Understanding the Economics of Squid Jigging in New Zealand Waters

New Zealand

Final Report

February 2019

asia pacific

About MRAG Asia Pacific

MRAG Asia Pacific is an independent fisheries and aquatic resource consulting company dedicated to the sustainable use of natural resources through sound, integrated management practices and policies. We are part of the global MRAG group with sister companies in Europe, North America and the Asia Pacific.

2/29 Woodstock Rd Toowong Qld 4066 Australia	PO Box 732 Toowong Qld 4066 Australia	P: +61 7 3371 1500 F: +61 7 3100 8035 E: info@mragasiapacific.com.au

Acknowledgements

This study is the product of contributions from a large number of people and the collection of data and information across multiple sources and agencies. Thanks in particular go to the staff at MPI (most notably John Moriarty, Susannah Barham, Tiffany Bock and Matthew Baird) who responded to numerous data requests and Solander for providing a comprehensive library of historical records.

Executive summary

BACKGROUND

The squid jig fishery in New Zealand was developed by Japanese vessels during the late 1960s in order to supplement poor catches being experienced in their own waters. The fishery grew steadily such that during the 1980s up to 204 foreign squid jig vessels were operating annually in New Zealand waters (60-90% of which were Japanese). However, in the late 1990s vessel numbers decreased rapidly and have not returned to the fishery since. Since 2006/07, no more than five vessels have operated in the fishery in any year resulting in annual catches being less than 5% of the TACC. This is despite a gear specific portion of the squid Total Allowable Commercial Catch (TACC) being reserved exclusively for squid jig harvesting, and the continuing operation of a seemingly profitable trawl fishery targeting squid. With that background, Ministry for Primary Industries: Fisheries New Zealand (MPI) commissioned MRAG Asia Pacific to quantitatively assess the underlying economics of squid jigging in New Zealand in order to understand why there has been minimal activity in the jig fishery.

METHODOLOGY

This study was informed by a combination of literature review, stakeholder consultation (both on-site and remote) and economic analysis.

A country visit to New Zealand was undertaken between 3rd and 7th September 2018 and included on-site consultations with industry and government representatives in Wellington, Nelson and Auckland. Key outcomes from the inception meeting with MPI were that:

- The main focus of the study should be to examine the economic viability of squid jigging in New Zealand waters;
- The analysis should be undertaken from the perspective of an investor seeking to enter the fishery through outright purchase of a small or large vessel;
    - Small vessels should have ability to operate in coastal areas;
    - Large vessels should have the potential to operate throughout New Zealand's EEZ;
    - Outright purchase assumes that the vessel is not debt-financed and that it will be an asset held by a New Zealand company (not chartered from other companies);
- The analysis should be focused on operations in the New Zealand squid jig fishery only (rather than considering the economic implications of participation in other fisheries); and
- To the extent possible, the analysis should compare inputs and values with other major squid jig fisheries around the world.

The economic analysis was conducted using a standard cost benefit analysis framework with the squid jig vessel as the proposed investment.

POTENTIAL DRIVERS BEHIND INITIAL FISHERY DECLINE

Our research indicates the initial decline of the jig fishery in the mid-1990s was driven by a combination of factors. At that time, the foreign jigging fleet was dominated by Japanese vessels, operating in New Zealand for a relatively short season (between Dec – Apr/May) as part of an annual fishing plan that involved multiple fishing grounds. In the mid-1990s, a major economic recession in Japan led to Japanese vessels withdrawing from squid fisheries globally, including New Zealand. Around the same time, other squid jig fisheries in the Eastern Pacific Ocean and the Southwest Atlantic were developing or maturing, offering considerably higher catch rates than New Zealand. Newer Chinese and Taiwanese vessels entering the global jig fleet preferentially focused on these fisheries, meaning there was little demand to access New Zealand resources once the Japanese vessels had departed.

LEGISLATIVE ENVIRONMENT AND RECENT HISTORY

Arrow squid (encompassing two related species *Nototodarus gouldi* and *Nototodarus sloanii)* were introduced into the quota management system (QMS) in 1987 with quota management areas (QMAs) set based on a combination of fishing method and geographical area. TACCs are agreed annually, with a gear-specific allocation (SQU1J) set aside for exclusive use by jiggers.

In the early-2000s, catches from a number of alternative foreign squid fisheries declined, making the New Zealand fishery more commercially attractive and leading to a brief period of renewed interest in the fishery by Japanese companies. However, anecdotal evidence suggests a number of regulatory changes (including immigration and food safety changes) served to make the business operating environment more challenging and ultimately contributed to ongoing limited uptake of available jigging quota.

In more recent years, a key change to the operating environment has been the introduction of the *Fisheries (Foreign Charter Vessels and Other Matters) Amendment Act 2014* which requires all fishing vessels operating in New Zealand waters be flagged to New Zealand (unless exempted). This new measure effectively prohibits the dominant business model responsible for the substantial majority of catch across the history of the jig fishery (i.e. chartering of foreign-owned vessels). The reflagging requirement also presents a range of other actual or perceived barriers to foreign companies entering the fishery (e.g. minimum wage requirements for foreign crew, administrative processes associated with reflagging, etc) which are likely to result in low levels of quota usage by foreign companies.

ECONOMIC ANALYSIS

Results from the economic analysis of squid jigging exclusively in New Zealand waters under the current regulatory framework and market conditions were not favourable. Vessel profitability was measured through both standard profit/loss assessments and net present value (NPV) analysis (assuming an investor was seeking at least 10% return on investment). Both small-scale and large-scale vessels are expected to generate negative returns against both measures. As a result, the base case model estimates that return on investments (ROI) would be negative. These results are summarised in the table below:

	Small scale (NZ$)	Large scale (NZ$)
Standard Profit/loss	-1.106 million	-8.667 million
NPV	-3.620 million	-19.982 million
ROI	-2.5%	-4.0%

Notwithstanding that, the modelling indicated that annual revenue from jigging activities is expected to surpass annual *variable* costs (just not by enough to cover *fixed* costs as well). In practice, this means squid jigging in New Zealand offers some potential to form a profitable part of an annual fishing plan for a migratory vessel, where participation in other ‘primary’ fisheries cover at least the fixed costs of a vessel.

A range of scenarios were assessed to test the sensitivity of results to alternative policy, operational and economic settings (similar to those likely to be found in other major squid jig fisheries globally). A number of these generated more profitable outcomes, however very few of the scenarios are likely to be plausible in New Zealand. This is due a combination of both biological constraints and the current regulatory environment. The real value in testing these scenarios was in understanding the profitability of squid jigging in New Zealand in the context of alternative fisheries. This provides an important insight into the relative commercial attractiveness of the New Zealand fishery and helps explain the very low level of participation amongst vessels capable of accessing multiple fisheries.

Finally, to examine whether jigging could be undertaken profitably as part of a multi-gear operation, a mixed jig/longline operation was considered (consultation with industry suggested this was the most plausible combination). While the economics of longline fishing were not investigated in detail, threshold analysis was conducted to understand the annual value this secondary operation would need to generate to justify the vessel investment. In order to achieve a 10% ROI, our results indicate that additional present values of NZ$3.62 million and NZ$19.98 million would need to be generated by small and large vessels respectively. In practice, this means that after-tax revenues from longline operations would need to be 245% more valuable than jigging for small vessels and 492% for large vessels. Without detailed knowledge of the longline sector, it is not possible to comment on the likelihood of achieving such high revenues. Nevertheless, if such revenues were possible, it's not clear why a vessel would invest in the less profitable squid jigging sector.

CONCLUSIONS

Overall, the analysis concluded that squid jigging in New Zealand waters, under the current market and regulatory environment, is not viable. Biological limitations such as stock abundance and short season lengths mean that squid jigging in New Zealand is unlikely to be viable as an exclusive (domestic) operation under current market conditions, while the current regulatory framework, in particular the requirement for New Zealand vessel registration, prohibits the business model responsible for the overwhelming majority of historical catch in the fishery (i.e. by foreign chartered vessels operating in New Zealand as part of a seasonal annual fishing plan).

Consultation with foreign fleet owners indicated that when catches in major foreign fisheries are poor, which leads to high prices and makes New Zealand catch rates more attractive (as is currently the case), New Zealand would be considered a reasonable alternative (particularly as a secondary option in the off-season of the main fishery). However, even under economically 'optimal' conditions, practical interest in the fishery is limited because of administrative and economic implications associated with the current regulatory framework. While changes in the regulatory framework may lead to increased foreign interest in the New Zealand fishery, any such change would need to be weighed very carefully against the body of considerations which led to the establishment of the current regulatory framework in the first place (e.g. labour abuses on foreign vessels).

If a choice was made by an investor to jig exclusively in New Zealand waters, it appears the fishery is better suited to small scale vessels. This is because catch rates for large scale vessels do not increase at the same rate as their capital and operational costs. Nevertheless, all modelled measures of economic performance for both small and large vessels (i.e. profit and loss, NPV and ROI) are negative, indicating that neither operation would be viable in the current operating environment.

Contents

Figures

Tables

1 Introduction

Squid jigging is a specialised form of fishing that exclusively targets squid and other cephalopod species. Over several hundred years it has developed from small-scale hand line to large-scale automated methods (Arkhipkin et al., 2015). The specialised components unique to this gear type are the hook/jig (Figure 1a) which is hauled through blocs (Figure 1b) at alternating speeds to create sporadic movement through the water column. Larger-scale, automated operations can have up to 120 machines running concurrently (Figure 1c). Squid are drawn off the seabed and attracted to the jigs as they pass through bright lights shone into the water from the vessel. The need to use lights restricts efficient operations to depths through which light can effectively pass; typically between 150-200m (Industry Representatives, pers. comm., September 2018).

Figure 1: a) Squid jig (Sharnbrook Tackle, 2018); b) Automated hauling blocs (PRO Japan, 2016); c) Large scale squid jig vessel (Yates, 2005).

In the past, a substantial squid jig fishery existed in New Zealand waters. However, vessel numbers rapidly decreased by the late 1990s and have not returned to the fishery since. This is despite a portion of the squid Total Allowable Commercial Catch (TACC) being reserved exclusively for squid jig harvesting.

Despite the departure of squid jig vessels from New Zealand waters, the squid trawling fishery remains active. The underlying economics of jigging in New Zealand has been often been cited by industry as the reason for the lack of squid jigging effort, however, there were no obvious changes to the fishery which would have intuitively led to the sudden and sustained departure of vessels around 1997. Since 2006/07, no more than five vessels have operated in the fishery in a given year resulting in annual catches being less than 5% of the TACC. With that background, Ministry for Primary Industries: Fisheries New Zealand (MPI) commissioned MRAG Asia Pacific to quantitively assess the underlying economics of squid jigging in New Zealand to examine viability and help understand why there has been minimal uptake of quota.

This report is structured around four main sections. Following this introduction, section 2 outlines the methodology used for this study and section 3 presents the methodology outcomes (both qualitative and quantitative). Finally, section 4 discusses the implications from the economic analysis and the likelihood of a squid jig fishery in New Zealand under the status quo.

2 Methodology

Broadly, this study was informed through a combination of literature review, stakeholder consultation (both on-site and remotely) and economic analysis. The following sections outline the process undertaken.

2.1 Consultation process

A range of stakeholders were consulted for the study, largely during a country visit to New Zealand undertaken between 3rd and 7th September 2018. The process commenced with an inception meeting with MPI (Tiffany Bock, Team Manager Deepwater Fisheries; Matthew Baird, Policy Analyst) to ensure there was agreement by all parties on the scope and purpose of the study. Following this, consultations with stakeholders took place in Wellington, Nelson and Auckland. Representatives from the following organisations were consulted:

- MPI;
- Sustainable Fisheries Partnership;
- Resource Wise;
- Solander;
- Talleys Group Limited;
- Sealord International;
- Maruha Nichiro;
- Forestry and Bird; and
- WWF New Zealand.

2.2 Defining the scope

Details of the scope of the study were agreed with MPI at the inception meeting. Key outcomes included:

- The main focus of the study should be to examine the economic viability of squid jigging in New Zealand waters;
- The analysis should be undertaken from the perspective of an investor seeking to enter the fishery through outright purchase of a small or large vessel;
    - Small vessels should have ability to operate in coastal areas;
    - Large vessels should have the potential to operate throughout New Zealand’s EEZ;
    - Outright purchase assumes that the vessel is not debt-financed and that it will be an asset held by a New Zealand company (not chartered from other companies);

- The analysis should be focused on operations in the New Zealand squid jig fishery only (rather than considering the economic implications of participation in other fisheries); and
- To the extent possible, the analysis should compare inputs and values with other major squid jig fisheries around the world.
-

While the main focus of the study was to examine the economic viability question, other key tasks (which would help provide context to the economic viability discussions) included:

- Identifying the major squid jig fisheries around the world;
- Describing the history and current state of play for the squid jig fishery in New Zealand;
- Identifying, if possible, why squid jig vessels suddenly departed the fishery after 1997; and
- Summarising the operational and regulatory environment for squid jigging in New Zealand.

2.3 Quantitative analysis method

The quantitative economic analysis was conducted using a standard cost-benefit analysis (CBA) framework. Through this approach, three different output values were derived:

- Standard profit/loss over a 10-year period;
- Net Present Value (NPV); and
- Return on Investment (ROI)

The standard profit/loss analysis took all costs and benefits after tax (net income) and summed them over a 10-year period. The purpose of this output was to provide a simple profitability statement irrespective of discounted cash flows which provide comparisons with alternative options.

NPV analysis was then employed because it provides an output which goes beyond just simple profit/loss statements. While profit/loss statements will tell an investor if a project will make money or not, NPV will indicate how an investment will compare against alternative investments by assuming a benchmark ROI is to be achieved.

For example, suppose an investment of $10,000 is made and one year later it has generated revenues of $10,100. Whilst the investment has made a profit of $100, it has only produced an ROI of 1% (i.e. 100÷10,000 = 0.01 or 1%). This would be inadequate to an investor expecting an ROI of at least 6% (for example). Therefore, if an investor could find a project that provided a profit of at least $600, then they would choose that over the one that only provides $100.

NPV analysis uses this expected ROI and includes it as part of the NPV formula to tell the analyst if the investment will at least meet this benchmark. It is calculated through the following formula:

$$NPV = \left(\sum_{t=0}^{n} \frac{(B_t + C_t)}{(1+r)^t} \right)$$

where B is the benefit at time t (annually in this case), C is the cost which is always less than zero (C < 0) and r is the discount rate or expected ROI (r > 0). Essentially, the result of an NPV analysis is the sum of all the cash flows (whether negative or positive) from each year in the analysis after they have been discounted. The denominator $(1+r)^t$ is known as the discount factor.

The impact of discounting can be seen in Table 1. In this example we have assumed *r* is equal to 15%. Note that after making an initial investment of $20 at Year 0, the total standard profit from the cash flows is $8 (seen in the final column of row 1). However, once the cash flows have been discounted (according to row 2), the sum of the discounted cash flows is now $0 (see in row 3). This sum of $0 is the investment NPV and shows that not only does the investment produce a profit of $8, but also that it meets the investor benchmark ROI of 15%.

Table 1: An example of cash flows and the impact of the discount factor (r = 15%)

Year (t)	**0**	**1**	**2**	**3**	**4**	**Sum (Profit/loss)**
1) Cash Flow $(B_t + C_t)$	-$20	$7	$7	$7	$7	$8
2) Discount Factor $(1 + r)^t$	1.00	1.15	1.32	1.52	1.75	
3) Discounted Cash Flow	-$20	$6	$5	$5	$4	$0

3 Study outcomes

3.1 Major squid jigging fisheries around the world

Squid is a generic common name used to identify a range of cephalopod species. These species tend to be spatially discrete. For example, *Illex argentinus* is found the in the Southwest Atlantic around Argentina and the Falkland Islands; *Dosidicus gigas* is found in the Eastern Pacific off the western coast of the both Americas; *Todarodes pacificus* is found in the Northwest Pacific around Japan, Korea, and China; and *Nototodarus sloanii* and *N. gouldi* are found in the Southwest Pacific around Australia and New Zealand.

Details of historic global catches by species can be seen in Table 2. It is worth highlighting that the main species targeted in New Zealand, *N. sloanii,* regularly makes up only ~2-3% of global catches. By contrast, *I. argentinus* and *T. pacificus* together have historically made up 40-50% of global catches. In more recent years, *D. gigas* has become the dominant species by volume (particularly since catches from Southwest Atlantic have substantially declined).

The *I. argentinus* fishery in the Southwest Atlantic was regularly cited during consultation has having a major influence on both global catches and the historic squid jig fishery in New Zealand. As with the *D. gigas* fishery, *I. argentinus* is targeted by vessels from a number of flag States but was dominated by Argentina which typically took a quarter of catches leading up to 2010 (Arkhipkin et al., 2015). However, the dynamics in this fishery appear to be shifting. Larger numbers of Chinese vessels are fishing both Eastern Pacific and Southwest Atlantic squid stocks. This is consistent with consultation and is raised in Harkell (2018).

The likely low-cost operations of this Chinese fleet (and its target fisheries) form much of the comparative basis when analysing the viability of New Zealand squid fisheries (discussed in section 3.4.2). Furthermore, this shift in dominant squid fishing flag States is later described as a likely contributor to the sustained absence from the squid fishery in New Zealand (see section 3.2.2).

Table 2: Global catches (MT) by species 2001 – 2010 (Arkhipkin et al., 2015).

Species	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Nototodarus sloanii	44,862	63,096	57,383	108,437	96,398	89,403	73,921	56,986	47,018	33,413
Todarodes pacificus	528,523	504,438	487,576	447,820	411,644	388,087	429,162	403,722	408,188	357,590
Illex argentinus	750,452	540,414	503,625	178,974	287,590	703,804	955,044	837,935	261,227	189,967
Dosidicus gigas	244,955	412,431	402,045	834,754	779,680	871,359	688,423	895,365	642,855	815,978
Todarodes sagittatus	1,915	3,163	954	594	574	526	1,112	774	980	973
Illex illecebrosus	5,699	5,527	10,583	28,103	13,837	21,619	10,479	20,090	22,912	20,660
Illex coindetii	2,596	2,559	2,006	2,264	5,533	4,650	4,132	4,573	4,349	3,889
Ommastrephes bartramii	23,870	14,947	18,964	11,478	14,430	9,401	22,156	24,400	36,000	16,800
Martialia hyadesi	117	2	37	59	3	0	4	0	4	0
Doryteuthis (Loligo) gahi	76,865	36,411	76,746	42,180	70,721	52,532	59,405	58,545	48,027	71,838
Doryteuthis (Loligo) opalescens	85,829	72,879	39,330	39,596	55,732	49,205	49,447	36,599	92,376	129,936
Doryteuthis (Loligo) pealeii	14,211	16,684	11,929	13,537	16,967	15,899	12,327	11,400	9,293	6,689
Loligo reynaudii	3,373	7,406	7,616	7,306	10,362	6,777	9,948	8,329	10,107	10,068
Loligo forbesii	70	140	536	261	272	472	721	664	455	554
Loligo vulgaris	2	2	2	1	3	5	7	7	6	22
Sepioteuthis lessoniana	5,574	5,826	6,333	5,500	3,811	3,584	3,646	4,528	4,523	4,526
Loliginids	198,893	218,551	261,907	209,894	209,110	202,616	206,861	208,218	216,658	236,499
Onykia (Moroteuthis) ingens					109	22	68	34	87	36
Moroteuthis robusta					5	13	6			
Berryteuthis magister				1,132	1,068	1,084	48,981	54,868	60,639	59,306
Squid not reported by species	230,214	281,935	317,097	303,241	327,225	316,989	337,574	356,864	372,825	430,416
Nototodarus sloanii (%)	2.0%	2.9%	2.6%	4.9%	4.2%	3.3%	2.5%	1.9%	2.1%	1.4%
Todarodes pacificus (%)	23.8%	23.1%	22.1%	20.0%	17.9%	14.2%	14.7%	13.5%	18.2%	15.0%
Illex argentinus (%)	33.8%	24.7%	22.8%	8.0%	12.5%	25.7%	32.8%	28.1%	11.7%	8.0%
Dosidicus gigas (%)	11.0%	18.9%	18.2%	37.3%	33.8%	31.8%	23.6%	30.0%	28.7%	34.2%

3.2 A brief history and description of squid jigging in New Zealand

The development and decline of the squid fishery in New Zealand over a ~30-year period is broadly documented and understood. Standard high-level figures such as total vessel capacity and catch levels through that period are widely available. However, more specific details around exactly who operated these vessels, and the key drivers for their departure, have not been the focus of dedicated study. Outlining the history of the squid jig fishery in New Zealand helps understand the drivers behind both the limited harvest of available squid jig quota in recent years and how larger squid jig fisheries influence activity in the New Zealand fishery.

3.2.1 The New Zealand squid jig fishery leading up to the decline in the 1990s

Historical catch and effort data for squid jigging in New Zealand waters has been found through numerous records that date back as far as the 1970s (e.g. Sealord, 1977). Often the 1990s are discussed as the peak of the fishery, but older documents indicate there were substantial numbers of vessels operating in the fishery (albeit with lower catch rates) prior to this. For example, Table 3 shows that up to 156 squid jig vessels were operating in New Zealand during the 1970s.

Table 3: Squid jig catch and effort data 1972 – 1976 (Sealord, 1977)

Year	1972/73	1973/74	1974/75	1975/76
No: Vessels	71	156	151	128
Total Catch/ Tonnes	13423	14761	18947	19598
Catch/Vessel	189.1	94.6	125.5	153.0
Catch/Boat/Day	3.9	1.5	1.6	1.6

Furthermore, while NZFIA (1991) reported that a limit of 106 vessels was set from 1978, Table 3 and Table 4 indicate that vessel numbers remained constant through the '70s and into the 1981/82 season. This then reportedly continued with up to 204 vessels until 1989 as shown in Table 5.

Table 4: Squid jig catch and effort data 1981/82 (Tyson et al., 1982)

	No. of vessels	Total vessel-days squid caught (total A)	No. of hours fishing	No. of vessel-days squid caught, but no hours given*	Total vessel-days with nil catch (total B)	No. of hours fishing with nil catch	No. of vessel-days with nil catch, but no hours given†	Total catch (t)	Catch (t) per vessel-day
Japan	73	7 232	101 873	32	142	879	0	25 435.3	3.4
Korea	5	556	7 273	57	4	24	0	1 544.1	2.8
Joint venture	58	5 744	71 450	685	26	184	2	17 669.9	3.1
Total	136	13 532	180 596	774	172	1 087	2	44 649.3	3.3

Table 5: Squid jig effort data 1980 – 1989 (NZFIA, 1991)

Year	Domestic	Japan	USSR	Korea	Taiwan	Total
1980		162		12	30	204
1981		91		9	41	141
1982		109		9	51	169
1983		125		16	56	197
1984		120		17	52	189
1985		115		13	38	166
1986		122		11	8	141
1987		116	1	22	4	143
1988		150	1	13		164
1989	1	146	3	22		172

Whilst there are inconsistencies in vessels numbers between the different data sources (e.g. Tyson et al. [1982] report 136 vessels operating in the 1981/82 seasons while NZFIA [1991] reports no less than 141 during the same period), aside from a short dip in catch and effort between 1991 and 1994 (Figure 2), it is clear that in terms of vessel numbers, the fishery peaked long before 1997 and may have already been in decline by then.

3.2.2 The impact of foreign fleets and likely drivers behind the fishery decline between 1990s and early 2000s

Whilst vessel numbers may have already been in decline prior to 1997, it is clear there was a marked decline in catch and effort post 1997 (which does not recover to any comparative levels) (Figure 2). There is little evidence that the biological or environmental factors changed to a degree that would have driven such a reduction in the fishery. Therefore, other factors must have been at play.

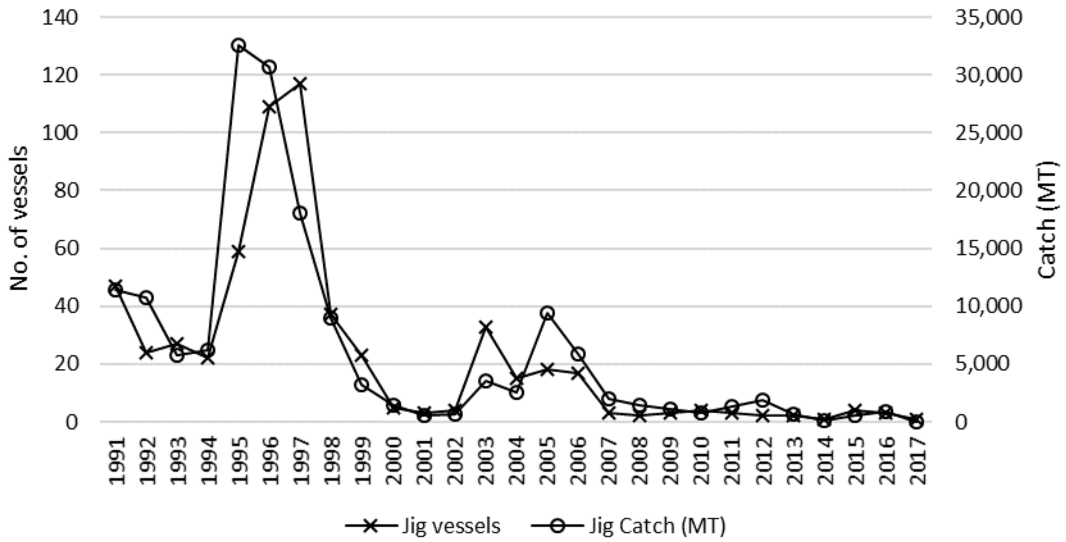


Figure 2: Squid jig catch and effort data 1991 – 2018 (MPI NZ, 2018b)

A review of literature and discussions with industry suggests the main departure from the fishery in 1997 was more likely driven by a complex mix of factors that did not, at least initially, include New Zealand regulations. Given the complexity of the relationships between all factors, it is difficult to attribute the precise level of impact each factor has had on the fishery.

Firstly, it must be recognised that the New Zealand squid fishery (for both trawl and jigging) is seasonal and relatively short. As shown in Table 6, logbook data suggests the season for jiggers runs between December and April/May. This is also validated by reports such as Yamashita and Muta (2003).

Table 6: Effort days for squid jig vessels in New Zealand waters by month; 1990/91 – 2008/09; shading indicates relative frequency through the seasons – green: high; yellow: medium; red: low (MPI NZ, 2018b)[1].

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total Days
1990	0	0	0	0	0	0	0	0	0	0	0	65	
1991	605	851	1,174	545	17	0	0	0	0	0	0	61	3,253
1992	267	394	408	259	57	0	0	0	0	0	0	44	1,429
1993	361	404	320	245	27	0	0	1	0	0	0	46	1,404
1994	184	170	217	183	90	6	5	0	0	0	5	35	895
1995	431	908	1,032	999	208	0	0	0	1	0	0	43	3,622
1996	682	1,634	1,856	1,215	10	0	0	0	1	0	0	243	5,641
1997	1,969	2,569	2,507	1,052	0	0	2	0	1	0	0	42	8,142
1998	448	744	747	579	2	1	1	0	0	0	0	15	2,537
1999	338	520	542	122	0	0	0	0	0	0	0	12	1,534
2000	53	86	82	73	5	0	0	0	0	0	0	0	299
2001	22	46	60	51	18	0	0	0	5	1	0	0	203
2002	49	78	103	69	0	0	0	0	0	0	0	4	303
2003	129	130	147	159	82	3	0	0	0	0	0	18	668
2004	153	155	141	130	78	0	0	0	0	0	0	94	751
2005	336	341	416	483	235	40	0	0	0	0	0	49	1,900
2006	371	440	477	426	42	0	0	0	0	0	0	32	1,788
2007	77	80	79	43	3	0	0	0	0	0	0	15	297
2008	##	##	##	##	##	##	##	##	##	##	##	##	##
2009	42	43	52	61	21	1	0	0	0	0	0	7	227

The season for trawlers is a little more prolonged with squid-targeted sets often recorded throughout the year. Nevertheless, there is a clear peak period between January and June, similar to the jig season (Table 7).

[1] ## has been used to replace figures when there were less than 3 vessels having recorded catch and effort.

Table 7: Squid-targeted sets for trawl vessels in New Zealand waters by month – 1990/91 – 2008/09; shading indicates relative frequency through the seasons – green: high; yellow: medium; red: low (MPI NZ, 2018b).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1990	1,462	2,525	2,370	968	328	171	1	11	10	5	3	162	8,016
1991	2,215	2,775	3,099	1,612	515	215	65	0	2	0	10	240	10,748
1992	12	2,391	2,597	1,937	470	384	29	4	13	2	1	3	7,843
1993	3	2,465	2,971	1,791	481	172	7	24	3	3	1	0	7,921
1994	28	2,581	2,948	2,286	1,562	453	30	9	32	0	2	11	9,942
1995	51	3,074	3,156	2,949	818	371	22	2	73	7	18	30	10,571
1996	136	2,562	3,101	2,839	765	178	2	2	39	45	4	4	9,677
1997	1,604	2,491	2,680	1,750	952	359	12	2	4	35	23	96	10,008
1998	1,698	2,216	1,953	624	695	192	4	1	11	7	23	354	7,778
1999	1,891	1,929	1,626	841	465	69	3	6	19	10	13	719	7,591
2000	920	1,500	1,264	761	647	62	28	15	55	21	56	121	5,450
2001	971	1,818	1,721	1,334	765	220	66	58	69	116	98	209	7,445
2002	1,240	1,786	1,797	1,210	611	243	31	19	32	108	103	85	7,265
2003	1,284	2,172	2,043	1,216	813	304	4	0	0	68	26	188	8,118
2004	1,505	1,764	1,762	1,469	883	370	29	0	8	50	33	294	8,167
2005	1,845	2,322	2,568	1,606	973	401	89	7	15	34	67	220	10,147
2007	1,070	1,229	1,330	941	490	41	33	2	0	5	56	180	5,377
2008	718	1,266	1,169	838	106	27	5	0	6	8	0	66	4,209
2009	572	767	856	804	419	218	154	4	1	0	2	16	3,813

The fact that squid are recorded as the target species in some trawls throughout the year suggests that squid are always present but less abundant outside the peak season. As such, trawlers would be likely making opportunistic sets while targeting other species throughout the off-season.

By contrast, squid jigging is a specialised method of fishing which can only effectively target cephalopods. Although it is technically possible for vessels to refit gear to target different species in New Zealand, industy consultees indicated that would not have been practical. Accordingly, given the need for the vessel to remain efficiently active throughout the year, this meant leaving the fishing grounds to continue jigging elsewhere (Sea Resources Limited, 2011).

The available evidence indicates that foreign jiggers operated in New Zealand as part of an annual fishing plan which sought to maximise the number of productive fishing days. In practice, New Zealand grounds were fished seasonally during the off-season of, or in transit to, their main fishing grounds. Arkhipkin et al. (2015) reported that the squid jig fishery in New Zealand developed in the late 1960s because around that time Japanese vessels needed to increase catches in their off-season to supplement poor catch rates they were experiencing during peak seasons in their own waters (see catches sharply dropping in Figure 3 around 1962/63 and again in 1968/69). Similarly, industry consultees indicated that New Zealand offered an efficient transiting point offering catch opportunities for vessels tracking towards Southwest Atlantic (also confirmed by Hufflet, 1993).

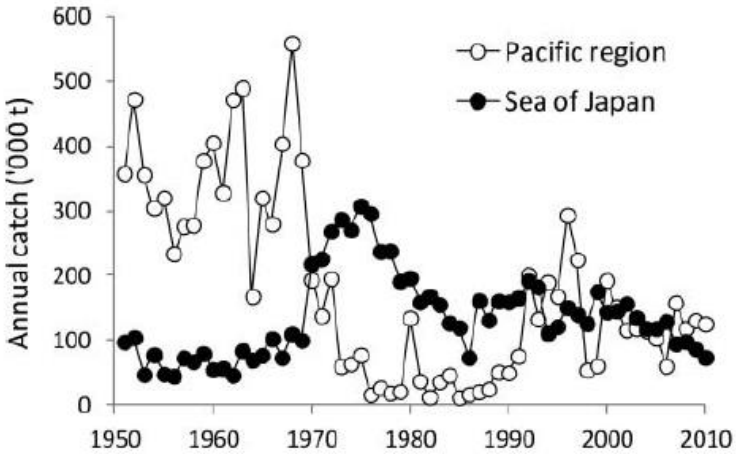


Figure 3: Total annual catch of a common Japanese squid species (Todarodes pacificus) – 1950 – 2010 (Arkhipkin et al., 2015).

Irrespective of the motivations for why the fishery was historically targeted, it is clear from Table 5 that in the lead up to the 1990s, the nation with the most fishing vessels jigging in New Zealand was Japan. During that time, Japanese vessels consistently made up ~60 – 90% of the total vessels operating in the area (e.g. NZFIA, 1991). The strong relationship between jigging in New Zealand and the presence of Japanese-flagged vessels plays an important role in understanding the contributing factors for why the fishery declined in the mid-late 1990s.

At this point, it is worth highlighting that Japanese vessels targeting *T. pacificus* in Japanese waters began experiencing good growth in catch rates by the late 1980s and constantly through the 1990s (Figure 4). Considering lower catch in Japan was the driver to developing the New Zealand squid jig fishery, the improved Japanese domestic catch rates would initially appear to offer an explanation for the mass exit from the New Zealand. However, given the New Zealand squid season is aligned with the Japanese off-season, and now that the fishery and business relationships were established, there was no operational justification for exiting the New Zealand season following a few bumper Japanese seasons. The more likely explanation for the exit from New Zealand waters was due to broader domestic economic factors in Japan. To provide further evidence of this, it was worth investigating the actual drivers behind the increased Japanese catch rates.

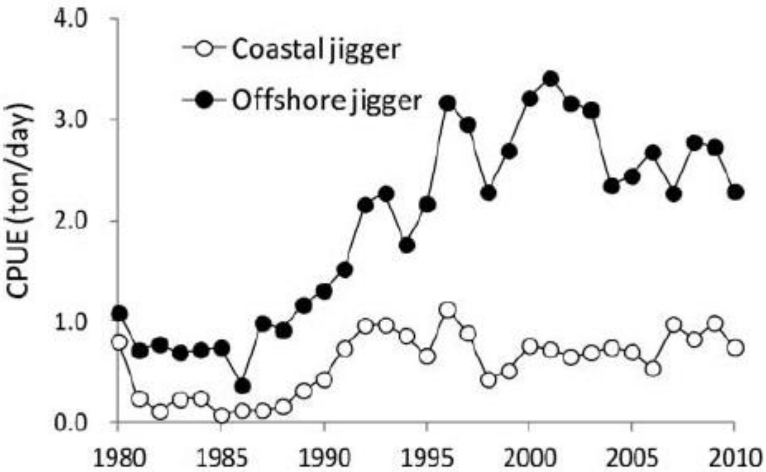
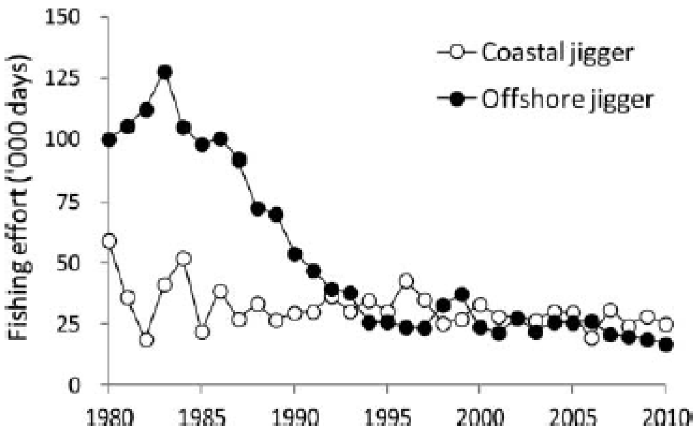


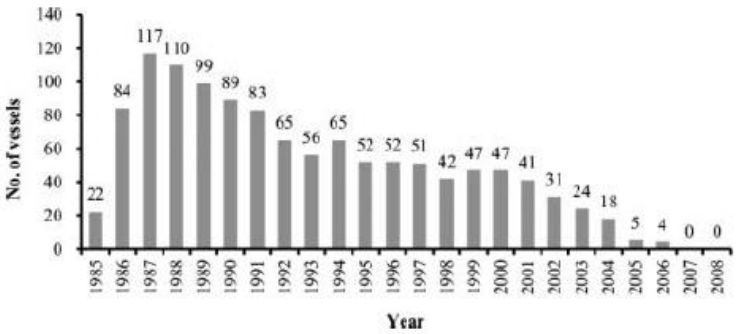
Figure 4: CPUE (tons/day) by year for jigging vessels targeting a common Japanese squid species (Todarodes pacificus) – 1980 – 2010 (Arkhipkin et al., 2015).

Catch per unit of effort (CPUE) is a composite measure of catch rates which consists of both a numerator (catch) and a denominator (effort). From 1980 onwards, total catches of *T. pacificus* across the Pacific region and Sea of Japan decreased (Figure 3), while CPUE for the jigger fleet generally increased (Figure 4). This indicates that the denominator (effort) must be decreasing at a faster rate than the numerator (catch). This decrease in effort by Japanese vessels is evident by 1984 in the Northwest Pacific (Figure 5a) and by 1987 in the Southwest Atlantic (followed by another declined by 2001) (Figure 5b)[2]. This suggests that Japanese vessel numbers decreased globally rather than having specifically only departed the New Zealand fishery.

Through consultation, industry representatives suggested that such a decrease in effort was likely driven by the lead up to, and exacerbated throughout, the Japanese “lost decade” in the 1990s. This period was characterised by a long-lasting recession in Japan where many companies (including fishing companies) were over leveraged and became insolvent following increases in interest rates.



a)



b)

Figure 5: a) Fishing effort days targeting a common Japanese squid species (Todarodes pacificus) in and around Japanese waters – 1980 – 2010; b) Number of Japanese vessels operating in south west Atlantic ocean – 1985 – 2008 (Arkhipkin et al., 2015).

Accordingly, it is likely that the catalyst to the decline in the New Zealand squid jig fishery was driven by external factors and were outside the control of New Zealand entities. It is possible that this was exacerbated by a drop in catches relative to the number of vessel operating in 1997 (Figure 2), but with the exception of that year, trends in catches tended to track trends in vessel numbers.

Nevertheless, whilst broader economic factors were likely behind the initial departure of Japanese vessels from New Zealand waters, this does not explain why other vessels did not move in to replace the lost capacity. Rather, the reasons behind the sustained absence from the fishery are likely to lie

[2] When using vessel numbers as a proxy to effort days.

in a combination of changes in the composition of the global squid jigging fleet, changes in the relative attractiveness of New Zealand compared to alternative squid fishing grounds (noting that New Zealand was typically a secondary fishery for most foreign vessels) and changes to the business environment. In particular, by the mid-1990s, around the time Japanese vessels appeared to be departing squid fisheries globally, catch and CPUE in Southwest Atlantic was beginning to substantially increase (Figure 6). Newer vessels entering the global squid jig fleet from China/Taiwan were likely attracted to the Southwest Atlantic fishery over New Zealand.

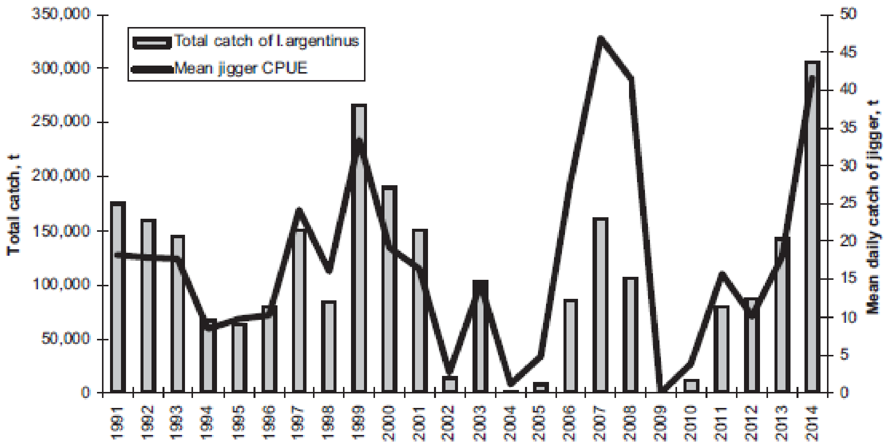


Figure 6: Annual jigger catch in Southwest Atlantic zones: 1991 – 2014 (Arkhipkin et al., 2015).

In addition, industry consultees indicated that by the early 1990s it was becoming increasingly difficult to finalise deals with charter companies. This was largely due to increasing costs associated with management levies impacting charter fees. The prior business relationships that had already been established with Japanese companies helped offset these effects, but it would be logical to conclude that once Japanese vessels had left, commencing new business relationships in this environment could be difficult; especially when New Zealand was no longer the best off-season alternative. Collectively, these trends may explain why new capacity did not move in to fish in New Zealand when the Japanese capacity left.

3.2.3 Foreign fleets and New Zealand regulation during the 2000s

A decline in catches in the Southwest Atlantic during the early-mid 2000s (Figure 6) appears to have coincided with a brief resurgence of catch and effort in New Zealand waters (Figure 2). This also occurred during a time when Japanese entities were re-exploring the economic feasibility of the fishery (e.g. Yamashita and Muta, 2003).

However, newer regulations had begun increasing barriers to entry which reduced the efficiency of chartering foreign vessels. For example, one regulation required what is known as an Approval in Principle (*Immigration Regulation 1997* superseded by *Immigration Act 2009*) where more than six foreign crew were hired for a single vessel (which seems inevitable when chartering a foreign vessel). Communications between New Zealand organisations and government departments indicated that the process often created delays in engaging the foreign vessel. In addition, New Zealand food and safety regulations had become stricter than the Japanese equivalent. These higher standards were reportedly applicable to foreign vessels even if product was never intended to be consumed domestically. The combination of these newer regulations reportedly stunted the redevelopment of the fishery during this period.

3.3 Current fisheries legislation and impacts

The above section discussed some of the developments in legislation through the early 2000s and how these may have influenced the stagnation of the squid jig fishery in the past. However, an understanding of the current legislative environment is an important part of understanding the viability of the squid jig fishery today.

Arrow squid (encompassing two related species *Nototodarus gouldi* and *Nototodarus sloanii)* were introduced into the quota management system (QMS) in 1987 with quota management areas (QMAs) set based on a combination of fishing method and geographical area. Three QMAs were set, two method-specific (SQU 1J and SQU 1T) and one standard QMA (SQU 6T) (MPI NZ, 2016). SQU1J quota allows fishers to jig for squid in all areas other than the Southern Islands (SQU6T) and the Kermadec Area (SQU10T) (see Figure 7), however SQU6T or SQU10T quota may be fished by any method (including jig) (Table 8)[3].

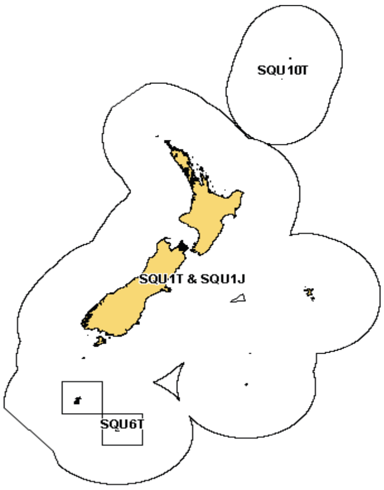


Figure 7: New Zealand waters and fishstock areas relevant to squid

Arrow squid is a Tier 1 fish stock managed under the National Fisheries Plan for Deepwater and Middle-depth Fisheries (National Deepwater Plan). Within the National Deepwater Plan it is classed as a Tier 2 stock. Tier 2 fisheries are typically less valuable bycatch fisheries or are only target fisheries at certain times of the year. SQU 1J is treated as a Tier 2 fish stock because of the low volume of catches (MPI NZ, 2016).

Table 8: Definition of fishing areas by gear for squid

Area	Gear	Fishstock
All New Zealand waters except Southern Islands and Kermadec Areas	All methods	1T
All New Zealand waters except Southern Islands and Kermadec Areas	Jigging	1J
Southern Islands	All methods	6T
Kermadec	All methods	10T

Figure 8 which shows the highest densities of squid jigging effort have historically been around the Northwest and Eastern coasts of the South Island. In relatively high overall effort years, jigging has extended into the Stewart Snares Shelf area, however in low overall effort years jigging in this area has been limited. To that end, it is worth highlighting that the exclusion of 6T and 10T areas from 1J quota does not appear to have been a crucial factor influencing the existence of the squid jig fishery.

[3]It is worth noting there was confusion amongst at least some industry participants around whether jigging could be undertaken in the 6T and 10T areas.

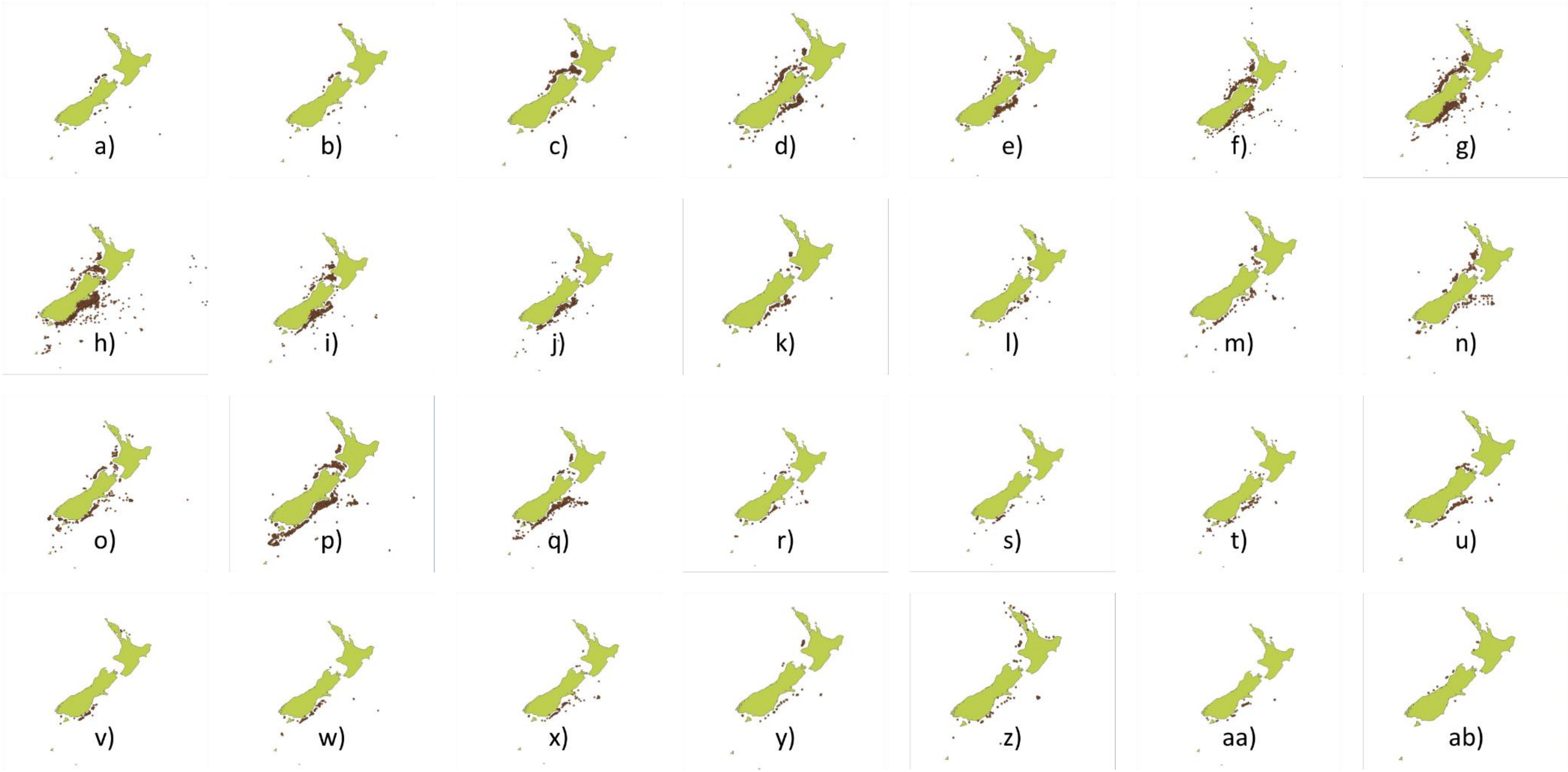


Figure 8: Squid jigging effort by area in New Zealand waters: a) 1990; b) 1991; c) 1992; d) 1993; e) 1994; f) 1995; g) 1996; h) 1997; i) 1998; j) 1999; k) 2000; l) 2001; m) 2002; n) 2003; o) 2004; p) 2005; q) 2006; r) 2007; s) 2008; t) 2009; u) 2010; v) 2011; w) 2012; x) 2013; y) 2014; z) 2015; aa) 2016; and ab) 2017.

Whilst historical catch and effort data shows squid jiggers largely operate above 47°S, it should be noted that trawlers and jiggers have largely operated in different areas, with the majority of trawl effort occurring below 47°S (Figure 9). Water depths within the SQU6T area appear shallow enough (<150m) for jigging operations (Annex 1.2), so there are no apparent depth limitations to squid jigging in that area. Nevertheless, although trawl effort data suggests that the SQU6T area is a commercially viable fishing ground (at least for trawling), jiggers steaming south of Stewart Island face practical and financial risks which influence its commercial attractiveness. These include:

- Safety risks associated with increased exposure to extreme weather given jig vessels are often smaller than other commercial fishing vessels and jigging is a stationary operation;
- Financial risks due to reduced operational efficiency because increased rocking of vessels in that area can shift light beams out of line with the jig lure[4]; and
- Financial risks associated with the longer steam time to Southern Islands locations given jiggers typically have a smaller storage capacity than trawlers operating in the area.

To that end, jigging is likely to occur in this area only when these risks are sufficiently outweighed by attractive catch rates in times of high squid density, or where relatively high levels of jigging density around the South Island push vessels south.

The conclusion that there is at least a perception that waters south of Stewart Island are less prospective for jiggers is consistent with consultation with industry. Furthermore, surveys such as Yamashita and Muta (2003) indicate that the potential benefit of any higher catch rates is offset by their irregularity.

One policy option open to New Zealand to encourage jigging in southern areas may be to alter the nature of the SQU1J quota right to allow use in the SQU6T (and SQU10T) area (i.e. when there are reports of squid around the Southern Islands, jiggers may benefit from being able to fish there with SQU1J quota). This would deal with the potentially limiting constraint of needing access to SQU6T quota, however our understanding is that making this work commercially would likely require a ‘critical mass’ of vessels to access the area in order to efficiently locate (and share knowledge of) commercial densities of squid (which may not be achieved with small numbers of participants). It is also worth noting that constraints around SQU6T quota was not raised by consultees as a contributing reason for the decline of jigging effort in New Zealand.

[4] Standard jigging operations recommend hauling the jig from shade to light while squid sit in the shaded area underneath the vessel. Squid are known to strike as the jig passed into the light. Constantly shifting light beams are unnatural and have been reported to scatter squid shoals.

Figure 9: Squid fishing effort by area in New Zealand waters 1991 – 2017 a) all squid jig set locations in the time period; b) proportion of jigging effort north and south of the 47°S line by year; c) all squid trawl set start locations in the time period; d) proportion of trawl effort north and south of 47°S line by year.

3.3.1 Practical implications of Fisheries (Foreign Charter Vessels and Other Matters) Amendment Act 2014

Whilst the New Zealand fisheries management framework provides for squid jigging, consultations with industry also highlighted a range of actual or perceived barriers to quota uptake, at least for foreign owned vessels. In particular, the requirement under the *Fisheries (Foreign Charter Vessels and Other Matters) Amendment Act 2014* that fish cannot be taken in New Zealand waters unless, "*the vessel is a New Zealand ship or has been exempted under section 103A(1)* [of the Act]"effectively prevents the business model responsible for the majority of historic squid catches (i.e. chartering foreign vessels for a portion of the year).

Consultation with industry representatives revealed that the choice to not operate a jig vessel in the fishery is not only being driven by economic factors (such as the cost of compliance), but also the administrative burden of complying with the amendment.

For example, any chartered vessels jigging in New Zealand would likely only register to New Zealand for a portion of the year. Amongst other reasons, this is because these vessels also operate in other waters and under different bilateral and/or unilateral arrangements which means they cannot maintain New Zealand registration all year.

Furthermore, industry representatives suggested that, at least in the past, Japanese vessel officers that are part of their domestic Maritime Union can only serve on Japanese-flagged vessels (although attempts to verify this have not been successful). Whilst this may not be important to officers willing to serve internationally on any flagged vessel, the crew on vessels which are registered to Japan for the majority of the year may be hesitant to lose coverage by their relevant union.

Finally, financial institutions can be hesitant to provide credit for assets outside their jurisdiction. The concern for financial institutions rests with the increased risk of not being able to efficiently repossess the asset if the debtor defaults on repayments. In the case of a Japanese vessel and creditor for example, the creditor will likely retain some claim to the asset until all debts are cleared. When the asset is registered in Japan, that ownership claim is clear if ever challenged through a judicial process. By contrast, if that asset is then re-registered in New Zealand, and records are not transferred correctly, the Japanese financial institution may have difficulty demonstrating legal ownership over the asset if there is any challenge to repossession. Furthermore, any New Zealand based purchaser may be at risk given the ownership structure is not clear across multiple jurisdictions and may be purchasing an asset from an entity without ownership rights. All of this means that vessels can have specific covenants in their finance agreements which prohibits registration in another country.

Even if companies opt to re-register vessels for a portion of the year, there are a range of administrative processes involved which are likely to create barriers to reflagging. For example, in their submission on the proposed Bill, Sea Resources Limited (2011) suggest the process would involve:

- Applying for ships name in New Zealand registry;
- Applying for registration under the [New Zealand] Ship Registration Act 1992;
- Deleting from the Japanese Registry and transfer mortgages/financial liens to the New Zealand Registry;
- Attempting to maintain existing Hull & Machinery and P & I Covers in the name of the owners [but] noting interest of New Zealand charterers;
- Delisting as Japanese vessel or temporarily suspending from relevant RFMO registration;
- Cancelling current jurisdictions fishing licences held in the name as Japanese vessel and trying to maintain rights when relisting the vessel on the original registry;
- Reregistering satellite communications with provider under the New Zealand flag;
- Cancelling following certificates and re-issuing under New Zealand registry:

- Radio Licence Callsign;
- Ship Inspection Certificate;
- Certificate of Nationality
- International Tonnage Certificate;
- International Antifouling Certificate;
- International Oil Pollution Certificate;
- International Sewage Pollution Certificate; and
- International Deratting Exemption Certificate.

These ultimately create administrative burdens which cut into the overall viability of the chartering agreement between New Zealand and foreign companies.

3.4 Economic analysis of squid jigging viability in New Zealand

In addition to reviewing historical trends in the New Zealand squid fishery, a key aim of this study was to examine the economic viability of jigging under current economic and market conditions. At the outset, conducting economic analysis requires a good understanding of the key inputs to fishing operations. A number of inputs are generic to jigging and fishing globally, so they have been applied as found in literature or through industry knowledge. However, literature review and consultation with stakeholders revealed that there are a number of inputs specific to jigging and/or fishing in New Zealand waters under New Zealand regulations. These are discussed in more detail in the following sections and a summary of all key inputs for the model can be found in Table 9.

Table 9: Key inputs for analysing the economics of squid jigging operations in New Zealand waters

	30m Vessel (<65m)			Large vessel (>65m)		
	Min	**Ave**	**Max**	**Min**	**Ave**	**Max**
CAPEX						
Vessel cost (NZ$)	4,286,467	5,715,289	7,144,111		28,576,444	
Vessel Life Years		20			20	
Vessel size		30			65	
Engine Power (kw)		383			1277	
OPEX Fuel						
Fuel consumption (MT) per day reported	0.90	1.05	1.20	3	3.5	4
% Fishing Fuel Consumption for lights without LED		0.65				
% Fishing fuel reduction with LED lights	0.240	0.265	0.290	0.240	0.265	0.290
Diesel MT:L conversion		1130			1130	
Oil costs (NZ$/L)	0.257	0.722	1.187	0.257	0.722	1.187
Diesel to oil conversion multiplier	1.467	2.071	3.601	1.467	2.071	3.601
Marine Diesel (NZ$/L)	0.531	1.494	2.457	0.531	1.494	2.457
Revenue Driver						
Fishing days	50.56	59.58	68.61	50.56	59.58	68.61
Multiplier for foreign waters	1	1.5	2	1	1.5	2
Fishing Days foreign waters	75.83	89.37	102.91	75.83	89.37	102.91
Catch/day (MT)	1.5	2.75	4	4	8	12
% Catch reduction due to LED	15%	20%		15%	20%	
Catch/day multiplier foreign waters	2	2.5		2	2.5	
Catch/day in comparative foreign fishery	3.75	6.875	10	10	20	30
Market price (NZ$/kg)	0.97	3.39	5.82	0.97	3.39	5.82
Duty into Japan	0	3%		0%	3%	
OPEX R&M and Labour						
Repair and maintenance % of depreciation	6.67%	16.67%	26.67%	6.67%	16.67%	26.67%

	30m Vessel (<65m)			Large vessel (>65m)		
	Min	**Ave**	**Max**	**Min**	**Ave**	**Max**
Labour costs	30%	38%	45%	30%	38%	45%
Intl Labour as % of NZ (Comparison)	6%	10%		6%	10%	
Administrative costs						
NZ Tax (low value for foreign comparison)	20%	28%		20%	28%	
Administrative costs (cost-recovery levy) (NZ$/kg caught)	0.0181	0.0425	0.1327	0.0181	0.0425	0.1327
Annual depreciation schedules for vessels (NZ$) straight line		285,764			1,428,822	
Administration and contingency		10%			10%	
Cost of equity						
Discount rate (cost of equity)	6.4%	9.5%	14.8%	6.4%	9.5%	14.8%

3.4.1 Description of key inputs to squid jigging in New Zealand Waters

3.4.1.1 Fuel consumption

Fuel consumption for vessels using ~400kw and ~1300kw engines (for small vessels and large vessels, respectively) will be relatively consistent for every hour and unit of capacity used (i.e. full-steam or searching). However, jigging typically has an additional fuel consumption input given the lights needed to attract squid when jigging at night. The typical metal halide lamps used are very energy intensive and some reports such as Seo et al. (2012) indicate that up to 65% of fuel costs could be attributable to fuel consumption by lamp generators.

Consultation with industry representatives revealed that under typical squid jigging conditions, smaller vessels will consume approximately 1-2 MT/day and large vessels between 3-4 MT/day. When modelling this default scenario, these figures can be used simply in conjunction with normal fuel cost multipliers (as shown in Table 9). However, additional variables must be included when modelling scenarios that account for new light emitting diode (LED) technologies.

By replacing old metal halide lamps with relatively new LED technologies, Seo et al. (2012) and Park et al. (2015) indicate that fuel savings could be between 24-29% of total fuel consumption. This would mean that at least 24% of default fuel consumption could be reduced with the deployment of LEDs. Notwithstanding this, the same references note a link between employing LEDs and a reduction in catching efficiency (between 15 – 20%). Therefore, conservative modelling of any fuel reductions from LEDs should also include a reduction in catch rates.

3.4.1.2 Fishing days

Analysis to estimate the likely number of days available for squid jigging in New Zealand was based on logbook submissions provided in MPI NZ (2018b), as reported in Table 6.

Overall, the evidence indicates that the total fishing days available for squid in New Zealand is primarily limited by the availability of commercially viable levels of stock rather than operational conditions (e.g. days where swells are not conducive to fishing). Industry consultees overwhelmingly nominated stock availability as the key driver of season length, while views on the impact of weather conditions on jigging operations were mixed: some stated that fishing could not occur in poor weather, some stated that fishing could occur in poor weather but operational efficiency was reduced (e.g. large swells altered the direction of lights making catching less efficient) and some stated that weather had no impact. The proposition that stock availability is the main driver of season length is also supported by the fact that both trawl and jig fisheries operate for similar length seasons (i.e. trawlers don't appear to operate for a longer season than jiggers despite a likely capacity to operate in heavier swells; Figure 10).

In terms of total days available in a season, there does not appear to be any operational advantage for a jigging vessel that chooses to operate south of 47°S. This is because the seasons in both areas overlap as shown in Table 20 and Table 21 of Annex 1.1 (i.e. any time spent in southern areas will come at the cost of time that could be spent in northern areas).

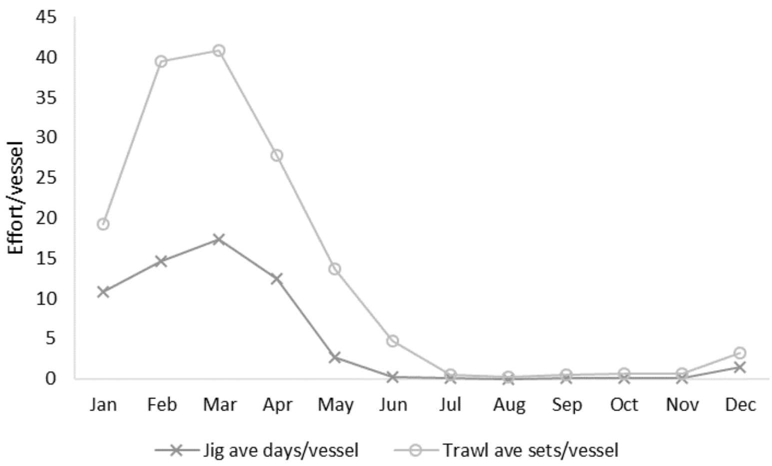


Figure 10: Average monthly figures on effort per vessel targeting squid in New Zealand waters: 1991 - 2005 (MPI NZ, 2018b).

From the perspective of the entire fleet, logbook data on the number of days used per year per vessel were of good quality. However, it was difficult to find sufficient time series data which cleanly split the different vessel-length classes (i.e. those vessels <65m versus those >65m).

As discussed in section 3.3, there is the potential for larger vessels to operate in different waters to smaller vessels, but the season length appeared similar across both zones. Therefore, it was assumed that both vessel-length classes would have the opportunity to fish approximately the same number of days each year. This is because season length was determined by stock availability as opposed to conducive fishing weather.

Given the potential for season length to vary between years, a range of possible season lengths was determined using a 95% confidence interval. The upper and lower bounds of a 95% confidence interval ($CI_{95\%}$) were constructed using the following formula:

$$CI_{95\%} = \bar{x} \pm \left(t_{df=(N-1),\alpha/2=0.025} \cdot \left[\frac{\sigma}{\sqrt{N}} \right] \right)$$

Where $\bar{x}$ was the average fishing days per vessel per year, t is the critical t-value quantifying the probability of certain values according to the degrees of freedom (df) and the chosen level of significance (α), σ is the standard deviation of the dataset and N is the number of records.

Average days fished per vessel from 1991 – 2005 (N=15) were used as the raw data for this analysis. These years were chosen as they appeared the most prevalent fishing seasons within the data available whilst also giving a reasonable sample size. These data were plotted in a histogram (Figure 11) for visual inspection of normally distributed data because this is an important assumption in constructing a confidence interval. Visual inspection of these data suggested their distribution was approximately normal and this was validated by skewness values of -0.67 (0 is optimal but anything between -2 and 2 is considered reasonable).

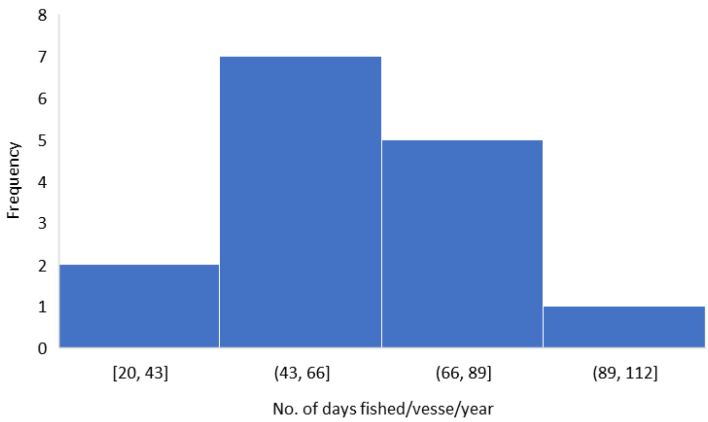


Figure 11: Histogram of annual days fished north of 47ºS line; Skewness: -0.67; 0 is optimal, anything with absolute value <2 is an indication of data normality.

Once the confidence interval inputs were estimated (as shown Table 10), it was reasonable to conclude with 95% confidence that a squid jig vessel could operate efficiently in New Zealand waters for ~51 – 69 days (with an average of ~60). These were the values used for the feasibility analysis.

Table 10: Variables and inputs to construct the 95% confidence interval of jigging days available in New Zealand waters

Unit	Value
Mean annual days operating ($\bar{x}$)	59.58
Number of records (N)	15
Standard deviation (σ)	16.3
T-stat ($t_{df=(N-1),\alpha/2=0.025}$)	2.145
95% CI	50.56 – 68.61

3.4.1.3 Catch availability

Total catch is a function of fishing days available and the catch rate that can be achieved per day, so the latter input was also investigated in detail. Much the same as fishing season data, initial review of catch data from MPI NZ (2018b) indicated inter-annual variability in catch rates. Therefore, a range of plausible catch rates values were estimated.

Unlike the data on effort days, raw logbook catch data were highly variable year-on-year and did not demonstrate the same characteristics of normal distribution. When data are not normally distributed they do not have a balanced level of likely values either side of an average. Therefore, without employing complex analytical methods which account for unbalanced variability, constructing confidence intervals using these data would be less appropriate. As such, analysis on possible catch rates was more weighted on data collected through consultation and literature review.

Industry consultees advised that historical squid jigging effort in New Zealand produced an average catch rate of 3-4MT/day for larger vessels and 1-2MT/day for smaller vessels. Squid abundance can, at times, be high enough to support higher catch rates (e.g. 7-12MT/day) but the processing and freezing capacity onboard then becomes a limiting factor. Consultees advised that these higher catch rates were sufficiently infrequent that the necessary capital investments could not be justified to fully realise the potential benefits of these sporadic catches.

The catch rates reported through consultation were very consistent with those found in Yamashita and Muta (2003) and Tyson et al. (1982). Again, while higher catch rates were occasionally recorded, these were infrequent so 3-4MT/day were considered the expected value.

As a cross-check on model catch rate inputs, catch rate data (for all squid jig vessels from 1991 – 2005 [N=15]) from MPI NZ (2018b) were transformed in an attempt to produce more normally distributed data. This was done by taking the natural log of each data point which is a standard conversion process to normalise data. This generated skewness score of -0.085 but suggested data were a little more uniformly distributed rather than normally. Nevertheless, for sake of the analysis, the necessary confidence interval inputs were estimated. After conversion back to their original form by taking the exponential of the estimates, it was concluded with 95% confidence that the catch rates in the fishery could take on a range of 3.18 – 5.26MT/day with an average of 4.09MT/day (see Table 11). Again, this showed reasonable consistency with other data already collected.

Table 11: Variables and inputs to construct the 95% confidence interval of catch rates possible in New Zealand waters

Unit	Value
Mean catch per day ($\bar{x}$)	4.09
Number of records (N)	15
Standard deviation (σ)	0.455
T-stat ($t_{df=(N-1),\alpha/2=0.025}$)	2.145
95% CI	3.18 – 5.26

To be conservative, the average catch rates reported in consultation were considered the minimum that could be achieved on a long-term basis by the fishery. This value is considered conservative for several reasons. Firstly, the purpose of this analysis is to understand why the fishery is seemingly unattractive. Therefore, an analysis which uses the average catch rates as the pessimistic scenario can help explain what makes the fishery so unattractive (i.e. even setting likely above-average catches as the "best guess" scenario is not enough to make the fishery appear viable). Secondly, assuming industry could reasonably implement some recent changes in onboard freezer capacity technology that have been developed since the squid jig fishery was last exploited in earnest (i.e. post 2005)[5], average catch rates for this analysis were biased upwards (Table 9).

3.4.1.4 Market price for squid

Establishing a single market price for squid is difficult given its seasonal and annual volatility. Therefore, a price range was estimated with sensitivity analysis conducted around this range.

Overall, discussions with industry indicated that squid prices are set by a world price and are highly dependent on catch volumes from major fisheries in Southwest Atlantic and Eastern Pacific. Relatively low catches out of these major fisheries in recent years has led to substantially increased world prices. As a result, data collected for current prices were considered to be at the upper end of the overall price range. Moreover, given the world commodity-style pricing for squid, sources of data from different markets were not deemed to impact the time series value[6].

Industry also indicated that there was very little price differentiation between species. This could be deceptive considering New Zealand species reportedly tended to fetch higher than average prices (sometimes up to 10%) but this is explained by timing as opposed to species quality (C Hufflett, pers. comm., 14 Sep 2018). New Zealand product tends to hit the global market before the major supply from Eastern Pacific and Southwest Atlantic meaning the New Zealand price is established before the prices experienced during high-supply periods have lowered the annual average price.

[5] Such developments are found on pocket long liners operating in the Pacific Ocean fisheries (Harris, 2015)

[6] When products are traded and demanded globally (or at least in multiple countries), prices tend to be relatively even across all markets (once all handling costs are factored in). If one market offers a higher price, it will attract product (and vice versa) so there is an incentive for all markets to price evenly.

The next step taken to estimate the full range of likely prices was researching the UN Comtrade database (United Nations, 2018). Unfortunately, this database reports squid trade in an aggregated cephalopod category (HS Code 30741). Therefore, some transformation work was needed to try and extract the likely New Zealand squid contribution to these price records.

HS code 30741 exports from New Zealand to all trade partners can be seen in Figure 12. It was reasonable to assume that that these were all trawled product because there would not have been any New Zealand-flagged jigging occurring during this period[7] and there are few other methods to commercially harvest cephalopods. In addition to UN Comtrade data, some squid jig spot prices were sourced from literature and consultation and can also be seen in Figure 12.

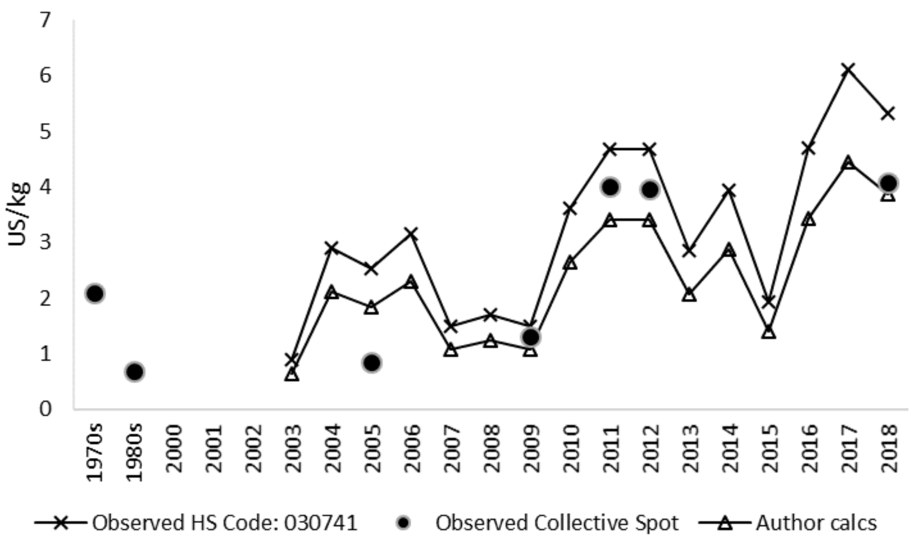


Figure 12: Nominal market price for whole squid exported from New Zealand, author's calculations based on an estimated multiplier from observed data and a collection of spot prices from literature and consultation: 1970s – 2018. Data points from 1970s and 1980s were qualitative to indicate the level of fluctuation experienced in the early years of the New Zealand squid jig fishery (United Nations, 2018 and author's notes).

Whilst demonstrating the same overall trends, HS code 30741 data were consistently higher than the collective spot prices. Industry consultees advised that jig product tends to be what sets the world squid price because it is the most abundant and that trawl prices tend to be lower by approximately US$0.20/kg due to its lower quality (Taiwanese Industry Representative, pers comm., November 2018). Therefore, given the New Zealand UN Comtrade data were likely trawled product, their higher prices far beyond 10% were inconsistent with theory. This suggested that UN Comtrade data included other species that could have been of higher value than squid or perhaps were inflated by the cost of insurance and freight (a limitation to the trade data that is acknowledged by United Nations [2018]).

As further evidence that the UN Comtrade data were likely inflated above expected squid prices, consultation with several stakeholders consistently reported squid prices were currently high at ~US$4/kg. This is much lower than reported figures from the last few years under HS code 30741 in Figure 12. Therefore, to use this publicly available data in this analysis (and if replicated in future), a multiplier was needed to estimate likely squid prices from New Zealand.

In 2018, squid prices were observed in Hachinohe, Japan auction markets at US$4.07/kg. Knowing that trawl prices were likely US$0.20/kg less than this, it was reasonable to assume squid trawl prices from New Zealand would likely be ~US$3.87/kg in 2018. Following this, the observed spot prices were compared to the observed UN Comtrade United Nations (2018) data given they

[7] Primary fish trade tends to be reported by harvesting flag State, not area of operation.

appeared closely linked. This showed that on average, spot prices for jigged squid were 73% of the HS Code 30741 data (3 out of 4 were tight between 85-87% but the 2005 spot price was only 34%). As a result, the "Author calcs" series in Figure 12 was derived by applying the 73% multiplier to each observed point from HS code 30741 data.

Ultimately, the observed spot prices are important in determining likely prices and this economic analysis placed more weight on those than what was derived from UN Comtrade data. However, the spot prices used appeared randomly and inconsistently in literature. Therefore, the purpose of this price analysis was to demonstrate the validity of using UN Comtrade data to replicate this study in future in case sufficient spot price data series are not available.

3.4.1.5 Labour costs

Under current legislation, the labour costs for crew operating in New Zealand waters will depend on their nationality.

Immigration NZ (2018) states that foreign crew on a New Zealand registered vessel must be paid the hourly minimum wage plus an additional NZ$2/hour[8]. The current minimum wage is NZ$16.50/hour. The actual structure of employee hours onboard a vessel is unclear (i.e. 24 hours a day or only time on deck?) but regulations dictate that crew should be employed for at least 42 hours per week while operating in New Zealand waters.

By contrast, New Zealand citizen crew can reportedly be paid a crew share. Industry representatives suggest that standard crew share (in total) would be approximately 30% of catch revenue. However, lower catches (and thus overall revenue) in the squid jig fishery means that squid vessels would likely need to pay a higher proportion of catch revenue to entice good crew away from competing and more valuable fisheries.

Given the need to pay above the minimum wage for foreign crew, there appeared to be a general consensus amongst industry that employing domestic crew (and thus paying crew share) would likely be the optimal scenario under current regulations. Therefore, crew share was used as the only labour cost structure in this analysis. The upper bound for crew share is difficult to quantify, so to be conservative 30% has been set as the minimum and 45% set as the maximum.

Importantly, industry reported that sourcing domestic crew has been difficult in recent years due to an unwillingness to spend long periods at-sea. They reported further that this also limits the ability of New Zealand-crewed squid jig vessels to consider year-round fishing by transiting to other distant and foreign fishing grounds.

3.4.1.6 Cost-recovery levy

An important cost relevant to New Zealand fisheries, which is less likely to be applicable in global squid fisheries (particularly high seas ones operating outside the Argentine and Peruvian EEZs), is the fisheries management cost-recovery levy. The process for determining this cost is well-defined in New Zealand legislation and is based on the costs associated with management of the specific fishery (stock assessment research, observers, etc.) and linked to the associated fisheries' TACCs[9]. These costs are then proportionately assigned to relevant quota owners. Therefore, the reduction in TACC for squid jigging has effectively removed this cost-recovery levy for the time being. Nevertheless, if the fishery were to become active again, it is a cost that must be considered.

Past levy figures for all squid fisheries can be seen in Table 12. Despite low landings for jig vessels in 2015-2017 (Figure 2), the cost recovery levy was relatively high due to the TACC. To determine likely future cost-recovery levies, it is worth noting that SQU1J was consistently assigned ~25% of the total

---

[8] All vessels fishing in New Zealand waters would be registered in New Zealand (see section 3.3)

[9] http://www.legislation.govt.nz/regulation/public/2001/0229/latest/whole.html

levy for squid fishstocks which equated to approximately NZ$0.02-0.04/kg of SQUI1J TACC. As such, these seemed relevant values to be set as the minimum and average levy for this analysis. The high of NZ$0.13/kg for SQU1J in 2016/17 is the result of a low TACC but a continued high total levy and was considered the maximum (worst case) scenario.

Table 12: Fisheries management cost recovery levies for squid stocks, 2015/16 - 2016/17 (MPI NZ, 2017).

Fishstocks	2015/16			2016/17		
	Levies (NZ$)	TACC (kg)	NZ$/TACC	Levies (NZ$)	TACC (kg)	NZ$/TACC
SQU10T	170	N/A	N/A	175	N/A	N/A
SQU1J	908,635	50,212	0.02	663,543	5,000	0.13
SQU1T	1,450,724	44,741	0.03	1,157,845	44,741	0.03
SQU6T	1,180,743	32,369	0.04	785,687	32,369	0.02
Total	3,540,272	127,322	0.03	2,607,250	82,110	0.03

In terms of how to build these figures into the model, it was assumed that if the squid jig fishery existed, vessels would seek to catch their full Annual Catch Entitlement (ACE). Therefore, all possible quota (in the model as ACE) that was subject to the cost-recovery levy was assumed to be caught by the vessel. As such, the NZ$/TACC figures were multiplied by the modelled catches to generate a likely cost-recovery line in the budget.

3.4.1.7 Cost of capital

The terms of reference for this work did not place a big focus on investment-style analysis, but it is a useful approach to understand why the private sector may not view this fishery as a viable option. In short, all capital investments made (e.g. fishing vessels, equipment) will be made assuming that a sufficient ROI is likely. A rational investor would typically assess the potential ROI against other investment opportunities with similar risk profiles to determine if it is a worthwhile pursuit. As a different perspective, companies may also already have a benchmark ROI for all of their investments determined by shareholders and creditors. In either case, this ROI measure would be considered the organisation cost of capital.

Applying a reasonable cost of capital (r) is an important step in any investment analysis. If the rate is not already specified by company records, it can be estimated in a number of ways (other than through surveys or experience). Firstly, a comparable publicly listed company with similar activities could be used to understand how a broad scope of investors would price a certain risk. Following this, there are two common methods to quantify r:

- Capital Asset Pricing Model (CAPM); or
- Extracting *r* from the Dividend Discount Model (DDM).

Each method requires certain assumptions to hold true (particularly CAPM), so in some cases one method may be more appropriate than the other. These methods and their assumptions are further outlined in the sections below.

Capital asset pricing model

The CAPM method uses the following formula:

$$r = RF + \beta(M)$$

where RF is the risk-free rate of return (set by the Government's bond rate), M is the index return over and above the risk-free rate, which is adjusted by β and measures the relative risk for an investment of this type. In essence, this method prices an investment relative to the returns that could be made by investing in a standard market index fund. As such, it also assumes some significant link between the company return and market index returns (which does not always exist).

Estimating the beta coefficient (β) is sensitive to the index used as a measure of return, the number of years back that are sampled, and the time scale as the measure of the return (e.g. daily, monthly, annual returns). For this analysis, we have chosen monthly returns over the last four years for the NZX Top 50 index.

The next step is to extract the comparable company returns from public records. The returns records should meet the time criteria. These company returns are then regressed against the index returns. If a significant link between the two sets of values is found, then the regression output would include a valid estimate of the β coefficient.

Following this step, it is necessary to consider that the current estimated company β is influenced by the level of debt it holds (or its financial leverage) which carries different risk. As such, this estimate of β is considered its levered beta (β_L). Unlevering this β_L is particularly important in this economic study because we have assumed no debt financing for the investment. Once the unlevered beta (β_U) has been estimated, then we have a true estimate of the asset risk relative to the market index. The unlevered beta can be derived through the following formula from Courtois et al. (2007):

$$\beta_U = \beta_L / \left(1 + [1 - tax\ rate] \cdot \frac{D}{E}\right)$$

Where β_L is the estimated beta coefficient from regressing the company returns against the market index returns and $\frac{D}{E}$ is the company debt/equity ratio. The outcomes from this analysis are presented in the estimates section below.

Dividend discount model

Extracting r from the dividend discount model (DDM) uses a rearranged version of the following formula from Courtois et al. (2007) where:

$$P_0 = D_1/(r - g)$$

becomes

$$r = (D_1/P_0) + g$$

and considers that

$$D_1 = D_0(1 + g)$$

Where P_0 is the current price of the company stock, D_0 and D_1 are the current and next year dividends respectively and g is the sustainable growth rate of the company. Methods to estimate g can also be found in Courtois et al. (2007) and the remaining variables can be extracted from the same public records used for the CAPM method. The DDM approach is more straightforward but assumes company dividends are paid (or that potential dividends can be estimated). It also does not rely on significant links between company and market index returns as with CAPM. The outcomes from this analysis are presented in the estimates section below.

Estimates of the squid jigging cost of capital

The New Zealand Stock Exchange has very few publicly listed companies that can be drawn from for this analysis. Only one was found that primarily harvested fish through wild catch methods (Sanford Ltd). However, for a range of reasons outlined below, this was not considered the most ideal candidate due to its other food service revenue streams (ultimately forming a risk profile different to wild catch harvest). As such, another candidate company (New Zealand King Salmon Co Ltd) with a capital and revenue structure more similar to purely fishing for squid was considered. A brief description of the two companies used for this analysis is presented below:

- Sanford Ltd (SAN): A New Zealand based fishing and food services company that harvests a range of species (including squid).
- New Zealand King Salmon Co Ltd (NZK): A New Zealand based salmon aquaculture company. This company was chosen because it does not diversify its revenue through other major operations such as food services (as is the case with SAN) and their key revenue is closely associated with environmental factors which matches harvest fisheries.

The method described for estimating company βs was employed for both SAN and NZK. Estimates of the SAN β coefficient demonstrated a market index link with less than 95% confidence but could be accepted with 90% confidence. However, the NZK estimates of β did not demonstrate links to the market index with any useful level of confidence. A summary of the results can be seen in Table 13 and raw data in Annex 1.3.

Given that SAN was shown to be a reasonable candidate for CAPM, the unlevering method was also employed to establish the actual asset risk. Following this, it was determined that SAN had a β_U value of 0.43. This led to an estimate of r as 6.03% (see Table 13).

Because both SAN and NZK showed evidence that their returns were perhaps not significantly linked to market returns (NZK particularly more so than SAN), and both paid regular dividends, DDM was used to estimate r for both companies. Estimates of g for NZK were very high in 2016 and 2017 (7% and 20.3%, respectively) perhaps due to its new publicly listing status. Therefore, estimates of g at 5.69% for 2018 appeared more plausible in the long-term. Estimates of g for SAN were relatively stable and averaged 2.96% for 2016-2018. Using the DDM approach, estimates of r for SAN and NZK were 6.41% and 14.76%, respectively (see Table 13).

Table 13: Key input values to determine estimates of squid jigging cost of capital

Variable	Sanford (SAN)	NZ Salmon (NZK)
β_L	0.513	0.824
β_L p-value	0.053	0.432
Company Tax rate	28%	N/A
D/E (2018)	0.27	N/A
β_U	0.430	N/A
CAPM (*r*) (2016-2018)	6.03%	N/A
g	2.96%	5.69%
D_1(NZ$/share)	0.238	0.054
P_0 (NZ$/share)	6.905	2.680
DDM (*r*)	6.41%	14.76%

There are some key conclusions to draw from this cost of capital analysis. Firstly, both the CAPM and DDM approaches provided ~6% as an estimated cost of capital for SAN. Consultation with financial industry experts suggested this would be low for an activity purely based on extraction of primary resources (such as fishing). Consultation and past experience suggest at least 10% would be more likely. Therefore, even though SAN hold substantial squid quota, investors appear to not see that as the only defining aspect to their business. Secondly, given the weak linkage between NZK and the market index, only the estimates of their r using DDM were considered in this analysis. This estimate of r for NZK (14.76%) is also more plausible given past similar analysis (Reid and Campbell, n.d.).

It is possible that 14.76% for squid fishing may still be high given fishing vessels, as an asset, are more easily relocated to more profitable fisheries (even if through sale to another organisation) compared with more permanent aquaculture structures. Furthermore, squid quota itself would likely hold some value as a durable right if squid fishing in New Zealand became viable again (thus perhaps reducing risk). Based on that, it is plausible that some investors may consider investments in vessels for squid fishing less risky than sea-based aquaculture farms.

Considering these main conclusions, it was considered that 6.41% was the minimum cost of capital for this analysis and 14.76% as the maximum. The mid-point of 10.58% is consistent with the ~10% estimate from consultation so this was used as the average.

3.4.2 Results

The economic feasibility of squid jigging in New Zealand waters was estimated using the inputs from Table 9 and the cost benefit methodology from section 2.3. The base case results can be seen in Table 14 for the smaller jig vessel and Table 15 for the larger vessel. This base case uses the average figures from all inputs in Table 9. The "Total" column in both tables provides a sum of all projected net benefit values across the 10 years without applying any discount factors typically used for NPV analysis.

Table 14 and Table 15 show that over the next 10 years, both vessel-size classes are forecast to generate negative profit and loss values (-NZ$1.106 million for smaller vessels and -NS$8.667 million for larger vessels found in the Total columns). These negative numbers indicate that even without factoring in the cost of capital (i.e. the foregone revenue from other investments), the fishery is not expected to produce a profit by any standard measure. Furthermore, the final Total figure (albeit negative) is significantly propped up by the assumption that if the investor should seek to exit the fishery after 10 years, the vessel will have a market value equal to its carrying value at that time. Another perspective on this is that even once the expected life of the vessel has passed (20 years), the fishery is not expected to provide sufficient returns to have paid off the vessel. Therefore, the company would need a new source of finance (without any obvious means of recovery) by the time a new vessel is required.

Once discounted revenues are taken into consideration, the results are even less favourable. Under the base case, NPVs are projected to be -NZ$3.62 million for smaller vessels and -NZ$19.982 million for larger vessels. Given the base case cost of capital is 10.58%, this would be the minimal accepted ROI. However, this investment is expected to only produce an ROI of -2.5% for small vessels and -4.0% for larger vessels. On this basis, these investments would not be accepted as viable.

Whilst the decision on the proposed investment seems clear, it is worth drilling down into these results a little further. Revenue from annual operations is modelled to surpass expected annual variable costs, but not enough to cover annual fixed costs as well. For example, after labour, fuel, etc., small vessels are expected to have an annual net benefit of NZ$175,000 (Table 14). This suggests that if a vessel could find a primary fishery for part of the year that covered annual fixed costs, and then there were no other more profitable alternatives afterwards, fishing in New Zealand could then provide an incremental benefit. This is consistent with the part-year chartered approach which has historically been the preferred business model.

Table 14: Projected 10-year economic performance of small squid jig vessels operating in New Zealand waters (NZ$'000s)

Year	0	1	2	3	4	5	6	7	8	9	10	Total
Capital cost vessel	(5,715)										2,858	(5,715)
Benefits												
Catch Rev		556	556	556	556	556	556	556	556	556	556	
Costs												
Fuel Costs		(105)	(105)	(105)	(105)	(105)	(105)	(105)	(105)	(105)	(105)	
Repair and Maintenance		(48)	(48)	(48)	(48)	(48)	(48)	(48)	(48)	(48)	(48)	
Labour		(208)	(208)	(208)	(208)	(208)	(208)	(208)	(208)	(208)	(208)	
Import Duty to Japan		(17)	(17)	(17)	(17)	(17)	(17)	(17)	(17)	(17)	(17)	
Cost Recovery Levy		(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	(7)	
Contingency and Admin		(39)	(39)	(39)	(39)	(39)	(39)	(39)	(39)	(39)	(39)	
Depreciation*		(286)	(286)	(286)	(286)	(286)	(286)	(286)	(286)	(286)	(286)	
Tax		43	43	43	43	43	43	43	43	43	43	
Net Benefit	(5,715)	175	175	175	175	175	175	175	175	175	3,033	(1,106)

NPV	(3,620)
ROI	-2.5%

*Depreciation was only factored in to determine the taxes paid, it has not been directly included in the net benefit row.

Table 15: Projected 10-year economic performance of large squid jig vessels operating in New Zealand waters (NZ$'000s)

Year	0	1	2	3	4	5	6	7	8	9	10	Total
Capital cost vessel	(28,576)										14,288	
Benefits												
Catch Rev		1,617	1,617	1,617	1,617	1,617	1,617	1,617	1,617	1,617	1,617	
Costs												
Fuel Costs		(352)	(352)	(352)	(352)	(352)	(352)	(352)	(352)	(352)	(352)	
Repair and Maintenance		(238)	(238)	(238)	(238)	(238)	(238)	(238)	(238)	(238)	(238)	
Labour		(606)	(606)	(606)	(606)	(606)	(606)	(606)	(606)	(606)	(606)	
Import Duty to Japan		(49)	(49)	(49)	(49)	(49)	(49)	(49)	(49)	(49)	(49)	
Cost Recovery Levy		(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	(20)	
Contingency and Admin		(127)	(127)	(127)	(127)	(127)	(127)	(127)	(127)	(127)	(127)	
Depreciation*		(1,429)	(1,429)	(1,429)	(1,429)	(1,429)	(1,429)	(1,429)	(1,429)	(1,429)	(1,429)	
Tax		337	337	337	337	337	337	337	337	337	337	
Net Benefit	(28,576)	562	562	562	562	562	562	562	562	562	14,850	(8,667)

NPV	(19,982)
ROI	-4.0%

*Depreciation was only factored in to determine the taxes paid, it has not been directly included in the net benefit row.

Given this analysis suggests squid jigging in New Zealand waters is not economically viable in its own right, we undertook a separate analysis on the viability of a multi-purpose vessel. The consultation discussed earlier indicated that the configuration of a squid jig vessel was most conducive to accommodating longline gear as a secondary gear type (or vice versa). This analysis has not investigated the economics of a secondary longline fishery, but it is possible to quantify the level of economic benefit that would be needed to justify the investment as a multi-fishery vessel (over and above the current squid jig projections).

In essence, the benefit of this secondary operation would need to be sufficiently large that it increased the overall ROI to be equal with the expected cost of capital. From a quantitative perspective, this occurs when the NPV is equal to zero (see section 2.3).

To estimate the minimum value required by this secondary operation, a dummy variable was placed in the model which represented its annual (after tax) benefit. We then used threshold analysis to determine the value at which this annual variable would lift the NPV from a negative number to zero. Under the base case, the secondary operation would need to raise ~NZ$604K each year for small vessels and ~NZ$3.33 million for large vessels. Importantly, relative to potential squid revenue, this represents the need for a 245% increase in after-tax profit for small vessels and 492% for large vessels which is substantial and is discussed further in section 4.

3.4.2.1 Sensitivity analysis

Whilst the base case produced negative profitability results, it was estimated using only the average input values as shown in Table 9. To test the impact of alternative scenarios, sensitivity analysis was used to understand the underlying drivers of the results.

Ten different scenarios were run to demonstrate the sensitivity of results to changes in certain inputs values. Nine of the scenarios looked at the impact from changing specific inputs in isolation such as labour or catch rates. The tenth scenario was an “optimal” combination of values that inputs would likely take on if the vessel was operating in a low-cost but high-value environment in either the Eastern Pacific or Southwest Atlantic squid jig fisheries.

Details of the different scenarios are presented in Table 16. The table also includes some notes on the plausibility of each scenario in New Zealand. Whilst many of the scenarios are considered implausible in New Zealand, it is worth noting that many of the values reflect those which can be experienced in alternative squid jig fisheries around the world (namely Eastern Pacific and Southwest Atlantic).

Table 16: Description of scenarios used for sensitivity analysis

Scenario	Details	Plausible	Notes
1	Vessel cost set to zero.	=	Vessel costs set to zero indicates a full vessel purchase subsidy. Whilst unlikely for a vessel owned by a New Zealand company, it is possible that companies supported by other governments could have their vessels subsidised[10].
2	Catch rates set to 10MT/day for small vessels and 30MT/day for large vessels.	✕	Whilst plausible in the Eastern Pacific according to Arkhipkin et al. (2015), catch rates are driven by the biological characteristics of the target stock and local environmental conditions. It will not be possible to significantly increase and sustain catch rates in New Zealand waters.
3	Price set to NZ$5.82/kg and Japanese import duty removed.	✕	Japanese vessels would likely be exempt from import duties but seeing them operate in New Zealand would be implausible under current regulations. Also, prices cannot be controlled unless total global catch is controllable, so it is implausible to assume that prices will remain high indefinitely (unless done so artificially through a price floor set by the government or through production cartels akin to OPEC).
4	Fishing days set to 137 days/vessel/year.	✕	As with catch rates, this number of fishing days is plausible in Eastern Pacific and Southwest Atlantic. However, like catch rates, the seasonal availability of squid (and thus fishing days available) means this is implausible in New Zealand.
5	Labour rates set to 6% of current New Zealand requirements.	✕	Labour rates set to the level under this scenario are not plausible in New Zealand waters under the current regulations. These are more likely applicable to fleets operating within jurisdictions with relaxed labour laws.
6	No fuel cost.	=	Like the vessel subsidy scenario, this is unlikely under New Zealand governments, but could be possible for companies supported by other governments.
7	Installing LEDs but with minimal impact on fishing.	=	Switching to LED technologies is plausible and will bring substantial fuel savings. However, replacing metal halide lamps with LEDs has been linked to reductions in catch. Unless technologies have improved, or better methods have been developed, minimal fishing impact when using LEDs is perhaps unlikely.

[10] Noting that subsidies may enable fishers to catch fish at levels that would otherwise be uneconomical, thereby placing extra pressure on stocks.

Scenario	Details	Plausible	Notes
8	Tax rate set to 20% and cost-recovery levy removed.	✗	As a vessel registered in New Zealand, it is expected that New Zealand corporate tax rates would apply. Furthermore, fishing in New Zealand requires quota, against which levies are charged, so a total removal of levies seems implausible under current regulations.
9	Installing LEDs and experiencing reduced catch rates.	✓	This scenario assumes both fuel savings and reductions in catch rates as reported in published literature.
Optimal	See notes	✗	• LEDs installed with minimal impact to fishing; • Fuel costs: NZ$0.53/L • Fishing days: 137/vessel/year • Catch rates: 10MT/day for small vessels, 30MT/day for large • Labour costs: 6% of current requirements • Tax rate: 20% • Cost recovery levy: NZ$0 • Cost of capital: 6.4%

The results from this sensitivity analysis can be seen in both Table 17 and Table 18. With the exception of the Optimal scenario (found at the end of Table 18), the results are listed in order of highest to lower impact on vessel profitability. Whilst a number of top ranked scenarios have the potential to generate standard profits, it is worth highlighting that only two of the scenarios (zero vessel cost and the optimal scenario) generate sufficient change to vessel economics that they generate an ROI which matches the likely cost of capital. On their own, the rest of the inputs will have minimal impact.

Furthermore, the reasons that many of these scenarios are not plausible in the New Zealand context are either due to the regulatory framework (which would require reversal of government policy to change) or they are due to factors which cannot be controlled. This is an important finding when considering the economic and political implications of any policy changes.

Table 17: Top five scenario results from sensitivity analysis in terms of positive influence to economic profitability.

Scenario	**1**		**2**		**3**		**4**		**5**	
Vessel size (Small/Large)	S	L	S	L	S	L	S	L	S	L
Capital cost vessel	0	0	(5,715)	(28,576)	(5,715)	(28,576)	(5,715)	(28,576)	(5,715)	(28,576)
Annual Benefits										
Catch Rev	556	1,617	2,021	6,063	953	2,773	1,280	3,724	556	1,617
Annual Costs										
Fuel Costs	(105)	(352)	(105)	(352)	(105)	(352)	(243)	(811)	(105)	(352)
Repair and Maintenance	0	0	(48)	(238)	(48)	(238)	(48)	(238)	(48)	(238)
Labour	(208)	(606)	(758)	(2,274)	(357)	(1,040)	(480)	(1,396)	(10)	(29)
Import Duty to Japan	(17)	(49)	(61)	(182)	0	0	(38)	(112)	(17)	(49)
Cost Recovery Levy	(7)	(20)	(25)	(76)	(7)	(20)	(16)	(47)	(7)	(20)
Contingency and Admin	(34)	(103)	(100)	(312)	(52)	(165)	(82)	(260)	(19)	(69)
Depreciation	0	0	(286)	(1,429)	(286)	(1,429)	(286)	(1,429)	(286)	(1,429)
Tax	(52)	(136)	(179)	(336)	(27)	132	(24)	159	(18)	159
Net Benefit (10 yrs)	1,329	3,506	4,599	8,643	707	(3,394)	625	(4,098)	465	(4,095)
NPV	796	2,102	(201)	(9,607)	(2,534)	(16,821)	(2,583)	(17,244)	(2,679)	(17,242)
IRR	N/A*	N/A*	9.9%	3.8%	1.6%	-1.5%	1.4%	-1.9%	1.0%	-1.9%

Table 18: Bottom four and the optimal scenario results from sensitivity analysis in terms of positive influence to economic profitability.

Scenario	**6**		**7**		**8**		**9**		**Optimal**	
Vessel size (Small/Large)	S	L	S	L	S	L	S	L	S	L
Capital cost vessel	(5,715)	(28,576)	(5,715)	(28,576)	(5,715)	(28,576)	(5,715)	(28,576)	(5,715)	(28,576)
Annual Benefits										
Catch Rev	556	1,617	528	1,536	556	1,617	472	1,374	3,040	8,844
Annual Costs										
Fuel Costs	0	0	(83)	(278)	(105)	(352)	(83)	(278)	(68)	(228)
Repair and Maintenance	(48)	(238)	(48)	(238)	(48)	(238)	(48)	(238)	(48)	(238)
Labour	(208)	(606)	(198)	(576)	(208)	(606)	(177)	(515)	(55)	(159)
Import Duty to Japan	(17)	(49)	(16)	(46)	(17)	(49)	(14)	(41)	(91)	(265)
Cost Recovery Levy	(7)	(20)	(7)	(19)	0	0	(6)	(17)	0	0
Contingency and Admin	(28)	(91)	(35)	(116)	(38)	(125)	(33)	(109)	(26)	(89)
Depreciation	(286)	(1,429)	(286)	(1,429)	(286)	(1,429)	(286)	(1,429)	(286)	(1,429)
Tax	11	229	40	327	29	236	49	351	(493)	(1,287)
Net Benefit (10 yrs)	(271)	(5,879)	(1,039)	(8,398)	(1,168)	(9,452)	(1,256)	(9,028)	19,730	51,482
NPV	(3,120)	(18,311)	(3,580)	(19,821)	(3,657)	(20,452)	(3,710)	(20,198)	12,128	26,587
IRR	-0.6%	-2.7%	-2.4%	-3.9%	-2.7%	-4.4%	-2.9%	-4.2%	38.8%	21.2%

4 Discussion

Broadly, there are two ways the squid resource in New Zealand could be harvested through jig gear:

- A domestically-based vessel using the fishery exclusively[11]; or
- A foreign vessel fishing part of the year, using the fishery as a secondary ground.

Given current regulatory and operating environment, this analysis has focused on the first method of utilisation to understand the fundamental economics. As such, the New Zealand squid jig fishery has been assessed from the perspective of a domestic investor seeking information on the likelihood of making a reasonable return on investment.

Based on the inputs used in Table 9, our results indicate that squid jigging exclusively in New Zealand waters is not an economically viable option under current conditions. Although annual earnings (even before favourable tax outcomes) would be above annual operating costs (labour, fuel, etc.), they would not be sufficient to cover total costs (which include fixed costs such as vessel repayments, stakeholder returns, etc.). This latter aspect is the key reason a dedicated squid jigging operation in New Zealand is not viable under current market conditions and is consistent with the absence of domestic squid jig vessels operating in the fishery.

If a choice was made to operate exclusively in New Zealand waters (i.e. not seek other fishing grounds in the off-season), our analysis indicates the economics of the squid jig fishery are better suited to smaller scale vessels (albeit the ROI figures for both are negative: -2.5% for small vessels Vs -4% for larger vessels). This result appears driven by the low catch rates seemingly available even for larger scale vessels, coupled with the lower initial capital investment required for a smaller vessel. Furthermore, industry representatives suggested that smaller scale vessels would be more adaptable to using different gear types.

Although some vessels may be technically capable of using multiple gears (e.g. jig/longline) which may be deployed seasonally, our analysis indicates that, in order to achieve a ROI of 10%, an investor would need to make an additional present value of NZ$3.62 million for small vessels and NZ$19.98 million for large vessels from the non-jig component. In practice, this means that under the squid jig/longline multi-gear vessel scenario, the longline component would need to generate an additional ~NZ$604K each year for small vessels and ~NZ$3.33 million for large vessels to achieve a 10% ROI. In comparison to what we estimate can be achieved by squid jigging operations, this represents a 245% increase in after-tax revenues for small vessels and 492% increase for large vessels. It is uncertain whether such returns are possible, and if they were, it is unclear why the vessel operator would invest in the less profitable jigging operation.

While our results were pessimistic about the viability of a dedicated New Zealand squid jig vessel, the modelling suggest that the fishery could form a profitable secondary part of an annual fishing plan for a migratory jigging vessel, assuming profits from their primary fishing grounds were sufficient to cover fixed costs. This is because the economics of the fishery seem sufficient to cover variable costs. This multi-fishery harvesting approach is consistent with the preferred historic model for accessing the fishery, with foreign vessels fishing part of the year in New Zealand to supplement their primary operations. However, discussions with industry indicate that the current regulatory environment, and in particular the requirement for New Zealand vessel registration, present a range of actual or perceived barriers to this approach.

Importantly, some of the regulatory costs often cited as barriers (e.g. payment of minimum wages and cost recovery levies) are within the variable costs which we estimate to be exceeded by operating revenues. To that end, it is not necessarily the direct economic impact of those

[11] Domestic vessels have been assumed to fish only locally given the difficulties faced trying to source crew willing to spend sufficient time at sea to reach other squid grounds (see section 3.4.1.5).

regulations alone which is driving disinterest of foreign flagged vessel operators in the fishery. A key additional factor is likely to be the administrative burden associated with entry (e.g. seeking the necessary permits to hire foreign crew; dealing with the complications associated with re-registering the vessel for a small portion of the year; etc). Informal discussions with some Taiwanese industry representatives during the course of the study highlighted that – even in the current market circumstances under which entry into the New Zealand fishery should be attractive (i.e. a high current global price for squid and limited catch in other major squid fisheries) – interest in entering the New Zealand fishery remained muted given the regulatory framework in place.

In addition to regulatory barriers, this study has also highlighted that relative attractiveness of alternative squid jig fisheries around the world is likely to play a big part in influencing low quota uptake. Since the New Zealand squid jig fishery was first developed, a number of new squid jig fisheries have opened up. Several of these fisheries, such as the Eastern Pacific, offer higher catch rates than New Zealand (up to 300%; Arkhipkin et al., 2015). In addition to the superior catch rates, consultation with foreign fishing companies highlighted that access arrangements in those other fisheries are less administratively burdensome (particularly if they are on the high seas). The impact of this relative difference in economic/administrative attractiveness of alternative squid fisheries on participation rates in the New Zealand squid fishery should not be underestimated.

In short then, the absence of activity in the jig sector in recent years can largely be explained by the combination of two constraints:

- biological limitations such as stock abundance and short season lengths mean that squid jigging in New Zealand is unlikely to be viable as an exclusive (domestic) operation under current market conditions; and
- the current regulatory framework, in particular constraints associated with the requirement for New Zealand vessel registration, together with the superior commercial attractiveness of alternative global squid fisheries has limited interest by foreign vessels (who have previously accessed the fishery as part of a seasonal annual fishing plan).

While the sensitivity analysis suggests that in the current market environment an operation exclusively dedicated to squid jigging in New Zealand is unlikely to be viable, an operation which involved fishing in New Zealand during the 'high season' as part of an annual fishing plan involving other global squid fisheries would have greater chances of commercial success (and uptake of SQU1J quota). Facilitating access for such vessels would likely require changes to the existing regulatory framework to reduce actual and perceived barriers. Nevertheless, any such changes would need to be weighed very carefully against the body of considerations which led to the establishment of the current regulatory framework (e.g. labour abuses on foreign chartered vessels).

Finally, it is worth highlighting that the economics of the fishery presented in this analysis reflect an operational optimum which is important but not easily quantifiable. During consultation, industry representatives highlighted that each year squid stocks tend to occur in slightly different areas at slightly different times. Industry representatives highlighted the importance of a "critical mass" of vessels operating in the fishery which essentially act as sighting vessels for one another. Without this critical mass, it was reported that harvesting can become substantially less efficient. Therefore, any efforts to encourage fishery participation may need to focus on attracting numerous vessels.

4.1 Analysis limitations

Although not expected to substantially change the overall results, there are a number of limiting factors to this analysis that should be set out.

Firstly, this analysis has focused on the financial and economic aspects of the fishery; it has not attempted to analyse, or place any weight on, its environmental or social performance. We acknowledge that different types of fisheries have different environmental and social characteristics, although the intent of the current study was to examine the economic viability of jigging and gain an insight into the likely drivers behind private sector decisions.

Secondly, the analysis has considered squid jigging fisheries around the globe as the alternative option to squid fishing in New Zealand. This may be the case for foreign squid jig vessels seeking the best arrangements for the jig vessels. However, for New Zealand companies, the decision is likely more local in scope and the alternative option to squid jigging appears to be trawling for squid.

Thirdly, this analysis has not incorporated any cost of acquiring quota to participate in the fishery. A completely new entrant to the fishery would need to secure ACE either through their own quota share or through leasing. For our purposes, we assumed that investments in a squid jig vessel would be made by current holders of applicable squid quota. This does not mean that the quota would then have no value, just that it would already be an asset held which does not factor into the CBA methodology. Furthermore, assigning a value to the quota would be difficult given public records of quota transactions do not exist and standard valuation methods would have produced a negative value given the current value of the fishery (i.e. current holders would need to actually pay potential holders to take it). Overall, including the value to secure quota would have only further decreased the estimated value of the fishery.

Finally, this analysis has provided estimates based on single point values combined with a series of scenarios to test sensitivity of the results. This limitation could influence overall results. Holding a constant value (albeit an average) for all inputs over the entire time series of this analysis does not necessarily reflect the expected variations and could bias the result (either upwards or downwards). In any future versions of the model, Monte Carlo simulations could be built into analysis to account for inter-annual variability and uncertainty. This would also provide a more accurate risk profile of the results by producing a probability distribution of analysis results.

5 References

ARKHIPKIN, A. I., P. G. K. RODHOUSE, G. J. PIERCE, W. SAUER, M. SAKAI, L. ALLCOCK, J. ARGUELLES, J. R. BOWER, G. CASTILLO, L. CERIOLA, C.-S. CHEN, X. CHEN, M. DIAZ-SANTANA, N. DOWNEY, A. F. GONZÁLEZ, J. G. AMORES, A. G. COREY P. GREEN, L. C. HENDRICKSON, C. IBÁÑEZ, K. ITO, P. JEREB, Y. KATO, O. N. KATUGIN, M. KAWANO, H. KIDOKORO, V. V. KULIK, V. V. LAPTIKHOVSKY, M. R. LIPINSKI, B. LIU, L. MARIÁTEGUI, W. MARIN, A. MEDINA, K. MIKI, K. MIYAHARA, N. MOLTSCHANIW SKYJ, H. MOUSTAHFID, J. NABHITABHATA, N. NANJO, C. M. NIGMATULLIN, T. OHTANI, G. PECL, J. A. A. PEREZ, U. PIATKOWSKI, P. SAIKLIANG, C. A. SALINAS-ZAVALA, M. STEER, Y. TIAN, Y. UETA, D. VIJAI, T. WAKABAYASHI, T. YAMAGUCHI, C. YAMASHIRO, N. YAMASHITA & L. D. ZEIDBERG (2015). World Squid Fisheries. *Reviews in Fisheries Science & Aquaculture,* 23**,** 160.

COURTOIS, Y., G. C. LAI & P. P. DRAKE (2007). *Cost of Capital,* Charlottesville, Virginia, USA, CFA Institute.

HARKELL, L. (2018). *Chinese Vessels Amass Near Argentine Waters Ahead Of Squid Season Start* [Online]. London, UK: Undercurrent News. Available: https://www.undercurrentnews.com/2018/12/13/chinese-vessels-amass-near-argentine-waters-ahead-of-squid-season-start/ [Accessed].

HARRIS, C. (2015). *An Economic Analysis of Domesticating a Fishery in Tuvalu in Comparison to Selling Foreign Access Rights.* Ma Research, University of Queensland.

HUFFLET, C. (1993). The New Zealand Jig Fishery, Nelson, New Zealand, Unknown

IMMIGRATION NZ (2018). *Standard Principles For Crew Employment Agreements* [Online]. Wellington, New Zealand: Immigration New Zealand. Available: https://www.immigration.govt.nz/new-zealand-visas/apply-for-a-visa/tools-and-information/work-and-employment/standard-principles-for-crew-employment-agreements/slider [Accessed 08/11/2018].

LI NZ (2007) Paper Chart: NZ 14600 New Zealand including Norfolk Island and Campbell Island / Motu Ihupuku, Wellington, New Zealand, Land Information New Zealand (*Toitū te whenua*).

MPI NZ (2016). Review of Management Controls for the Arrow Squid Jigging Fishery (SQU 1J) in 2016. MPI Discussion Paper No: 2016/12. Wellington, New Zealand, Ministry for Primary Industries.

MPI NZ (2017). Annual Review Report For Deepwater Fisheries: 2016/17, Welllington, New Zealand, Ministry for Primary Industries

MPI NZ (2018a). Deemed value rates. Wellington, New Zealand: Ministry for Primary Industries.

MPI NZ (2018b). Logbook effort data. Wellington, New Zealand: Ministry for Primary Industries.

NZFIA (1991). Management Options for the Squid Fishery 1991-1992, Wellington, New Zealand, New Zealand Fishing Industry Association Inc.

PARK, J.-A., C. GARDNER, Y.-S. JANG, M.-I. CHANG, Y.-I. SEO & D.-H. KIM (2015). The economic feasibility of light-emitting diode (LED) lights for the Korean offshore squid-jigging fishery. *Ocean & Coastal Management,* 116**,** 311-317.

PRO JAPAN (2016). *The Lure of Success* [Online]. Tokyo, Japan. Available: https://www.gov-online.go.jp/eng/publicity/book/hlj/html/201602/201602_03_en.html [Accessed 06/12/2018].

REID, C. & H. F. CAMPBELL (n.d.). Bioeconomic Analysis of the Queensland Beam Trawl Fishery, Brisbane, QLD, Australia, University of Queensland Department of Economics.

SEA RESOURCES LIMITED (2011). Fishing (Foreign Charter Vessels and Other Matters) Bill Submission for Select Committee. Unknown.

SEALORD (1977). Sealord Squid Fishery Report, Nelson, New Zealand,

SEO, J.-N., H.-C. AN & D.-H. KIM (2012). Estimating the economic effectiveness of LED fishing light systems for the squid jigging fishery. *Journal of the Korean society of Fisheries Technology,,* 48**,** 346-351.

SHARNBROOK TACKLE (2018). *Jumbo Commercial Squid Jig* [Online]. Jumbo Commercial Squid Jig. Available: https://www.sharnbrooktackle.com/acatalog/Jumbo-Commercial-Squid-Jig-139.html [Accessed 06/12/2018].

TYSON, P. J., S. D. CANNING & C. A. CAREY (1982). The 1981-82 Foreign and Joint Venture Squid Jig Fishery, Wellington, New Zealand, Fisheries Research Division

UNITED NATIONS (2018). UN comtrade. New York, USA: United Nations.

YAMASHITA, H. & M. MUTA (2003). Report Of Joint Research Cruise On New Zealand Southern Arrow Squid *Nototodarus sloanii* By Japan Marine Fishery Resources Research Center And New Zealand Squid Fishery Management Company Limited: January – April 2003, JAMARC Report No.15: 2002. Tokyo, Japan, Japan Marine Fishery Resources Research Center

YATES, O. (2005). Observations Of High Sea Jigging Vessels From A Falkland Islands Fishery Patrol Vessel, London, UK, Falklands Conservation

1 Annexes

1.1 Raw catch and effort data

Table 19: Effort days for squid jig vessels in New Zealand waters by month; 1990/91 – 2017/18; shading indicates relative frequency through the seasons – green: high; yellow: medium; red: low (MPI NZ, 2018b)[12].

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total Days
1990	0	0	0	0	0	0	0	0	0	0	0	65	
1991	605	851	1,174	545	17	0	0	0	0	0	0	61	3,253
1992	267	394	408	259	57	0	0	0	0	0	0	44	1,429
1993	361	404	320	245	27	0	0	1	0	0	0	46	1,404
1994	184	170	217	183	90	6	5	0	0	0	5	35	895
1995	431	908	1,032	999	208	0	0	0	1	0	0	43	3,622
1996	682	1,634	1,856	1,215	10	0	0	0	1	0	0	243	5,641
1997	1,969	2,569	2,507	1,052	0	0	2	0	1	0	0	42	8,142
1998	448	744	747	579	2	1	1	0	0	0	0	15	2,537
1999	338	520	542	122	0	0	0	0	0	0	0	12	1,534
2000	53	86	82	73	5	0	0	0	0	0	0	0	299
2001	22	46	60	51	18	0	0	0	5	1	0	0	203
2002	49	78	103	69	0	0	0	0	0	0	0	4	303
2003	129	130	147	159	82	3	0	0	0	0	0	18	668
2004	153	155	141	130	78	0	0	0	0	0	0	94	751
2005	336	341	416	483	235	40	0	0	0	0	0	49	1,900
2006	371	440	477	426	42	0	0	0	0	0	0	32	1,788
2007	77	80	79	43	3	0	0	0	0	0	0	15	297
2008	##	##	##	##	##	##	##	##	##	##	##	##	##
2009	42	43	52	61	21	1	0	0	0	0	0	7	227
2010	70	64	49	46	1	0	0	0	0	0	0	13	243
2011	51	56	67	42	1	0	0	0	0	0	0	0	217
2012	##	##	##	##	##	##	##	##	##	##	##	##	##
2013	##	##	##	##	##	##	##	##	##	##	##	##	##
2014	##	##	##	##	##	##	##	##	##	##	##	##	##
2015	18	27	31	31	30	10	0	0	0	0	0	0	147
2016	17	33	37	11	0	0	1	0	0	0	0	0	99
2017	##	##	##	##	##	##	##	##	##	##	##	##	##

[12] ## has been used to replace figures when there were less than 3 vessels having recorded catch and effort.

Table 20: Effort days for squid jig vessels in New Zealand waters North of 47°S by month; 1990/91 – 2017/18; shading indicates relative frequency through the seasons – green: high; yellow: medium; red: low (MPI NZ, 2018b)[13].

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total Days
1990	0	0	0	0	0	0	0	0	0	0	0	63	
1991	601	661	1,153	544	17	0	0	0	0	0	0	61	3,037
1992	266	393	408	259	57	0	0	0	0	0	0	44	1,427
1993	361	399	317	245	27	0	0	1	0	0	0	46	1,396
1994	184	170	217	183	90	6	5	0	0	0	5	35	895
1995	431	905	1,029	999	208	0	0	0	1	0	0	43	3,616
1996	682	1,621	1,855	1,214	10	0	0	0	1	0	0	243	5,626
1997	1,927	2,552	2,504	1,051	0	0	2	0	1	0	0	42	8,079
1998	444	743	747	579	2	1	1	0	0	0	0	15	2,532
1999	337	515	542	122	0	0	0	0	0	0	0	12	1,528
2000	53	86	82	73	5	0	0	0	0	0	0	0	299
2001	22	46	60	51	18	0	0	0	5	1	0	0	203
2002	49	70	102	69	0	0	0	0	0	0	0	4	294
2003	129	130	129	159	82	3	0	0	0	0	0	18	650
2004	136	151	140	127	77	0	0	0	0	0	0	94	725
2005	300	130	410	482	235	40	0	0	0	0	0	49	1,646
2006	359	417	477	426	42	0	0	0	0	0	0	32	1,753
2007	71	80	79	43	3	0	0	0	0	0	0	15	291
2008	##	##	##	##	##	##	##	##	##	##	##	##	##
2009	36	36	52	61	21	1	0	0	0	0	0	7	214
2010	70	64	49	46	1	0	0	0	0	0	0	13	243
2011	51	56	67	42	1	0	0	0	0	0	0	0	217
2012	##	##	##	##	##	##	##	##	##	##	##	##	##
2013	##	##	##	##	##	##	##	##	##	##	##	##	##
2014	##	##	##	##	##	##	##	##	##	##	##	##	##
2015	18	25	31	31	30	10	0	0	0	0	0	0	145
2016	17	33	37	11	0	0	1	0	0	0	0	0	99
2017	##	##	##	##	##	##	##	##	##	##	##	##	##

[13] ## has been used to replace figures when there were less than 3 vessels having recorded catch and effort.

Table 21: Effort days for squid jig vessels in New Zealand waters South of 47ºS by month; 1990/91 – 2017/18; shading indicates relative frequency through the seasons – green: high; yellow: medium; red: low (MPI NZ, 2018b)[14].

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total Days
1990	0	0	0	0	0	0	0	0	0	0	0	2	
1991	4	190	21	1	0	0	0	0	0	0	0	0	216
1992	##	##	##	##	##	##	##	##	##	##	##	##	##
1993	0	5	3	0	0	0	0	0	0	0	0	0	8
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
1995	0	3	3	0	0	0	0	0	0	0	0	0	6
1996	0	13	1	1	0	0	0	0	0	0	0	0	15
1997	42	17	3	1	0	0	0	0	0	0	0	0	63
1998	4	1	0	0	0	0	0	0	0	0	0	0	5
1999	1	5	0	0	0	0	0	0	0	0	0	0	6
2000	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	8	1	0	0	0	0	0	0	0	0	0	9
2003	0	0	18	0	0	0	0	0	0	0	0	0	18
2004	17	4	1	3	1	0	0	0	0	0	0	0	26
2005	36	211	6	1	0	0	0	0	0	0	0	0	254
2006	12	23	0	0	0	0	0	0	0	0	0	0	35
2007	6	0	0	0	0	0	0	0	0	0	0	0	6
2008	##	##	##	##	##	##	##	##	##	##	##	##	##
2009	##	##	##	##	##	##	##	##	##	##	##	##	##
2010	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	##	##	##	##	##	##	##	##	##	##	##	##	##
2013	0	0	0	0	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0	0
2015	##	##	##	##	##	##	##	##	##	##	##	##	##
2016	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0	0	0	0	0

[14] ## has been used to replace figures when there were less than 3 vessels having recorded catch and effort.

Table 22: Effort sets for squid trawl vessels in New Zealand waters by month; 1990/91 – 2017/18; shading indicates relative frequency through the seasons – green: high; yellow: medium; red: low (MPI NZ, 2018b).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1990	1,462	2,525	2,370	968	328	171	1	11	10	5	3	162	8,016
1991	2,215	2,775	3,099	1,612	515	215	65	0	2	0	10	240	10,748
1992	12	2,391	2,597	1,937	470	384	29	4	13	2	1	3	7,843
1993	3	2,465	2,971	1,791	481	172	7	24	3	3	1	0	7,921
1994	28	2,581	2,948	2,286	1,562	453	30	9	32	0	2	11	9,942
1995	51	3,074	3,156	2,949	818	371	22	2	73	7	18	30	10,571
1996	136	2,562	3,101	2,839	765	178	2	2	39	45	4	4	9,677
1997	1,604	2,491	2,680	1,750	952	359	12	2	4	35	23	96	10,008
1998	1,698	2,216	1,953	624	695	192	4	1	11	7	23	354	7,778
1999	1,891	1,929	1,626	841	465	69	3	6	19	10	13	719	7,591
2000	920	1,500	1,264	761	647	62	28	15	55	21	56	121	5,450
2001	971	1,818	1,721	1,334	765	220	66	58	69	116	98	209	7,445
2002	1,240	1,786	1,797	1,210	611	243	31	19	32	108	103	85	7,265
2003	1,284	2,172	2,043	1,216	813	304	4	0	0	68	26	188	8,118
2004	1,505	1,764	1,762	1,469	883	370	29	0	8	50	33	294	8,167
2005	1,845	2,322	2,568	1,606	973	401	89	7	15	34	67	220	10,147
2006	1,517	1,987	1,580	1,170	723	282	6	0	2	105	233	509	8,114
2007	1,070	1,229	1,330	941	490	41	33	2	0	5	56	180	5,377
2008	718	1,266	1,169	838	106	27	5	0	6	8	0	66	4,209
2009	572	767	856	804	419	218	154	4	1	0	2	16	3,813
2010	475	755	935	471	517	414	166	2	1	7	7	16	3,766
2011	698	766	1,154	847	415	228	43	0	5	1	5	17	4,179
2012	316	774	930	763	523	104	36	2	11	9	0	5	3,473
2013	445	636	639	518	297	61	0	0	0	1	2	15	2,614
2014	244	470	619	361	246	68	5	1	0	0	15	14	2,043
2015	249	484	717	260	192	9	3	2	2	1	5	7	1,931
2016	257	585	833	535	392	245	8	0	0	3	2	6	2,866
2017	234	591	889	463	268	128	2	3	2	0	1	5	2,586

Table 23: Effort sets for squid trawl vessels in New Zealand waters North of 47ºS by month; 1990/91 – 2017/18; shading indicates relative frequency through the seasons – green: high; yellow: medium; red: low (MPI NZ, 2018b).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1990	8	217	384	78	264	163	0	2	6	5	3	4	1,134
1991	29	66	104	9	197	194	62	0	1	0	10	18	690
1992	0	37	210	429	446	363	24	3	8	2	0	1	1,523
1993	0	15	297	399	265	118	0	10	2	3	1	0	1,110
1994	25	57	146	919	1,498	312	12	0	20	0	2	11	3,002
1995	36	315	528	411	503	301	21	1	72	4	13	26	2,231
1996	114	664	1,134	483	535	172	1	2	35	44	4	4	3,192
1997	62	78	608	955	676	167	11	0	0	34	23	0	2,614
1998	283	333	531	371	485	177	4	1	10	7	20	12	2,234
1999	210	281	409	416	368	62	1	0	19	10	13	30	1,819
2000	274	109	491	638	628	60	28	15	53	12	49	29	2,386
2001	421	390	741	767	653	176	50	39	61	114	97	176	3,685
2002	187	300	513	543	485	216	26	19	32	76	95	74	2,566
2003	318	704	819	582	632	209	2	0	0	50	11	83	3,410
2004	529	119	94	136	288	129	14	0	6	32	9	41	1,397
2005	119	113	179	246	701	198	68	0	9	12	20	22	1,687
2006	120	126	102	271	473	243	6	0	1	20	42	14	1,418
2007	147	89	90	219	311	31	10	1	0	2	13	61	974
2008	125	176	31	134	79	27	5	0	0	7	0	2	586
2009	6	1	26	44	60	50	22	4	1	0	2	0	216
2010	11	23	4	39	94	121	95	2	1	3	5	4	402
2011	31	287	169	77	35	22	6	0	5	1	1	7	641
2012	14	50	92	57	150	19	28	2	2	3	0	0	417
2013	12	12	4	83	3	10	0	0	0	0	0	3	127
2014	2	37	16	82	20	7	0	0	0	0	6	0	170
2015	17	27	61	68	124	8	0	1	0	0	0	0	306
2016	37	48	59	76	112	215	1	0	0	1	1	1	551
2017	21	10	51	74	23	93	0	3	0	0	0	3	278

Table 24: Effort sets for squid trawl vessels in New Zealand waters South of 47ºS by month; 1990/91 – 2017/18; shading indicates relative frequency through the seasons – green: high; yellow: medium; red: low (MPI NZ, 2018b).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1990	1,454	2,305	1,986	889	64	8	0	8	2	0	0	158	6,874
1991	2,185	2,709	2,995	1,603	317	20	0	0	1	0	0	222	10,052
1992	12	2,354	2,384	1,507	15	21	5	1	5	0	0	2	6,306
1993	1	2,448	2,667	1,390	210	44	1	8	1	0	0	0	6,770
1994	2	2,520	2,793	1,359	31	95	17	0	12	0	0	0	6,829
1995	11	2,755	2,625	2,537	309	56	0	0	0	0	5	4	8,302
1996	15	1,890	1,965	2,355	224	6	1	0	4	1	0	0	6,461
1997	1,539	2,405	2,071	794	267	191	1	2	4	1	0	96	7,371
1998	1,415	1,877	1,422	250	200	13	0	0	0	0	3	342	5,522
1999	1,676	1,641	1,213	381	68	6	2	0	0	0	0	685	5,672
2000	635	1,388	764	101	7	2	0	0	2	9	7	92	3,007
2001	547	1,365	939	515	78	35	1	0	0	0	0	33	3,513
2002	1,030	1,472	1,278	663	121	25	0	0	0	32	8	11	4,640
2003	960	1,442	1,179	615	172	95	0	0	0	18	14	105	4,600
2004	976	1,638	1,660	1,319	586	238	15	0	2	16	24	253	6,727
2005	1,722	2,184	2,364	1,342	227	181	21	0	6	22	47	198	8,314
2006	1,367	1,799	1,450	887	247	39	0	0	0	85	191	495	6,560
2007	849	1,080	1,231	718	148	1	19	0	0	3	43	118	4,210
2008	593	1,090	1,138	704	27	0	0	0	6	1	0	64	3,623
2009	566	766	830	760	359	168	132	0	0	0	0	16	3,597
2010	464	732	931	432	423	293	71	0	0	4	2	12	3,364
2011	667	479	985	770	380	206	37	0	0	0	4	10	3,538
2012	302	724	838	706	373	85	8	0	9	6	0	5	3,056
2013	433	624	635	435	294	51	0	0	0	1	2	12	2,487
2014	242	433	603	279	226	61	5	1	0	0	9	14	1,873
2015	232	457	656	192	68	1	3	1	2	1	5	7	1,625
2016	220	537	774	459	280	30	7	0	0	2	1	5	2,315
2017	213	581	838	389	245	35	2	0	2	0	1	2	2,308

1.2 Maritime chart for Southern Islands

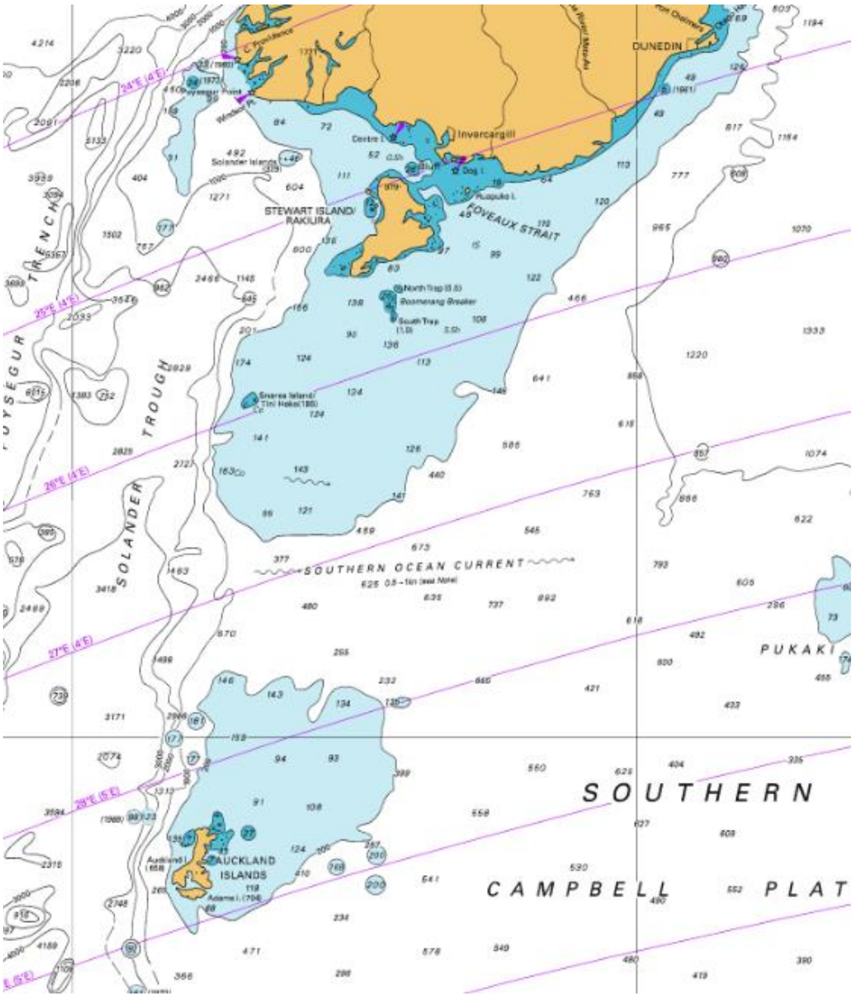


Figure 13: Maritime charts indicating seabed depths around Southern Islands: white: >200m; light blue ≤200m; and dark blue ≤30m (LI NZ, 2007).

1.3 Financial analysis raw data

Table 25: Monthly yields for NZX50 index, SAN, NZK and NZ Govt 1-year bonds – Jan 2014 – Dec 2018.

Month	NZX50 Index	SAN	NZK	NZ Govt
Jan-14	2.2%	-3.2%	#N/A	2.88%
Feb-14	2.9%	0.0%	#N/A	2.93%
Mar-14	2.2%	-1.1%	#N/A	3.05%
Apr-14	2.3%	-4.3%	#N/A	3.23%
May-14	-1.0%	-4.9%	#N/A	3.38%
Jun-14	-0.3%	2.2%	#N/A	3.52%
Jul-14	-0.8%	0.0%	#N/A	3.67%
Aug-14	2.6%	3.7%	#N/A	3.69%
Sep-14	0.4%	16.6%	#N/A	3.71%
Oct-14	2.7%	3.1%	#N/A	3.68%
Nov-14	0.2%	-1.0%	#N/A	3.67%
Dec-14	2.5%	-4.8%	#N/A	3.67%
Jan-15	2.8%	4.0%	#N/A	3.67%
Feb-15	2.4%	0.0%	#N/A	3.63%
Mar-15	-1.0%	-2.0%	#N/A	3.63%
Apr-15	-0.6%	0.2%	#N/A	3.63%
May-15	1.7%	5.4%	#N/A	3.53%
Jun-15	-0.4%	5.5%	#N/A	3.34%
Jul-15	1.4%	-4.7%	#N/A	3.13%
Aug-15	-6.2%	-1.2%	#N/A	2.95%
Sep-15	0.1%	-2.2%	#N/A	2.85%
Oct-15	7.0%	1.0%	#N/A	2.86%
Nov-15	2.7%	18.1%	#N/A	2.89%
Dec-15	2.9%	-1.8%	#N/A	2.79%
Jan-16	-1.6%	0.0%	#N/A	2.74%
Feb-16	2.2%	8.9%	#N/A	2.62%
Mar-16	6.3%	1.6%	#N/A	2.43%
Apr-16	0.7%	-3.1%	#N/A	2.34%
May-16	3.1%	-3.3%	#N/A	2.38%
Jun-16	-1.1%	-2.6%	#N/A	2.37%
Jul-16	5.6%	1.8%	#N/A	2.37%
Aug-16	1.3%	6.8%	#N/A	2.24%
Sep-16	-0.9%	6.7%	#N/A	2.23%
Oct-16	-7.0%	-3.6%	#N/A	2.16%
Nov-16	0.7%	12.1%	10.2%	2.07%
Dec-16	-0.3%	0.4%	7.6%	2.03%
Jan-17	1.1%	4.5%	8.6%	1.99%
Feb-17	1.7%	7.1%	-2.9%	2.02%
Mar-17	0.3%	-2.0%	-0.7%	1.98%
Apr-17	2.7%	-0.5%	-3.0%	1.98%
May-17	1.0%	-2.2%	5.3%	1.98%
Jun-17	1.5%	-0.4%	17.4%	1.95%

Month	NZX50 Index	SAN	NZK	NZ Govt
Jul-17	2.1%	4.3%	1.8%	1.96%
Aug-17	1.0%	1.5%	5.3%	1.95%
Sep-17	1.5%	6.9%	2.3%	1.95%
Oct-17	1.9%	0.0%	30.8%	1.94%
Nov-17	1.3%	4.0%	-5.0%	1.93%
Dec-17	2.6%	2.5%	1.3%	1.88%
Jan-18	-0.1%	-4.8%	2.6%	1.88%
Feb-18	-1.5%	-4.2%	-17.4%	1.91%
Mar-18	0.4%	-2.5%	11.4%	1.93%
Apr-18	2.0%	3.4%	8.3%	2.01%
May-18	1.7%	0.7%	-2.6%	2.02%
Jun-18	2.1%	0.9%	7.2%	2.01%
Jul-18	-1.0%	-1.0%	15.9%	1.94%
Aug-18	5.2%	0.8%	-0.7%	1.91%
Sep-18	0.7%	3.2%	-0.3%	1.90%
Oct-18	-5.3%	-7.7%	-3.3%	1.90%
Nov-18	-0.1%	-5.4%	-6.4%	1.98%
Dec-18	#N/A	#N/A		#DIV/0!

Table 26: SAN beta coefficient regression analysis output

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.2534
R Square	0.0642
Adjusted R Square	0.0478
Standard Error	4.87
Observations	59

ANOVA

	df	*SS*	*MS*	*F*	*Sig F*
Regression	1	92.732	92.732	3.91	0.0528
Residual	57	1351.90	23.718		
Total	58	1444.63			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.548	0.688	0.797	0.429	-0.829	1.925	-0.829	1.925
SAN Coefficient	**0.513**	0.259	1.977	**0.053**	-0.007	1.032	-0.007	1.032

Table 27: NZK beta coefficient regression analysis output

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.1646
R Square	0.0271
Adjusted R Square	-0.0152
Standard Error	0.0946
Observations	25

ANOVA

	df	*SS*	*MS*	*F*	*Sig F*
Regression	1	0.0057	0.0057	0.6402	0.4318
Residual	23	0.2059	0.0090		
Total	24	0.211633			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.030	0.021	1.403	0.174	-0.014	0.074	-0.014	0.074
NZK Coefficient	**0.824**	1.029	0.800	**0.432**	-1.306	2.953	-1.306	2.953

Table 28: Dividend Discount Model analysis output (SAN and NZK).

	SAN				NZK			
	2018	**2017**	**2016**		**2018**	**2017**	**2016**	
P_o	6.9051	7.6090	6.2156		2.6800	1.6638	1.2198	
SO	93,626,735	93,626,735	93,649,596		138,475	138,158	110,191	
EPS	45.2	40.1	37.1		0.12	0.16	0.02	
Div/share	23	23	23		0.0512	0.0206		
DPR	0.5088	0.5736	0.6199		0.4269	0.1286		
RR	0.4912	0.4264	0.3801		0.5731	0.8714	1.0000	
NI	42,303	37486	34744		16125	22764	2593	
Beg Yr Equity	575,836	558,135	513070		158675	37014	36783	
End Yr Equity	581,934	575,836	558135		166301	158675	37014	
Av Equity	578,885	566,986	535,603		162,488	97,845	36,899	
Reported ROE	7.3%	6.6%	6.50%					
Calc ROE	7.3%	6.6%	6.5%		9.9%	23.3%	7.0%	
g	3.6%	2.8%	2.5%		5.7%	20.3%	7.0%	
D_o	0.230	0.230	0.230		0.230	0.230	0.230	
D_1	0.238	0.236	0.236		0.243	0.277	0.246	
r (cost of equity)	7.04%	5.93%	6.26%	6.41%	14.76%	36.90%	27.21%	26.29%