Difficulty. *Australian Journal of Agricultural and Resource Economics*, 43(4), 457-477. doi:10.1111/1467-8489.00090
- Corlett, E. (2022, 8 March). 'Everything is rising': New Zealanders make painful sacrifices as living costs skyrocket. Retrieved from <https://www.theguardian.com/world/2022/mar/09/everything-is-rising-new-zealanders-make-painful-sacrifices-as-living-costs-skyrocket>

- Court, C. D., Hodges, A. W., Clouser, R. L., & Larkin, S. L. (2017). Economic impacts of cancelled recreational trips to Northwest Florida after the Deepwater Horizon oil spill. *Regional Science Policy and Practice*, 9(3), 143-164. doi:10.1111/rsp3.12099
- Cruise Milford Sound. (2022). Bus from Queenstown to Milford Sound. Retrieved from <https://www.cruisemilfordnz.com/milford-sound-info/bus-from-queenstown-to-milford-sound/>
- Czajkowski, M., Giergiczny, M., Kronenberg, J., & Englin, J. (2016). The Individual Travel Cost Method with Consumer-Specific Values of Travel Time Savings. *Environmental and Resource Economics*. doi:10.1007/s10640-019-00355-6
- de Lange, W. P., de Groot, N. P. H. M., & Moon, V. G. (2016). Burial and degradation of Rena oil within coastal sediments of the Bay of Plenty. *New Zealand Journal of Marine and Freshwater Research*, 50, 159-172. doi:10.1080/00288330.2015.1062401
- Deacon, R. T., & Kolstad, C. D. (2000). Valuing beach recreation lost in environmental accidents. *Journal of Water Resources Planning and Management-Asce*, 126(6), 374-381. doi:10.1061/(asce)0733-9496(2000)126:6(374)
- Deere-Jones, T. (2016). Ecological, Economic and Social Costs of Marine/Coastal Spills of Fuel Oils (Refinery Residuals). *A Report to the European Climate Foundation*.
- Degange, A. R., Doroff, A. M., & Monson, D. H. (1994). Experimental Recovery of Sea Otter Carcasses at Kodiak Island, Alaska, Following the Exxon Valdez Oil Spill. *Marine Mammal Science*, 10(4), 492-496. doi:10.1111/j.1748-7692.1994.tb00509.x
- Deloitte. (2022). *Building resilience through disruption - New Zealand ports and freight yearbook*. Retrieved from <https://www2.deloitte.com/content/dam/Deloitte/nz/Documents/icp/nz-ports-and-freights-2022v1.pdf>
- Dempsey, T., Ross, P. M., Hartland, A., McSweeney, C., & Battershill, C. N. (2016). Measurement of shipwreck-derived waterborne trace metals using DGT samplers. *New Zealand Journal of Marine and Freshwater Research*, 50, 115-130. doi:10.1080/00288330.2015.1127829
- Department of Conservation. (2021). Birds A-Z. Retrieved from <https://www.doc.govt.nz/nature/native-animals/birds/birds-a-z/>
- Depellegrin, D., & Blažauskas, N. (2013). Integrating Ecosystem Service Values into Oil Spill Impact Assessment. *Journal of Coastal Research*, 29(4), 836-846. doi:10.2112/JCOASTRES-D-11-00191.1
- Dhakal, B., Yao, R. T., Turner, J. A., & Barnard, T. (2012). Recreational users' willingness to pay and preferences for changes in planted forest features. *Forest Policy and Economics*, 17, 34-44. doi:https://doi.org/10.1016/j.forpol.2011.11.006
- DOC. (2004). *Regional Economic Impacts of West Coast Conservation Land*. Wellington, NZ: Department of Conservation Retrieved from <https://www.doc.govt.nz/Documents/conservation/threats-and-impacts/benefits-of-conservation/regional-economic-impacts-of-west-coast-conservation-land.pdf>
- DOC. (2005). *Regional Economic Impacts of Abel Tasman National Park and Queen Charlotte Track*. Wellington, NZ: Department of Conservation
- DOC. (2006a). *Regional Economic Impacts of Fiordland National Park*. Wellington, NZ: Department of Conservation
- DOC. (2006b). *The value of conservation*. Wellington, NZ: Department of Conservation Retrieved from <https://www.cbd.int/financial/values/NewZealand-valueconservation.pdf>
- DOC. (2007). *Fiordland National Park Management Plan*. (978-0-478-14279-2). Invercargill, NZ: Southland Conservancy Conservation Management Planning Series

- DOC. (2017a). *Conserving Fiordland's biodiversity, 1987-2015*. (978-1-98-851440-6). Te Anau, New Zealand: Department of Conservation Retrieved from <https://www.doc.govt.nz/globalassets/documents/science-and-technical/sap263entire.pdf>
- DOC. (2017b). International visitors' trends in national parks 2016-2017. Retrieved from <https://www.doc.govt.nz/our-work/monitoring-reporting/national-status-and-trend-reports-2016-2017/visitors-national-parks-2016-2017/>
- Du Preez, M., Dicken, M., & Hosking, S. G. (2012). The Value Of Tiger Shark Diving Within The Aliwal Shoal Marine Protected Area: A Travel Cost Analysis. *South African Journal of Economics*, 80(3), 387-399. doi:10.1111/j.1813-6982.2011.01292.x
- Edwards, A., & Stephenson, W. (2013). Assessing the Potential for Surf Break Co-Management: Evidence from New Zealand. *Coastal Management*, 41(6), 537-560. doi:10.1080/08920753.2013.842681
- Efimova, E. (2019). *A Random Utility Model of Beach Use on the East Coast of the United States: Per-trip Values and Hypothetical Beach Closures*. (PhD). University of Delaware, Ann Arbor. ProQuest Dissertations & Theses A&I database. (13904135)
- Egan, A. L., Chilvers, B. L., & Cassells, S. (2021). Does size matter? The direct economic costs associated with the MV Rena oil spill. *Marine Pollution Bulletin*, 173, 112978. doi:<https://doi.org/10.1016/j.marpolbul.2021.112978>
- Egan, A. L., Rolfe, J., Cassells, S., & Chilvers, B. L. (2022). Potential changes in the recreational use value for Coastal Bay of Plenty, New Zealand due to oil spills: A combined approach of the travel cost and contingent behaviour methods. *Ocean & Coastal Management*, 228, 106306. doi:<https://doi.org/10.1016/j.ocecoaman.2022.106306>
- Ellenberg, U. (2013, Updated 2017). Fiordland crested penguin. *Miskelly, C.M.* New Zealand Birds Online. Retrieved from <https://nzbirdsonline.org.nz/species/fiordland-crested-penguin>
- Employment New Zealand. (2020, 01 April 2020). Previous minimum wage rates. Retrieved from <https://www.employment.govt.nz/hours-and-wages/pay/minimum-wage/previous-rates/>
- Englin, J., & Cameron, T. A. (1996). Augmenting travel cost models with contingent behavior data. *Environmental and Resource Economics*, 7(2), 133-147. doi:10.1007/BF00699288
- Englin, J., & Shonkwiler, J. S. (1995). Estimating Social Welfare Using Count Data Models: An Application to Long-Run Recreation Demand Under Conditions of Endogenous Stratification and Truncation. *The Review of Economics and Statistics*, 77(1), 104-112. doi:10.2307/2109996
- English, E., Herriges, J. A., Lupi, F., McConnell, K., & Haefen, R. H. v. (2019). Fixed Costs and Recreation Value. *American Journal of Agricultural Economics*, 101(4), 1082-1097. doi:10.1093/ajae/aaz012
- English, E., von Haefen, R. H., Herriges, J., Leggett, C., Lupi, F., McConnell, K., . . . Meade, N. (2018). Estimating the value of lost recreation days from the Deepwater Horizon oil spill. *Journal of Environmental Economics and Management*, 91, 26-45. doi:<https://doi.org/10.1016/j.jeem.2018.06.010>
- Environment Foundation. (2022, 24 August 2021). Legislation. *Environment Guide*. Retrieved from <https://www.environmentguide.org.nz/issues/coastal/im:3043/legislation/>
- Environment Southland. (2012). *Deed of Agreement Between The New Zealand Cruise Ship Industry and Environment Southland*. Southland Regional Council

- Environment Southland. (2021a). *Deed of Agreement Between The New Zealand Cruise Ship Industry and Environment Southland*. Southland Regional Council
- Environment Southland. (2021b). New cruise ship deed of agreement signed [Press release]. Retrieved from <https://www.es.govt.nz/about-us/news?item=id:2dv9d7nc417q9sgoat75>
- Espiner, N., Stewart, E. J., Espiner, S., & Degarege, G. (2021). *Exploring the impacts of the Covid-19 national lockdown on outdoor recreationists' activity and perceptions of tourism* (LEAP Research Report 56). Retrieved from <https://researcharchive.lincoln.ac.nz/bitstream/handle/10182/13786/Leap%2056%20-%20Outdoor%20recreation%20tourism%20and%20the%20lockdown.pdf?sequence=1&isAllowed=y>
- Etkin, D. S. (2000). *Worldwide analysis of marine oil spill cleanup cost factors*. Paper presented at the Proceedings of the 23 Arctic and Marine Oilspill Program (AMOP) Technical Seminar, Canada.
- Exxon Valdez Oil Spill Trustee Council. (2014). *Exxon Valdez Oil Spill Restoration Plan 2014 Update: Injured Resources and Services*. Retrieved from Anchorage, Alaska: <http://www.evostc.state.ak.us/index.cfm?FA=status.injured>
- Faau, T. N., Morgan, T. K. K. B., & Hikuroa, D. C. H. (2017). Ensuring objectivity by applying the Mauri Model to assess the post-disaster affected environments of the 2011 MV Rena disaster in the Bay of Plenty, New Zealand. *Ecological Indicators*, 79, 228-246. doi:<https://doi.org/10.1016/j.ecolind.2017.03.055>
- Finlayson, C. (2014). *Crown Position on the Resource Consent Application for the Rena Wreck*. Office of the Attorney-General Retrieved from <https://www.crownlaw.govt.nz/assets/Uploads/Reports/cabinet-paper.pdf>
- Fiordland Marine Guardians. (2017). Beneath the Reflections. In *A user's guide to the Fiordland (Te Moana o Atawhenua) Marine Area* (pp. 1-150). Wellington, NZ: Ministry for the Environment.
- Fisheries New Zealand. (2020a). Commercial. *Region - North East Coast North Island (FMA1)*. Retrieved from <https://fs.fish.govt.nz/Page.aspx?pk=41&tk=405&fyk=38>
- Fisheries New Zealand. (2020b). *OIA19-0472*. Wellington, NZ: Ministry for Primary Industries
- Fisheries New Zealand. (2020c). Region - Southland/Fiordland (FMA5). *Commercial*. Retrieved from <https://fs.fish.govt.nz/Page.aspx?pk=41&fyk=55>
- Fisheries New Zealand. (2020d). *rep log 12994*. Wellington, NZ: Ministry for Primary Industries
- Fleming, C. M., & Bowden, M. (2009). Web-based surveys as an alternative to traditional mail methods. *Journal of Environmental Management*, 90(1), 284-292. doi:<https://doi.org/10.1016/j.jenvman.2007.09.011>
- Fleming, C. M., & Cook, A. (2008). The recreational value of Lake McKenzie, Fraser Island: An application of the travel cost method. *Tourism Management*, 29(6), 1197-1205. doi:<https://doi.org/10.1016/j.tourman.2008.02.022>
- Folkersen, M. V., Fleming, C. M., & Hasan, S. (2018). Deep sea mining's future effects on Fiji's tourism industry: A contingent behaviour study. *Marine Policy*, 96, 81-89. doi:<https://doi.org/10.1016/j.marpol.2018.08.001>
- Fonseca, S., & Rebelo, J. (2010). Economic Valuation of Cultural Heritage: Application to a museum located in the Alto Douro Wine Region– World Heritage Site. *PASOS Revista de Turismo y Patrimonio Cultural*, 8(2), 339-350. doi:<https://doi.org/10.25145/j.pasos.2010.08.024>
- Fraser, B., Monchy, P. d., & Murray, W. (2012). *The Rena volunteer programe*. Retrieved from https://www.boprc.govt.nz/media/225011/the_rena_volunteer_programme.pdf

- Freeman, A. M., Herriges, J. A., & Kling, C. L. (2014). *The measurement of environmental and resource values : theory and methods* (Third edition ed.): RFF Press.
- Freeman, D., Schnabel, K., Marshall, B., Gordon, D., Wing, S., Tracey, D., & Hitchmough, R. (2013). Conservation status of New Zealand marine invertebrates. In *New Zealand threat classification series 9* (pp. 24). Wellington, NZ: Department of Conservation.
- Frost, K. J., Lowry, L. F., & Ver Hoef, J. M. (1999). Monitoring the Trend of Harbor Seals in Prince William Sound, Alaska, After the Exxon Valdez Oil Spill. *Marine Mammal Science*, *15*(2), 494-506. doi:10.1111/j.1748-7692.1999.tb00815.x
- García-Negro, M. C., Villasante, S., Penela, A. C., & Rodríguez, G. R. (2009). Estimating the economic impact of the Prestige oil spill on the Death Coast (NW Spain) fisheries. *Marine Policy*, *33*(1), 8-23. doi:10.1016/j.marpol.2008.03.011
- Garshelis, D. L. (1997). Sea Otter Mortality Estimated from Carcasses Collected after the Exxon Valdez Oil Spill. *Conservation Biology*, *11*(4), 905-916. Retrieved from <http://www.jstor.org/stable/2387325>
- Gartrell, B. D., Battley, P. F., Clumpner, C., Dwyer, W., Hunter, S., Jensen, M., . . . Ziccardi, M. H. (2019). Captive husbandry and veterinary care of seabirds during the MV Rena oil spill response. *Wildlife Research*, *46*(7), 610-621. Retrieved from <https://doi.org/10.1071/WR19006>
- Gartrell, B. D., Collen, R., Dowding, J. E., Gummer, H., Hunter, S., King, E. J., . . . Ward, J. M. (2013). Captive husbandry and veterinary care of northern New Zealand dotterels (*Charadrius obscurus aquilonius*) during the CV Rena oil-spill response. *Wildlife Research*, *40*(7), 624-632. doi:10.1071/WR13120
- Garza, M. D., Prada, A., Varela, M., & Rodríguez, M. X. V. (2009). Indirect assessment of economic damages from the Prestige oil spill: consequences for liability and risk prevention. *Disasters*, *33*(1), 95-109. doi:10.1111/j.1467-7717.2008.01064.x
- Garza-Gil, M. D., Prada-Blanco, A., & Vázquez-Rodríguez, M. X. (2006a). Estimating the short-term economic damages from the Prestige oil spill in the Galician fisheries and tourism. *Ecological Economics*, *58*(4), 842-849. doi:<https://doi.org/10.1016/j.ecolecon.2005.09.009>
- Garza-Gil, M. D., Surís-Regueiro, J. C., & Varela-Lafuente, M. M. (2006b). Assessment of economic damages from the Prestige oil spill. *Marine Policy*, *30*(5), 544-551. doi:<https://doi.org/10.1016/j.marpol.2005.07.003>
- Graham, L., Hale, C., Maung-Douglass, E., Sempier, S., Skelton, T., Swann, L., & Wilson, M. (2017). *Oil spill science: The Deepwater Horizon Oil Spill's impact on bottlenose dolphins* (MASGP-17-002). Retrieved from <http://masgc.org/oilscience/oil-spill-science-dolphins.pdf>
- Graves, P. (2013). Chapter 15: Environmental Valuation: The Travel Cost Method. In *Environmental Economics: An Integrated Approach*. Hoboken: CRC Press.
- Great Sights. (2022). Milford Sound Day Tours. Retrieved from https://www.greatsights.co.nz/new-zealand-tour-destinations/milford-sound-tours?utm_source=milford-sound.co.nz&utm_medium=bus-coach-text&utm_campaign=milford-sound
- Great South. (2019a). *Southland Tourism Key Indicators*. Retrieved from <https://greatsouth.nz/storage/app/media/Southland%20Key%20Indicators%20-%20A4%20-%20August%202019.pdf>
- Great South. (2019b). *Southland Tourism Key Indicators: June 2019*. Retrieved from <https://greatsouth.nz/storage/app/media/30%20June%202019%20Southland%20Tourism%20Key%20Indicators.pdf>

- Grigalunas, T. A., Anderson, R. C., Brown, G. M., Congar, R., Meade, N. F., & Sorensen, P. E. (1986). Estimating the Cost of Oil Spills: Lessons from the Amoco Cadiz Incident. *Marine Resource Economics*, 2(3), 239-262. doi:10.1086/mre.2.3.42628902
- Han, S.-H., Byun, W.-H., Lee, T. J., & Lee, C.-K. (2013). Research Note: Travel Time as a Proxy for Travel Cost in a Heritage Tourist Destination. *Tourism Economics*, 19(6), 1467-1474. doi:10.5367/te.2013.026
- Hanley, N., & Ruffell, R. (1992). *The Valuation of Forest characteristics*. Retrieved from <https://EconPapers.repec.org/RePEc:qed:wpaper:849>
- Hansen, B. H., Salaberria, I., Read, K. E., Wold, P. A., Hammer, K. M., Olsen, A. J., . . . Kjørsvik, E. (2019). Developmental effects in fish embryos exposed to oil dispersions – The impact of crude oil micro-droplets. *Marine Environmental Research*, 150, 104753. doi:<https://doi.org/10.1016/j.marenvres.2019.104753>
- Harris, B. S., & Meister, A. D. (1981). A Report on the Use of a Travel Cost Demand Model for Recreation Analysis in New Zealand: An Evaluation of Lake Tutira. In Discussion Paper in Natural Resource Economics.
- Hatch, A. C., & Burton, G. A. (1999). Phototoxicity of fluoranthene to two freshwater crustaceans, *Hyalella azteca* and *Daphnia magna*: measures of feeding inhibition as a toxicological endpoint. *Hydrobiologia*, 400, 243-248. doi:10.1023/a:1003750911423
- Heal, G. M., Barbier, E. B., Boyle, K. J., Covich, A. P., Gloss, S. P., Hershner, C. H., . . . Shrader-Frechette, K. (2005a). Aquatic and Related Terrestrial Ecosystems. In *Valuing Ecosystem Services: Toward Better Environmental Decision-Making* (pp. 34). Washington, D.C.: National Academies Press.
- Heal, G. M., Barbier, E. B., Boyle, K. J., Covich, A. P., Gloss, S. P., Hershner, C. H., . . . Shrader-Frechette, K. (2005b). Translating Ecosystem Functions to the Value of Ecosystem Services: Case Studies. In *Valuing Ecosystem Services: Toward Better Environmental Decision-Making* (pp. 47). Washington, D.C.: National Academies Press.
- Heays, A. (Personal Communication, 15 April 2020). [Quick question (when you have the time - no rush)].
- Hellerstein, D., & Mendelsohn, R. (1993). *A Theoretical Foundation for Count Data Models*. Retrieved from <https://EconPapers.repec.org/RePEc:pra:mprapa:25265>
- Henkel, L. A., & Ziccardi, M. H. (2017). Life and Death: How Should We Respond to Oiled Wildlife? *Journal of Fish and Wildlife Management*, 9(1), 296-301. doi:10.3996/062017-JFWM-054
- Hensher, D., Rose, J., & Greene, W. (2015). Statistical inference. In D. A. Hensher, J. M. Rose, & W. H. Greene (Eds.), *Applied Choice Analysis* (2 ed., pp. 320-359). Cambridge: Cambridge University Press.
- Heubeck, M., Camphuysen, K. C. J., Bao, R., Humple, D., Rey, A. S., Cadiou, B., . . . Thomas, T. (2003). Assessing the impact of major oil spills on seabird populations. *Marine Pollution Bulletin*, 46(7), 900-902. doi:10.1016/s0025-326x(03)00098-5
- Hill, S., & Bryan, J. (1997). The Economic Impact of the Sea Empress Spillage. *International Oil Spill Conference Proceedings*, 1997(1), 227-233. doi:10.7901/2169-3358-1997-1-227
- Hjermann, D. Ø., Melsom, A., Dingsør, G. E., Durant, J. I. M., Eikeset, A. M., Røed, L. P., . . . Stenseth, N. C. (2007). Fish and oil in the Lofoten–Barents Sea system: synoptic review of the effect of oil spills on fish populations. *Marine Ecology Progress Series*, 339, 283-299. Retrieved from <https://www.int-res.com/abstracts/meps/v339/p283-299/>

- Horn, S. A., & Neal, C. P. (1981). The Atlantic Empress Sinking—a Large Spill Without Environmental Disaster. *International Oil Spill Conference Proceedings, 1981*(1), 429-435. doi:10.7901/2169-3358-1981-1-429
- Houngbeme, D. J.-L., Igue, C. B., & Cloquet, I. (2020). Estimating the value of beach recreation in Benin. *Tourism Recreation Research*, 1-13. doi:10.1080/02508281.2020.1777052
- Huang, C.-H. (2017). Estimating the environmental effects and recreational benefits of cultivated flower land for environmental quality improvement in Taiwan. *Agricultural Economics*, 48(1), 29-39. doi:10.1111/agec.12292
- Huff, J. K. (2016). *Climate change and recreation: Impacts of climate change on landscape services associated with tourism in Big Bend National Park*. (Ph.D.). Texas A&M University, Ann Arbor. ProQuest Dissertations & Theses A&I database. (10290978)
- Hunter, S. A., Tennyson, A. J. D., Bartle, J. A. S., Miskelly, C., Waugh, S., McConnell, H. M., . . . Gartrell, B. (2019). Assessing avian mortality during oil spills: a case study of the New Zealand MV ‘Rena’ oil spill, 2011. *Endangered Species Research*. doi:10.3354/esr00974
- Hynes, S., & Greene, W. (2016). Preference Heterogeneity in Contingent Behaviour Travel Cost Models with On-site Samples: A Random Parameter vs. a Latent Class Approach. *Journal of Agricultural Economics*, 67(2), 348-367. doi:https://doi.org/10.1111/1477-9552.12143
- Inland Revenue. (2020). Kilometre rates for the 2019-2020 income year. Retrieved from <https://www.ird.govt.nz/income-tax/income-tax-for-businesses-and-organisations/types-of-business-expenses/claiming-vehicle-expenses/kilometre-rates-2019-2020>
- Intercity. (2022). Bookings. Retrieved from https://www.intercity.co.nz/?utm_source=milford-sound.co.nz&utm_medium=bus-coach-text-ic&utm_campaign=milford-sound
- International Maritime Organization. (2019a). Convention on Limitation of Liability for Maritime Claims (LLMC). Retrieved from <https://www.imo.org/en/About/Conventions/Pages/Convention-on-Limitation-of-Liability-for-Maritime-Claims-%28LLMC%29.aspx>
- International Maritime Organization. (2019b). International Convention on Civil Liability for Bunker Oil Pollution Damage (BUNKER). Retrieved from [https://www.imo.org/en/About/Conventions/Pages/International-Convention-on-Civil-Liability-for-Bunker-Oil-Pollution-Damage-\(BUNKER\).aspx](https://www.imo.org/en/About/Conventions/Pages/International-Convention-on-Civil-Liability-for-Bunker-Oil-Pollution-Damage-(BUNKER).aspx)
- International Maritime Organization. (n.d.-a). International Convention for the Prevention of Pollution from Ships (MARPOL). Retrieved from [http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-\(MARPOL\).aspx](http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-(MARPOL).aspx)
- International Maritime Organization. (n.d.-b). International Convention on Civil Liability for Oil Pollution Damage (CLC). Retrieved from [http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-on-Civil-Liability-for-Oil-Pollution-Damage-\(CLC\).aspx](http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-on-Civil-Liability-for-Oil-Pollution-Damage-(CLC).aspx)
- International Maritime Organization. (n.d.-c). International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC). Retrieved from [http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-on-Oil-Pollution-Preparedness,-Response-and-Co-operation-\(OPRC\).aspx](http://www.imo.org/en/About/Conventions/ListOfConventions/Pages/International-Convention-on-Oil-Pollution-Preparedness,-Response-and-Co-operation-(OPRC).aspx)
- IOPC Funds. (2019). *International Oil Pollution Compensation Funds: Annual Report 2018*. Retrieved from United Kingdom:

- https://www.iopcfunds.org/uploads/tx_iopcpublications/Annual_Report_2018_for_WEB_e..pdf
- IOPC Funds. (2022). About us. Retrieved from <https://iopcfunds.org/about-us/>
- IPIECA. (2015a). *A guideline to shoreline clean-up techniques* (521). Retrieved from United Kingdom: <https://www.ipieca.org/resources/good-practice/a-guide-to-shoreline-clean-up-techniques/>
- IPIECA. (2015b). *Tiered preparedness and response* (526). Retrieved from United Kingdom: <https://www.ipieca.org/resources/good-practice/tiered-preparedness-and-response/>
- IPIECA. (2015c). Figure 5: A complete model. In: *Tiered preparedness and response*. United Kingdom: IPIECA-IOPC. <https://www.ipieca.org/resources/good-practice/tiered-preparedness-and-response/>. Reproduced by permission of Edward White, IPIECA.
- IPIECA. (2016). *Controlled in-situ burning of spilled oil* (523). Retrieved from United Kingdom: <https://www.ipieca.org/resources/good-practice/controlled-in-situ-burning-of-spilled-oil/>
- IPIECA. (2017). *Key principles for the protection, care and rehabilitation of oiled wildlife*. Retrieved from <https://www.ipieca.org/resources/awareness-briefing/key-principles-for-the-protection-care-and-rehabilitation-of-oiled-wildlife/>
- IPIECA, IMO, & OGP. (2012). *Sensitivity mapping for oil spill response* (477). Retrieved from United Kingdom: <https://www.ipieca.org/resources/good-practice/sensitivity-mapping-for-oil-spill-response/>
- ITOPF. (2011a). *Effects of Oil Pollution on Fisheries and Mariculture* (11). Retrieved from UK: https://www.itopf.org/fileadmin/uploads/itopf/data/Documents/TIPS_TAPS_new/TIP_11_Effects_of_Oil_Pollution_on_Fisheries_and_Mariculture.pdf
- ITOPF. (2011b). *Effects of Oil Pollution on the Marine Environment* (13). Retrieved from UK: https://www.itopf.org/fileadmin/uploads/itopf/data/Documents/TIPS_TAPS_new/TIP_13_Effects_of_Oil_Pollution_on_the_Marine_Environment.pdf
- ITOPF. (2011c). *Fate of Marine Oil Spills* (2). Retrieved from UK: <https://www.itopf.org/knowledge-resources/documents-guides/fate-of-oil-spills/>
- ITOPF. (2011d). *Use of booms in oil pollution response* (3). Retrieved from UK: <https://www.itopf.org/knowledge-resources/documents-guides/tip-03-use-of-booms-in-oil-pollution-response/>
- ITOPF. (2012a). *Leadership, command & management of marine oil spills* (10). Retrieved from UK: <https://www.itopf.org/knowledge-resources/documents-guides/tip-10-leadership-command-management-of-oil-spills/>
- ITOPF. (2012b). *Use of skimmers in oil pollution response* (5). Retrieved from UK: <https://www.itopf.org/knowledge-resources/documents-guides/tip-05-use-of-skimmers-in-oil-pollution-response/>
- ITOPF. (2014, 23 May 2014). Torrey Canyon, United Kingdom, 1967. *In Action*. Retrieved from <https://www.itopf.org/in-action/case-studies/case-study/torrey-canyon-united-kingdom-1967/>
- ITOPF. (2018). New Zealand. *Country & Territory Profiles*. Retrieved from <https://www.itopf.org/knowledge-resources/countries-territories-regions/new-zealand/?L=>
- ITOPF. (2019). *Oil Tanker Spill Statistics 2018*. Retrieved from <https://www.itopf.org/news-events/news/2018-tanker-oil-spill-statistics-number-of-spills-remains-low/#:~:text=The%20estimated%20total%20amount%20of,impacts%20compared%20to%20crude%20oil.>

- ITOPF. (2020). *Oil Tanker Spill Statistics 2019*. Retrieved from <http://www.itopf.org/knowledge-resources/documents-guides/document/oil-tanker-spill-statistics-2019/>
- IUCN. (2021). The IUCN Red List of Threatened Species. Version 2021-2. Retrieved from <https://www.iucnredlist.org/>
- Jiang, L. (2015). *Economic Value of Freshwater Recreational Angling in Otago: A Travel Cost Method Approach*. (Master of Commerce Thesis). University of Otago, Otago, NZ. Retrieved from <http://hdl.handle.net/10523/5614>
- Judd, S. (2014). Compensation for Pollution from the *Rena*. *New Zealand Journal of Public and International Law*, 12(2), 30. Retrieved from <https://www.victoria.ac.nz/law/centres/nzcpl/publications/nz-journal-of-public-and-international-law/previous-issues/volume-122,-december-2014/judd.pdf>
- Kenter, J. O., O'Brien, L., Hockley, N., Ravenscroft, N., Fazey, I., Irvine, K. N., . . . Williams, S. (2015). What are shared and social values of ecosystems? *Ecological Economics*, 111, 86-99. doi:<https://doi.org/10.1016/j.ecolecon.2015.01.006>
- Kerr, G. (2010). *A New Zealand Perspective on Value Transfer*. Paper presented at the AARES Annual Conference, Melbourne, Australia. <https://researcharchive.lincoln.ac.nz/handle/10182/3486>
- Kerr, G. N., & Latham, N. (2011). New Zealand Marine Recreational Fishing Values. In *Report prepared for the New Zealand Marine Research Foundation: Land Environment & People*.
- , G. N., & Greer, G. (2004). New Zealand River Management: Economic Values of Rangitata River Fishery Protection. *Australasian Journal of Environmental Management*, 11(2), 139-149. doi:10.1080/14486563.2004.10648607
- Kerr, G. N., Sharp, B. M. H., & Gough, J. D. (1986). *Economic Benefits of Mt. Cook National Park* (12). Retrieved from <https://core.ac.uk/download/pdf/80828083.pdf>
- Kim, D., Yang, G.-g., Min, S., & Koh, C.-h. (2014). Social and ecological impacts of the Hebei Spirit oil spill on the west coast of Korea: Implications for compensation and recovery. *Ocean & Coastal Management*, 102, 533-544. doi:<https://doi.org/10.1016/j.ocecoaman.2014.05.023>
- Kim, T.-G., Opaluch, J., Moon, D. S.-H., & Petrolia, D. R. (2017). Natural resource damage assessment for the Hebei Spirit oil spill: An application of Habitat Equivalency Analysis. *Marine Pollution Bulletin*, 121(1), 183-191. doi:<https://doi.org/10.1016/j.marpolbul.2017.05.064>
- Kipperberg, G., Onozaka, Y., Bui, L. T., Lohaugen, M., Refsdal, G., & Sæland, S. (2019). The impact of wind turbines on local recreation: Evidence from two travel cost method – contingent behavior studies. *Journal of Outdoor Recreation and Tourism*, 25, 66-75. doi:<https://doi.org/10.1016/j.jort.2018.11.004>
- Klein, Y. L., Osleeb, J. P., & Viola, M. R. (2004). Tourism-Generated Earnings in the Coastal Zone: A Regional Analysis. *Journal of Coastal Research*, 20(4), 1080-1088. Retrieved from <http://ezproxy.massey.ac.nz/login?url=http://search.ebscohost.com/login.aspx?direct=true&AuthType=ip,cookie,url,uid&db=iih&AN=15223102&site=ehost-live&scope=site>
- Kleppe, A., & Jensen, J. (2018). *Valuing the Recreational Benefits of Bore and Hellestø Beaches*. (Master of Business Administration). University of Stavanger, Norway. Retrieved from <https://uis.brage.unit.no/uis-xmlui/handle/11250/2563468>
- Klerks, P. L., Kascak, A., Cazan, A. M., Adhikary, N. D., Chistoserdov, A., Shaik, A., . . . Louka, F. R. (2018). Effects of the Razor Clam *Tagelus plebeius* on the Fate of

- Petroleum Hydrocarbons: A Mesocosm Experiment. *Archives of Environmental Contamination and Toxicology*, 75(2), 306-315. doi:10.1007/s00244-018-0515-0
- Kosenius, A.-K., & Horne, P. (2016). Welfare effects of mining externalities: a combined travel cost and contingent behaviour study. *Journal of Environmental Economics and Policy*, 5(3), 265-282. doi:10.1080/21606544.2015.1107511
- Krinsky, I., & Robb, A. L. (1986). On Approximating the Statistical Properties of Elasticities. *The Review of Economics and Statistics*, 68(4), 715-719. doi:10.2307/1924536
- Kubiszewski, I. (2019). The Genuine Progress Indicator: A Measure of Net Economic Welfare. In B. Fath (Ed.), *Encyclopedia of Ecology (Second Edition)* (pp. 327-335). Oxford: Elsevier.
- Kuosmanen, T., Nillesen, E., & Wesseler, J. (2004). Does ignoring multideestination trips in the travel cost method cause a systematic bias? *Australian Journal of Agricultural and Resource Economics*, 48(4), 629-651. doi:10.1111/j.1467-8489.2004.00266.x
- Landry, C. E., Lewis, A. R., Liu, H., & Vogelsong, H. (2016). Addressing Onsite Sampling in Analysis of Recreation Demand: Economic Value and Impact of Visitation to Cape Hatteras National Seashore. *Marine Resource Economics*, 31(3), 301-322. doi:10.1086/686892
- Langangen, Ø., Olsen, E., Stige, L. C., Ohlberger, J., Yaragina, N. A., Vikebø, F. B., . . . Hjermann, D. Ø. (2017). The effects of oil spills on marine fish: Implications of spatial variation in natural mortality. *Marine Pollution Bulletin*, 119(1), 102-109. doi:https://doi.org/10.1016/j.marpolbul.2017.03.037
- Lankia, T., Neuvonen, M., & Pouta, E. (2019). Effects of water quality changes on the recreation benefits of swimming in Finland: Combined travel cost and contingent behavior model. *Water Resources and Economics*, 25, 2-12. doi:https://doi.org/10.1016/j.wre.2017.10.002
- Laurila-Pant, M., Lehtikoinen, A., Uusitalo, L., & Venesjärvi, R. (2015). How to value biodiversity in environmental management? *Ecological Indicators*, 55, 1-11. doi:https://doi.org/10.1016/j.ecolind.2015.02.034
- Lincoln University. (n.d.). New Zealand Nonmarket Valuation Database. Retrieved from <http://selfservice.lincoln.ac.nz/nonmarketvaluation/>
- Liu, X., & Wirtz, K. W. (2006). Total oil spill costs and compensations. *Maritime Policy & Management*, 33(1), 49-60. doi:10.1080/03088830500513352
- Living Economics. (n.d.). Complements and Substitutes (transcript). Retrieved from <https://livingeconomics.org/article.asp?docId=289>
- Lockwood, S., Weaver, C. K., Munshi, D., & Simpson, M. (2016). The self-organising of youth volunteers during the Rena oil spill in New Zealand. *New Zealand Journal of Marine and Freshwater Research*, 50(1), 28-41. doi:10.1080/00288330.2015.1063515
- Loomis, J. (2003). Travel cost demand model based river recreation benefit estimates with on-site and household surveys: Comparative results and a correction procedure. *Water Resources Research*, 39(4). doi:10.1029/2002WR001832
- Loomis, J. (2006). A comparison of the effect of multiple destination trips on recreation benefits as estimated by travel cost and contingent valuation methods. *Journal of Leisure Research*, 38(1), 46-60. Retrieved from <https://www.scopus.com/inward/record.uri?eid=2-s2.0-33646534874&partnerID=40&md5=de5d78d6488cfe1ac61d7aae902c2393>
- Loomis, J., Creel, M., & Park, T. (1991). Comparing benefit estimates from travel cost and contingent valuation using confidence intervals for Hicksian welfare measures. *Applied Economics*, 23(11), 1725-1731. doi:10.1080/00036849100000067

- Loomis, J., & Santiago, L. E. (2011). Testing Differences in Estimation of River Recreation Benefits for International and Domestic Tourists as a Function of Single- Versus Multiple-Destination Day Trips. *Journal of Hospitality Marketing & Management*, 20(2), 143. doi:10.1080/19368623.2011.536058
- Loomis, J., Tadjion, O., Watson, P., Wilson, J., Davies, S., & Thilmany, D. (2008). A Hybrid Individual—Zonal Travel Cost Model for Estimating the Consumer Surplus of Golfing in Colorado. *Journal of Sports Economics*, 10(2), 155-167. doi:10.1177/1527002508320136
- Loomis, J., Yorizane, S., & Larson, D. (2000). Testing Significance of Multi-Destination and Multi-Purpose Trip Effects in a Travel Cost Method Demand Model for Whale Watching Trips. *Agricultural and Resource Economics Review*, 29(2), 183-191. doi:10.1017/S1068280500005311
- Loureiro, M. L., & Loomis, J. B. (2013). International Public Preferences and Provision of Public Goods: Assessment of Passive Use Values in Large Oil Spills. *Environmental and Resource Economics*, 56(4), 521-534. doi:10.1007/s10640-012-9556-4
- Loureiro, M. L., Loomis, J. B., & Vázquez, M. X. (2009). Economic Valuation of Environmental Damages due to the Prestige Oil Spill in Spain. *Environmental and Resource Economics*, 44(4), 537-553. doi:10.1007/s10640-009-9300-x
- Loureiro, M. L., Ribas, A., López, E., & Ojea, E. (2006). Estimated costs and admissible claims linked to the Prestige oil spill. *Ecological Economics*, 59(1), 48-63. doi:https://doi.org/10.1016/j.ecolecon.2005.10.001
- Lundy, S. (2011). Rena: Hundreds cleaning beaches. Retrieved from https://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=10758786
- Mahlatini, P., Hove, A., Maguma, L. F., & Chemura, A. (2018). Using direct use values for economic valuation of wetland ecosystem services: a case of Songore wetland, Zimbabwe. *GeoJournal*. doi:10.1007/s10708-018-9947-3
- Mäntymaa, E., Jokinen, M., Juutinen, A., Lankia, T., & Louhi, P. (2021). Providing ecological, cultural and commercial services in an urban park: A travel cost–contingent behavior application in Finland. *Landscape and Urban Planning*, 209, 104042. doi:https://doi.org/10.1016/j.landurbplan.2021.104042
- Marini Govigli, V., Górriz-Mifsud, E., & Varela, E. (2019). Zonal travel cost approaches to assess recreational wild mushroom picking value: Trade-offs between online and onsite data collection strategies. *Forest Policy and Economics*, 102, 51-65. doi:https://doi.org/10.1016/j.forpol.2019.02.003
- Maritime New Zealand. (2018). *New Zealand marine oil spill readiness and response strategy 2018-2022*: Wellington : Maritime New Zealand, 2018.
- Maritime New Zealand. (2019). *Request for Official Information - breakdown of costs associated with Maritime NZ's response to the grounding of the MV Rena*. (F27334).
- Maritime New Zealand. (2021). Legislation, regulations and conventions. *Environment*. Retrieved from <https://www.maritimenz.govt.nz/public/environment/legislation-regulations.asp>
- Maritime New Zealand. (2022). Oil Pollution Levy Rates. *Fees and levies*. Retrieved from <https://www.maritimenz.govt.nz/content/fees/default.asp>
- Maritime New Zealand. (n.d.-a). Maritime and marine protection rules. *rules*. Retrieved from https://www.maritimenz.govt.nz/rules/default.asp#all_maritime_rules
- Maritime New Zealand. (n.d.-b). MV Rena. *Spill response case studies*. Retrieved from <https://www.maritimenz.govt.nz/public/environment/responding-to-spills/spill-response-case-studies/rena.asp>
- Maritime New Zealand. (n.d.-c, 2014). Timeline. Retrieved from <https://www.maritimenz.govt.nz/about/what-we-do/history-of-MNZ/timeline.asp>

- Marsh, D., & Schischka, T. (2008). *Shared fisheries; Results from an investigation into the value of the recreational and commercial catch in a New Zealand quota management area*. Paper presented at the Australian Agricultural and Resource Economics Society, Canberra, Australia.
- Martín-Fernández, J., del Cura-González, M. I., Gómez-Gascón, T., Oliva-Moreno, J., Domínguez-Bidagor, J., Beamud-Lagos, M., & Pérez-Rivas, F. J. (2010). Differences between willingness to pay and willingness to accept for visits by a family physician: a contingent valuation study. *BMC public health*, *10*, 236-236. doi:10.1186/1471-2458-10-236
- Martínez-Espiñeira, R., & Amoako-Tuffour, J. (2008). Recreation demand analysis under truncation, overdispersion, and endogenous stratification: An application to Gros Morne National Park. *Journal of Environmental Management*, *88*(4), 1320-1332. doi:<https://doi.org/10.1016/j.jenvman.2007.07.006>
- Martínez-Espiñeira, R., & Amoako-Tuffour, J. (2009). Multi-Destination and Multi-Purpose Trip Effects in the Analysis of the Demand for Trips to a Remote Recreational Site. *Environmental Management*, *43*(6), 1146-1161. doi:10.1007/s00267-008-9253-9
- Martínez-Espiñeira, R., Loomis, J. B., Amoako-Tuffour, J., & Hilbe, J. M. (2008). Comparing recreation benefits from on-site versus household surveys in count data travel cost demand models with overdispersion. *Tourism Economics*, *14*(3), 567-576.
- Matkin, C. O., Ellis, G. M., Dahlheim, M. E., & Zeh, J. (1994). Chapter 8 - Status of Killer Whales in Prince William Sound, 1985-1992. In T. R. Loughlin (Ed.), *Marine Mammals and the Exxon Valdez* (pp. 141-162). San Diego: Academic Press.
- Matthew, N. K., Shuib, A., Ramachandran, S., & Mohammad-Afandi, S. H. (2019). Economic Valuation Using Travel Cost Method (Tcm) In Kilim Karst Geoforest Park, Langkawi, Malaysia. *Journal of Tropical Forest Science*, *31*(1), 78-89. doi:10.26525/jtfs2019.31.1.078089
- Mayer, M., & Woltering, M. (2018). Assessing and valuing the recreational ecosystem services of Germany's national parks using travel cost models. *Ecosystem Services*, *31*(Part C), 371-386. doi:10.1016/j.ecoser.2017.12.009
- McClure, T. (2021, 6 May). New Zealand to spend millions weaning holiday towns off international tourism. *The Guardian*. Retrieved from <https://www.theguardian.com/world/2021/may/06/new-zealand-tourism-changes-environment-milford-sound>
- McCrea-Strub, A., & Pauly, D. (2011). Oil and Fisheries in the Gulf Of Mexico. *Ocean & Coastal Law Journal*, *16*(2), 473. Retrieved from <http://ezproxy.massey.ac.nz/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=edb&AN=67408201&site=eds-live&scope=site>
- McKenzie, P. (2022). New Zealand offshore drilling rig prompts furious backlash from climate activists. Retrieved from <https://www.theguardian.com/world/2022/jan/14/new-zealand-offshore-drilling-rig-prompts-furious-backlash-from-climate-activists>
- McLean, I. G. (2018). *Analysis of the grounding of the MV Rena in New Zealand, 5 October, 2011*. Peer J Preprints. Retrieved from <https://doi.org/10.7287/peerj.preprints.26542v1>
- Mendelsohn, R., Hof, J., Peterson, G., & Johnson, R. (1992). Measuring Recreation Values with Multiple Destination Trips. *American Journal of Agricultural Economics*, *74*(4), 926. Retrieved from <http://ezproxy.massey.ac.nz/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=edsjsr&AN=edsjsr.1243190&site=eds-live&scope=site>
- Milford Sound Tourism Ltd. (2019). *Milford Sound PAX Numbers*.

- Millennium Ecosystem Assessment. (2005a). *Ecosystems and Human Well-being: Synthesis*. Retrieved from <https://www.millenniumassessment.org/documents/document.356.aspx.pdf>
- Millennium Ecosystem Assessment. (2005b). *Ecosystems And Human Well-Being: Wetlands And Water Synthesis*. World Resources Institute, Washington, DC.
- Mingie, J. C. (2011). *Estimating wildlife viewing recreational demand and consumer surplus*. (M.S. Dissertation/Thesis). Mississippi State University, Ann Arbor, United States. ProQuest Dissertations & Theses A&I database. (1497276)
- Resource Management Act 1991, 1991 No 69 C.F.R. § 330 (1991).
- Ministry for the Environment. (2011). *Rena: Long-term Environmental Recovery Plan*. (ME 1084). Wellington, NZ: Ministry for the Environment
- Ministry of Business Innovation and Employment. (2013). *Regional Estimates of Tourism Expenditure: Method, concepts and results*. (978-0-478-41385-4). Retrieved from <https://www.mbie.govt.nz/assets/02416ac5f3/regional-estimates-tourism-expenditure-method-concepts-results.pdf>
- Ministry of Business Innovation and Employment. (2015). *rte-pivot-table-ye-march-2015*. Retrieved from <https://www.mbie.govt.nz/immigration-and-tourism/tourism-research-and-data/tourism-data-releases/monthly-regional-tourism-estimates/regional-tourism-estimates/>
- Ministry of Business Innovation and Employment. (2019). *New Zealand Tourism Forecasts 2019-2025*. Ministry of Business, Innovation, and Employment. Retrieved from <https://www.mbie.govt.nz/assets/a8bba25fdf/new-zealand-tourism-forecasts-2019-2025.pdf>
- Ministry of Business Innovation and Employment. (2020). *August 2020 Annual Tourism Estimates for RTO/Country/Product*. Retrieved from: <https://www.mbie.govt.nz/immigration-and-tourism/tourism-research-and-data/tourism-data-releases/monthly-regional-tourism-estimates/latest-update/data-download/>
- Ministry of Business Innovation and Employment. (2021). *June-2021 Annual Tourism Estimates for RTO/Product*. Data Source: Tourism Electronic Card Transactions (TECTs). Retrieved from: <https://www.mbie.govt.nz/immigration-and-tourism/tourism-research-and-data/tourism-data-releases/tourism-electronic-card-transactions/data-download/>
- Ministry of Fisheries. (2020). *NZ Fisheries General Statistical Areas* [Mapinfo TAB file and Arc Shapefile]. Retrieved from: <https://koordinates.com/layer/4182-nz-fisheries-general-statistical-areas/metadata/>
- Maritime Transport Act 1994, 1994 No 104 C.F.R. (1994).
- Mitre Peak Cruises. (2022). All Tours. Retrieved from https://www.mitrepeak.com/all-tours/?gclid=Cj0KCQjwpcOTBhCZARIsAEAYLuUiKUcixLPRdBQlt7x1NnGMGU6LPVksn6HaPGbrHawSklewqTpTxXIaAsqVEALw_wcB
- Moller, T. H., Dicks, B., Whittle, K. J., & Girin, M. (1999). Fishing and Harvesting Bans in Oil Spill Response. *International Oil Spill Conference Proceedings, 1999*(1), 693-699. doi:10.7901/2169-3358-1999-1-693
- Muller, C. F., Holland, J. D., Kay, T. J., & Hytten, K. F. (2018). Conjoint analysis of small-boat recreational fishers in New Zealand. *New Zealand Geographer, 74*(1), 27-35. doi:<https://doi.org/10.1111/nzg.12181>
- Murdoch, S. (2013). *Independent Review of Maritime New Zealand's Response to the MV Rena Incident on 5 October 2011*. Retrieved from <https://www.maritimenz.govt.nz/public/environment/responding-to-spills/documents/Independent-Review-MNZ-response-to-Rena.pdf>

- National Research Council. (1985). *Oil in the Sea: Inputs, Fates, and Effects*. Washington, DC: The National Academies Press.
- National Research Council. (2003). *Oil in the sea III: inputs, fates, and effects*. Washington DC: National Academy Press.
- NCSS. (2020). Negative Binomial Regression. In *NCSS Documentation* (pp. 1-36): NCSS LLC.
- New Zealand Cruise Association. (2020). 2019-20 Cruise Ship Schedule. Retrieved from <https://newzealandcruiseassociation.com/2019-20-cruise-ship-schedule/>
- NOAA. (2018, 25 June 2018). What is an oil seep? Retrieved from <https://oceanservice.noaa.gov/facts/oilseep.html>
- NOAA. (2019, 03 June 2019). Oil Types. Retrieved from <https://response.restoration.noaa.gov/oil-and-chemical-spills/oil-spills/oil-types.html>
- Northern, T. (2019, 31 January). [Replug 12802].
- NZHerald. (2011, 15 November). Rena spill: BoP beaches re-open. Retrieved from https://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=10766205
- Oldham, K., Cunningham, C., & Spinetto, J. (2020). Quantifying financial liabilities from offshore oil activities a New Zealand case study. *Journal of International Maritime Safety, Environmental Affairs, and Shipping*, 4(3), 122-133. doi:10.1080/25725084.2020.1805216
- Olsvik, P. A., Hansen, B. H., Nordtug, T., Moren, M., Holen, E., & Lie, K. K. (2011). Transcriptional evidence for low contribution of oil droplets to acute toxicity from dispersed oil in first feeding Atlantic cod (*Gadus morhua*) larvae. *Comparative Biochemistry and Physiology Part C: Toxicology & Pharmacology*, 154(4), 333-345. doi:<https://doi.org/10.1016/j.cbpc.2011.07.002>
- Omwenga, R. M. (1995). *The Manawatu River water quality improvement project : an economic policy study : a thesis submitted in partial fulfilment of the requirements for the degree of Masters of Agricultural Sciences in Resource and Environmental Economics at Massey University*. (Master of Agricultural Science (M.Agr.Sc.) Masters). Massey University, Retrieved from <http://hdl.handle.net/10179/5538>
- OPOL, & Oil & Gas UK. (2012). *Oil spill cost study - OPOL financial limits* (1 903 003 79 9). Retrieved from <http://oilandgasuk.co.uk/wp-content/uploads/2015/04/Oil-spill-cost-study-120531.pdf>
- Orchard, S. (2020). Legal protection of New Zealand's surf breaks: top-down and bottom-up aspects of a natural resource challenge. *Australasian Journal of Environmental Management*, 27(1), 6-21. doi:10.1080/14486563.2020.1719439
- Overmans, S., Nordborg, M., Diaz-Rua, R., Brinkman, D. L., Negri, A. P., & Agusti, S. (2018). Phototoxic effects of PAH and UVA exposure on molecular responses and developmental success in coral larvae. *Aquatic Toxicology*, 198, 165-174. doi:10.1016/j.aquatox.2018.03.008
- Pak, M., & Türker, M. F. (2006). Estimation of recreational use value of forest resources by using Individual Travel Cost and Contingent Valuation Methods (Kayabaşı Forest Recreational Site Sample). *Journal of Applied Sciences*, 6(1), 1-5. doi:10.3923/jas.2006.1.5
- Pan, G., Qiu, S., Liu, X., & Hu, X. (2015). Estimating the economic damages from the Penglai 19-3 oil spill to the Yantai fisheries in the Bohai Sea of northeast China. In (Vol. 62, pp. 18-24).
- Parsons, G., Firestone, J., Yan, L., & Toussaint, J. (2020). The effect of offshore wind power projects on recreational beach use on the east coast of the United States: Evidence from contingent-behavior data. *Energy Policy*, 144, 111659. doi:<https://doi.org/10.1016/j.enpol.2020.111659>

- Parsons, G., & Wilson, A. (1997). Incidental and Joint Consumption in Recreation Demand. *Agricultural and Resource Economics Review*, 26. doi:10.1017/S1068280500000782
- Pascoe, S. (2019). Recreational beach use values with multiple activities. *Ecological Economics*, 160, 137-144. doi:https://doi.org/10.1016/j.ecolecon.2019.02.018
- Pearce, D., Markandya, A., & Barbier, E. (1989). Blueprint for a Green Economy. *XF2006304284*. doi:10.4324/9780203097298
- Perry, N. (2022). New Zealand welcomes back first cruise ship since COVID hit. Retrieved from https://www.washingtonpost.com/world/new-zealand-welcomes-back-first-cruise-ship-since-covid-hit/2022/08/11/6eda88ae-19d1-11ed-b998-b2ab68f58468_story.html
- Phaneuf, D. J., Kling, C. L., & Herriges, J. A. (2000). Estimation and Welfare Calculations in a Generalized Corner Solution Model with an Application to Recreation Demand. *The Review of Economics and Statistics*, 82(1), 83-92. doi:10.1162/003465300558650
- Phaneuf, D. J., & Smith, V. K. (2005). Chapter 15 Recreation Demand Models. In K.-G. Mler & J. R. Vincent (Eds.), *Handbook of Environmental Economics* (Vol. 2, pp. 671-761): Elsevier.
- Piatt, J. F., Lensink, C. J., Butler, W., Marshal, K., & Nysewander, D. R. (1990). Immediate Impact of the 'Exxon Valdez' Oil Spill on Marine Birds. *The Auk*, 107(2), 387-397. doi:10.2307/4087623
- Piper, D. (2022). Why is Marsden Point oil refinery closing and should we care? Retrieved from <https://www.stuff.co.nz/national/explained/128390299/why-is-marsden-point-oil-refinery-closing-and-should-we-care#:~:text=On%20August%206%2C%202021%2C%20Refining,its%20name%20to%20Channel%20Infrastructure.>
- Piriority One. (2011). Newsletter: December 2011 [Press release]
- Pokki, H., Jacobsen, J. B., Olsen, S. B., & Romakkaniemi, A. (2020). Understanding angler profiles in cases of heterogeneous count data – A travel cost model. *Fisheries Research*, 221, 105377. doi:https://doi.org/10.1016/j.fishres.2019.105377
- Poor, P. J., & Smith, J. M. (2004). Travel Cost Analysis of a Cultural Heritage Site: The Case of Historic St. Mary's City of Maryland. *Journal of Cultural Economics*, 28(3), 217-229. doi:10.1023/B:JCEC.0000038020.51631.55
- Port of Tauranga Limited. (2021a). Port Trade and Statistic Information [Press release]. Retrieved from www.port-tauranga.co.nz
- Port of Tauranga Limited. (2021b). *Taking care of tomorrow: Integrated Annual Report 2021*. Port of Tauranga. Retrieved from <http://www.port-tauranga.co.nz/investors/financial-information/download-annual-report/>
- Port of Tauranga Limited. (2022). Cruise Schedules. Retrieved from <https://www.port-tauranga.co.nz/cargo-and-shipping/cruise-schedules/#:~:text=Tauranga%20hosted%20116%20cruise%20ship,ship%20destinations%20in%20New%20Zealand.>
- Prayaga, P., Rolfe, J., & Stoeckl, N. (2010). The value of recreational fishing in the Great Barrier Reef, Australia: A pooled revealed preference and contingent behaviour model. *Marine Policy*, 34(2), 244-251. doi:https://doi.org/10.1016/j.marpol.2009.07.002
- Radio New Zealand. (2012, 30 November). Bay of tourism looking to better summer. Retrieved from <https://www.rnz.co.nz/news/rena-grounding/122228/bay-tourism-looking-to-better-summer>
- Randall, A. (1994). A Difficulty with the Travel Cost Method. *Land Economics*, 70(1), 88-96. doi:10.2307/3146443

- Rares, S. (2017). *Ships that Changed the Law - The Torrey Canyon Disaster*. Retrieved from <https://www.fedcourt.gov.au/digital-law-library/judges-speeches/justice-rares/rares-j-20171005>
- RealNZ. (2022). Nature Cruises: Piopiotahi Milford Sound. Retrieved from <https://www.realnz.com/en/destinations/milford-sound/>
- Refsdal, G., & Lohaugen, M. (2016). *Estimating the Non-Market Value of a Single Site: The Case of the Dalsnuten Recreation Area*. (Master of Business Administration). University of Stavanger, Norway. Retrieved from <https://uis.brage.unit.no/uis-xmlui/handle/11250/2412150>
- Remoundou, K., Koundouri, P., Kontogianni, A., Nunes, P. A. L. D., & Skourtos, M. (2009). Valuation of natural marine ecosystems: an economic perspective. *Environmental Science & Policy*, 12(7), 1040-1051. doi:<https://doi.org/10.1016/j.envsci.2009.06.006>
- Ribeiro, L. C. D. S., Souza, K. B. D., Domingues, E. P., & Magalhães, A. S. (2020). Blue water turns black: economic impact of oil spill on tourism and fishing in Brazilian Northeast. *Current Issues in Tourism*, 1-6. doi:10.1080/13683500.2020.1760222
- Ritchie, B. W., Crotts, J. C., Zehrer, A., & Volsky, G. T. (2013). Understanding the Effects of a Tourism Crisis: The Impact of the BP Oil Spill on Regional Lodging Demand. *Journal of Travel Research*, 53(1), 12-25. doi:10.1177/0047287513482775
- Robertson, H. A., Baird, K., Dowding, J. E., Elliott, G. P., Hitchmough, R. A., Miskelly, C. M., . . . Taylor, G. A. (2016). Conservation status of New Zealand birds. In *NEW ZEALAND THREAT CLASSIFICATION SERIES 19*. Wellington, NZ: Department of Conservation.
- Rogers, A. A., Dempster, F. L., Hawkins, J. I., Johnston, R. J., Boxall, P. C., Rolfe, J., . . . Pannell, D. J. (2019). Valuing non-market economic impacts from natural hazards. *Natural Hazards*, 99(2), 1131-1161. doi:10.1007/s11069-019-03761-7
- Rolfe, J., & Dyack, B. (2011). Valuing Recreation in the Coorong, Australia, with Travel Cost and Contingent Behaviour Models. *Economic Record*, 87(277), 282-293. doi:10.1111/j.1475-4932.2010.00683.x
- Rosenthal, D. H. (1987). The Necessity for Substitute Prices Recreation Demand Analyses. *American Journal of Agricultural Economics*, 69(4), 828-837. doi:10.2307/1242194
- Ross, P. M., Battershill, C. N., & Loomb, C. (2016a). The wreck of the MV Rena: spatio-temporal analysis of ship-derived contaminants in the sediments and fauna of Astrolabe Reef. *New Zealand Journal of Marine and Freshwater Research*, 50(1), 87-114. doi:10.1080/00288330.2015.1077873
- Ross, P. M., Fairweather, R. M., Culliford, D. P., Park, S., Pilditch, C. A., & Battershill, C. N. (2016b). In situ sampling reveals rapid uptake and depuration of polycyclic aromatic hydrocarbons by surf clams (*Paphies subtriangulata*) affected by the Rena oil spill. *New Zealand Journal of Marine and Freshwater Research*, 50, 56-69. doi:10.1080/00288330.2015.1084934
- Sarder, M. D., Miller, C., & Richard, B. (2011). *Modeling logistical & economical impact of oil spill on the gulf coast*. Paper presented at the 61st Annual IIE Conference and Expo Proceedings.
- Schiel, D. R., Ross, P. M., & Battershill, C. N. (2016a). Environmental effects of the MV Rena shipwreck: cross-disciplinary investigations of oil and debris impacts on a coastal ecosystem. *New Zealand Journal of Marine and Freshwater Research*, 50, 1-9. doi:10.1080/00288330.2015.1133665
- Schiel, D. R., South, P. M., & Lilley, S. A. (2016b). Effects of the MV Rena oil spill on intertidal rocky reefs in the Bay of Plenty, New Zealand. *New Zealand Journal of Marine and Freshwater Research*, 50(1), 70-86. doi:10.1080/00288330.2015.1031682

- Schwacke, L. H., Smith, C. R., Townsend, F. I., Wells, R. S., Hart, L. B., Balmer, B. C., . . . Rowles, T. K. (2014). Health of Common Bottlenose Dolphins (*Tursiops truncatus*) in Barataria Bay, Louisiana, Following the Deepwater Horizon Oil Spill. *Environmental Science & Technology*, 48(1), 93-103. doi:10.1021/es403610f
- Senior Oil Spill Response Technician (Personal Communication, 2021, 4 November). [Equipment and charge out rates and].
- Shaw, D. (1988). On-site samples' regression: Problems of non-negative integers, truncation, and endogenous stratification. *Journal of Econometrics*, 37(2), 211-223. doi:https://doi.org/10.1016/0304-4076(88)90003-6
- Shigenaka, G. (2014). *Twenty-Five Years After the Exxon Valdez Oil Spill: NOAA's Scientific Support, Monitoring, and Research*. Retrieved from https://response.restoration.noaa.gov/sites/default/files/Exxon_Valdez_25YearsAfter_508_0.pdf
- Shrestha, R. K., Seidl, A. F., & Moraes, A. S. (2002). Value of recreational fishing in the Brazilian Pantanal: a travel cost analysis using count data models. *Ecological Economics*, 42(1), 289-299. doi:https://doi.org/10.1016/S0921-8009(02)00106-4
- Sievwright, K. A., Battley, P. F., McConnell, H., Armstrong, D. P., & Morgan, K. J. (2019). Survival rates of oil-rehabilitated and non-rehabilitated little penguins after the C/V Rena oil spill, New Zealand. *Marine Pollution Bulletin*, 146, 317-325. doi:https://doi.org/10.1016/j.marpolbul.2019.06.027
- Sinclair, M., Mayer, M., Woltering, M., & Ghermandi, A. (2020). Valuing nature-based recreation using a crowdsourced travel cost method: A comparison to onsite survey data and value transfer. *Ecosystem Services*, 45, 101165. doi:https://doi.org/10.1016/j.ecoser.2020.101165
- Sivertsen, J. (2021, Nov 09). The 50 best beaches of New Zealand. Retrieved from <https://www.stuff.co.nz/travel/experiences/beaches/300427642/the-50-best-beaches-of-new-zealand>
- Smith, L. C., Smith, M., & Ashcroft, P. (2011). Analysis of Environmental and Economic Damages from British Petroleum's Deepwater Horizon Oil Spill. *Albany Law Review*, 74(1), 563-585. doi:10.2139/ssrn.1653078
- Smith, R. J. (1971). The Evaluation Of Recreation Benefits: The Clawson Method In Practice. *Urban Studies*, 8(2), 89-102. Retrieved from <http://www.jstor.org/stable/43080618>
- Smith, S. (2022). Oil, acid, plastic: Inside the shipping disaster gripping Sri Lanka. Retrieved from <https://www.unep.org/news-and-stories/story/oil-acid-plastic-inside-shipping-disaster-gripping-sri-lanka>
- Smith, V. K., & Kopp, R. J. (1980). The Spatial Limits of the Travel Cost Recreational Demand Model. *Land Economics*, 56(1), 64-72. doi:10.2307/3145830
- Sohngen, B., Lichtkoppler, F., & Bielen, M. (1999). The value of day trips to Lake Erie beaches.
- Stantec NZ Limited. (2021a). *Milford Opportunities Project - Hazards and visitor risk review report*. Retrieved from <https://www.milfordopportunities.nz/assets/Projects/210331-Hazards-and-Visitor-Risk-Review-Report.pdf>
- Stantec NZ Limited. (2021b). *Milford Opportunities Project: A masterplan for Milford Sound Piopiotahi and the Journey*. Retrieved from <https://www.milfordopportunities.nz/assets/Projects/210503-MOP-Masterplan-FINAL.pdf>
- Statistics New Zealand. (2018). Estimated Resident Population for Urban Areas, at 30 June (1996+) (Annual-Jun). In. Stats NZ, Infoshare: Statistics NZ.

- Statistics New Zealand. (2019a). Cruise ship traveller and expenditure statistics: Year ended June 2019. *Information Releases*. Retrieved from <https://www.stats.govt.nz/information-releases/cruise-ship-traveller-and-expenditure-statistics-year-ended-june-2019>
- Statistics New Zealand. (2019b, 21 November). National accounts (industry production and investment): Year ended March 2018. Retrieved from <https://www.stats.govt.nz/information-releases/national-accounts-industry-production-and-investment-year-ended-march-2018>
- Statistics New Zealand. (2019c, 19 March). Regional gross domestic product: Year ended March 2018. *Table: Gross domestic product (\$) by region, year ended March 2018*. Retrieved from <https://www.stats.govt.nz/information-releases/regional-gross-domestic-product-year-ended-march-2018#bay-of-plenty>
- Statistics New Zealand. (2019d). Tauranga City: Occupancy, monthly (stay-unit-night used). (ACS026AA).
- Statistics New Zealand. (2021a). *Estimated Resident Population for Territorial Authority Areas, at 30 June(1996+) (Annual-Jun)*. DPE052AA. Retrieved from: <https://infoshare.stats.govt.nz/ViewTable.aspx?pxID=3ef4f017-e5e9-4e4c-ba51-59e25ef383b9>
- Statistics New Zealand. (2021b). Quick stats about population counts for Te Anau. *2018 Census palce summaries: Te Anau*. Retrieved from <https://www.stats.govt.nz/tools/2018-census-place-summaries/te-anau>
- Statistics New Zealand. (2021c). *Regional gross deomestic product: Year ended March 2020*. Retrieved from: <https://www.stats.govt.nz/information-releases/regional-gross-domestic-product-year-ended-march-2020>
- Statistics New Zealand. (2022). Population. Retrieved from <https://www.stats.govt.nz/topics/population>
- Sumaila, U. R., Cisneros-Montemayor, A. M., Dyck, A., Huang, L., Cheung, W., Jacquet, J., . . . Quinn, T. (2012). Impact of the Deepwater Horizon well blowout on the economics of US Gulf fisheries. *Canadian Journal of Fisheries & Aquatic Sciences*, *69*(3), 499-510. doi:10.1139/f2011-171
- Surf Life Saving NZ. (2022). *Bay of Plenty Total Headcounts (2018 - 2022)*.
- Suris-Regueiro, J. C., Garza-Gil, M. D., & Varela-Lafuente, M. M. (2007). The Prestige oil spill and its economic impact on the Galician fishing sector. *Disasters*, *31*(2), 201-215. doi:10.1111/j.0361-3666.2007.01004.x
- Tardieu, L., & Tuffery, L. (2019). From supply to demand factors: What are the determinants of attractiveness for outdoor recreation? *Ecological Economics*, *161*, 163-175. doi:<https://doi.org/10.1016/j.ecolecon.2019.03.022>
- Te Mauri Moana. (2013). *Rena Environmental Recovery Monitoring Programme 2011-2013*. Retrieved from <https://sci.waikato.ac.nz/research/projects-and-case-studies/rena-research/Rena-report>
- The Treasury. (2013). Rena Grounding Costs [Press release]. Retrieved from <https://treasury.govt.nz/sites/default/files/2013-04/rena-costs-jan13.pdf>
- Toi Te Ora Public Health. (2011, 1 December). Update on the safety of shellfish collection. *Bay of Plenty and Lakes Districts*. Retrieved from https://www.toiteora.govt.nz/news_and_events/id/400
- Torres-Ortega, S., Pérez-Álvarez, R., Diaz-Simal, P., de Luis, J., & Piña-García, F. (2018). Economic Valuation of Cultural Heritage: Application of Travel Cost Method to the National Museum and Research Center of Altamira. *Sustainability*, *10*, 2550. doi:10.3390/su10072550

- Tourism Bay of Plenty. (2015). Visitor Centre Options Appraisal - December 2015 [Press release]. Retrieved from https://www.tauranga.govt.nz/Portals/0/data/future/visitor_info/files/visitor_information_options_appraisal.pdf
- Tourism Industry Aotearoa. (2021). Tourism by the numbers. *Quick Facts & Figures*. Retrieved from <https://www.tia.org.nz/about-the-industry/quick-facts-and-figures/#:~:text=Tourism%20was%20New%20Zealand's%20biggest,of%20New%20Zealand's%20total%20GDP.>
- U.S. EPA. (2019, 1 March 2019). Summary of the Oil Pollution Act. *Laws & Regulations*. Retrieved from <https://www.epa.gov/laws-regulations/summary-oil-pollution-act>
- UNESCO. (2004). *Convention Concerning The Protection Of The World Cultural And Natural Heritage*. (WHC-04/28.COM/15B). Paris: World Heritage Committee
- UNESCO. (2019). *Operational Guidelines for the Implementation of the World Heritage Convention*. (WHC.19/01). Paris, France: World Heritage Centre
- Voke, M., Fairley, I., Willis, M., & Masters, I. (2013). Economic evaluation of the recreational value of the coastal environment in a marine renewables deployment area. *Ocean & Coastal Management*, 78, 77-87. doi:<https://doi.org/10.1016/j.ocecoaman.2013.03.013>
- Voltaire, L., & Koutchade, O. P. (2020). Public acceptance of and heterogeneity in behavioral beach trip responses to offshore wind farm development in Catalonia (Spain). *Resource and Energy Economics*, 60, 101152. doi:<https://doi.org/10.1016/j.reseneeco.2020.101152>
- Voltaire, L., Lévi, L., Alban, F., & Boncoeur, J. (2017). Valuing cultural world heritage sites: an application of the travel cost method to Mont-Saint-Michel. *Applied Economics*, 49(16), 1593-1605. doi:10.1080/00036846.2016.1221046
- von Haefen, R. H., & Phaneuf, D. J. (2005). Kuhn-Tucker Demand System Approaches to Non-Market Valuation. In R. Scarpa & A. Alberini (Eds.), *Applications of Simulation Methods in Environmental and Resource Economics* (pp. 135-157). Dordrecht: Springer Netherlands.
- Wan-Yu, L., Pin-Zheng, C., & Chi-Ming, H. (2019). Assessing the Recreational Value of a National Forest Park from Ecotourists' Perspective in Taiwan. *Sustainability*(15), 4084. doi:10.3390/su11154084
- Wang, H., Paudel, K. P., & Caffey, R. H. (2019). Tourism for surf and marsh fishing in coastal Louisiana: effects of site closure, travel cost decrease, and entrance fee increase. *Journal of Environmental Economics and Policy*, 1-15. doi:10.1080/21606544.2019.1593249
- Wang, H., Paudel, K. P., & Caffey, R. H. (2020). Tourism for surf and marsh fishing in coastal Louisiana: effects of site closure, travel cost decrease, and entrance fee increase. *Journal of Environmental Economics and Policy*, 9(1), 21-35. doi:10.1080/21606544.2019.1593249
- Water Safety New Zealand. (2021). Recreation Statistics. Retrieved from <https://watersafety.org.nz/Recreation%20Statistics>
- Webby, A., & Ling, N. (2016). Acute sublethal toxicity of MV Rena contaminants (heavy fuel oil, oil dispersant and cryolite) to finfish and rock lobster. *New Zealand Journal of Marine and Freshwater Research*, 50(1), 144-158. doi:10.1080/00288330.2015.1104366
- Wells, P. G. (2017). The iconic Torrey Canyon oil spill of 1967 - Marking its legacy. *Marine Pollution Bulletin*, 115(1), 1-2. doi:<https://doi.org/10.1016/j.marpolbul.2016.12.013>
- Westfall, P. H., & Arias, A. L. (2020). *Understanding regression analysis : a conditional distribution approach*: CRC Press, Taylor & Francis Group.

- White, I., & Molloy, F. (2001). *Ships and the Marine Environment*. Retrieved from <https://www.itopf.org/knowledge-resources/documents-guides/ships-and-the-marine-environment-2001/>
- White, I. C., & Molloy, F. C. (2003). *Factors that Determine the Cost of Oil Spills*. Paper presented at the International Oil Spill Conference Proceedings. <https://doi.org/10.7901/2169-3358-2003-1-1225>
- Whitehead, J. C., Haab, T., Larkin, S. L., Loomis, J. B., Alvarez, S., & Ropicki, A. (2018). Estimating Lost Recreational Use Values of Visitors to Northwest Florida due to the Deepwater Horizon Oil Spill Using Cancelled Trip Data. *Marine Resource Economics*, 33(2), 119-132. doi:10.1086/697560
- WHOI. (2014, 28 July 2014). Natural Oil Seeps. Retrieved from <https://www.whoi.edu/oil/natural-oil-seeps>
- Willis, K. G. (1991). The Recreational Value Of The Forestry Commission Estate In Great Britain: A Clawson-Knetsch Travel Cost Analysis. *Scottish Journal of Political Economy*, 38(1), 58-75. doi:10.1111/j.1467-9485.1991.tb00301.x
- Wilson, R. D., Monaghan, P. H., Osanik, A., Price, L. C., & Rogers, M. A. (1974). Natural Marine Oil Seepage. *Science*, 184(4139), 857-865. Retrieved from <http://www.jstor.org/stable/1738168>
- Windle, J., & Rolfe, J. (2013). Estimating nonmarket values of Brisbane (state capital) residents for state based beach recreation. *Ocean & Coastal Management*, 85, 103-111. doi:<https://doi.org/10.1016/j.ocecoaman.2013.09.011>
- Woodfield, A., & Cowie, D. (1977). The Milford Track: Valuation Estimates Of A Recreation Good. *Australian Journal of Agricultural Economics*, 21(2), 97-110. doi:10.1111/j.1467-8489.1977.tb00197.x
- WorldData.info. (2022). Tourism in New Zealand. Retrieved from <https://www.worlddata.info/australia/new-zealand/tourism.php>
- Yardley, M. (2021, 3 August). Fresh vision for Milford Sound, but cruise ship ban goes too far. Retrieved from <https://www.stuff.co.nz/travel/destinations/nz/southland/125946218/fresh-vision-for-milford-sound-but-cruise-ship-ban-goes-too-far>
- Yender, R., Michel, J., & Lord, C. (2002). *Managing Seafood Safety after an Oil Spill*. Retrieved from Seattle: <https://response.restoration.noaa.gov/sites/default/files/managing-seafood-safety-oil-spill.pdf>
- Zambrano-Monserrate, M. A., Silva-Zambrano, C. A., & Ruano, M. A. (2018). The economic value of natural protected areas in Ecuador: A case of Villamil Beach National Recreation Area. *Ocean & Coastal Management*, 157, 193-202. doi:<https://doi.org/10.1016/j.ocecoaman.2018.02.020>
- Zandi, S., Limaie Soleiman, M., & Amiri, N. (2018). An economic evaluation of a forest park using the individual travel cost method (a case study of Ghaleh Rudkhan forest park in northern Iran). *Environmental & Socio-economic Studies*(2), 48. doi:10.2478/enviro-2018-0014
- Zawacki, W. T., Marsinko, A., & Bowker, J. M. (2000). A travel cost analysis of nonconsumptive wildlife-associated recreation in the United States. *Forest Science*, 46(4), 496-506.
- Zhang, F., Wang, X. H., Nunes, P. A. L. D., & Ma, C. (2015). The recreational value of gold coast beaches, Australia: An application of the travel cost method. *Ecosystem Services*, 11, 106-114. doi:<https://doi.org/10.1016/j.ecoser.2014.09.001>

Appendix

A: Surveys

A1: Coastal Bay of Plenty Survey



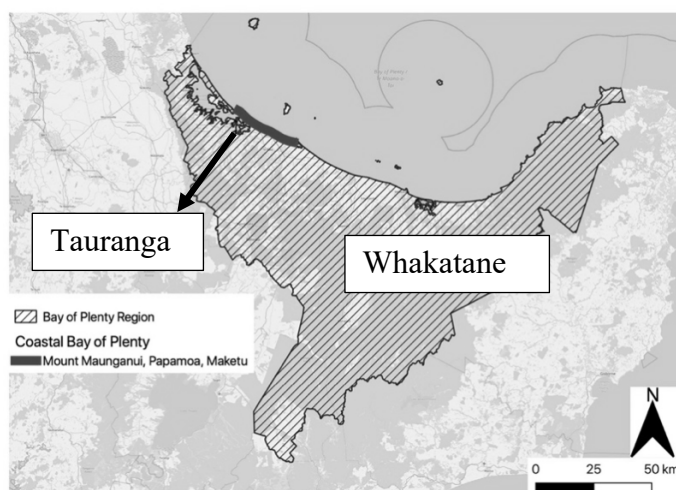
MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

We are interested in Coastal Bay of Plenty visitors' and residents' travel patterns and how they would change under some hypothetical scenarios. The survey asks questions about your current trip to the stretch of beach including **Mount Maunganui, Papamoa, and Maketu beaches**, where you travelled from, your main recreation activities while here, and some further information about you and your household. You and your responses are completely anonymous. The survey takes approximately 10 minutes to complete. If you cannot complete this survey now in person or would prefer to fill it in online, it is available at:

https://massey.au1.qualtrics.com/jfe/form/SV_8bPhL0VUQ19gPWJ



Your participation in this survey is much appreciated. This research project has Massey University ethics approval (4000023029). If you have any questions regarding the ethical consideration of this document, please contact the researcher at A.Egan@massey.ac.nz.



Thank you for choosing to help me with my research.
Alexandra Egan (PhD Student, Massey University)

Coastal Bay of Plenty

Please clearly mark your answers by ticking or crossing the item when prompted, or fill in the circle - ●

For the purposes of this survey, Coastal Bay of Plenty refers to the beaches of Mount Maunganui, Papamoa, and Maketu.

1. Please fill in the numbers corresponding to your postal code:

First Character:

① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨

Second Character:

① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨

Third Character:

① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨

Fourth Character:

① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨

OR please write your city/town of residence below:

2. A) Do you live within 20km to this beach?

Yes No

B) If yes, how close do you live?

_____ km

3. A) Is this your first time visiting the beaches of Bay of Plenty?

Yes No

B) IF NO, how many times have you visited Coastal Bay of Plenty since January 1, 2019?

Most Days (5 out of 7)

Most Weekends

Once a month

About 5 times a year

About 2-4 times a year

Once a year

Only once in two years

Exact number of trips if known: _____

4. Who are you traveling with? You may select multiple.

Family

Friends

Individually

Partner/Couple

Other

5. How many people are in your traveling party? Please write the appropriate number of people next to the corresponding age group.

_____ 16 and under

_____ 17-29

_____ 30-45

_____ 46-64

_____ 65+

6. What is the **primary** reason for this trip to Coastal Bay of Plenty?

Not applicable – I am a resident

Business

Visiting friends/relatives

Vacation/pleasure

Exercise

Social activities

Other (please specify): _____

7. What is the **principal** accommodation you used to visit Coastal Bay of Plenty?

My Home/Personal Residence

Hotel/Motor Lodge

Airbnb (or other home rental)

Campground

Hostel

Campervan/Self-contained vehicle

Beach/Holiday Home

Free Camping

Other (please specify): _____

8. What mode of transportation did you use to travel from your permanent residence to the Coastal Bay of Plenty area?

Personal Vehicle/Rental Car (Q9 onwards)

Bus (go to Q10 onwards)

Plane (go to Q10 onwards)

Walking (go to Q11 onwards)

Bike (go to Q11 onwards)

9. A) If you selected personal vehicle, how many kms (one-way) did you drive from your personal residence?

_____ km

B) What size motor vehicle did you use?

- Small (0-1500 cc) / 0 - 1.5 litres
- Compact (1501cc-2000cc) / 1.501 - 2.0 litres
- Medium (2001cc-3500cc) / 2.001 - 3.5 litres
- Large (3501cc or more) / 3.501 litres or more

C) What kind of fuel did the car use?

- Petrol Diesel
- Electric Hybrid
- Other

Please go to question 11.

10. If you arrived at Coastal Bay of Plenty by plane/long distance bus service, where did you board the aircraft/vehicle?

11. On this visit to Coastal Bay of Plenty, did/will you spend most of your day at the beach?

A) Most of time at beach
 Yes No

B) If you did other things as well, what percent of time did you spend at the beach? (Do not include travel time)

_____ %

12. Please rank your top 3 reasons (1 being the most important) in your decision to visit the Coastal Bay of Plenty (remember this refers to Mount Maunganui, Papamoa, and Maketu beaches).

- _____ Beaches
- _____ Swimming
- _____ Boating / Kayaking
- _____ Scenery
- _____ Marine Activities (charters, diving)
- _____ Walk / Hiking / Tramping
- _____ Camping
- _____ Shopping
- _____ Restaurants
- _____ Day trip elsewhere (Rotorua, etc.)
- _____ Wildlife
- _____ Other: _____

13. For this trip, please indicate if you have/will visit any other areas in Bay of Plenty, **and** how long you have/will visit (in days).

- Waihi Beach _____
- Matata _____
- Whakatane _____

- Rotorua _____
- Other _____

Please specify where for other: _____

Locals/Residents, please go to Q19.

Visitors, please continue to next section.

Visitors

For the next four questions, I want you to think about what you would do if conditions were different in Coastal Bay of Plenty. **Remember that Coastal Bay of Plenty here refers to the stretch of beach that includes Mt. Maunganui, Papamoa, and Maketu.**

Imagine that an oil spill occurred from a shipping accident off the coast of Tauranga. For the following scenarios that range from low to high impacts, please identify how poorer water quality would affect your visit behaviour.

14. Water quality is slightly worse than current conditions, with occasional traces of oil. You can still access the entire beach, but enter the water at your own risk.



- A)** Would you still have visited the following sites on this trip?
- a. Bay of Plenty Region Yes No
 - b. Coastal Bay of Plenty Yes No
- B)** How many times would you visit the Coastal Bay of Plenty in the next two years, if there had been an oil spill?
- Most Days (5 out of 7)
 - Most Weekends
 - Once a month
 - About 5 times a year
 - About 2-4 times a year
 - Once a year
 - Only once in two years
 - Zero – no visits
- C)** If you would not come to the Coastal Bay of Plenty, would you stay home or visit elsewhere?
- Stay Home Visit Elsewhere

15. Water quality is worse than current conditions, with many traces of oil. You are able to access the beach; however, you are unable to enter the water.



- A) Would you still have visited the following sites on this trip?
- Bay of Plenty Region Yes No
 - Coastal Bay of Plenty Yes No
- B) How many times would you visit the Coastal Bay of Plenty in the next two years, if there had been an oil spill?
- Most Days (5 out of 7)
- Most Weekends
- Once a month
- About 5 times a year
- About 2-4 times a year
- Once a year
- Only once in two years
- Zero – no visits
- C) If you would not come to the Coastal Bay of Plenty, would you stay home or visit elsewhere?
- Stay Home Visit Elsewhere

16. Water quality is considerably worse than current conditions, with remnants of oil across the beach. Swimming and other marine activities are prohibited, and the beach is only accessible above the high tide line.



- A) Would you still have visited the following sites on this trip?
- Bay of Plenty Region Yes No
 - Coastal Bay of Plenty Yes No
- B) How many times would you visit the Coastal Bay of Plenty in the next two years, if there had been an oil spill?
- Most Days (5 out of 7)
- Most Weekends
- Once a month
- About 5 times a year

- About 2-4 times a year
- Once a year
- Only once in two years
- Zero – no visits
- C) If you would not come to the Coastal Bay of Plenty, would you stay home or visit elsewhere?
- Stay Home Visit Elsewhere

17. Now imagine that oil has washed up along the entire coast of the Bay of Plenty region, and none of the beaches are swimmable and all the beaches are only accessible above the high tide line. Would you stay home or would you visit another region?

- Stayed Home Visited Elsewhere

18. How confident are you in your answers above? (Please answer as a percentage out of 100).

_____ %

Please go to Q24.

Locals/Residents

For the next four questions, I want you to think about what you would do if conditions were different in Coastal Bay of Plenty. **Remember that Coastal Bay of Plenty here refers to the stretch of beach that includes Mt. Maunganui, Papamoa, and Maketu.**

Imagine that an oil spill occurred from a shipping accident off the coast of Tauranga. For the following scenarios that range from low to high impacts, please identify how poorer water quality would affect your visit behaviour.

19. Water quality is slightly worse than current conditions, with occasional traces of oil. You can still access the entire beach, but enter the water at your own risk.



- A) Would you still have visited the Coastal Bay of Plenty on this trip?
- Yes No

- B)** How many times would you visit the Coastal Bay of Plenty in the next two years, if there had been an oil spill?
- Most Days (5 out of 7)
 - Most Weekends
 - Once a month
 - About 5 times a year
 - About 2-4 times a year
 - Once a year
 - Only once in two years
 - Zero – no visits
- C)** If you would not come to the Coastal Bay of Plenty, would you stay home or visit elsewhere?
- Stay Home Visit Elsewhere

20. Water quality is worse than current conditions, with many traces of oil. You are able to access the beach; however you are unable to enter the water.



- A)** Would you still have visited the Coastal Bay of Plenty on this trip?
- Yes No
- B)** How many times would you visit the Coastal Bay of Plenty in the next two years, if there had been an oil spill?
- Most Days (5 out of 7)
 - Most Weekends
 - Once a month
 - About 5 times a year
 - About 2-4 times a year
 - Once a year
 - Only once in two years
 - Zero – no visits
- C)** If you would not come to the Coastal Bay of Plenty, would you stay home or visit elsewhere?
- Stay Home. Visit Elsewhere

21. Water quality is considerably worse than current conditions, with remnants of oil across the beach. Swimming and other marine activities are prohibited, and the

beach is only accessible above the high tide line.



- A)** Would you still have visited the Coastal Bay of Plenty on this trip?
- Yes No
- B)** How many times would you visit the Coastal Bay of Plenty in the next two years, if there had been an oil spill?
- Most Days (5 out of 7)
 - Most Weekends
 - Once a month
 - About 5 times a year
 - About 2-4 times a year
 - Once a year
 - Only once in two years
 - Zero – no visits
- C)** If you would not come to the Coastal Bay of Plenty, would you stay home or visit elsewhere?
- Stay Home. Visit Elsewhere

22. Now imagine that oil has washed up along the entire coast of the Bay of Plenty region, and none of the beaches are swimmable and all the beaches are only accessible above the high tide line. Would you stay home or would you visit another region?

- Stay Home Visit Elsewhere

23. How confident are you in your answers above? (Please answer as a percentage out of 100).

_____ %

Please go to Q24.

24. How long is your visit to the Bay of Plenty region? (N/A if resident)

_____ days _____ nights N/A

25. How long is your visit to this recreation site, Coastal Bay of Plenty?

_____ days _____ nights

26. How long are you away from home on this trip? (This includes places you have visited other than these beaches)

_____ days _____ nights

27. A) How much did your group's accommodation cost for one night?

NZ\$ _____ N/A

B) How much did/will your group spend today on miscellaneous items? (food, etc.)

NZ\$ _____

28. On a scale of 0 to 5 (where 0 indicates no influence, and 5 indicates the primary reason), **how much influence** would you say the beaches and marine activities had on your decision to visit Coastal Bay of Plenty? (If a resident/local, this refers to your decision to stay versus visit somewhere else).

0 1 2 3 4 5

29. At what point in planning your trip did you decide to visit Coastal Bay of Plenty?

- Before leaving home
- En-route (after beginning your travels)
- While in the Bay of Plenty region
- Not applicable

30. What is the approximate one-way distance from your personal residence to your most preferred alternative recreation site if you did not visit Coastal Bay of Plenty?

_____ km

31. Which of these categories best describes your annual **household income** before tax? (NZD).

- Less than \$45,000
- \$45,001-\$60,000
- \$60,001-\$80,000
- \$80,001-\$100,000
- \$80,001-\$100,000
- \$100,001-\$120,000
- \$120,001-\$140,000.
- \$140,001-\$160,000
- \$160,001-\$180,000.
- \$180,001-\$200,000
- More than \$200,000

32. Which of these categories best describes your annual **personal income** before tax?

- Less than \$45,000
- \$45,001-\$60,000
- \$60,001-\$80,000
- \$80,001-\$100,000

- \$80,001-\$100,000
- \$100,001-\$120,000
- \$120,001-\$140,000.
- \$140,001-\$160,000
- \$160,001-\$180,000.
- \$180,001-\$200,000
- More than \$200,000

33. What is your current employment status?

- Employed full time (>30 hrs/week)
- Employed part time
- Not employed
- Student
- Retired

34. What is the highest level of education that you have completed?

- Some High School
- High School Graduate
- High School equivalent
- Tertiary/Trade Certificate or equivalent
- Bachelors/University Degree
- Postgraduate qualification

35. What gender do you identify with?

- Male
- Female
- Other
- I would prefer not to answer

36. What is your age in years?

- 18-29
- 30-45
- 46-64.
- 65+

37. What ethnicity do you identify with? You may select multiple responses.

- New Zealander/Pākehā
- European
- Māori
- Pacific peoples
- Asian
- Middle Eastern/Latin American/African
- Other ethnicity

If you have any comments, please write below:

Thank you for completing this survey! If you have any questions or concerns, feel free to contact me at:

Alexandra Egan
A.Egan@massey.ac.nz

A2: Fiordland National Park Survey



MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

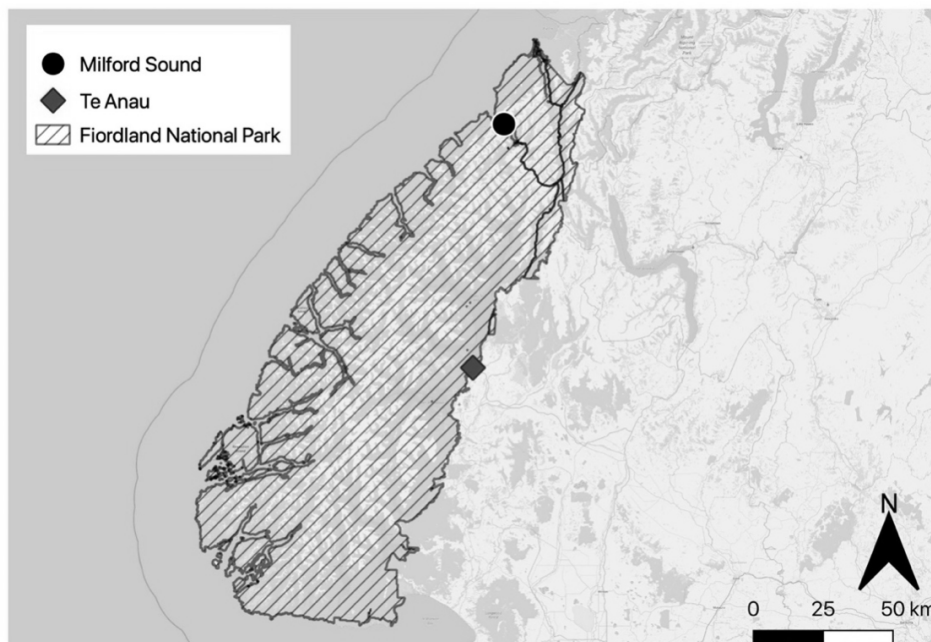
We are interested in Fiordland visitors' travel patterns and how they would change under some hypothetical scenarios. The survey asks questions about your current trip to Fiordland National Park, where you travelled from, your main recreation activities while here and some further information about you and your household. You and your responses are completely anonymous. The survey should take approximately 15 minutes to complete. If you cannot complete this survey now in person, and would prefer to fill it in online, it is available at:

https://massey.au1.qualtrics.com/jfe/form/SV_d6XEHwaDyFDhTIX



Your participation in this survey is much appreciated.

This research project has Massey University ethics approval (4000023029). If you have any questions regarding the ethical consideration of this document, please contact the researcher at A.Egan@massey.ac.nz.



Thank you for choosing to help me with my research.

Alexandra Egan (PhD Student, Massey University)

Fiordland National Park

Please clearly mark your answers by ticking or crossing the item when prompted, or fill in the circle - ●

1. Please fill in the numbers corresponding to your postal code:

First Character:

0 1 2 3 4 5 6 7 8 9

Second Character:

0 1 2 3 4 5 6 7 8 9

Third Character:

0 1 2 3 4 5 6 7 8 9

Fourth Character:

0 1 2 3 4 5 6 7 8 9

2. A) Is this your first-time visiting the Fiordland area?

Yes No

B) IF NO, how many times have you visited the Fiordland area since January 1, 2016

0 1 2 3 4 5+

C) How many times have you visited Milford Sound since January 1, 2016.

0 1 2 3 4 5+

D) Have you visited the Fiordland area prior to January 1, 2016?

Yes No

3. Who are you traveling with? You may select multiple responses.

- Family
- Friends
- Individually
- Partner/Couple
- Other

4. How many people are in your traveling party? Please write the appropriate number of people next to the corresponding age group.

_____ 16 and under

_____ 17-29

_____ 30-45

_____ 46-64

_____ 65+

5. What is the **primary** reason for this trip to the Fiordland area?

- Not applicable – I am a resident
- Business
- Visiting friends/relatives

- Vacation/pleasure
- Hunting/fishing
- Exercise
- Social activities
- Other (please specify): _____

6. What is the principal accommodation you used to visit the Fiordland area?

- My Home/Personal Residence
- Hotel/Motor Lodge
- Airbnb (or other home rental)
- Campground
- Hostel
- Campervan/Self-contained vehicle
- Beach/Holiday Home
- Free Camping
- Other (please specify): _____

7. On a scale of 0 to 5 (where 0 indicates no influence, and 5 indicates the primary reason), **how much influence** would you say Fiordland National Park had on your decision to take this trip?

0 1 2 3 4 5

8. At what point in planning your trip did you decide to visit the Fiordland area?

- Before leaving home
- En-route (after beginning your travels)
- While in the region (Southland)
- Not applicable

9. A) What is the principal mode of transportation you used to travel from your home to Fiordland?

- Personal Vehicle/Rental Car
- Bus
- Plane
- Walking
- Bike

B) What is the principal mode of transportation you are using to travel within Fiordland?

- Personal Vehicle/Rental Car
- Bus
- Plane
- Walking
- Bike

If you selected Personal Vehicle/Rental Car for Q9A or Q9B, please answer the following question. If not, skip to Q11.

10. A) If you selected personal vehicle, how many kms (one-way) did you drive from your personal residence?

_____ km

B) What size motor vehicle did you use?

- Small (0-1500 cc) / 0 - 1.5 litres
- Compact (1501cc-2000cc) / 1.501 - 2.0 litres
- Medium (2001cc-3500cc) / 2.001 - 3.5 litres
- Large (3501cc or more) / 3.501 litres or more

C) What kind of fuel did the car use?

- Petrol Diesel
- Electric Hybrid
- Other

If you answered Plane or Bus for Q9A or Q9B, please answer the following question. If not, skip to Q12.

11. If you arrived in Fiordland by plane/long distance bus service, where did you board the aircraft/vehicle?

12. Please rank your **top 3 reasons** (1 being the most important) in your decision to visit Fiordland National Park.

- _____ Scenery
- _____ Boating / Kayaking
- _____ Marine Activities (charters, diving)
- _____ Walk / Hiking / Tramping
- _____ Camping
- _____ UNESCO World Heritage Site
- _____ Wildlife
- _____ Cycling
- _____ Hunting
- _____ Fishing
- _____ Tours
- _____ Other commercial charters
- _____ Other: _____

13. For this trip, please indicate if you have visited/will visit any of these areas in the Fiordland area, and how long you visited (in days).

- Te Anau _____
- Milford Sound _____
- Manapouri _____
- Doubtful Sound _____
- Dusky Sound _____
- Other _____

Please specify where for other: _____

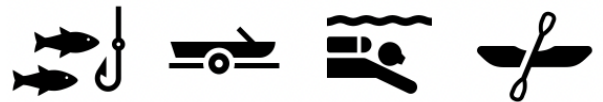
14. Please indicate if you have visited each of the following sites on this trip and how much time you spent at each (in days).

- Queenstown _____
- Christchurch _____
- Stewart Island _____
- Invercargill _____
- Mount Cook _____
- Dunedin _____
- Wanaka _____
- Arrowtown _____
- Tekapo _____
- Catlins _____
- Other: _____

For the next four questions, I want you to think about what you would do if water quality conditions were different to now.

Imagine that an oil spill occurred from a cruise ship in Milford Sound. For the following scenarios that range from low to high impacts, please identify how the poorer water quality would affect your visit behaviour.

15. Water quality is slightly worse than current conditions, with occasional traces of oil. You can still access the sound, but conduct recreational activities at your own risk.



A) Would you still have visited on this trip:

- a. Milford Sound Yes No
- b. Fiordland National Park Yes No
- c. Southland Region Yes No

B) How many times would you visit Fiordland in the next five years, if there had been an oil spill in Milford Sound?

- 0 1 2 3 4 5+

C) If you would not come to Fiordland, would you have stayed home or visited elsewhere?

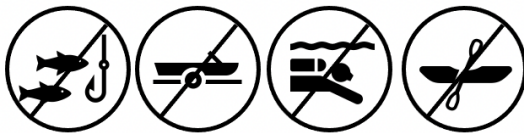
- Stayed Home. Visited Elsewhere

16. Water quality is worse than current conditions, with many traces of oil. Activities are allowed on the water, but nothing below the water (no fishing, scuba, etc.).



- A)** Would you still have visited on this trip:
- a. Milford Sound Yes No
 - b. Fiordland National Park Yes No
 - c. Southland Region Yes No
- B)** How many times would you visit Fiordland in the next five years, if there had been an oil spill in Milford Sound?
- 0 1 2 3 4 5+
- C)** If you would not come to Fiordland, would you have stayed home or visited elsewhere?
- Stayed Home Visited Elsewhere

17. Water quality is considerably worse than current conditions, with remnants of oil along the shore. No recreational activities allowed, just viewing from land.



- A)** Would you still have visited on this trip?
- a. Milford Sound Yes No
 - b. Fiordland National Park Yes No
 - c. Southland Region Yes No
- B)** How many times would you visit Fiordland in the next five years, if there had been an oil spill in Milford Sound?
- 0 1 2 3 4 5+
- C)** If you would not come to Fiordland, would you have stayed home or visited elsewhere?
- Stayed Home Visited Elsewhere

18. How confident are you in your answers above? (Please answer as a percentage out of 100).

_____ %

19. How long is your visit to the Southland region? N/A if resident of Southland.

_____ days _____ nights N/A

20. How long is your visit to Fiordland National Park area (including Te Anau)?

_____ days _____ nights

21. How long are you away from home on this trip? (this includes other places you visited on this trip other than Fiordland)

_____ days _____ nights

22. A) How much did your group's accommodation cost for one night?

NZ\$

B) How much did/will your group spend today on miscellaneous items? (food, etc.)

NZ\$

23. What is the one-way distance from your home to your most preferred alternative vacation site if you did not visit Fiordland?

_____ km

24. Which of these categories best describes your annual household income before tax? (NZD).

- Less than \$45,000
- \$45,001-\$60,000
- \$60,001-\$80,000
- \$80,001-\$100,000
- \$80,001-\$100,000
- \$100,001-\$120,000
- \$120,001-\$140,000.
- \$140,001-\$160,000
- \$160,001-\$180,000.
- \$180,001-\$200,000
- More than \$200,000

25. Which of these categories best describes your personal annual income before tax?

- Less than \$45,000
- \$45,001-\$60,000
- \$60,001-\$80,000
- \$80,001-\$100,000
- \$80,001-\$100,000
- \$100,001-\$120,000
- \$120,001-\$140,000.
- \$140,001-\$160,000
- \$160,001-\$180,000.
- \$180,001-\$200,000
- More than \$200,000

26. What is your current employment status?

- Employed full time (>30 hrs/week)
- Employed part time
- Not employed
- Student
- Retired

27. What is the highest level of education that you have completed?

- Some High School
- High School Graduate
- High School equivalent
- Tertiary/Trade Certificate or equivalent

- Bachelors/University Degree
- Postgraduate qualification

28. What gender do you identify with?

- Male
- Female
- Other
- I would prefer not to answer

29. What is your age in years?

- 18-29
- 30-45
- 46-64
- 65+

30. What ethnicity do you identify with? You may select multiple responses.

- New Zealander
- European
- Māori
- Pacific peoples
- Asian
- Middle Eastern/Latin American/African
- Other ethnicity

Thank you for completing this survey! If you have any questions or concerns, feel free to contact me at:

Alexandra Egan
A.Egan@massey.ac.nz

B: Tables

B1: Descriptive Statistics - Coastal Bay of Plenty

VARIABLE		PERCENTAGES
# of respondents		193
Response rate		44.47%
First Visit	Yes	7.77%
Gender	Female	46.63%
	Male	52.33%
	Other	0.00%
	Prefer to not answer	1.04%
Employment Types	Full time	54.40%
	Part time	16.06%
	Retired	7.77%
	Student	5.70%
	Unemployed	7.25%
	Self Employed	7.77%
	Did not answer	1.04%
Trip Decision	Before leaving home	82.90%
	While in the region	3.11%
	En-route	5.70%
	N/A	7.25%
	Did not answer	1.04%
Primary Reason	Business	1.55%
	Visiting friends/relatives	9.84%
	Vacation/pleasure	66.32%
	Hunting/fishing	0.00%
	Exercise	3.63%
	Social Activities	6.22%
	Selected Multiple	1.04%
	Other	1.04%
	N/A	9.84%
	Did not answer	0.52%
Number 1 Reason	Beaches	47.15%
	Swimming	14.51%
	Boating/Kayaking	0.00%
	Scenery	5.70%
	Marine Activities	1.04%
	Walk/hiking/tramping	8.29%
	Camping	0.00%
	Shopping	0.00%
	Restaurants	0.52%

	Day trip elsewhere	0.00%
	Wildlife	0.00%
	Other	21.76%
	Selected Multiple	0.52%
	Did not answer	0.52%
Number 2 Reason	Beaches	18.65%
	Swimming	30.57%
	Boating/Kayaking	1.55%
	Scenery	13.99%
	Marine Activities	1.55%
	Walk/hiking/tramping	13.47%
	Camping	1.55%
	Shopping	2.59%
	Restaurants	3.11%
	Day trip elsewhere	0.00%
	Wildlife	0.52%
	Other	9.84%
	Selected Multiple	0.00%
	Did not answer	2.59%
Number 3 Reason	Beaches	11.40%
	Swimming	6.74%
	Boating/Kayaking	2.07%
	Scenery	30.57%
	Marine Activities	3.11%
	Walk/hiking/tramping	12.95%
	Camping	2.07%
	Shopping	3.63%
	Restaurants	11.40%
	Day trip elsewhere	1.55%
	Wildlife	0.52%
	Other	9.84%
	Selected Multiple	0.00%
	Did not answer	4.15%
Age Group of Respondent	18-29	26.94%
	30-45	30.57%
	46-64	29.53%
	65+	10.36%
	Did not answer	2.59%
Accommodation	AirBnB (home rental)	12.44%
	Beach/Holiday Home	13.47%
	My Home/Personal residence	44.04%
	Campervan/Self-contained Vehicle	3.63%

	Campground	4.66%
	Free Camping	0.00%
	Hostel	2.59%
	Hotel/Motor Lodge	7.25%
	Other	8.81%
	Selected Multiple	2.59%
	Did not answer	0.52%
Ethnicity	Asian	2.59%
	European	17.62%
	European/Asian	0.52%
	European/ Māori	1.04%
	European/Pacific Peoples	0.52%
	Māori	7.25%
	Māori /Pacific Peoples	0.52%
	Middle Eastern/Latin American/African	3.63%
	New Zealander	35.75%
	New Zealander/European	15.03%
	New Zealander/European/ Māori	2.07%
	New Zealander/European/ Māori /Middle Eastern/Latin American/African	0.52%
	New Zealander/Māori	5.70%
	New Zealander/Māori/Pacific Peoples	0.52%
	North American	0.52%
	Other	3.11%
	Pacific Peoples	1.04%
	South American	1.04%
Did not answer	1.04%	
Travelling Party	Family	31.09%
	Individually	15.54%
	Friends	22.28%
	Partner/Couple	17.10%
	Other	1.55%
	Selected Multiple	11.40%
	Did not answer	1.04%
Education	Some High School	6.22%
	High School Graduate	14.51%
	High School Equivalent	3.63%
	Tertiary/Trade Certificate	13.47%
	Bachelors/University Degree	38.86%
	Postgraduate Qualification	15.54%

	Other	6.74%
	Did not answer	1.04%
Annual Household Income	Less than \$45,000	17.10%
	\$45,001-\$60,000	7.25%
	\$60,001-\$80,000	10.88%
	\$80,001-\$100,000	12.95%
	\$100,001-\$120,000	6.74%
	\$120,001-\$140,000	8.81%
	\$140,001-\$160,000	6.22%
	\$160,001-\$180,000	5.18%
	\$180,001-\$200,000	7.77%
	More than \$200,000	10.88%
	Did not answer	6.22%
	Annual Personal Income	Less than \$45,000
\$45,001-\$60,000		15.54%
\$60,001-\$80,000		15.03%
\$80,001-\$100,000		12.95%
\$100,001-\$120,000		5.70%
\$120,001-\$140,000		2.07%
\$140,001-\$160,000		3.11%
\$160,001-\$180,000		0.52%
\$180,001-\$200,000		1.55%
More than \$200,000		6.22%
Did not answer		7.77%
Influence		0
	1	3.11%
	2	3.63%
	3	11.40%
	4	24.35%
	5	53.89%
	Did not answer	1.55%

B2: Descriptive Statistics – Fiordland National Park

VARIABLE		PERCENTAGES
# of respondents		351
Response rate		76.30%
First Visit	Yes	36.75%
Visit Prior to 2016	Yes	48.43%
Gender	Female	61.54%
	Male	34.76%
	Other	0.00%
	Prefer to not answer	2.28%
Employment Types	Full time	68.38%
	Part time	14.25%
	Retired	3.70%
	Student	3.70%
	Unemployed	0.00%
	Self Employed	1.42%
	Did not answer	2.85%
Trip Decision	Before leaving home	89.17%
	While in the region	3.99%
	En-route	3.99%
	N/A	2.85%
Primary Reason for trip	Business	0.28%
	Visiting friends/relatives	2.28%
	Vacation/pleasure	86.61%
	Hunting/fishing	0.00%
	Exercise	1.99%
	Social Activities	0.85%
	Selected Multiple	1.71%
	Other	5.41%
	N/A	0.85%
Number 1 Reason	Scenery	59.83%
	Boating/Kayaking	2.56%
	Marine Activities	0.85%
	Walk/hiking/tramping	26.50%
	Camping	1.42%
	UNESCO	0.28%
	Wildlife	1.14%
	Cycling	0.28%
	Hunting	0.00%
	Fishing	0.00%
	Tours	1.99%
	Other commercial charters	0.00%
	Other	3.70%
	Did not answer	1.42%
Number 2 Reason	Scenery	22.51%
	Boating/Kayaking	7.12%
	Marine Activities	3.70%
	Walk/hiking/tramping	22.79%

	Camping	3.13%
	UNESCO	4.27%
	Wildlife	17.66%
	Cycling	0.85%
	Hunting	0.28%
	Fishing	1.42%
	Tours	10.26%
	Other commercial charters	0.00%
	Other	1.42%
	Did not answer	4.56%
Number 3 Reason	Scenery	9.12%
	Boating/Kayaking	7.41%
	Marine Activities	3.99%
	Walk/hiking/tramping	13.11%
	Camping	6.27%
	UNESCO	5.98%
	Wildlife	23.36%
	Cycling	3.42%
	Hunting	0.28%
	Fishing	2.28%
	Tours	10.83%
	Other commercial charters	0.00%
	Other	5.70%
	Did not answer	8.26%
Accommodation	AirBnB (home rental)	12.82%
	Beach/Holiday Home	2.85%
	My Home/Personal residence	3.70%
	Campervan/Self-contained Vehicle	12.54%
	Campground	19.94%
	Free Camping	0.28%
	Hostel	7.41%
	Hotel/Motor Lodge	30.20%
	Other	5.98%
	Selected Multiple Options	3.99%
	Did not answer	0.28%
Ethnicity	Asian	3.99%
	European	14.81%
	European/Middle Eastern/Latin American/African	0.28%
	European/Other	0.28%
	Irish	0.57%
	Māori	0.28%
	Māori/Pacific Peoples	0.28%
	Middle Eastern/Latin American/African	1.14%
	New Zealander	54.13%

	New Zealander/Asian	1.14%
	New Zealander/European	10.83%
	New Zealander/European/Asian	0.28%
	New Zealander/European/Māori	0.28%
	New Zealander/European/Other	0.28%
	New Zealander/Māori	3.13%
	New Zealander/Other	1.14%
	New Zealander/Pacific Peoples	0.28%
	Other	3.99%
	Pacific Peoples	0.57%
	N/A	2.28%
Travelling Party	Family	37.61%
	Individually	9.12%
	Friends	7.41%
	Partner/Couple	32.48%
	Other	0.28%
	Multiple	13.11%
Education	Some High School	3.42%
	High School Graduate	5.98%
	High School Equivalent	3.42%
	Tertiary/Trade Certificate	15.38%
	Bachelors/University Degree	39.89%
	Postgraduate Qualification	28.77%
	Did not answer	3.13%
Annual Household Income	Less than \$45,000	10.54%
	\$45,001-\$60,000	6.27%
	\$60,001-\$80,000	9.12%
	\$80,001-\$100,000	15.67%
	\$100,001-\$120,000	9.40%
	\$120,001-\$140,000	5.98%
	\$140,001-\$160,000	8.55%
	\$160,001-\$180,000	5.41%
	\$180,001-\$200,000	10.26%
	More than \$200,000	12.25%
	Did not answer	6.55%
Annual Personal Income	Less than \$45,000	19.09%
	\$45,001-\$60,000	12.82%
	\$60,001-\$80,000	15.95%
	\$80,001-\$100,000	17.95%
	\$100,001-\$120,000	7.98%
	\$120,001-\$140,000	3.99%
	\$140,001-\$160,000	2.85%
	\$160,001-\$180,000	1.99%
	\$180,001-\$200,000	1.99%

	More than \$200,000	3.99%
	Did not answer	11.40%
Influence	0	
	1	
	2	
	3	
	4	
	5	
	Did not answer	

B3: Sociodemographic Relationships with Travel Cost - Coastal Bay of Plenty

	GENDER		AGE		ANNUALHI		EMPLOYD		EDUCD	
	NT	T	NT	T	NT	T	NT	T	NT	T
TCppT2	-0.00517***	-0.00618	-0.00577***	-0.01005	-0.03843***	-0.00714	-0.00501***	-0.0074	-0.00513***	-0.01026
Log likelihood function	-966.57059	-376.76506	-1061.7172	-376.12407	-1394.7129	-377.01178	-966.65925	-377.01453	-967.22516	-376.61459
Chi-squared	33374.6615	3656.88836	32921.3152	3582.46409	32672.8087	3710.20088	33183.926	3716.74553	33711.2406	3672.89442
McFadden Pseudo R-squared	0.9452489	0.8291477	0.9394079	0.8264595	0.9213409	0.8310964	0.9449467	0.8313426	0.9457312	0.8298219
AIC	10.058	3.946	11.044	3.939	14.494	3.948	10.059	3.948	10.065	3.944
Constant	4.79418***	3.661	5.99646***	4.84576	5.63508***	3.26246	5.12751***	3.16617	5.00523***	3.26044
Alpha	3.23087***	5.90697	1.10989***	4.01019	1.04627***	11.2469	3.23278***	12.2124	3.24740***	8.60939
Coefficient	0.30525	0.25197	-0.02368***	-0.01653	.13954D-05**	-.46423D-06	-0.29428	-0.05152	-0.06086	0.34544
CS	\$193.42	\$161.81	\$173.31	\$99.50	\$26.02	\$140.06	\$199.60	\$135.14	\$194.93	\$97.47
Lower CI (2.5%)	\$157.33	\$15.61	\$159.29	\$20.82	\$25.86	\$7.14	\$164.03	\$8.43	\$159.37	\$14.99
Upper CI (2.5%)	\$252.59	-\$19.67	\$189.37	-\$31.46	\$26.18	-\$8.32	\$257.41	-\$8.61	\$251.28	-\$21.90
TCAppT2	-0.00272***	-0.00834***	-0.00273***	-0.00687***	-0.01298***	-0.00641***	-0.00269***	-0.00831***	-0.00274***	-0.00817***
Log likelihood function	-957.79568	-371.86119	-958.01064	-370.87109	-1277.2414	-373.084	-956.98358	-376.02373	-957.92056	-375.27132
Chi-squared	31803.0692	3457.11659	32042.9296	3437.07221	31782.814	3536.61053	32214.7952	3503.20416	32515.6535	3507.94729
McFadden Pseudo R-squared	0.943189	0.8229586	0.9435783	0.8224994	0.9256062	0.8257748	0.9439192	0.823266	0.9443579	0.8237538
AIC	9.967	3.895	9.969	3.885	13.277	3.908	9.958	3.938	9.968	3.93
Constant	4.87877***	5.92334***	5.17571***	6.17740***	5.55817***	6.01805***	5.22224***	6.02180***	5.11961***	5.95369***
Alpha	2.97216***	0.57827	2.97951***	0.60315	1.07042***	0.5861	2.96050***	0.581	2.97554***	0.58878
Coefficient	0.20996	0.11416	-0.0043	-0.01179	.64923D-05***	-.35067D-05	-0.39342	-0.05806	-0.17648	0.05371
CS	\$367.65	\$119.90	\$366.30	\$145.56	\$77.04	\$156.01	\$371.75	\$120.34	\$364.96	\$122.40
Lower CI (2.5%)	\$318.40	\$90.19	\$315.46	\$106.15	\$76.04	\$120.41	\$321.44	\$89.25	\$314.05	\$90.93
Upper CI (2.5%)	\$436.30	\$178.85	\$436.91	\$241.58	\$78.01	\$215.86	\$444.75	\$182.45	\$438.52	\$192.39

***, **, * ==> Significance at 1%, 5%, 10% level.

B4: Sociodemographic Relationships with Travel Cost – Fiordland National Park

	GENDER		AGE		ANNUALHI		EMPLOYD		EDUCD	
	NT	T	NT	T	NT	T	NT	T	NT	T
TCppT2	-.00133***	-.00177***	-.00134***	-.00188***	-.00133***	-.00185***	-.00135***	-.00186***	-.00135***	-.00187***
Log likelihood function	-489.71002	-240.82225	-507.25859	-250.52547	-507.737	-251.032	-507.771	-250.818	-507.771	-251.081
Chi-squared	105.22198	-	100.44152	-	100.7401	-	100.9785	-	100.9785	-
McFadden Pseudo R-squared	0.0970108	-	0.0900854	-	0.090252	-	0.09044	-	0.09044	-
AIC	2.904	1.44	2.913	1.45	2.916	1.453	2.916	1.452	2.916	1.453
Constant	.43715***	1.05580***	0.19834	.87303***	.49787**	1.13810***	.45541**	1.16049***	.45541**	1.12124***
Alpha	1.21357***	.21524D-04	1.12060***	.24233D-04	1.12618***	.29082D-04	1.12768***	.22538D-04	1.12768***	.24492D-04
Coefficient	0.02054	0.10269	0.00604	0.00504	-.33829D-06	-.43177D-06	0.00675	-0.0996	0.00675	-0.03786
CS	\$751.88	\$564.97	\$746.27	\$531.91	\$751.88	\$540.54	\$740.74	\$537.63	\$740.74	\$534.76
Lower CI (2.5%)	\$509.45	\$407.59	\$510.51	\$391.58	\$517.75	\$406.71	\$519.18	\$397.83	\$519.18	\$396.47
Upper CI (2.5%)	\$1,462.16	\$910.60	\$1,277.75	\$809.91	\$1,457.79	\$882.84	\$1,352.27	\$825.12	\$1,352.27	\$834.03
TCAppT2	-.00022***	-.00066***	-.00024***	-.00070***	-.00023***	-.00070***	-.00024***	-.00069***	-.00022***	-.00069***
Log likelihood function	-493.95309	-242.47074	-511.76036	-252.2968	-512.349	-252.5	-512.398	-253.016	-511.492	-252.998
Chi-squared	102.86548	-	96.14406	-	98.40948	-	98.42093	-	96.728	-
McFadden Pseudo R-squared	0.0943052	-	0.0858686	-	0.087623	-	0.087624	-	0.086387	-
AIC	2.929	1.45	2.939	1.46	2.942	1.462	2.942	1.464	2.937	1.464
Constant	.32871**	1.14469***	0.03389	.92118***	.39043**	1.14952***	.30150*	1.18215***	.54927**	1.19177***
Alpha	1.26129***	0.19781	1.15679***	0.18052	1.17120***	0.18644	1.17064***	0.1863	1.15907***	0.18551
Coefficient	-0.04506	0.10531	0.00694	0.00589	-.53197D-06	-.30687D-06	0.04487	-0.01136	-0.2779	-0.0234
CS	\$4,545.45	\$1,515.15	\$4,166.67	\$1,428.57	\$4,347.83	\$1,428.57	\$4,166.67	\$1,449.28	\$4,545.45	\$1,449.28
Lower CI (2.5%)	\$3,297.01	\$1,252.13	\$3,119.91	\$1,188.11	\$3,207.59	\$1,188.62	\$3,129.15	\$1,197.79	\$3,222.51	\$1,202.34
Upper CI (2.5%)	\$7,265.65	\$1,882.07	\$6,394.72	\$1,788.22	\$6,684.18	\$1,766.04	\$6,668.04	\$1,770.10	\$7,415.65	\$1,797.34

***, **, * ==> Significance at 1%, 5%, 10% levels

B5: Summary of consumer surplus (CS, per person/trip) results from studies looking at coastal recreation using the individual travel cost method (ITCM), sometimes combined with contingent behaviour (CB)

Authors	Year	Type of Site	Location	Type of TCM	CS pp/trip
Börger, T., Campbell, D., White, M. P., Elliott, L. R., Fleming, L. E., Garrett, J. K., . . . Taylor, T.	2021	Blue space (coastal)	International, Europe	ITCM/CB	€41.32 for TC model Improved water quality: €129.25 per adult/year Worse water quality: €403.57 lost per adult/year
Houngbeme, D. J.-L., Igue, C. B., & Cloquet, I.	2020	Beach	Benin, West Africa	ITCM	USD 0.87-1.11
Hynes, S., & Greene, W.	2016	Beach/ walking track	Galway Bay, Ireland	ITCM/CB	\$27.21-\$59.21
Kipperberg, G., Onozaka, Y., Bui, L. T., Lohaugen, M., Refsdal, G., & Sæland, S.	2019	Beach/ Recreation area	Rogaland County, Norway	ITCM/CB	For Dalsnuten - Current conditions: NOK 78.45; wind scenario: NOK 61.77. For Sola/Orre - Current conditions: NOK 134.89; wind scenario: NOK 77.87
Prayaga, P., Rolfe, J., & Stoeckl, N.	2010	Fishing	Capricorn Coast, Queensland, Australia	ITCM/CB	AUD 166.82
Rolfe, J., & Dyack, B.	2011	Estuary	Coorong, Australia	ITCM/CB	AUD 242.08 (AUD 186.97 - 328.41)
Sohngen, B., Lichtkoppler, F., & Bielen, M.	1999	Beach	Lake Erie, Ohio, USA	TCM	USD 22 - 62
Voltaire, L., & Koutchade, O. P.	2020	Beach	Catalonia, Spain	ITCM/CB	Accounting for unobserved heterogeneity in trip preferences: R €18.22-18.81, T €63.49-89.76. Accounting for on-site sampling bias: R €9.01-11.54, T €74.66-80.23 (R=residents, T=tourists)
Windle, J., & Rolfe, J.	2013	Beach	Brisbane, AUS	ITCM	Day trips: AUD 40.05-89.60. Overnight trips: AUD 212.63-234.14
Zambrano-Monserrate, M. A., Silva-Zambrano, C. A., & Ruano, M. A.	2018	Beach	Villamil Beach National Recreation	ITCM	USD 16.95-21.73

			Area, Guayas, Ecuador		
Zhang, F., Wang, X. H., Nunes, P. A. L. D., & Ma, C	2015	Beach	Gold Coast, Australia	ITCM	AUD 19.47

B6: Summary of consumer surplus (CS, per person/trip) results from similar studies using the individual travel cost method (ITCM).

Authors	Year	Type of Site	Location	Type of TCM	Sampling Method	CS pp/trip
Alberini, A., & Longo, A.	2006	UNESCO	Armenia	ITCM/CB	On-site	AMD 13,850-22,000
Bowker, J. M., English, D., Bergstrom, J. C., & Starbuck, C. M.	2005	National Park - Forest	United States of America	ITCM	On-site	US\$98.82
Clough, P. W. J., & Meister, A. D.	1991	National Park - Ski Field	Whakapapa, New Zealand	ITCM	On-site	NZD\$174 (winter) and NZD\$147 (summer)
Han, S.-H., Byun, W.-H., Lee, T. J., & Lee, C.-K.	2013	UNESCO	Hahoe Heritage Village, South Korea	ZTCM	On-site	USD 11.56-61.46
Martínez-Espiñeira, R., & Amoako-Tuffour, J.	2009	UNESCO	Gros Morne National Park, Canada	ITCM	On-site	CAN\$ 1135-2528
Mayer, M., & Woltering, M.	2018	National Park	Germany	ZTCM	On-site	lower-limit values vary from €2.4-€15.7, upper-limit values lie between €3.3-€23.3
Poor, P. J., & Smith, J. M	2004	UNESCO	Historic St. Mary's City, Maryland, USA	ZTCM	On-site	\$19.26, \$9.93, and \$8.00, for the linear, semi-log and log-log models, respectively.
Torres-Ortega, S., Pérez-Álvarez, R., Diaz-Simal, P., de Luis, J., & Piña-García, F.	2018	UNESCO	Cantabria, Spain	ITCM and ZTCM	On-site	€27.16- €38.77
Voke, M., Fairley, I., Willis, M., & Masters, I.	2013	National Park	Pembrokeshire National Park, UK	ITCM	On-site	£148.39
Voltaire, L., Lévi, L., Alban, F., & Boncoeur, J.	2017	UNESCO	Mount-Saint-Michel, France	ZTCM	On-site	SP-D visitors was €136 SPM and €142 RPPM. Domestic visitors CS was €278 SPM and €281 RPPM.

B7: Landings (kg) and Port Landing Value (PLV) (NZD 2019) for FMA5 and SA032 for years 2015 to 2019. The percent of FMA5 that SA032 is for each year is presented to demonstrate that it is not a statistically significant commercial fishing area for the management area.

Year	FMA5 Landings	SA032 Landings	% SA032 Landings	FMA5 PLV (NZD 2019)	SA032 PLV (NZD 2019)	% SA032 PLV
2015	36797327	279629	0.76	\$36,582,591.3	\$646,748.13	1.77
2016	38652667	282590	0.73	\$37,838,676.2	\$623,953.49	1.65
2017	35268911	423922	1.20	\$31,199,630.5	\$1,005,196.95	3.22
2018	36749402	423008	1.15	\$35,391,773.5	\$999,108.68	2.82
2019	51125756	293449	0.57	\$86,721,187.2	\$5,391,943.59	6.22

Source: Fisheries New Zealand (2020d)

C: Statements of Contribution



GRADUATE
RESEARCH
SCHOOL

STATEMENT OF CONTRIBUTION DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

We, the student and the student's main supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the student's contribution as indicated below in the Statement of Originality.

Student name:	Alexandra Egan
Name and title of main supervisor:	Professor B. Louise Chilvers
In which chapter is the manuscript/published work?	Chapter 4
What percentage of the manuscript/published work was contributed by the student?	90%
Describe the contribution that the student has made to the manuscript/published work: The student was responsible for the methodology, formal analysis, investigation, data curation, and the writing – original draft preparation. The student was also responsible for responding to reviewers.	
Please select one of the following three options:	
<input checked="" type="radio"/>	The manuscript/published work is published or in press Please provide the full reference of the research output: Egan, A. L., Chilvers, B. L., & Cassells, S. (2021). Does size matter? The direct economic costs associated with the MV Rena oil spill. Marine Pollution Bulletin, 173, 112978. doi: https://doi.org/10.1016/j.marpolbul.2021.112978
<input type="radio"/>	The manuscript is currently under review for publication Please provide the name of the journal:
<input type="radio"/>	It is intended that the manuscript will be published, but it has not yet been submitted to a journal
Student's signature:	Alexandra Egan Digitally signed by Alexandra Egan Date: 2022.10.04 18:29:58 -04'00'
Main supervisor's signature:	Barbara Louise Chilvers Digitally signed by Barbara Louise Chilvers DN: cn=Barbara Louise Chilvers, o=MZ, ou=Massey University, email=barb@lucy@massey.ac.nz, c=New Zealand Date: 2022.10.04 12:42:36 +12'00'

This form should be placed at the beginning of each relevant thesis chapter.

STATEMENT OF CONTRIBUTION DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

We, the student and the student's main supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the student's contribution as indicated below in the Statement of Originality.

Student name:	Alexandra Egan				
Name and title of main supervisor:	Professor B. Louise Chilvers				
In which chapter is the manuscript/published work?	Chapter 6				
What percentage of the manuscript/published work was contributed by the student?	85%				
Describe the contribution that the student has made to the manuscript/published work: The student was responsible for conceptualization, methodology, software, formal analysis, investigation, data collection, writing – original draft preparation, visualization, and funding acquisition.					
Please select one of the following three options:					
<input type="radio"/>	The manuscript/published work is published or in press Please provide the full reference of the research output:				
<input type="radio"/>	The manuscript is currently under review for publication Please provide the name of the journal:				
<input checked="" type="radio"/>	It is intended that the manuscript will be published, but it has not yet been submitted to a journal				
Student's signature:	Alexandra Egan	Digitally signed by Alexandra Egan Date: 2022.10.04 18:31:59 -0400'	Main supervisor's signature:	Barbara Louise Chilvers	Digitally signed by Barbara Louise Chilvers DN: cn=Barbara Louise Chilvers, ou=Massey University, ou=Wellington, ou=School of Veterinary Science, email=barbaral@massey.ac.nz, date=2022.10.04 13:48:17 +1200'
<i>This form should be placed at the beginning of each relevant thesis chapter.</i>					

STATEMENT OF CONTRIBUTION DOCTORATE WITH PUBLICATIONS/MANUSCRIPTS

We, the student and the student's main supervisor, certify that all co-authors have consented to their work being included in the thesis and they have accepted the student's contribution as indicated below in the Statement of Originality.

Student name:	Alexandra Egan
Name and title of main supervisor:	Professor B. Louise Chilvers
In which chapter is the manuscript/published work?	Chapter 7
What percentage of the manuscript/published work was contributed by the student?	90%

Describe the contribution that the student has made to the manuscript/published work:
The student was responsible for the methodology, formal analysis, investigation, data curation, and the writing – original draft preparation.

Please select one of the following three options:

The manuscript/published work is published or in press
Please provide the full reference of the research output:

The manuscript is currently under review for publication
Please provide the name of the journal:

It is intended that the manuscript will be published, but it has not yet been submitted to a journal

Student's signature:	Alexandra Egan	Main supervisor's signature:	Barbara Louise Chilvers
	<small>Digitally signed by Alexandra Egan Date: 2022.10.04 18:33:04 +04'00'</small>		<small>Digitally signed by Barbara Louise Chilvers DN: cn=Barbara Louise Chilvers, ou=Vet, o=Massey University, email=barbaral@massey.ac.nz, postalCode=4113, c=NZ Date: 2022.10.04 12:43:22 +1200</small>

This form should be placed at the beginning of each relevant thesis chapter.

Wednesday, March 8, 2023 at 09:19:32 Eastern Standard Time

Subject: Re: Permission to use an image in thesis
Date: Wednesday, 8 March 2023 at 9:18:45 AM Eastern Standard Time
From: Alexandra Egan
To: Edward White
Attachments: image420561.png, image120961.png

Thank you! Just to reiterate for both our records, here is my information.

Name: Alexandra L. Egan
Degree: PhD in Veterinary Science, Massey University, New Zealand
Topic: Direct economic losses of oil spills in populated and remote locations within New Zealand.
Figure requested: Figure 5: The complete model from the *Tiered preparedness and response good practice guidelines*.
Will be reproduced in my PhD thesis (title is topic), on page 14.

Thank you again for responding so promptly,
Alexandra

From: Edward White [REDACTED]
Date: Wednesday, 8 March 2023 at 6:38 AM
To: Alexandra Egan [REDACTED]
Subject: FW: Permission to use an image in thesis

Hi Alexandra,

Yes you can use Figure 5: The Complete Model from the *Tiered preparedness and response good practice guidelines* in your PhD thesis.

Kind regards,

Edward

Edward White
Communications Manager

From: Segall, Alex [REDACTED]
Sent: 08 March 2023 11:14
To: Edward White [REDACTED]
Subject: FW: Permission to use an image in thesis

Hi Edward,

Please see the below email: a PhD student would like permission to reproduce a figure from a joint IOGP-Ipieca Report. In the front matter to this document, it's stated that any reproduction permission needs to be sought from Ipieca rather than IOGP.

I'll leave this with you.

Regards,

Page 1 of 2