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NEW ZEALAND INSTITUTE OF ECONOMIC RESEARCH

They that go down to the sea in ships

The case for reforming the New Zealand fisheries management system

NZIER report to LegaSea

July 2019

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Executive Summary

New Zealand's fisheries management system needs reform. Basic changes are needed to deliver greater economic benefits to all New Zealanders and to protect marine resources for future generations.

The Treaty requires unique approaches

The settlement of Māori grievances over long-standing Crown breaches of the Treaty of Waitangi, some of which stemmed from the introduction of the current fisheries management system itself, are a unique part of the New Zealand fisheries environment. The settlement included granting iwi shares of fishing quota and protecting customary fishing rights. No reform of fisheries management can be contemplated without active engagement with Māori.

Managing fisheries is more complex than first thought

Using quota rights to manage fisheries access has not delivered the promised stewardship of stocks because the fundamental nature of ocean fish as a biological resource differs from that suggested by economic theory. Calculating ecologically desirable fishing effort requires considering not just the effect of fishing on the long-term stocks of individual species, but on issues like predator-prey relationships across species and the wider environmental effects of fishing (e.g. seabed damage).

Calculating the socioeconomically desirable fishing effort involves adding the economic and social effects of different types and methods of fishing, into the equation.

The current state of fisheries management is unsatisfactory

The societal value of the fishery is deteriorating, as evidenced:

- In plateauing commercial returns
- Sustainability risks for future catches
- Increasing demand yet deteriorating supply for recreational catches
- Increasing environmental harm
- Lack of entry and exit into the quota market.

Fishing quotas are now concentrated in a few large owners.

The regime has been unable to address key sustainability issues like bycatch (the wrong species of fish or precious birds and marine mammals being caught), high-grading (where setting allowable catch on the basis on quantity induces fishers to only take the highest quality fish and discard the rest) and under-reporting.

Inshore fisheries are coming under increasing pressure. Recreational catch limits for popular species are being reduced as a result of declining stocks e.g. blue cod in the Marlborough Sounds.

Examining the history of the current regime shows that policy was often directed at developing the fishing industry as a highly efficient, export-orientated industry, leading to tensions between different types of fishing. At the same time, growth in exports is

now coming from aquaculture. The benefits of recreational fishing, fishing as a tourist attraction and domestic seafood consumption (from high-end restaurants to fish and chips by the beach) have been discounted.

The move away from quota holders paying resource rentals to levy-based funding of administrative and research costs means that a valuable natural resource is given away, with little benefit going to the public at large.

LegaSea propose an alternative approach

LegaSea have proposed fundamental reforms of the New Zealand fishing regime.

In developing their proposal, LegaSea have sought to:

- Avert depletion and restore sustainability of fish stocks and ecosystem services
- Sustain the societal value of fishing, including recreational and customary fishing, as well as increasing the returns from commercial catch, and increasing the value (including health benefits) derived from the local consumption of seafood
- Discouraging inefficient investment and effort.

Key features of LegaSea's proposal are set out in Table 1.

Table 1 A new regime for managing inshore fisheries

Main features
A new independent Crown Entity authority to set catch limits and undertake scientific research
Māori and the Crown will have shared governance; fulfilling Treaty obligations for tino rangatiratanga (chieftainship) and enabling greater expression of kaitiakitanga (guardianship) of marine resources.
Statutory recognition of non-commercial stakeholders in the new fisheries management system.
Priorities for Ministerial action explicitly set out in the Fisheries Act, prioritising sustained ecological resources, environmental interests, and high value Māori customary and recreational fishing.
Limits on catch will be reset, generally at lower levels to ensure stocks recover and become abundant
Commercial permits to be sold via competitive tendering, replacing current levy-based funding. The payment to the Crown will be a form of resource rental payment and would be used, in part, to finance regulatory and research functions.
Outputs for commercial fishing will be set in multi-species terms
Commercial fishing will be subject to effort limits and gear controls, directed in part at limiting effects on other native species, like seabirds and mammals
Independent monitoring of commercial fishing will combine self-reporting and electronic monitoring, audits and observers

Source: LegaSea

An innovative transition

LegaSea propose that the Crown should buy-back existing quotas at their commercial value as part of the move to the new regime. This is an innovative approach to one of the perennial issues in regulatory reform.

LegaSea have clearly stated that their proposal is not intended to change the substantive rights to fish commercially Māori have at present. These rights will be carried-over into the new regime, albeit with some changes in the names applied to some of those rights. Rather than owning quota, Maori will share in the proceeds of selling permits, which they will also be free to acquire via tendering.

Initial calculations suggest that the combination of buy-back (an upfront cost) and tendering (a long-term revenue stream) could be fiscally neutral to the Crown over the long term.

Next steps

A full assessment of the LegaSea proposal against the current regime will require further analysis. However, at a high level, it does compare favourably with the current regime, when assessed against the recommendations of the economic literature on fisheries regulation.

Table 2 How the economic literature, the current Act and the LegaSea proposal compare

Criteria	What the economic literature recommends	What the current Fisheries Act contains	LegaSea proposal
Limited rights to fish imposed	✓	?	✓
Regime based on nature of fish and fishing	×	×	✓
Limits designed to maximise social return	✓	×	✓
Liquid market for rights to fish	✓	×	Tendering
Limits set based on up-to-date science	✓	×	✓
Resources rentals paid	✓	×	✓
Economies of scale reduce costs	✓	✓	×
Māori interests recognised	✓	✓	✓

Source: the authors

We consider the LegaSea proposal is worthy of further consideration by Ministers, Māori, all fishers, environmental NGOs, academics and the public.

We recommend the Government direct officials to:

- Work with LegaSea to develop a more detailed description of the new proposal
- Test the assumptions and results of the modelling of the financial impact of the proposed transition
- Assess, in a transparent and consultative way, the LegaSea proposal against a clear set of national wellbeing-enhancing criteria
- Use that assessment as the basis of consultation with Māori, representatives of all groups of fishers and the public. Independent facilitators should guide the consultation
- Confirm that the proposals are not a contemporary breach of the Treaty
- Confirm that the proposals are consistent with New Zealand's international obligations
- Once the benefits are confirmed and there is support for the proposal, prepare a draft bill including the transitional provisions for the consideration of Ministers and for discussions with Maori and other stakeholders
- Prepare a draft Regulatory Impact Statement based on the proposal.

Officials should report back to Ministers in time for legislation to be at least introduced in the current Parliamentary term.

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1. Introduction

> *To be clear, the problem of overfishing is not a failure of fishermen, it is a failure of government. Fishermen fish and governments regulate. (Kurlansky 2019)*

LegaSea, the public outreach initiative of the New Zealand Sport Fishing Council, has engaged NZIER to work with them on proposals to reform the management of New Zealand's fisheries.

In 1986, New Zealand introduced what was, at the time, a radical new system for managing commercial inshore fishing, based on economic principles designed to maximise the economic value of fishing to New Zealand.

Central to the commercial fishing part of the regime were two separate pillars:

- The setting of a Total Allowable Commercial Catch (TACC), which is the amount of fish that could be caught commercially[1]
- Introducing Individual Tradable Quotas, or ITQs, which grant perpetual property rights to fish given species in given locations.

The overall management system is called the Quota Management System (QMS).[2]

The idea was that by having a property right in a fishery, fishers would become stewards of the sea, acting to fish sustainably, as this would be in their best economic interests. Reduction in catch limits would reduce the total level of fishing effort (which was driven by the combination of fleet size and technology employed), which at the time was greater than required to harvest sustainably.

1.1. A new approach

After revisiting the basic economic principles underlying fisheries management, looking at overseas and local experience and taking a whole-of-New Zealand approach LegaSea has developed a new regime for fishing management. Their regime is directed at maximising the wellbeing of all New Zealanders, rather than primarily focusing on the financial interests of commercial fishers and seeing the export of fish as the over-arching goal of fishing policy.

We consider that the LegaSea proposal is worthy of detailed scrutiny by the Government, followed by consultation with all people with a stake in fishing.

In this report, we compare the current regime with what LegaSea has proposed, using a simple set of criteria. The proposal ranks highly on most of those criteria.

[1] Under the legislation, the Minister first sets a Total Allowable Catch (TAC), which is a level intended to maintain sustainable stock levels, and then makes allocations for customary fishing, recreational fishing and other fish mortalities, with the residual being the TACC.

[2] A glossary of terms used in this report is included in Appendix A.

1.2. The Treaty of Waitangi – an essential New Zealand aspect of fisheries management

By the Treaty of Waitangi, iwi granted the Crown "te Kawanatanga katoa" – governance over their country – in return for a guarantee from the Crown that they would retain "te tino rangatiratanga o o ratou w(h)enua o ratou kainga me o ratou taonga katoa" – highest chieftainship over their lands, villages and valued possessions.[3] The Crown soon breached this promise and it was only in 1989 did they start to settle long-standing Māori grievances over fisheries management, some of which were contemporary breaches flowing from the introduction of the QMS.[4]

The QMS, however, provided part of the settlement, with Māori being granted 10% of existing quota and a guarantee a 20% share of quota for any species subsequently added to the QMS.

It has been the policy of successive governments not to breach te Tiriti o Waitangi through its contemporary actions. While Section 9 of the Treaty of Waitangi (Fisheries Claims) Settlement Act 1992 declares that all current and future claims by Māori in respect of commercial fishing are finally settled, claims in respect of non-commercial fishing continue to give rise to Treaty obligations on the Crown.

For these and other reasons, fisheries policy in New Zealand is subject to additional considerations that do not apply in other countries. We therefore paid special attention to how the LegaSea proposal addresses Māori fishing rights issues.

[3] As the Waitangi Tribunal held in its *Report on Stage 1 of the Te Paparahi o Te Raki Inquiry*, it is the version of the Treaty in te reo Māori – te Tiriti o Waitangi – **as the tribal signatories understood it in 1840**, that represents the enduring agreement between the Crown and tangata whenua. This is important, because te Tiriti and the Treaty are not translations of each other. Specifically, the Tribunal has ruled that "te Kawanatanga katoa" did not mean "sovereignty" to Māori in 1840 and "te tino rangatiratanga" did not mean "full exclusive and undisturbed possession" (Waitangi Tribunal 2014).

[4] This is recorded in the preamble to the Treaty of Waitangi (Fisheries Claims) Settlement Act 1992.

2. Criteria for assessing change

2.1. Why regulation is needed

Fishing is as old as time. It is one of the last remnants of hunter-gathering, where wild animals are caught for food.

Fishing provided early Māori with a source of protein and they developed regulations, or rāhui, to manage stocks. Trading in fish took place between iwi prior to European contact (Waitangi Tribunal 1988). Europeans first came to New Zealand in the early 1800s seeking whales and seals, providing Māori further opportunities for trade.

Internationally, fish were originally seen as an unlimited resource (H. Stewart 2018). Opening the Fisheries Exhibition in 1882, the great British naturalist Thomas Huxley, reflecting the view of the times, said:

> *I believe, then, that the cod fishery, the herring fishery, the pilchard fishery, the mackerel fishery, and probably all the great sea fisheries, are inexhaustible; that is to say, that nothing we do seriously affects the number of the fish. And any attempt to regulate these fisheries seems consequently, from the nature of the case, to be useless* (Foster and Lankester 1903).

Crutchfield and Pontecorvo observed: "Traditionally, and with few exceptions, the world's fisheries have been developed on the basis of free fishing"[5] (Crutchfield and Pontecorvo 1962).

Garret Hardin, in his famous article the *Tragedy of the Commons* (Hardin 1968), explained the effect of free fishing:

> *Likewise, the oceans of the world continue to suffer from the survival of the philosophy of the commons. Maritime nations still respond automatically to the shibboleth of the "freedom of the seas." Professing to believe in the "inexhaustible resources of the oceans," they bring species after species of fish and whales closer to extinction.*

But advances in marine technology, especially the advent of powered ships, refrigeration and canning, while initially leading to greatly increased harvests, saw once plentiful fishing ground coming under pressure. The pause in fishing in European waters during the First World War, and the resultant boom in harvest, was a watershed moment in man's understanding of the limits of fishing (H. Stewart 2018).

Faced with evidence that free fishing could not be allowed to continue, governments around the world started to put in place regulations, often in the form of limits on the number of vessels allowed to fish and on fishing equipment (size of nets) and restrictions on fishing seasons (Peart 2018).

[5] One important point of terminology that often bedevils studies of fisheries management, is the difference between "open access" and "common property". An "open access" regime is one where no one has the legal right to exclude anyone from using a resource. This is "free fishing". In "common property" regimes, members of a clearly defined group have the right to exclude non-members from access. The confusion stems, in part, from "The Tragedy of the Commons" (Hardin 1968). What Hardin was discussing was, in fact, an open access regime, although he called it a "commons". In this report, we will always use "open access" and "free fishing" to describe an unregulated state.

Attention soon turned to studying the relationship between fishing effort and fish stocks.

2.1.1. The golden age of fisheries economics

The early 1950s saw three key developments in the science and economics of fishing, which continue to form the basis of much of the economic literature on fisheries management.

The effect of fishing on fish stocks

First, Milner Schaefer developed a model that posits a relationship between growth of a fish population and the size of the fish population (Schaefer 1954). This model, and its subsequent refinements, suggests that there is a "maximum sustainable yield" (MSY) for any fish stock, which can be used to determine the appropriate harvesting effort.

The concept of MSY has gained wide currency internationally as an appropriate goal in fishing. It is enshrined in the United Nations Law of the Sea Convention (UNCLOS) (Emery, Gardner, and Cartwright 2017) and, locally in the Fisheries Act 1996[6].

The optimal level of fishing

The Canadian economist H. Scott Gordon published the seminal work in fisheries economics in 1954 (Gordon 1954). Gordon's key finding was that open access would lead to a level of harvesting where all economic profits (or rents) would be exhausted and, provided other conditions were met, could lead to the extinction of the resource. This point would be above the maximum sustainable yield. He recommended that fishing should be targeted at maximising total economic profits, which occurs at a point termed "maximum economic yield" (MEY), which is **below** maximum sustainable yield.

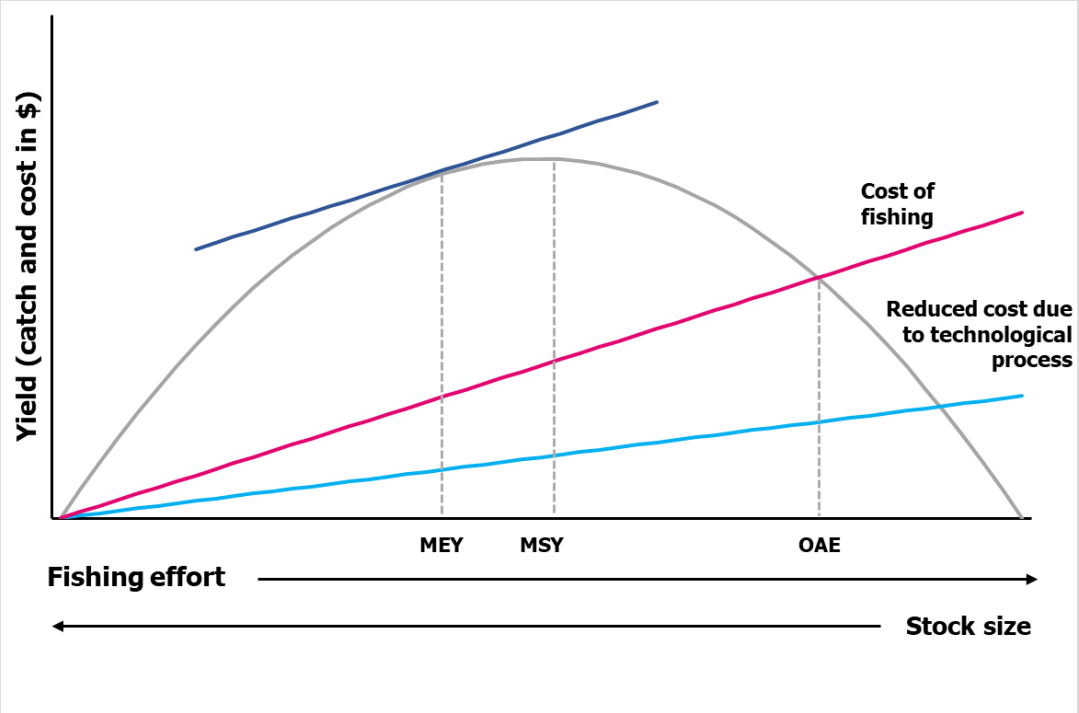
Figure 1 shows in highly stylised form the key insights from the Gordon/Schaefer model, as it has become known, as applied to a single species stock. Diagrams like this are still very common in the economic literature (Hoshino et al. 2018 is an example).

The model is based on two propositions. The first is that the yield from fishing initially increases with effort, before declining, as fishing eventually has an impact of fish stocks. This is why the curve is an inverted U shape.[7] The maximum point of the curve represents the MSY, that is the effort that can be applied each year that sustains the stock through time.

6 For example, under Section 13(2), the Minister is required to set a total allowable catch that maintains the stock at or above a level that can produce the maximum sustainable yield.

7 The yield curves used in the economic literature are mathematically more complex than this but have this general shape. (Conrad 2010)

Figure 1 Maximum economic yield is an important goal



MEY = Maximum Economic yield; MSY = Maximum Sustainable Yield; OAE = Open Access Effort.

Source: (Sterner 2003)

The second proposition is that the cost of fishing in the absence of any controls also increases with total effort: as more fishers join the fleet, more effort is required: boats need to go further and fish for longer, as stocks become depleted. Costs are highest at the point of total depletion.

Yield and cost can be thought of as the benefits and costs of fishing respectively. The difference between the two curves, the benefits minus the costs, represents the total return to fishing.

Fishing remains profitable for an individual fisher up to the point where the private costs they incur equals revenue, which is the point open access effort (OAE) in Figure 1. Notice that this level of effort is more than the MSY.

Notice also that at this point, benefits equal costs, meaning that fishing is just "breaking even".

Figure 1 also shows the effect of a reduction in costs (say from technology that improves the performance of boats, like the introduction of satellite navigation). This has the effect of increasing OAE but has no effect on MSY. The result will be **less** sustainable fishing. This result has been repeatedly validated by practical experience.

While biological studies, and indeed the New Zealand Fisheries Act, suggest that the goal of fisheries management should be MSY, the near-universal recommendation of the economics literature is that the goal be MEY.

Achieving MEY involves a trade-off between two competing elements: higher revenue (which comes from greater catches) against lower harvesting costs (which is a

combination of both effort and abundance. If there are more fish, then the effort to catch each individual fish is lower).

From society's point of view, MEY is the desirable level of total effort.[8]

> *Economic rent is a key component of a fishery's net economic return. It reflects the return to the owner of the fishery resource, and represents the value generated by the fish stock as an input into the production process. A key reason for purposing MEY is to maximise the resource rents generated from a fishery. A separate issue relates to what share of the total resource rent generated in a fishery is captured by the community (as opposed to those catching the fish) (Vieira and Pascoe 2013).*

In Gordon's model, the biomass that supports MEY is always greater than that which supports MSY, meaning that the lower effort is required to achieve the greater economic benefit from a fishery (Grafton et al. 2010).

But from the point of view of individual fishers, if there was no regulation, the optimal point is where total effort equals OAE. However, at this point fishers are only just covering their costs, meaning that fishing is just profitable. This is the core insight from the model: that the absence of regulation will have two effects: stock depletion and low social returns to fishing effort. (Gunnlaugsson and Agnarsson 2019) present evidence that in Iceland, the introduction of an ITQ system did eventually lead to the generation of significant economic rents that were mostly captured by fishers until the introduction of a resource rental fee in 2002.

Figure 1 is based on the effort involved in and revenue from landing fish, not the eventual consumption of fish. That is, it largely ignores the costs and benefits of post-landing value-adding activities like processing, wholesale and retail selling and food preparation. (Christensen 2010) suggests that including all the value chain from landing fish to consumption would move MEY closer to, but still always below, MSY.

(Hilborn 2007) presents the results of the standard Gordon-Schaefer model in terms of the relationship between fishing effort and the various benefits derived from fishing. He examines four different benefits: employment, yield, profit and ecosystem protection.

Figure 2 again shows a highly stylised version of the yield curve in the Gordon-Schaefer model. As before, maximum effort leads to depletion, while a MSY is somewhat lower. Assuming employment also increases with effort, we can see that maximum employment is also at the point of depletion. Moving to from OAE to MSY means less employment.

As before, MEY, the point of maximum profit or rent is lower than MSY, which means that again, lower employment is associated with greatest rent.

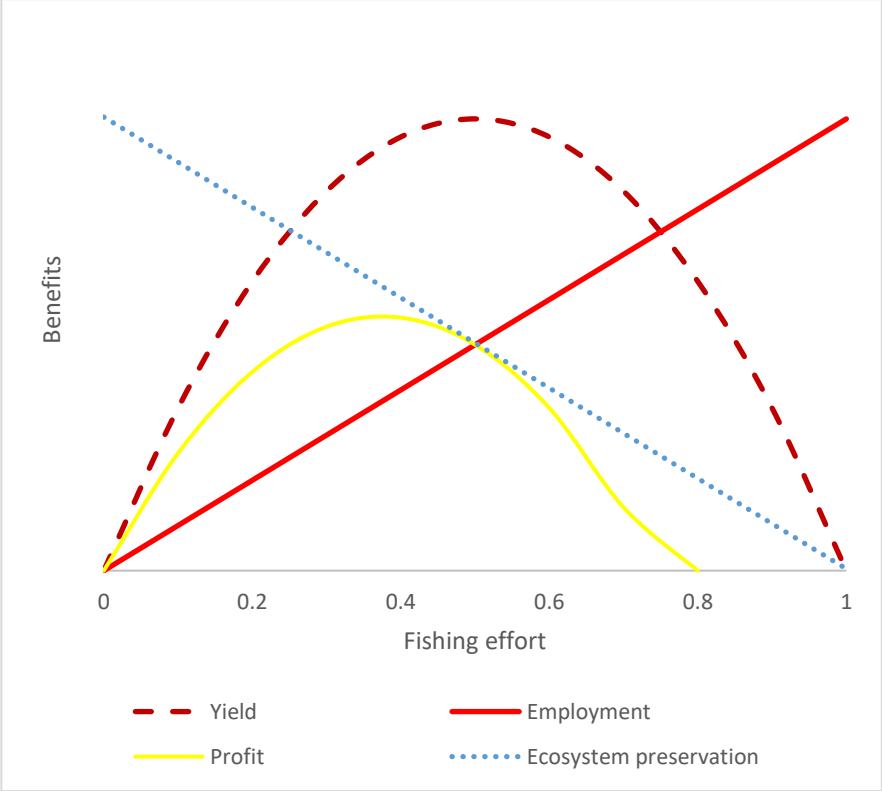
A benefit included in Hilborn's analysis that does not appear in the original literature on fisheries management is ecosystem preservation, which includes not just the biomass of the fish in question, but all environmental considerations, like bycatch,

[8] Geometrically, this is also the point where the slope of the cost curve equals the slope of the yield curve, which is also the familiar economic case of marginal return equalling marginal cost. As the example of the fall in costs from technology shows, MEY will only be equal to MSY when costs are zero.

habitat damage and impact on other uses. Here, the maximum benefit is at the point of **minimum** exploitation.

Hilborn suggests that it is not possible to maximise all four areas of potential benefit simultaneously, which has important implications when assessing where fisheries management policies have been successful. This very much depends on what objectives society is trying to achieve.

Figure 2 Different benefits have different relationships to effort



Source: (Hilborn 2007)

How to achieve the optimal level of effort

Finally, the Canadian economist Anthony Scott proposed that single ownership of a fishery was required to achieve the social optimum that Gordon had developed (Scott 1955). This result is at odds with the traditional finding in economics that the uncoordinated actions of individuals would lead to the highest attainable level of national prosperity. Few governments were attracted to Scott's monopoly proposal.

Later work by Colin Clark and his collaborators showed, however, that under certain conditions, for example if the discount rate facing the fisher was greater than the intrinsic growth rate of the fishery, it was possible that even with private ownership, extinction would be the result (C. W. Clark 1973), (C. W. Clark and Munro 1975).

2.1.2. Key elements in regulations

Gordon, Schaefer and Scott's insights have spawned a vast literature[9] and have been the analytical basis for much modern fisheries management (Sterner 2003). But it can be summarised in two core elements. The first is that the biological nature of fish stocks means that the usual recommendation in economics that producers should stop producing when marginal cost equals market price does not hold in the long-run. Rather, the efficient level of fishing is the potentially much lower level that generates MEY. The second, which flows from open access, is that the "invisible hand" does not work in fishing, as it leads to the OAE level of effort shown in Figure 1.[10] Hardin made this point explicitly in the *Tragedy of the Commons* (Hardin 1968).[11]

2.1.3. Property rights

Scott's "property rights" finding has been supplemented, albeit not without some confusion, with similar results from environmental economics. Natural resource economics and environmental economics, while similar, have developed separately, based on different themes (Pearce 2002). Unlike natural resource economics, which has long understood that the socially optimal effort is below that generated by unrestricted competition (Hotelling 1931), environmental economics proceeds from the basis that properly functioning markets are the best way of allocating society's scarce resources between their multiple alternative uses. It is only when markets "fail", usually due to externalities, that regulation is required (Baumol and Oates 1988).

When the environmental revolution arrived in the 1960s, spurred in large part by the publication in 1962 of *Silent Spring* by Rachel Carson, economists already had a clear view of the nature of the pollution "problem" (externalities) and a ready solution (pollution taxes) (Oates 2000).

> *For some 40 years prior to … 1960, the sole economic response to the problem of externalities was that the externality in question should be taxed* (Hahn and Stavins 2011).

A key refinement in environmental economics came with the publication in 1960 of the "The Problem of Social Cost" by Professor Ronald Coase (Coase 1960). Coase

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9 A search in the popular *EconLit* electronic database under the American Economic Association's code Renewable Resources and Conservation: Fishery; Aquaculture (Q22), retrieved 3,603 articles in academic journals, 148 books and 125 working papers had been published since 1990.

10 Adam Smith in the *Wealth of Nations* used the term "the invisible hand" to describe the forces that lead people, when following their own interests, to also act in the public interest:

> *He generally, indeed, neither intends to promote the public interest, nor knows how much he is promoting it. By preferring the support of domestic to that of foreign industry, he intends only his own security; and by directing that industry in such a manner as its produce may be of the greatest value, he intends only his own gain, and he is in this, as in many other cases,* ***led by an invisible hand*** *to promote an end which was no part of his intention. Nor is it always the worse for the society that it was no part of it. By pursuing his own interest he frequently promotes that of the society more effectually than when he really intends to promote it* (Smith 1977 emphasis added).

11 The full quote from Hardin (p1244) is:

> *We can make little progress in working toward optimum population size until we explicitly exorcize the spirit of Adam Smith in the field of practical demography. In economic affairs, The Wealth of Nations (1776) popularized the "invisible hand," the idea that an individual who "intends only his own gain," is, as it were, "led by an invisible hand to promote . .,. the public interest". Adam Smith did not assert that this was invariably true, and perhaps neither did any of his followers. But he contributed to a dominant tendency of thought that has ever since interfered with positive action based on rational analysis, namely, the tendency to assume that decisions reached individually will, in fact, be the best decisions for an entire society. If this assumption is correct it justifies the continuance of our present policy of laissez-faire in reproduction. If it is correct we can assume that men will control their individual fecundity so as to produce the optimum population. If the assumption is not correct, we need to re-examine our individual freedoms to see which ones are defensible.*

suggested that individuals will always (subject to the cost of doing so) take opportunities for mutual improvement through exchange even in the face of market failures. This is known as "Coasean bargaining". The idea is that people will respond to the world in which they find themselves and will not accept an inferior position if a superior one is available.

In a world with no transaction costs, Coasean bargaining will result in the alignment of private and social costs, an idea known as the "Coase Theorem". By definition, such an alignment means that no externalities are present.

The Coase Theorem predicts that in a world in which all property rights are well-defined, assigned to someone and there are no transaction or policing costs, three important consequences follow:

- The value of all harmful and beneficial effects of alternative uses of the rights will fall on the owners and only the owners
- If the owners are utility maximisers, the rights will be used efficiently
- The initial distribution of rights will have no impact on the final pattern of production and consumption.

The Coase Theorem fundamentally altered the way environmental economists address externalities:

> *Following Coase, it became possible to think about solving the problem of pollution as one of clarifying poorly defined property rights. If resources such as clean air and water could be recognized as a form of property, whose corresponding rights can be traded in a market, private actors could allocate the use of this property in a cost-effective way* (Hahn and Stavins 2011).

Coase's ideas have been applied in natural resource economics to suggest that **trading** of property rights created by regulation will lead to efficient regulation (Scott 2010).

Property rights in fishing

The idea of using individual property rights to manage fisheries was first suggested in 1973 (Christy 1973).[12] Christy's "tentative suggestions", as he termed them, were for a system that would set a total allowable catch and then assign rights to fish a proportion of that quota to individual fishers, who would also be required to pay a licence fee, based on the revealed price of quota in the market. He also suggested that other regulations would be required to prevent abuse of the stock of fish, including limits on fish size, prohibition of destructive gear and controls to address bycatch and the effect of fishing one species on others.

Christy does not specify how the level of TAC should be determined nor does he explicitly state what level is appropriate, other than a reference to "optimizing economic yields", which is presumably MEY.

In a prescient observation of the future, Christy also observed:

> *The fisherman quota technique would not, however, we particularly better than other systems in resolving conflicts between the use of*

[12] Christy's paper it notable for its lack of citations to other work, including that by Schaefer, Gordon, Scott or Coase. An earlier work, co-authored with Anthony Scott (Christy and Scott 1965) shows, however, that he was familiar with the literature.

> *interrelated stocks. The problems of incidental catches, predator-prey relationships and gear conflicts would continue to plague fisheries management (Christy 1973).*

Guidance in fisheries management from organisations like the United Nations Food and Agriculture Organisation (FAO) continues to place heavy emphasis on the property-rights aspect of fisheries management (Shotton 1999)[13]. The preferred recommendation of the economic literature is almost exclusively that countries introduce an ITQ, although there are qualifications:

> *Rights-based management programmes may not be appropriate for all fisheries. Like all fisheries management regimes they have their shortcomings. The fundamental question is whether or not a rights-based programme that specifically designed for a particular fishery can achieve the management objectives of that fishery better than any other type of management (L. Anderson 2000)*

The three elements of the name Individual Transferable Quota ITQ describe the most important aspects of the economics underlying such regimes.

The quota element is perhaps the most important. The setting of a quota means that fishers have a limit on the **amount** of fish they can catch, usually expressed in tonnes of fish. The sum of quota is the total allowable catch (TAC) for the fishery. So, the right is not to catch fish, but to catch an amount of fish. In this, however, ITQs are not unique:

> *The procedure for setting the annual TAC in an ITQ programme is fundamentally the same as for any other TAC based management regime (L. Anderson 2000).*

The "individual" nature of these quota means that unlike regimes where a total catch limit for an area and/or species are set, with each fisher able to catch as much as they can until the fishery-wide limit is achieved, in an ITQ, the total that each fisher (often restricted to using a single vessel) is able to catch, independent of the catches of other fishers, is limited. In theory, this means that the incentive on fishers is to minimise costs, rather than maximise catch (Asche, Bjørndal, and Bjørndal 2014) and (Asche, Bjørndal, and Gordon 2009).

That quota is transferable means that, in time, rights should be owned by the most efficient fishers, since they will have an incentive to buy the quota from other, less efficient fishers.[14] Within a fishing seasons, tradability is also a way of dealing with bycatch: fishers can buy quota to match their actual catch. Whether this occurs in practice is less clear.

Daniel Bromley has been critical of the focus of fishery economics on property rights, and the idea that only by granting private property rights can economic efficiency be delivered (Bromley 1990; Bromley 2005 and Bromley 2015). He is also concerned that ITQ-based regulation often results in all, or at least most, of the economic rent from fishing accruing to quota owners, rather than being shared among all stakeholders (including the government via payment of rentals) fishers (Bromley 2009). While being

[13] (Cadima 2003), however, especially Chapter 5, is critical of centralised ITQ systems in comparison with co-management systems.

[14] This assumes that quota owners are also fishers. In New Zealand, with the introduction of the ACE system, quota owners can earn economic rents from owning quota without actually engaging in any fishing activity themselves.

somewhat contrarian in outlook, Bromley's main point has merit. There are other ways in which a socially optimal level of fishing effort can be achieved, including traditional input control regulation and taxes, especially resource rental taxes.

2.2. International experience

Since New Zealand introduced its ITQ scheme in 1986 (after Iceland had already made its individual fishing quotas tradeable), similar schemes have been introduced in Australia, Norway, Sweden, Chile, Denmark, the United States and Canada. There have been a significant number of studies of the outcomes of the introduction of these regimes (Grafton 1996), (Arnason 2002), (Gunnlaugsson and Agnarsson 2019).

It is clear that fisheries that have been made subject to ITQ-type regimes have seen eventual reductions in fishing effort (usually through the retirement of vessels) (Asche, Bjørndal, and Bjørndal 2014). Profits have also increased.

> *In all of these cases, the introduction of ITQs lead to increased profits and smaller fleets. Higher profits are the product of both higher revenue and less cost (Gunnlaugsson and Agnarsson 2019).*

The transition to fisheries generating economic rents, as predicted by the theoretical models, however was not instantaneous. (Gunnlaugsson and Agnarsson 2019), for example, estimate that the Icelandic fisheries did not start to generate rents until 2008-09, some twenty years after the ITQ system was fully implemented. While a dramatic devaluation of the Icelandic Krona during the Global Financial Crisis played a part, the authors also suggest the time it took for fishing effort to reduce was a significant reason for the delay.

What is less clear is if that reduction is the result of the property-right regime, or simply the result of reduction in quota. Regarding the Danish fishery, Peder Andersen and his co-authors note:

> *[T]he analyses also show that the resource rent in an ITQ-based fishery might not differ very much from the resource rent in a well-managed fishery based on effort restrictions (Andersen, Andersen, and Frost 2010)*.

The evidence is more mixed, however, on whether other aims, like sustainability and increased stewardship, were achieved (Arnason 2002). While in some cases the introduction of such regimes have led to examples of fisheries being restored, in others they have not: "ITQs can sometimes help, but they are not a panacea" (Tietenberg and Lewis 2012). After reviewing the literature on the effect of ITQs on fish stocks, James Acheson and his co-authors conclude:

> *In summary, despite the fact that ITQs are spreading rapidly, there is every reason to be sceptical about their effectiveness as a conservation device. In our view this is the major problem with ITQ management. ITQs may be highly successful in ending the race for fish and increase revenues to fishermen, but their limited success in improving stocks is a serious indictment (Acheson, Apollonio, and Wilson 2015).*

2.3. The core elements of modern regulation

Drawing the enormous literature on fishing regulation together we suggest that there are ten essential features for any regulatory regime in developed countries like New Zealand.

2.3.1. Limited rights to fish imposed

The first and most important element of any fisheries management system is that it addresses open access. This means that some restrictions must be imposed of who can fish, for what, where and when.

The core elements of the recommended regulatory regime in the modern fishing economic literature are:

- A cap on the total amount of fish that can be caught in an area
- A system for allocating this total among individual fishers.

Once use rights are granted, there are two main ways to control use (which are not mutually exclusive):

- Input controls, e.g. limits on vessel size, length of fishing seasons and fishing gear
- Output controls, e.g. catch limits, including ITQ-based system.

2.3.2. Regime based on the nature of fish and fishing

The Organisation for Economic Co-operation and Development (OECD) has recently noted that there are nine reasons why the ocean economy is different from land-based agriculture, all of which can have important implications for fisheries policy (Delpeuch and Hutniczak 2019):

1. The sea is much larger than the land, and is subject to very different legal systems (territorial seas,[15] contiguous zones,[16] economic exclusion zones[17] and the high seas).
2. Water is less transparent than air, and remote sensing technologies are limited in their ability to penetrate far below the surface.

15 The territory where all domestic laws, including criminal and commercial law apply. In New Zealand's case, the territorial sea extends 12 nautical miles (22.224 km) from the shore.

16 An area between the territorial limit and a further 12 nautical miles, over which states have limited sovereignty.

17 A sea zone prescribed by the United Nations Convention on the Law of the Sea over which a state has special rights regarding the exploration and use of marine resources. See Article 56 of the United Nations Convention on the Law of the Sea. New Zealand's exclusive economic zone (EEZ) extends 200 nautical miles or 370.4 km from the coast. The EEZ is approximately 15 times larger than the land mass of New Zealand. New Zealand's only maritime neighbour is Australia. The exclusive economic zones of New Zealand and Australia touch between Northland and Three Kings Islands and Lord Howe and Norfolk Islands in the north and between the Auckland Islands and Macquarie Island in the south and the Australia–New Zealand Maritime Treaty formally delimits the maritime boundary between the two countries in these areas. This simplifies the analysis of fishing policy in New Zealand to some extent, since it removes the need to consider how fishing zones are to be shared been countries, which is of some importance, for example, in the North Sea.

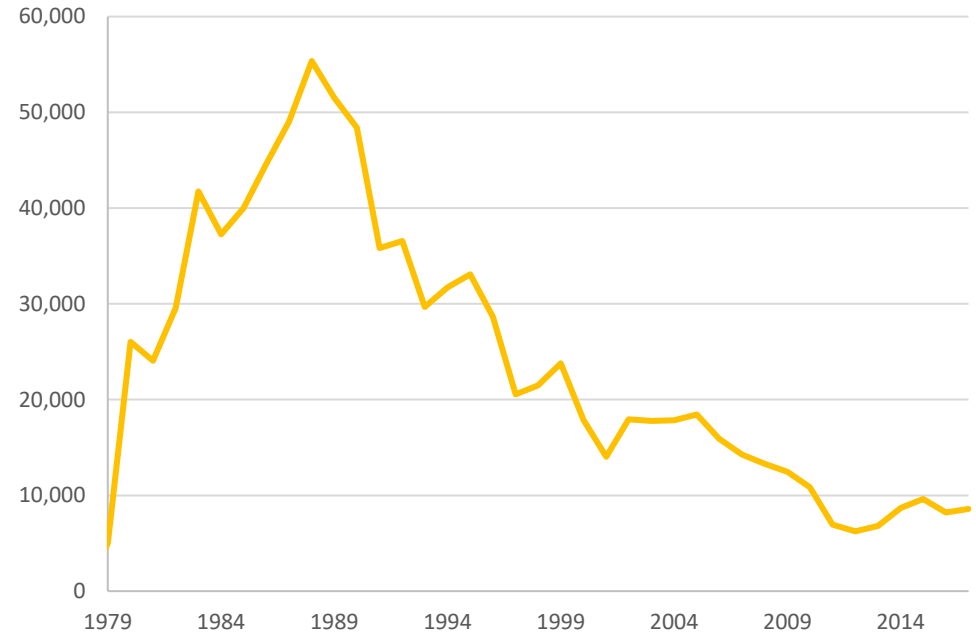
3. The ocean is more three dimensional than the land and spatial planning is therefore more complex.
4. The ocean is fluid and interconnected and what happens in one place can have implications elsewhere.
5. Maritime resources can move widely across oceans.
6. Some aggregations of fish and other species can move rapidly across the ocean.
7. Nutrients and other pollutants can remain in the ocean for decades.
8. Lack of ownership and responsibility in oceans is less favourable to sustainable development than on land.
9. Humans do no live in the sea and our presence in the sea is dependent on technology.

Fisheries are "coupled human and natural systems (CHNS)", with complex, dynamic and interconnected features (Ferraro, Sanchirico, and Smith 2019). Jianguo Liu and his co-authors suggest that CHNSs have the following features (Liu et al. 2007). When combined, these features can lead to considerable complexity that makes regulation of fisheries difficult:

- Reciprocal effects and feedback loops: in fisheries, the act of fishing effects fish stocks, which in turn leads to changes in fishing effort and practices
- Nonlinearity and thresholds: relationships between parts of the CHNS are not always simple and can exhibit tipping points, for example the point after which further fishing effort can lead to depletion of total stocks
- Surprises: because not everything about a CHNS is known, the unexpected can happen, like the collapse of the Orange Roughy fishery of Northern Ireland (Foley, van Rensburg, and Armstrong 2011)
- Legacy effects and time lags: the consequences of human actions on CHNSs may not be observable for some time, if there are time-lags between cause and effect. Some causes may have long-running (legacy) effects that endure. This was the case with the Orange Roughy fisheries in New Zealand (M. R. Clark et al. 2000)

Figure 3 The dramatic rise and fall of the Orange Roughy catch

Tonnes



Source: FAO

- Different CHNSs have different degrees of resilience, the ability to return to equilibrium after a disturbance.
- CHNSs are likely to be heterogeneous, and can vary across time, space and organisational units. Cultural factors on the human-side of a nature-human coupling can mean that different systems applying to seemingly the same subject matter, can led to different results in different communities.

2.3.3. Limits designed to maximise social return

The main insight from the Gordon/Schaefer model is that fishing effort must be restricted to the MEY. The question then becomes: what is the best way to calculate this limit? This is not a simple question to answer.

In practice, what is required is a bioeconomic model of the fishery, that combines the biological characteristics of the fish in question with the economic characteristics of the fishers who will catch them. Such models can be used to calculate optimal biomass, catch and effort levels that will achieve MEY (Vieira and Pascoe 2013).

> *While the term "MEY" refers to a yield or level of output, MEY is more a concept than an actual value. Unlike maximum sustainable yield (MSY), which is an actual harvest level, MEY requires both output and input use to be simultaneously at their economically optimal levels (Norman-López and Pascoe 2011).*

Increasingly, researchers are suggesting that models used to determine TAC should take more than just the effect of fishing on fish stocks into account (Hall and Mainprize 2004; J. L. Anderson et al. 2015; S. L. Smith et al. 2019). Such socioeconomic models

often involve supplementing traditional biological assessments with explicit assessments of the environmental effects of fishing (e.g. sea bed damage), the economic performance of the fishery (e.g. financial performance) and the distribution of gains from fishing (concentration of ownership). (Hoshino et al. 2018) report that while introducing management systems designed to achieve MEY in multi-species fisheries involves complexity, experience in Australia suggests that those challenges can be overcome. Both (S. L. Smith et al. 2019) and (J. L. Anderson et al. 2015) have presented worked examples of their models that demonstrate that they are at least feasible, in terms of data requirements and calculation of results.

Case studies based on a move by the Australian federal government to manage fisheries to achieve MEY suggest that reduction in effort of 50% below MSY-based limits may be required (Emery, Gardner, and Cartwright 2017).

2.3.4. Limits set based on up-to-date science

The maximum economic yield is, in part, dependent on biological condition of fish stocks and so its setting must be informed by clear scientific analysis of those stocks and other species.

There are several dimensions to the scientific basis required for effective management of fisheries.

First, Is our core understanding of what drives the state of fish stocks.

Our understanding of the biology and ecology of fish and fisheries is developing and any regulatory regime needs to be able to incorporate new developments.

Of particular importance is the science of multi-species fisheries, including predator-prey and competition relationship, and not just for fish within the ITQ (Ulrich et al. 2002).

2.3.5. Liquid markets

Economic efficiency is generally advanced if rights, goods and services can be traded in well-functioning markets, as this ensures that society's resources are being applied to their highest social use. This applies not only to the products of fishing, but also to rights to fish.

2.3.6. Resources rentals paid

Because they are the product of nature, harvesting and selling fish can give rise to economic rents – also known as super-profits. There are strong equity and efficiency grounds for taxing those rents. Many methods are available.

One important feature of economic rents is that they can be taxed with little or no efficiency cost (Garnaut 2010). This is because economic rents are an extra return above that required to compensate the owner of the capital earning the rent for risk and the opportunity cost of their investment. Taxing away that extra return, or a part of it, does not diminish the attractiveness of the investment compared to investment

that only earn "normal" (i.e. rent-free) profits. So just taxing rents would not cause investors to reduce the amount that they have invested.

Under a traditional income tax, economic rents are taxed at the same rate as all other returns to capital and labour. Some countries, therefore, impose additional taxes on owners of natural resources that can earn rents. The Australian Treasury has long favoured resource rental taxes, given the importance of extractive industries to Australia's economy (Australian Treasury 2009).

In open access fisheries, resource rent is either widely dissipated across multiple users and communities or is negative due to overcapacity. One of the results of the international reform of fishing, however, has been the concentration of rents in the hands of commercial operators (Høst and Christiansen 2018).

> *The use of market-based fisheries management has played a significant role in creating more profitable fishing sectors and has contributed to a wider transformation of Nordic fisheries. Today fishing activities are less embedded in coastal communities and more corporate in its nature than before. With less operators and fewer people engaged, and with fewer direct social benefits to coastal communities, resource rent taxation has become an increasingly reoccurring topic. A taxation of resource rent is under these conditions an instrument to reassure a return to society.(Høst and Christiansen 2018).*

Imposing resource rentals on fisheries is rare. New Zealand's brief period of applying such taxes was for many years one of the few examples. Greenland, Iceland and the Faroe Islands all have resource rental regimes in place currently (Høst and Christiansen 2018). Iceland's tax now contributes about 1.2% of national revenue (Gunnlaugsson, Kristofersson, and Agnarsson 2018).

2.3.7. Economies of scale reduce costs

Economies of scale that are passed on to consumers in the form of lower costs are socially beneficial and should be allowed to be generated. That said, if economies of scale lead to higher returns to producers because of the creation of natural monopolies, then overall social wellbeing will be reduced. It is for this reason, for example, that New Zealand and many other countries regulate natural monopolies under competition laws.

2.3.8. Māori interests recognised

In New Zealand, a vital additional element is that Māori have rights in relation to fishing under the Treaty of Waitangi that the Crown is obliged to advance.

2.3.9. Accommodating other uses

Increasingly in New Zealand, fishing is not the only use to which parts of the ocean can be put. Close to the shore, fishing competes with other human incursions into the sea, like marine cables, jetties and landing areas for fish. Aquaculture is an increasing use

of ocean water, in part as an antidote to some of the concerns we have discussed about the environmental impact of harvesting wild fish.

Marine protected areas often cut across fishing zones. They are established to preserve areas from intrusive human activity, with boating, swimming, diving and sight-seeing sometimes the only permitted activities.

2.3.10. Promoting other environmental goals

New Zealand's overall environmental record when subjected to detailed measurement, is proving, to be less impressive than we often imagine (Ministry for the Environment and Statistics New Zealand 2019). Fishing does not always have a benign effect on the marine environment, with seabed damage from trawling and the death of precious marine mammals and seabirds continuing areas of concern.

3. The current regime

The regulation of fishing in New Zealand is contained in the Fisheries Act 1996, and associated regulations, rules and practices.[18] The main focus of this section is on the QMS which applies to commercial fishing, although we do touch on customary and recreational fishing as well.

3.1. The current QMS system

The QMS regime covers 98 species or species groups divided into 642 stocks, which are a species or group of species contained within a specific geographical area called a Quota Management Area (Fisheries New Zealand 2018b). 348 of the stocks are targeted for commercial fishing. For purposes of determining fish stock status, Fisheries New Zealand, assess 685 separate stocks and sub-stocks.

A Total Allowable Catch (TAC) is set for most fish stocks, based on an assessment of sustainable harvest. Allowances are then made for customary, recreational and commercial fishers and for other mortality caused by fishing, to derive a Total Allowable Commercial Catch (TACC)

Annual TACC allocations or Annual Catch Entitlement (ACE) are distributed amongst ITQ holders which provide them with the right to catch up to their ACE allowance. Parties that report catches above their ACE are required to pay for additional allowance at a Deemed Value that is priced at a premium to discourage over fishing.

The annual allowance of ACE is only distributed to those that hold an ITQ, though both may be transferred between parties. ITQs provide a permanent source of ACE to their holders with each fishing year.

Anyone with a commercial fishing permit may fish commercially, but all catch must be balanced against ACE held in advance or purchased by the fisher. Both ITQ and ACE can be traded. In practice, significant amounts of ACE are leased to non-quota owners, while trading quota is rare (Stewart and Moriarity 2017).

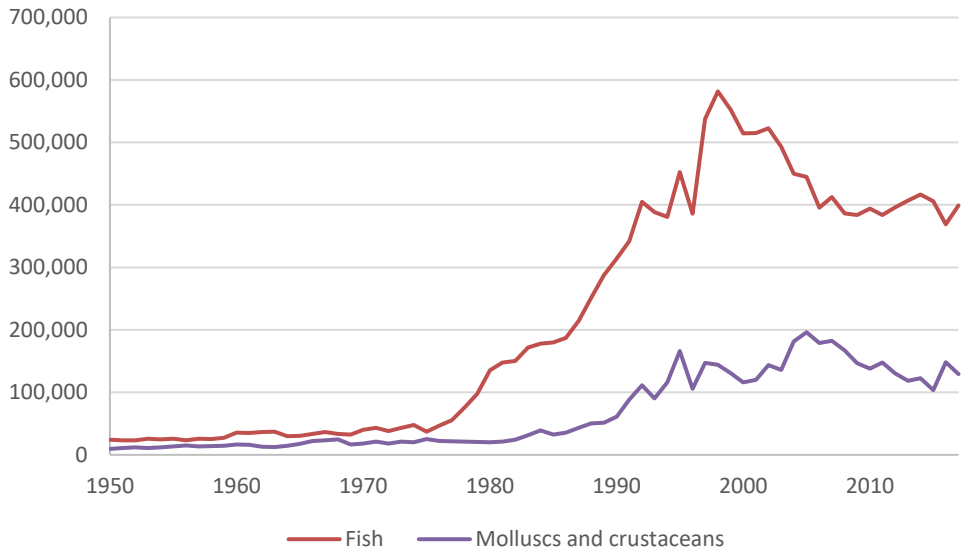
3.2. History

The context of the introduction of the QMS in the late 1980s was efforts introduced by the government of the day in the 1960s aimed at expanding the fishing industry, through de-regulation, concessional loans and export subsidies. Initially, the plan was successful, with the fleet growing from 1727 to 5178 vessels from 1963 to 1973, while landings increased by a 6%-7% annual rate over the twenty years to 1983 (Rees 2005).

[18] For a history of fisheries regulation in New Zealand, see (Sharp 1997; Yandle 2001) and for a more detailed description of the regime see (Lock and Leslie 2007).

Figure 4 Fishing grew quickly from the 1970s, but has plateaued since 2004

Total catch, tonnes



Source: FAO

This initial growth was not, however, sustainable.

> *This government-sponsored expansion took its toll: by the late 1970s the industry was again marked by overcapitalisation, inshore stocks were under threat, catches were declining and a number of fishers were in arrears on state loans (Winder 2018).*

Reform was intended to lead to a profitable, growing industry:

> *The objectives are to allow the industry to respond in an economically efficient manner to market forces, to compete internationally, increase profitability, and maximize returns to the nation through resource rentals (I. N. Clark, Major, and Mollett 1988)*

When first introduced, the Crown altered the level of the TACC via the ITQ market. If it wished to increase the amount that could be fished, it would sell more quota, while it would buy-back quota if it wished to reduce the TACC. By 1989, the cost of reducing TACC via buy-backs was proving unattractive to the government (Batstone and Sharp 1999). An alternative system was introduced in 1990, with quota rights being henceforth expressed as a percentage of the TACC. Any reduction of increase in quota was thus spread pro-rata across all quota holders.

When originally introduced, the QMS included a provision for the charging a resource rentals (set at a rate per tonne, that could be varied by way of regulation), with the intention being that the full rent earned by commercial fishers (that is, the super-profit from having the right to exploit a fishery) would be extracted (Batstone and Sharp 1999).

Subsequent changes to the regime have seen some deficiency that emerged from practical application of the theory (Mace, Sullivan, and Cryer 2014).

A major change was the introduction of annual catch entitlements (ACE) in 2001, under which quota owners receive an annual entitlement to take a percentage share of the TACC, expressed as a mass of a fish species. ACE is itself a form of quasi-property right, that they can sell or lease. ACE was introduced to address complexities and inconsistent administration of the ITQ regime. Its practical effect was to separate quota ownership from fishing. Fishing without quota, relying instead on ACE, is a significant part of some fisheries in New Zealand. (J. Stewart and Moriarity 2017) report that in one important fishing management area (FMA3, off the south east coast of the South Island), between 25% and 50% of ACE for red cod, gurnard, flatfish and rough skate were caught by ACE-fishers.

The introduction of ACE also had the effect of lessening the incentives to stewardship embedded in the original ITQ (Mace, Sullivan, and Cryer 2014).

Many other countries followed New Zealand's lead, and some form of ITQ-based fishing regulation is common in developed maritime countries. The Food and Agriculture Organisation, the United Nations Development Programme and the Organisation for Economic Co-operation and Development have all published extensively on fisheries management, often recommending ITQ-based approaches for both developed and developing countries.

The Treaty of Waitangi (Fisheries Claims) Settlement Act 1992 provides for iwi commercial interests in fisheries, through an allocation of ITQ in each fish stock. There is also a duty to provide 20% of new stocks brought into the QMS to iwi.

3.3. Policy objectives

The introduction of the current fisheries regime was motivated by a concern for the efficiency and long-run survival of the fishing and food processing sector from both an environmental and economic development perspective (Yandle 2001). At the time of implementation (the late 1980s), more weight was given to economic development issues, especially around removing excess capacity and setting the industry up to develop offshore fishing capacity (Sharp 1997).

The regime has led to concentration of the fishing industry. (Stewart, Walshe, and Moodie 2006) report that between 1986 and 2000, the number of quota owners declined by between 9 percent and 53 percent across twelve key species.

Different detailed considerations applied to different sectors of the industry.

3.3.1. Inshore fishing

Inshore industry policy was intended to address overfishing, overcapitalisation and excessive government regulation in the inshore fishery (Hersoug 2018).

When the regime was first introduced in 1986, it was widely believed that there had been a serious collapse in inshore fisheries. It was envisaged that quota would begin to aggregate in fewer, more efficient hands. In response to this the Crown assigned aggregation limits to prevent domination of the industry by a few players. Fewer fishers would be simpler to manage. By 1991, the policy had created confidence, at

least by major companies, that investment in quota was essential for the successful operation and long-term survival of a fishing business.

Whatever the intention of Parliament, growth in employment was short-lived (Williams et al 2017). Figures for the number of self-employed people engaged in the harvesting sector in New Zealand show a shift from 1,758 people in 2005 to 1,404 in 2014, a decline of 20% over nine years as (Williams et al 2017). This is evidenced by consolidation of ACE trading:

- Tied arrangements of Licensed Fish Receivers (LFRs) with quota holders for purchase of ACE and
- Tied arrangements of supply of ACE packages from LFRs to contracting harvesters.

Stewart and Leaver (2015) view this dominance as actually symbiotic and favourable for small harvesters, while Duncan (2011) says the large players are abusing their dominant position.

3.3.2. Deep-water and fish processing

The development of the current deep-water and fish processing industry policy was heavily influenced by the essential role played by foreign charter vessels. They had access to low cost labour and technology. They were therefore highly efficient.

Prior to the declaration of the EEZ in 1978, the New Zealand fishing industry was comprised of small vessels concentrating on inshore fisheries (Mace, Sullivan, and Cryer 2014). Expansion into deep-water fishing was constrained by lack of access to export markets, capital costs and limited knowledge of the industry (Sharp 1997).

At the same time policy sought a future state where New Zealanders would possess the equity associated with onshore processing and the industry profits and jobs that it would bring to New Zealanders. The desired future state was that New Zealand boats and crews would populate deep-water fisheries and New Zealanders would process the fish in New Zealand. At the same time, the government negotiated bilateral treaties with Japan, Korea and the Soviet Union that allowed vessels from those countries to continue to fish the EEZ, (Sharp 1997). As required by UNCLOS (Article 62), if New Zealand does not have the domestic capacity to harvest the living resources in its EEZ, it is required, through negotiation and other arrangements, to allow other countries access to the surplus allowable catch.

Today there is continued dominance of foreign charter vessels, simply because they are efficient in the eyes of New Zealand industry who utilise them. It is the labour conditions aboard these vessels, that have drawn recent criticism, not the lack of New Zealanders (Stringer, Simmons, and Coulston 2011). In response to concerns about crew conditions, in 2016, legislation was introduced to require all foreign charter vessels to reflag to New Zealand and operate under full New Zealand jurisdiction, including health and safety rules.

3.3.3. Fishing industry finance

The creation of ACE was in part designed to maintain the quality of equity in title to quota so that they would be good security for finance for fishing companies.

It was envisaged that quota owners would transact the associated ACE rather than the quota themselves. This meant the quota would be good collateral for finance loans.

Peart (2018) considers that the creation of ACE was intended to facilitate the participation of non-quota-owning fishers in the industry. While true in principle, in practice annual ACE transactions are not openly competitive but are controlled by tied arrangements between quota holders and large organisations such as Licensed Fish Receivers (LFRs), some of whom then re-package the quota and sell them to contracting harvesters on terms set by the LFRs. While the aggregation of quota is limited under the Fisheries Act, aggregation of ACE is not.

Quota holders can extract an economic rent simply from ownership of quota, that is enhanced by the tied arrangements. Thus, both the quota and ACE markets are far from competitive. There are considerable barriers to entry to the ACE market for small harvesters, who need long-term certainty of supply as much as the LFRs. Some claim that there is considerable dominance exercised by LFRs over harvesters in the catch market (Duncan 2011).

3.4. 30 years on

Practical experience, however, has shown that fishing is more complex than the theory behind the ITQ suggests.

3.4.1. Fishing is not the same as agriculture

Ocean-based harvesting of fish is not the same as farming on land: fish move, sometimes rapidly and inter-mingle, often in biologically beneficial ways.[19] Single-species quota, expressed in tonnes of fish, based on a defined geographical zone do not always encourage stewardship: sustainability issues like bycatch[20] (the wrong species of fish or precious birds and marine mammals being caught), high-grading (where fishers only take the highest quality fish and discard the rest despite the fact that this is illegal) and under-reporting have plagued New Zealand fishing (and have been common in other regimes as well). We return to these issues in more detail below.

> *QMS stock assessments apply to individual fish stocks and do not fully account for interactions between different stocks or interactions with the broader marine environment, like how catching fish affects other species through a food chain. About half of our fish stocks (mainly minor fished species) have too little information to reliably assess their stock status (Ministry for the Environment and Statistics New Zealand 2019).*

[19] Here by "fish" we mean finfish, rather than the wider definition of "fish" in the Fisheries Act that includes finfish and shellfish. Many shellfish are immobile (e.g. mussels) or live in limited habitats (e.g. crayfish).

[20] "Bycatch" can refer to both to catching, and then using, of different fish than those sought by the fisher or the catching and then discarding of unwanted fish (Pascoe 1997).

3.4.2. Fishing is not the only activity in the sea

Regulating inshore fishing is also impacted by other regulatory regimes, most notably the Resource Management Act (RMA), which is New Zealand's main spatial planning law, and which covers land and seabed use.[21] As well as regulating facilities used by fishing (like wharves), the RMA also regulates uses that can compete with fishing, like aquaculture, cables, mining, recreational use and marine protected areas.

Fishing not only impacts on fish, but on the marine environment more generally. Trawling damages sea beds. There are other pressures on marine environments and fish stocks unrelated to fishing, including erosion, run-off of heavy metals and nutrients, and climate change which may lead to seawater temperature increases and ocean acidification (Ministry for the Environment and Statistics New Zealand 2019; Sumaila 2012).

> *Broader aspects of ecosystem form and function, insofar as they support fisheries production, were never part of the initial rationale for the QMS which was designed simply to constrain catches at a single-species level (Mace, Sullivan, and Cryer 2014).*

3.4.3. Fishing has not grown as was expected

Commercial fishing makes a small contribution to New Zealand's economy. This is in part because, despite its large size (the fourth largest in the world), New Zealand's Exclusive Economic Zone (EEZ) is not as productive or abundant as other places in the world, due to a narrow continental shelf, limited nutrient upwelling and only being on the edge of the range of highly valued migratory species like tuna (Harte 2008).

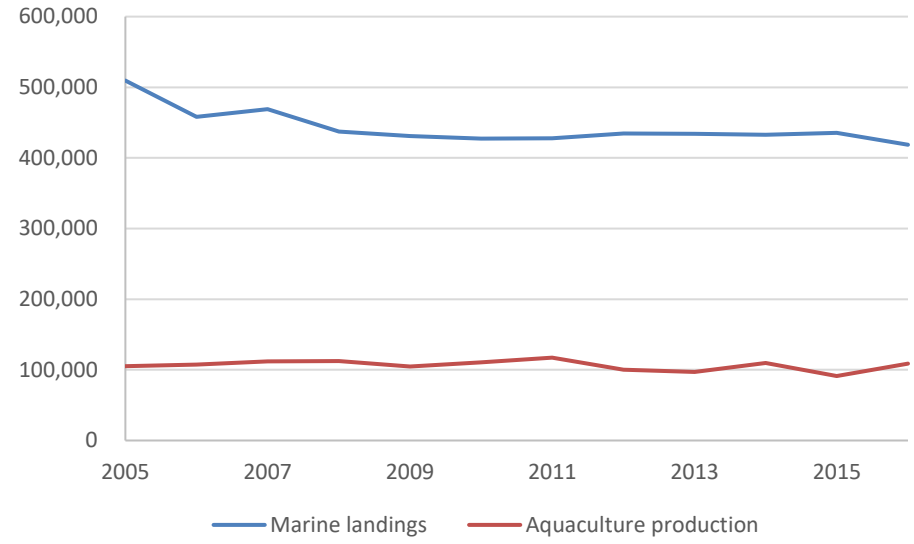
> *Two-thirds of our fishing zone is considered commercially barren, consisting of deep low-nutrient waters which plunge more than a kilometre down.*

Over the last ten years, the total level of marine landings and aquaculture production, measured in tonnes of fish, have remained largely the same.

[21] The RMA applies to the coast marine area, which it defined as the area between the boundary of the territorial sea (12 nautical miles from shore) and the mean high water springs (the high water mark).

Figure 5 Total catch is not growing

Tonnes

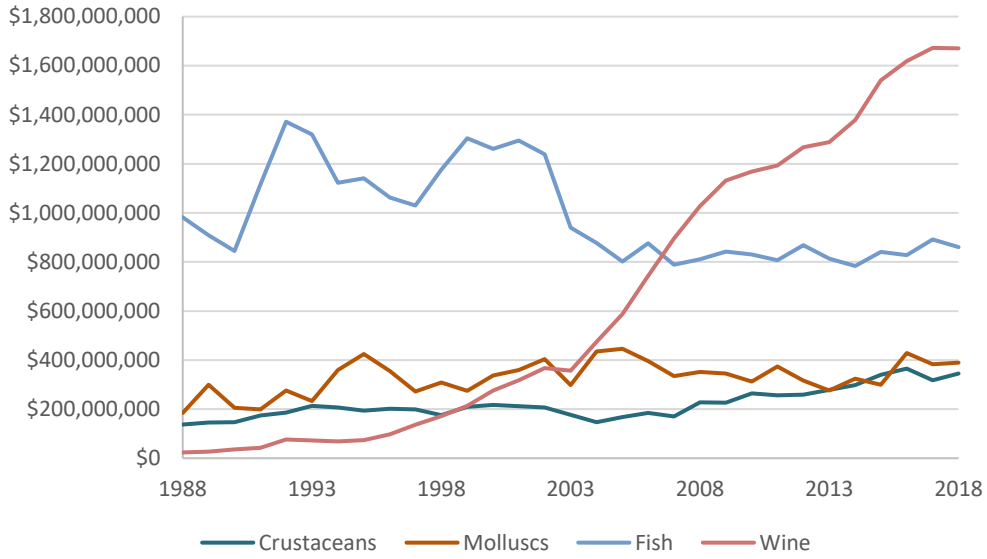


Source: OECD

As Figure 6 shows, since around the time the QMS was introduced, the New Zealand dollar value of exports of fish from New Zealand grew initially, but then declined in the early 2000's. For comparison purpose, we have included the exports from wine, calculated on the same basis.

Figure 6 Fishing exports are not growing

Value of exports, fob, in $NZ, indexed to CPI inflation.

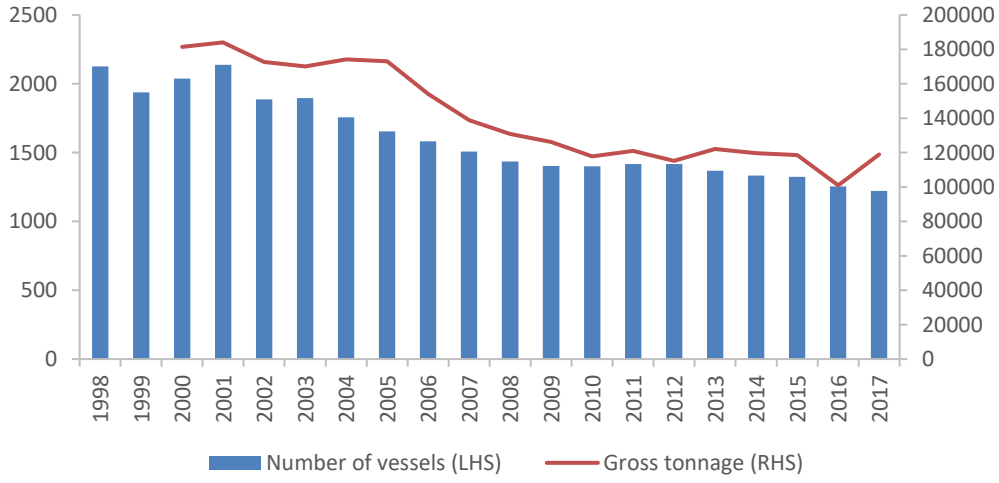


Source: Statistics New Zealand

The size of the fishing fleet, in terms of vessels and tonnage, has been steadily declining since 2000.

Figure 7 The New Zealand fishing fleet is shrinking

All fishing vessels

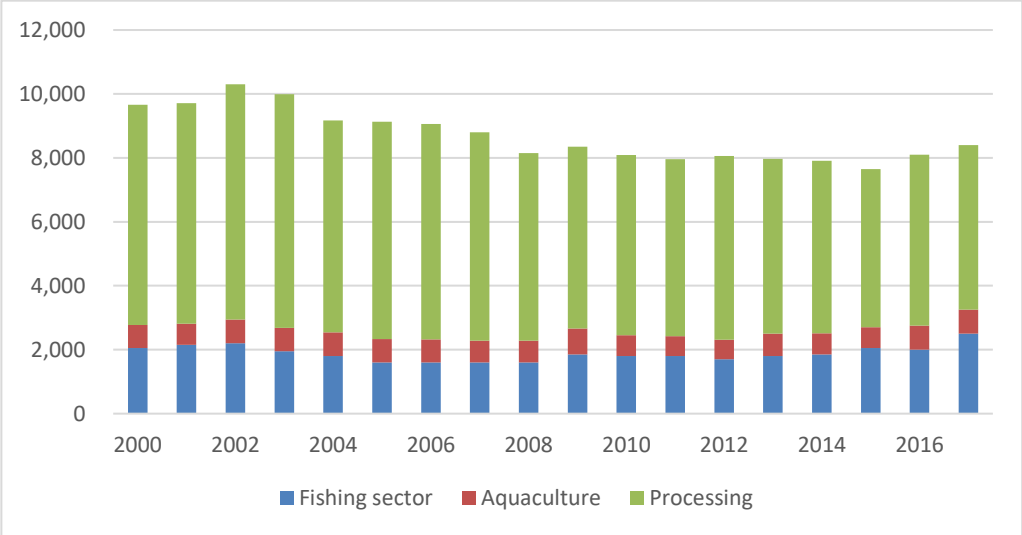


Source: OECD

Employment in the fishing sector, including fishing, aquaculture and processing, has also been in decline.

Figure 8 Total employment in the New Zealand fishing sector is also declining

Total employment



Source: OECD

Looking to the future, the Food and Agriculture Organisation has forecast limited growth in total seafood production, with most of that coming from aquaculture.

Table 3 A slow-growth industry in New Zealand

Thousands of tonnes, live weight equivalent

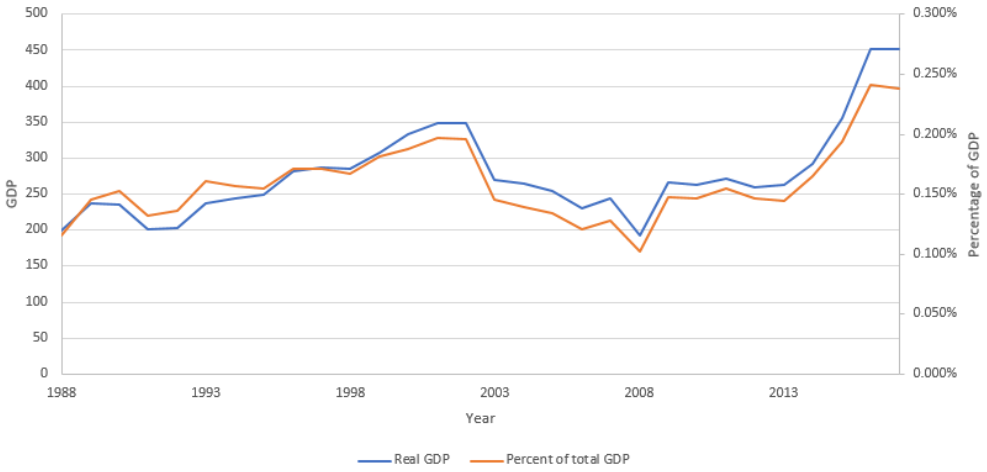
	Total		Aquaculture	
	2013-15 average	**2025 forecast**	**2013-15 average**	**2025 forecast**
Production	550	586	108	146
Food supply	115	122	25.5	24.7
Exports	422	447	Not Estimated	

Source: (FAO 2016)

In terms of contribution to the total economy, commercial fishing is very small. Its growth has been slightly faster than the rest of the economy, meaning that its share of total GDP has increased, but from a very low base. This is shown in the graph below.

Figure 9 Fishing is a small contributor to New Zealand's GDP

Real GDP from fishing and aquaculture, in millions of dollars and as a percentage of total GDP[22]



Source: Statistics New Zealand.

To put the 0.27% of GDP contribution of fishing to the economy into perspective, in 2018, the manufacturing sector contributed 11% of GDP; professional, scientific, technical, administrative and support services 11%, retail trade and accommodation 8% and financial and insurance services 6%, Agriculture 3.8% and Food Manufacturing 3.0%.

3.4.4. Tensions remain

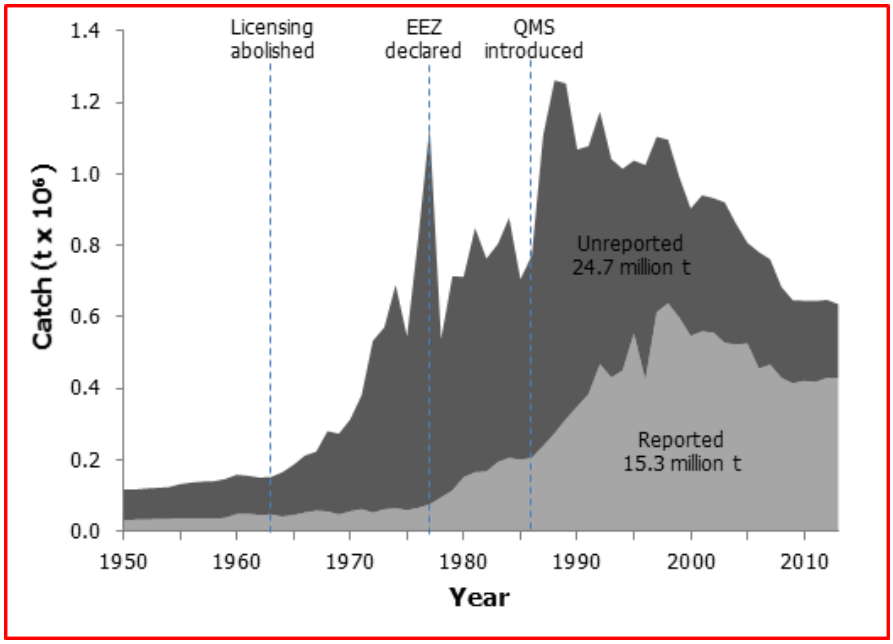
Tensions between different types of fishing – commercial, recreational and customary – have not been resolved and in some cases made worse by the current regime (Hersoug 2018). Giving commercial a statutory perpetual right to fish, while leaving the share of allowed catch allocated to recreational fishing to an unfettered ministerial discretion is one example (Borch 2010).

While the regime has been subject to significant changes since it was introduced, designed in part to overcome oversights in the original design (Mace, Sullivan, and Cryer 2014), those reforms have never successfully addressed the issues of bycatch, under-reporting and high-valuing (Hersoug 2018). We say "never successfully" because, while illegal under fisheries legislation, under-reporting and high-valuing do occur in New Zealand. (Simmons et al. 2016) report that over the period 1950-2010, the actual catch in New Zealand was over twice what official statistics suggest.

[22] Data limitations men that it is not possible to separate GDP from aquaculture from that produced by wild fishing.

Figure 10 Under-reporting has been a long-term problem

Extended reconstructed catch 1950-2013 (New Zealand and foreign flagged vessels)

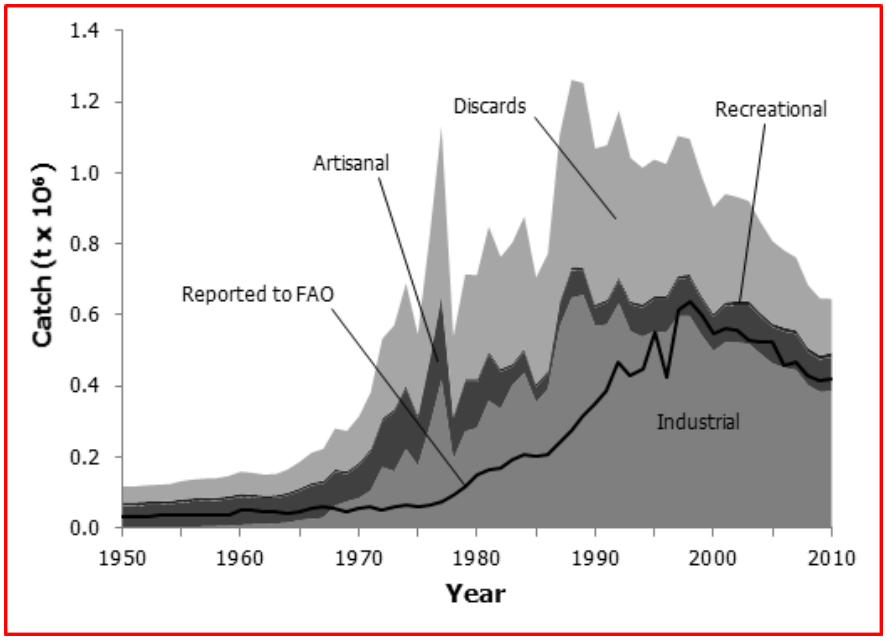


Source: (Simmons et al. 2016)

Most of this difference is due to unreported commercial catch and discarded fish.

Figure 11 Discarding is a major issue

Total reconstructed catch 1950-2010 (New Zealand and foreign flagged vessels)



Source: (Simmons et al. 2016)

Under-reporting and discarding are, therefore, regulatory problems, as well as problems created by the behaviour of fishers.

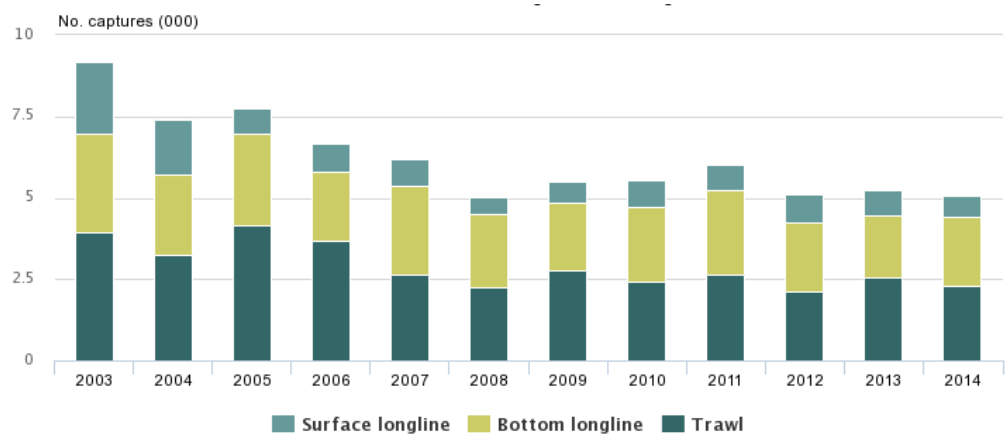
While stabilising in recent years, fishing continues to have an adverse effect on seabirds. Five species of seabirds threatened with extinction and six species of seabirds at risk of extinction have a high or very high risk of fishing-related deaths (Statistics New Zealand 2016c).

(Abraham and Richard 2018) report that seven of the ten species they examined showed evidence of decline in bycatch between 2002-01 and 2014-15. The only species to show clear evidence of an increase was the White-chinned Petrel. They attribute the reduction in bycatch to a reduction in fishing effort, not an improvement in prevention techniques.

> *It is clear from data on mitigation use, that there are improvements that could be made to reduce seabird captures across all fishing methods(Abraham and Richard 2018).*

Figure 12 Seabird bycatch is still an issue

Estimated total seabird bycatch

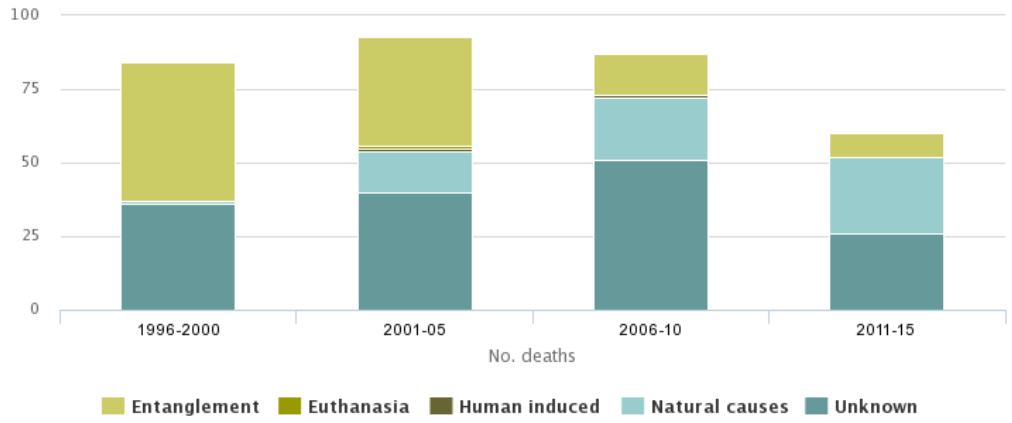


Source: (Statistics New Zealand 2016c)

Bycatch of marine mammals, some of New Zealand most treasured and at-risk species, is also a high-profile issue. (Statistics New Zealand 2016a) report 327 deaths of Hector's and Māui dolphins between 1921 and 2015. Entanglement in fishing gear accounted for up to 71.4 percent of the 301 dolphin deaths for which a cause of death was determined.

Figure 13 Entanglement of dolphins in fishing gear continues

Hector's and Māui dolphin deaths from entanglement, 1996 - 2015

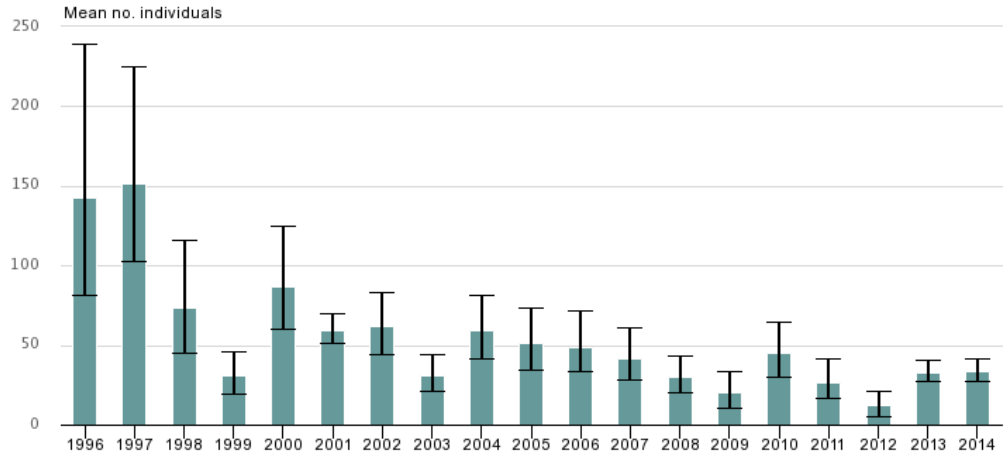


Source: (Statistics New Zealand 2016a)

Other species of mammals are also at risk.

Figure 14 Sea lions are still at risk of bycatch

Estimated sea lion bycatch. Error bars show the 95 percent confidence interval



Source: (Statistics New Zealand 2016b)

Incorporating recreational fishing into the QMS has also proved difficult and little progress has been made (Harte 2008; Winder 2018).

Attempts by successive governments to set up marine protection zones – areas that are off-limits to all fishing – have been controversial. For example, the Kermadec Ocean Sanctuary Bill 2016, which seeks to establish a 620,000 square kilometre fully-protected marine sanctuary 1000 kilometres northeast of New Zealand, has failed to gain enough support in Parliament to be enacted. The effect of the Sanctuary on quota

granted to Maori as part of the fisheries settlement has been particularly contentious (Parliament of New Zealand 2016).

3.4.5. Is fishing sustainable in New Zealand?

The Ministry for Primary Industries, and its predecessors, undertake extensive research into fish stocks, which it makes public.[23] Fish stock assessments by the Ministry for Primary Industries report that fish stocks have few sustainability issues (Fisheries New Zealand 2018b).

Care needs to be taken, however, as the Ministry uses a particular definition of "sustainable". Its four performance measures are:

- A soft limit: a biomass level below which a stock is deemed to be "overfished" or depleted and needs to be actively rebuilt
- A hard limit: a biomass level below which a stock is deemed to be "collapsed", and fishery closures should be considered
- An overfishing threshold: a rate of extraction that should not be exceeded as it will ultimately lead to stock biomass declining below the management targets and/or one of the biomass limits
- The management target – usually a biomass level that stocks are expected to fluctuate around, with at least a 50% probability of achieving the target (Ministry for Primary Industries 2019).

In its latest report, the Ministry for Primary Industries reports that 27 stocks were below the soft limit:

- southern bluefin tuna and Pacific bluefin tuna
- three stocks of black cardinalfish
- two stocks or orange roughy
- five stocks of bluenose
- three stocks of tarakihi
- two stocks of snapper
- two stocks of scallops
- two stocks of oysters,
- one stock each of flatfish, John dory, rock lobster, paua, pipi and freshwater eels (Ministry for Primary Industries 2019).

(Ministry for the Environment and Statistics New Zealand 2019) caution that "because of an incomplete understanding of the cumulative effects of fishing on the marine environment, it is unclear if the current levels of fishing are sustainable".

One measure of the abundance of current fisheries is how the limits placed on recreational fishing have changed over time.

[23] A major publication is the annual four volume Fisheries Assessment Plenary, which combines current and historical information about a wide range of fish included in the QMS (Fisheries New Zealand 2018a).

Table 4 Snapper limits have reduced significantly

Minimum legal size and bag limits for recreational fishing, Snapper 1 Quota Management Area

Date introduced	Minimum legal size (cms)	Bag limit
1 January 1985	25	30
30 September 1993	25	20
1 October 1994	27	15
13 October 1995	27	9
1 April 2014	30	7

Source: (Fisheries New Zealand 2018a)

3.5. Assessment of current regime

The current New Zealand QMS does not rate highly against all our criteria.

The main findings of our research are that: the societal value of the fishery is deteriorating, as evidenced in plateauing commercial returns and sustainability risks for future catches; increasing environmental harm and lack of entry and exit into the quota market.

Despite achieving its initial purposes of reducing over-capitalisation, the current regime has not delivered all it could to New Zealand.

Fishing is now concentrated in a few large owners. 78% of quota are owned by 10 entities.[24]

The regime has been unable to address key sustainability issues like bycatch, high-grading and under-reporting.

Inshore fisheries are coming under increasing pressure. Recreational catch limits for popular species are being reduced.

Official policy has largely been directed at developing the fishing as a highly efficient, export-orientated industry, leading to tensions between different types of fishing. At the same time, growth in exports is now coming from aquaculture. The benefits of recreational fishing, fishing as a tourist attraction and domestic seafood consumption (from high-end restaurants to fish and chips by the beach) have been discounted.

The move away from quota holders paying resource rentals to levy-based funding of administrative and research costs means that a valuable natural resource is given away, with little benefit going to the public at large.

Unchecked concentration of quota and fish processing facilities has created significant barriers to entry into commercial fishing.

The deficiencies we have identified in the current QMS go to the very core of the regime. As has been the case overseas, using property right to fish a single species has not delivered a sustainable, innovative, commercially viable and growing fishing industry.

[24] Data from Fishserve.

Our high-level assessment of the current regime, drawing together the experience outlined in Section 3.4, against the criteria in 2.3 are set out below.

Table 5 The current regime is not ideal

Feature	Comment
Limited rights to fish imposed	Yes, via QMS, TAC and ACE.
Regime based on nature of fish and fishing	No. Single species and location quota. Bycatch not well-managed.
Limits designed to maximise social return	No. Limits set to achieve maximum ecologically-sustainable yield.
Limits set based on up-to-date science	No. 56% of New Zealand's utilised fish stocks have not been scientifically assessed.
Liquid markets	No.
Sustainability delivered	No.
Resources rentals paid	No.
Economies of scale reduce costs	Yes.
Accommodating other uses	No.
Promoting other environmental goals	No.
Māori interests recognised	Yes.

Source: the authors

4. LegaSea's proposal

LegaSea have proposed fundamental reforms of the fishing regime. Key features are set out in Table 6. Details are in Appendix C.

Table 6 LegaSea's proposal

Main features
A new independent Crown Entity authority to set catch limits and undertake scientific research
Māori and the Crown will have shared governance; fulfilling Treaty obligation for tino rangatiratanga (chieftainship) and enabling greater expression of kaitiakitanga (guardianship) of marine resources.
Statutory recognition of non-commercial stakeholders in the new fisheries management system.
Priorities for Ministerial action explicitly set out in the Fisheries Act, prioritising sustained ecological resources, environmental interests, and high value Māori customary and recreational fishing.
Limits on catch will be reset, generally at lower levels to ensure stocks recover and become abundant
Commercial permits to be sold via competitive tendering, replacing current levy-based funding. The payment to the Crown will be a form of resource rental payment and would be used, in part, to finance regulatory and research functions.
Outputs for commercial fishing will be set in multi-species terms
Commercial fishing will be subject to effort limits and gear controls, directed in part at limiting effects on other native species, like seabirds and mammals
Independent monitoring of commercial fishing will combine self-reporting and electronic monitoring, audits and observers

Source: LegaSea

The core regulatory instrument under the proposal – which LegaSea have termed a "permit" – will be apply multi-species limits, using a "conversion grid" approach. While each permit will be issued in terms of a single species, a set of conversion factors, or grids, will be specified that allow other species to be landed against the permit. The ability to convert will, however, not be open ended. The intention is to allow some flexibility of catch, without impacting on the sustainability of other species.

For example, if a permit is issued for 100 tonnes of Gurnard, the conversion factors for Snapper might be 0.75 to 1 up to 10 tonnes of Snapper, 0.5 to 1 for between 10 tonnes and 15 tonnes of Snapper and zero thereafter.

The following combinations of fish could be landed.

Table 7 Permitted combinations of fish

Tonnes of fish that can be taken each year. Illustrative example only

	Gurnard	Snapper
Combination 1	100	0
Combination 2	87	10
Combination 3	77	15

Source: LegaSea

4.1.1. A new authority

LegaSea propose that decision-making around catch-limits, species equivalence "grids" and commissioning the required scientific and other research, should be removed from the Minister and placed in the hands of an independent statutory authority. Funding for the authority would come from proposed resource rentals.

4.1.2. Explicit priorities enacted

The current regime is silent on what priority should be assigned to commercial and non-commercial, both customary and recreational, fishing. While the Minister must take customary and recreational fishing into account when setting TACC, he has wide discretion to do so.

LegaSea propose that the legislation provide explicit guidance to how priorities should be assigned, including giving statutory recognition of non-commercial fishing and ecosystem services.

4.1.3. A reset of limits

LegaSea proposes to reduce current catch limits to enable stocks to return to abundance and strengthen ecosystem functions. In some cases reductions by as much as 40% may be imposed to comply with the new statutory minimum stock sizes.

Indicative reduction in a number of key species are set out in Table 8. The reductions were based on LegaSea's assessment of current stocks.

Table 8 Indicative reductions in catch limits

Species	Reduction
Hoki	40%
Jack mackerel	60%
Barracouta	20%
Southern Blue Whiting	40%
Arrow squid	0%
Ling	20%
Silver warehou	20%

Blue mackerel	80%
Oreo Dory	20%
Orange Roughy	20%
Red Cod	20%
Snapper	20%
Tarakihi	80%
Hake	60%
Spiny Dogfish	0%

Source: LegaSea

4.1.4. Permits to be tendered

The core regulatory mechanism proposed is a fishing permit.

The permits will assign a right to catch fish, expressed in multi-species terms, for a limited time. Permits will also impose effort restrictions.

Permits will be issued via competitive tender. The expectation is that those wishing to fish will be prepared to bid up to the total economic rent to acquire the right to fish. A system of "no fish, no pay" will apply, meaning that the Crown will bear the fiscal risk of lower than expected catch. Payments will be annual in arrears.

While tendering will replace current levies, the expectation is that the regime will be strongly revenue-positive to the Crown. This is a deliberate move away from the current approach where the economic benefits of fishing largely accrue to quota-holders.

4.1.5. Enhanced monitoring

The regime will be enforced via a combination of self-reporting, which will be validated by auditing, electronic-monitoring and inspection.

4.2. Initial assessment

We have not been asked to undertake a full economic assessment of the LegaSea proposal against the current regime and the common recommendations of the economic literature. Such an exercise would be required before any final decisions made.

We have, however, compared the proposal with both the literature, and the criteria we have developed from it and the current regime. This analysis has been desk-based and mainly qualitative.

Table 9 How the literature, the current Act and the LegaSea proposal compare

Criteria	Literature	Fisheries Act	LegaSea proposal
Limited rights to fish imposed	✓	?	✓
Regime based on nature of fish and fishing	×	×	✓
Limits designed to maximise social return	✓	×	✓
Liquid market for rights to fish	✓	×	Tendering
Limits set based on up-to-date science	✓	×	✓
Resources rentals paid	✓	×	✓
Economies of scale reduce costs	✓	✓	×
Māori interests recognised	✓	✓	✓

Source: the authors

4.3. An innovative transition

LegaSea propose that the Crown should buy-back existing quota at their commercial value as part of the move to the new regime. This is a highly innovative approach to one of the perennial stumbling blocks to regulatory reform.

In effect, LegaSea propose that the current regime be repealed, with quota owners being paid for their quota. They, along with all other potential entrants, will have to bid for permits under the new regime. There is no expectation that existing fishers will be assigned permits.

The amount of compensation paid will not include a component to compensate quota owners for the loss of future economic rents (monopoly profits) that they might have earned.

Current Māori rights will be carried over into the new regime, albeit with some possible changes in names, e.g. quota will be replaced by permits. Maori will receive an annual share of resource rentals, based on the proportion of quota currently allocated to iwi in the QMS. In future, these rentals will be payable regardless of whether iwi choose to fish themselves or not.

4.3.1. Fiscal effects

Together with LegaSea, we have undertaken preliminary modelling of the fiscal effects of the proposed transitional rule. Our aim has not been to forecast accurately the likely

costs and benefits of the proposal to New Zealand as a whole. This is not an economic assessment. Rather, it is an analysis from the Crown's perspective, as a way of demonstrating the potential viability of the proposal from a fiscal perspective.

We stress that these costings are preliminary and are based on several assumptions, given the available data. While we have data on current quota and landed catch size, we have had to assume and infer possible rental payments, buy-back costs and future stock levels.

We are confident that the assumptions are all reasonable, given the purposes of the modelling, which is to test a proposition. We also undertook some sensitivity test to determine if any of the assumptions were critical to the results.

The key assumptions in the model are set out in Table 10.

Table 10 Main assumptions

Assumptions	Reasoning	Description
The value of ITQs are based on the value of ACE it generates.	ITQ holders generate ACE based on the level of TACC for set for each year. In line with how businesses are valued based on their potential income, it has been assumed that ITQ can be valued the same way.	Earnings to valuation ratio of 10x has been assumed for the model valuation. This is based on typical earnings per share (EPS) ratios seen in financial markets. It is also consistent with studies of the value of fishing quota in New Zealand (Newell, Papps, and Sanchirico 2005). Given that the range of EPS ratios is vast we have sensitivity tested this assumption.
ITQ valuation will be affected by the level of risk the fish species it relates to.	ACE is only as valuable as the income generated from fish it allows the holder to catch. Any risks facing the fish species will be reflect in the future price of ACE and therefore the ITQ's value.	Nine types of risk alongside nine levels of upside and downside risk have been identified by LegaSea who have set implicit risk index for each species.
Post-quota adjustment, annual quota growth rate will be increased to reflect the return of fish stocks.	Significant initial reductions in quota will allow for fish stocks to replenish and reach a sustainable level. Reallocating quota when stocks return makes sense especially if the reduction result in fish stock surpassing existing levels.	Set to 1%.
Reductions in existing quota will be on a per species basis.	Fish species are at varying levels of vulnerability and require different levels of intervention.	Six levels of vulnerability have been identified by LegaSea who have also set implicit quota reduction rates for each species.

Resource rental rates will grow overtime.	The combination of reduced supply, increased competition and the opening of markets to spur innovation will have a mixed effect on how fishers will price quotas.	An average annual growth rate of 4.8% has been assumed. In fact, we expect that growth will be highest in the early years, as the reset in TAC pushes prices up initially.
A proportion of resource rental revenue will belong to Maori.	Honouring the Treaty of Waitangi, a proportion of revenue will always be allocated to Maori.	A 10.7% share has been assumed for the time being, based on the current proportion of quota given to Maori under the Treaty Settlement process.
Port prices (wholesale prices) as reported include additional costs from LFRs.	Port prices are currently listed by LFRs to FishServe (where the data is sourced) currently includes any costs the LFR charge for ACE.	A 30-50% adjustment to future port price has been made by LegaSea to reflect the abolishing of LFR in the proposed new scheme.

Source: LegaSea

The transition involves a large up-front payment, and an on-going revenue stream, in the form of resource rents from permits sales. We have, therefore, undertaken our analysis on a discounted cash-flow basis, to calculate the effect on the Crown over the long term. In all such exercises, the discount rate is a key determinant of the results. To cut through this issue, we calculated the internal rate of return of the scheme, which is the discount rate required to produce a zero net present value, that is, just break-even. Readers can compare the results with a range of appropriate discount rates when assessing the result.

Details of the model and the results are in Appendix D.

Initial calculations suggest that the combination of buy-back (an upfront cost) and tendering (a long-term revenue stream) will be at least fiscally neutral to the Crown over the long term.

We have modelled three main scenarios, based on low, medium and high costs of the buy-back. The results are summarised in Table 11.

Table 11 A wide range of results

	Low	Medium	High
Cost of buy-back	-$1.27 Billion	-$2.75 Billion	-$5.58 Billion
Internal rate of return	27.2%	12.9%	5.5%

Source: the authors

The result of our sensitivity testing is set out in Table 12. We show the cost of buy-back, IRR and the breakeven year under the low, medium and high scenarios. The first set of result ("Default") represents our central forecasts. The results are most sensitive

to the assumed growth in the resource rental prices, although we tested the case of zero growth, which while illuminating, is not realistic.

Table 12 Sensitivity testing

Adjustments		Scenario 1	Scenario 2	Scenario 3
Default	Cost of buy-back	-$1.27 Billion	-$2.75 Billion	-$5.58 Billion
	Internal rate of return	26.5%	12.5%	5.2%
	Breakeven year (Nominal)	2026	2030	2037
ACE buyout, valuation ratio at 7.5x	Cost of buy-back	-$0.95 Billion	-$2.06 Billion	-$4.18 Billion
	Internal rate of return	36.9%	17.0%	8.1%
	Breakeven year (Nominal)	2025	2028	2034
No future risk to ACE markets	Cost of buy-back	-$1.44 Billion	-$3.10 Billion	-$6.28 Billion
	Internal rate of return	24.1%	11.4%	4.5%
	Breakeven year (Nominal)	2026	2031	2038
No changes in resource quotas after initial reductions	Cost of buy-back	-$1.27 Billion	-$2.75 Billion	-$5.58 Billion
	Internal rate of return	40.5%	18.5%	9.0%
	Breakeven year (Nominal)	2024	2028	2033
No growth in resource rental prices.	Cost of buy-back	-$1.27 Billion	-$2.75 Billion	-$5.58 Billion
	Internal rate of return	20.4%	7.3%	0.4%
	Breakeven year (Nominal)	2026	2033	2044
Maori proportion of revenue 20%	Cost of buy-back	-$1.27 Billion	-$2.75 Billion	-$5.58 Billion
	Internal rate of return	24.9%	11.8%	4.7%
	Breakeven year (Nominal)	2026	2031	2038

Source: NZIER

4.3.2. Results show concept is worth considering

While tentative, our results suggest that the proposal would be fiscally positive to the Crown under the assumptions used.

5. Next steps

While the high-level economic principles that should guide regulation are well known, experience here and overseas has shown that actual fishing regulation is not simple. Approaches suitable for land-based agriculture do not always work well when applied to the sea.

Our knowledge of the ecology of fish is still developing and the application of what we know to New Zealand fisheries has not always been comprehensive.

We can see areas where the current New Zealand regime has not produced the promised results. The incentives on individual fishers are not aligned to stewardship of the sea. After 30 years' application of the QMS, some fisheries are under considerable pressure. Fishing is having clear impacts on other parts of the environment. Bycatch is not resolved. The seafood industry remains small.

We consider the LegaSea proposal is worthy of further development and consideration by Ministers, Māori, all fishers, environmental NGOs, academics and the public.

Areas where we see the most potential for improvement are in the proposal to base permits on multiple species and to regulate effort. Both aspects of the regime should reduce the effects of bycatch, especially on marine birds and mammals.

Moving to resources rental levies is well supported by the public finance literature and was, of course, a feature of the QMS when first introduced.

We note, however, that both the proposal and our assessment of it are at a high-level. Our modelling has been designed to provide a "proof of concept", rather than being definitive.

5.1. A work plan for officials

We recommend that Ministers commission work to develop and test the LegaSea's proposals more thoroughly. LegaSea and other stakeholders should be actively engaged in this work.

We recommend the Government direct officials to:

- Work with LegaSea to develop a more detailed description of the new proposal
- Test the assumptions and results of the modelling of the financial impact of the proposed transition
- Assess, in a transparent and consultative way, the LegaSea proposal against a clear set of national wellbeing-enhancing criteria, using appropriate qualitative and quantitative techniques.
- Use that assessment as the basis of consultation with Māori, representatives of all groups of fishers and the public. Independent facilitators should guide the consultation
- Confirm that the proposals are not a contemporary breach of the Treaty
- Confirm that the proposals are consistent with New Zealand's international obligations

- Once the benefits are confirmed and if there is support for the proposal, prepare a draft bill including the transitional provisions for the consideration of Ministers and for discussions with Māori and other stakeholders
- Prepare a draft Regulatory Impact Statement based on the proposal

That assessment should be forward looking, and not focus on re-litigation of past decisions. At the same time, practical experience of the New Zealand regime and those used in other countries should inform the analysis.

We suggest officials report back to Ministers in time for legislation to be at least introduced in the current Parliamentary term.

Appendix A Glossary of terms

Term	Description
Annual Catch Entitlement, ACE	The amount of fish allowed to be caught by species and area. A tradeable right that can be sold multiple times during the year.
Biomass	The living mass of a fish stock, expressed in units of weight. Biomass can also refer to one part of the stock e.g. Spawning biomass, vulnerable biomass or recruited biomass.
B_{MSY}	The average stock biomass that results from taking an average catch of Maximum Sustainable Yield (MSY).
Bycatch	The fish species or size class of those species, or unwanted non-fish species, caught in association with the target species. This can refer to marine mammals, seabirds and invertebrates.
Catch	The total weight, or sometimes number, of fish caught by fishing operations, commercial or non-commercial, customary or recreational.
Collapsed stock	A stock that is below the hard limit is deemed to be collapsed.
Commercial fisher	Person fishing for commercial purposes using a permit. Person fishing under the commercial fisheries regulations.
Customary fisher	Person fishing with a permit, for non-commercial customary purposes. Fishing can be under the customary regulations or the amateur fisheries regulations.
Customary fishing	Fishing for traditional purposes or cultural occasion using a permit. Permit is issued by the Kaitiaki or person from the iwi or hapu having authority over the catchment area.
Depleted	Fish stocks that are below the soft limit are deemed to be depleted. Stocks can become depleted through overfishing, or due to environmental factors, or a combination of factors.
Discards or dumped catch	The portion of fish catch, or marine life released or thrown away at sea.
Ecosystem.	A biological system comprising a community of living organisms, including humans, and its associated non-living environment, interacting as an ecological unit.
Exclusive Economic Zone, EEZ	The area of marine waters beyond the Territorial Sea, between 12 nautical miles and 200 nautical miles from the coast. An area where New Zealand has sovereign rights over the exploration and use of marine resources. Usually the EEZ extends to 200 nautical miles (370 km) offshore, except where resulting points would be closer to another country.
Fish stock	A fish species or group of species within a specified management area. As of 2018, there are 642 separate fish stocks within the Quota Management System (QMS).

Fisheries Management Area, FMA	An expanse of water within the EEZ used for management purposes. The EEZ is split into 10 FMAs.
Fishery	A broadly used term that can relate to one or many fish stocks, or one or many fishing methods, and is sometimes used in place of fish "stock"
Fishing year	For most fish stocks the fishing year starts on 1 October and extends to 30 September the following year. For selected stocks such as rock lobster, the year is 1 April to 31 March the following year. The 2nd year is often used as shorthand for the split years ie. 1 Oct 2014 to 30 Sept 2015 can be expressed as 2014-15 or just 2015.
Governance.	Decision-making process applying to fisheries. Who makes the decisions, who has input into the decision-making process, and what expertise is included in the process.
Hard limit	A biomass, stock size, limit below which fisheries should be considered for closure. If not closed, a time-bound rebuild is most often a part of the strategy applied after a fish stock is assessed to be below the hard limit.
Individual Transferable Quota, ITQ	A shareholding of potential catching rights within the Quota Management System. ITQs represent perpetual rights which can be traded and transferred. ITQs were established in 1986 and allocated in all the major inshore and deepwater fisheries. In 2018 there are 98 species or species groups, and these are managed as 633 separate fish stocks within the QMS.
Kaitiakitanga	The responsibilities and kaupapa passed down from the ancestors for mana whenua to take care of the places, natural resources and other taonga (treasures) in their rohe (local area), and the mauri (life force) of those places, resources and taonga. Includes caring for people.
Limit	A biomass or fishing mortality reference point that should be avoided with high probability. The Harvest Strategy Standard defines both soft limits and hard limits.
Maximum Effort Limit, MEL	Condition of a fishing permit describing the fishing equipment that can be deployed, and the maximum number of fishing days for each vessel. Requires vessels to clock in and out. Catch data is electronically recorded during unloading.
Minimum Legal Size, MLS	Fish above the Minimum Size Limit can be retained while those below it must be returned to the sea. Can apply to commercial and non-commercial catch. Different MLS can apply to commercial and recreational catch of the same species.
Maximum Sustainable Yield, MSY	The traditional management target for most fish stocks. The largest long-term average catch or yield that can be taken from a stock under prevailing ecological and environmental conditions, and the current selectivity patterns exhibited by the fishery.
Non-commercial fishing	Fishing undertaken for non-commercial purposes. Recreational (amateur) or Maori customary fishing.

Overexploitation	A situation where observed exploitation (or fishing mortality) rates are higher than target levels.
Overfishing	A situation where observed fishing mortality (or exploitation) rates are higher than target or threshold levels.
Population	A group of fish of one species that shares common ecological and genetic features. The stocks defined for the purposes of stock assessment and management do not necessarily coincide with self-contained populations.
Population dynamics	In general, this refers to the biological and fishing processes that result in changes in fish stock abundance over time.
Quota, rights, shares	A tradeable shareholding in the Total Allowable Commercial Catch (TACC). A right to harvest a particular species in a specific management area.
Quota holder	An individual or entity owning shares in the Total Allowable Commercial Catch (TACC). The holder is able to buy or sell quota shares within aggregation limits.
Quota Management Area, QMA	Every species in the QMS has a Quota Management Area applied within the Territorial Sea or EEZ. The size of the area varies depending on the characteristics of the fish stock. A QMA can include one or more Fisheries Management Areas. Can include several sub-stocks within one QMA.
Quota Management System, QMS	A system based on individual transferable property rights. Used to manage the majority of commercial catch of fish stocks from within New Zealand's EEZ.
Recreational fishers	People fishing under the amateur fisheries regulations. People fishing for non-commercial purposes.
Reference point	A benchmark against which the biomass or abundance of the stock or the fishing mortality rate (or exploitation rate) can be measured in order to determine its status. Reference points can be targets, thresholds or limits depending on their intended use.
Soft limit	A biomass, stock size, limit below which the requirement for a formal, time-constrained rebuilding plan is triggered.
Stock	This term can have different meanings. Under the Fisheries Act 1996 a stock is defined with reference to units for the purpose of fisheries management. A biological stock is population of a given species that forms a reproductive unit and spawns little if at all with other units.
Stock assessment	The analysis of available data to determine stock status, usually through application of statistical and mathematical tools to relevant data in order to obtain a quantitative understanding of the status of the stock relative to defined management benchmarks or reference points.
Stock status	Refers to a determination made, on the basis of stock assessment results, about the current condition of the stock. Stock status is often

	expressed relative to management benchmarks and biological reference points.
Sustainability	Refers to the ability of a fish stock to persist in the long-term. One of the dual purposes of the Fisheries Act 1996, alongside utilisation. Must be ensured. Ensuring sustainability is described, in part, in the Fisheries Act as maintaining the potential of fisheries resources to meet the reasonably foreseeable needs of future generations; and avoiding, remedying, or mitigating any adverse effects of fishing on the aquatic environment.
Target	Generally a biomass, fishing mortality or exploitation rate level that management actions are designed to achieve with at least 50% probability.
Territorial Sea	A belt of coastal waters extending at most 12 nautical miles (22.2km, 13.8 mi) from the baseline, usually the mean low water mark, of a coastal state.
Threshold	A biological reference point indicating that biomass has fallen below the target, or fishing mortality or exploitation rate has increased above its target. Additional management action may be required in order to prevent the stock from declining further and possibly breaching the soft limit.
Total Allowable Catch, TAC	The total amount of fish that the Minister of Fisheries authorises can be taken from each fish stock in any one year. It is the sum of the allowances set aside for Maori customary and recreational fishing interests, the allowance set aside to account for other sources of fishing related mortality, and the Total Allowable Commercial Catch (TACC).
Total Allowable Commercial Catch, TACC	The amount of the TAC which may be taken in any one year by commercial fishers. All catch of quota species must be reported.
UNCLOS	United Nations Convention on the Law of the Sea 1982.
Unfished, virgin biomass	The theoretical carrying capacity of the recruited, vulnerable or spawning biomass of a fish stock. It sometimes refers to the average biomass of the stock in the years before fishing started. More generally, it is the average over recent years of the biomass that theoretically would have occurred if the stock had never been fished.

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Appendix C LegaSea's proposal

Rescuing Fisheries

C.1 Scope

The LegaSea proposal applies to all fishing within New Zealand's exclusive economic zone.

C.2 Overarching principles

The following principles to guide drafting of new legislation that establishes a new fisheries governance board and management agency.

- All fisheries laws will conform with the principles of the Treaty of Waitangi.
- The living marine resources of Aotearoa New Zealand remain under the control of government and cannot become the private property of private companies or individuals or sold abroad.
- All fisheries must be biologically, economically, and socially sustainable. The legislation will prevent private sales of licences or fishing rights.
- To the greatest extent possible, commercial fishing rights will be granted in line with the principles of a market-based system.
- Catches will be landed in New Zealand and processed here for added value.
- Only New Zealand owned and registered companies, or private New Zealand citizens, paying taxes in New Zealand and complying with all relevant employment and maritime law will be able to participate in New Zealand's commercial fisheries.
- In the Territorial Sea there will be complete fleet separation. That is, only vessel owners will be eligible to own and operate a permit. There is no vertical integration permitted.

C.3 Create an overarching governance body

A new statutory body will be formed to set Total Allowable Catches (TACs) and direct fisheries research priorities. Members will be appointed by Cabinet and may serve a maximum of 2 three-year terms and comprise three representatives each of Māori and the Crown, with an independent chairman having the casting vote. For now, this is referred to as the Guardians of the Fishery (Kaitiaki o te Tauranga Ika).

This is a solution to the following problems:

- Avoids regulatory capture by being accountable to Cabinet and Parliament through an annual reporting regime.
- Makes TAC and "grid of transfer ratios" recommendations that conform to the Fisheries Act to achieve a return to abundance.
- Decision-making is principle-based underpinned by the need to provide for future generations' interests.
- Independent determination of research needs to inform decision making.

C.3.1 Minimum stock sizes are provided for in the Fisheries Act

A new statutory minimum stock size that guides TAC setting at no lower than 50% of the unfished biomass (this replaces the current 'at or above the biomass required to produce maximum sustainable yield, B_{msy}'). For stocks below that level the maximum time allowed for a 70% probability of being above target is 2 x T_{min} (the current timeframe specified in the Harvest Strategy Standard Guidelines, Ministry for Primary Industries). That is no longer than twice the time the stock would meet the target if there was no fishing mortality.

The benefits of maintaining stocks at these levels are the provision of essential ecosystem services and greater resilience against climate change and external shocks. There is no need to try and move to a version of ecosystem-based management that seeks to measure all the inputs and outputs of our inshore marine ecosystem, and then use this fine scale understanding to set catch limits.

The most effective way to provide for ecosystem services is to maintain stocks at a size that includes all representative age classes, provides for close to maximum yield, and provides for maximum resource rent to be generated and captured by government.

This is a solution to the following problems:

- Prevents stock depletion.
- Defends the functions of inshore ecosystems.
- Reduces costs to fishers.
- Improves catchability - lowers costs - promotes high value.
- Provides for a balanced age structure population.
- Avoids the expense associated with implementing a version of ecosystem-based management that seeks to measure all the inputs and outputs of our inshore marine ecosystem, and then use this fine scale understanding to set catch limits.

C.3.2 Allocating the Total Allowable Catch (TAC)

The new Fisheries Act will contain explicit priorities for the Minister when determinations are made in allocating the TAC. Allocation of catching opportunities should be guided by value to New Zealand. This will require some high-level value assumptions being made at the outset and incorporating design flexibility to provide for future amendment.

Having explicit allocation priorities will:

- Promote Customary Māori non-commercial fishing as a priority catch that must be allowed for.
- Promote non-commercial public fishing as the second priority.
- Balance of catch opportunities for commercial use can be allocated via permits.
- Provide for innovation to deliver high value commercial catches from inshore waters.

C.3.3 Commercial permits for a fixed term

Commercial fishing permits are issued for a fixed term, no longer than 5 to 8 years. The permit can only be used by the permit holder - there is no provision for absentee ownership. The permit limits the quantity of fish that can be landed, the amount of fishing effort that can be applied, and the area in which the permit can be used. There can be no private sales of permits or any fishing authority issued by the government.

Permits are allocated by competitive tender. Tender price would represent a resource rental.

Fixed-term permits will help:

- Remove the barriers to entry, encouraging people into fishing.
- Restore competition for fish and fish products.
- Prevent industry capture of the regulator.
- Provides a market for commercial access rights.
- Drives economic efficiency and innovation.

Output Limits (that replace the current species quota limits) are described as equivalents. That is, all catch is accounted for against a gross biomass limit, and particular species have attached transfer ratios to allow them to be counted as equivalents. For example, in the north the biomass limits would be snapper equivalents (SNAE). The other species that live with and are caught in the same areas have a conversion ratio to allow them to be defined as snapper equivalents. It may be that 2 kg of gurnard requires 1 kg of SNAE to be in balance. The ratio is a combination of economic value and ecological risk.

This resolves the following issues:

- Removes target and bycatch categories (catch is catch).
- Move from single species to multi-species management.
- Removes the current complexity of catch balancing and deemed values.
- Reduces economic incentives for discarding.
- Encourages innovation
- Removes the ability to deploy indiscriminate bulk harvesting methods.
- Improves public perception of effective management and fishing practices.

Research needs to be fisher-independent where possible. The reliance on a time series of Catch Per Unit of Effort (CPUE) analyses has enabled the overestimation of yields leading stock after stock to the edge of social, cultural, and economic collapse. This is particularly so in the inshore fisheries where there is widespread public observation of a continuous trend of depletion.

- Independent surveys at a maximum of 3-year intervals
- Monitor catch at age annually
- Maintain a balanced age structured population.

C.3.4 Input controls

Input controls are attached to each permit and are described as effort limits. Each permit holder is restricted to a maximum annual effort limit. For a long liner, this is daily maximum number of hooks set per day, and a maximum number of fishing days. There will be a complete ban on bottom trawling in the inshore fishery. Vessels log in/log out at end of each fishing day/trip.

This addresses:

- Increasing effort to maintain catch when stock is declining.
- The need for restrictions on bottom trawling in the inshore fishery.
- The risk of hyper-stable Catch Per Unit of Effort (CPUE) analysis.
- Prevents undetected efficiency creep occurring.
- Enable rapid response to any reports of spillage or dumped fish.

C.4 Monitoring

Monitoring will combine self-reporting catch and electronic monitoring. Daily catch returns will be submitted by permit holders reporting the green-weight of all catch. Cameras will be mounted in all vessels and used for validation of self-reported data. All vessels will operate the Vessel Monitoring System (VMS).

This is resolves the following issues:

- Zero discards of non-protected species. All catch will be landed.
- VMS will determine whether vessels are at sea fishing or in port. (validating the log in/out process)
- Incentivises honest self-reporting.
- Provides for independent monitoring of catch by video captured at sea.

C.5 Transition

Transitioning from the Quota Management System (QMS) to new arrangements will occur quickly following passage of the new legislation. It requires three separate processes:

- Drafting legislation to enable the new instruments to be used

- Completing a process of buyout of existing TACC shares in inshore fish stocks, and
- Tendering of the new permits.

C.5.1 New legislation.

Drafting the new Act will require the following detailed policy matters to be settled:

- Details of the governance body, new management areas, and the species trade-off mechanism.
- The permitted fishing methods and setting of input limits to be described with aggregations limits and maximum/minimum catch units settled.
- The data collection and management for monitoring arrangements, including an Integrated Electronic Monitoring Reporting System (IEMRS), and rules around penalties for permit holders who breach the new regulatory structure
- Defining new Fisheries Management Areas, which will involve both rohe moana, fisheries-management and regional development elements. In the first instance the existing statistical areas could be useful and if necessary these could be divided into smaller areas. As each area adds cost there will be the temptation to simply draw a ring around every harbour, this must be resisted - there must be a reasonable trade-off that gives effect to the regional development aspirations while avoiding unnecessary complexity.

C.5.2 Share buyback.

Completing a share buyout will at first require the agreement of Māori as these shares have been used in settling commercial fishing claims.

For the purpose of progressing this proposal the price is established by using 10 times the average of the last 5 years ACE price paid by fishers. Of note:

- Transition costs include the costs (if any) of rebuilding fish stocks to the new statutory targets. The time for rebuilding will vary across species but range from a few years to fifteen years. Some may never recover without additional conservation measures.
- New monitoring capacity as full electronic monitoring and reporting (IEMRS) capability implemented.
- The Crown to own and control the monitoring equipment except for smart phones used for logging in/out fishing days and reporting catch.
- Resource rental income will be constrained as stocks rebuild and a full yield becomes available for allocation. This doesn't translate to a direct cost as there are no resource rentals now and cost recovery levies are miniscule. It is a cost imposed by depleted stocks rather than transitioning regimes.
- Building computer capacity to operate the species trade-off mechanism that resolves landings back to the quota unit in real time and leaves the permit holder with the number of units remaining.

C.6 Māori

Māori to secure larger and more enduring returns from their Treaty Settlement. Currently the Settlement assets have largely been quota shares, with the inshore shares allocated on the basis of rohe moana and the deep-water shares allocated on the basis of population. These shares are currently subject to variation due to Ministerial decisions for each fish stock, this affects current rates of return. The principle of reforms is that Maori derive long term benefits from these changes.

While making no hard suggestion as to how the share buyback should or could be valued, or how the resource rental could be dispersed, we provide an example of a workable model -

- Total the revenue and deduct the costs of management ($60m)
- Set aside a discretionary research budget that may be used by the governing council, the Guardians of the Fishery (with the tentative Māori name Kaitiaki o te Tauranga Ika).

C.6.1 LegaSea proposal – Benefits to Maori

LegaSea has started on a journey to comprehensively reform fisheries in Aotearoa New Zealand. It is essential if any changes are to be made that Maori must not only support change, but become leaders in the effort to rebuild depleted fisheries, restore resilience to the marine environment, and revitalise fishing for the benefit of all New Zealanders.

The need for reform arises from the steady decline in abundance of our fish stocks around the coasts of Aotearoa. Our alternative to the Quota Management System offers pathways to abundance with Maori in a co-governance role with the Crown and receiving greater, ongoing income from fishing.

Currently commercial fishing returns are stagnant and the overfishing of inshore fish stocks means customary fishing is becoming harder – the fish just aren't there to catch any more. The loss of fish makes it harder for people to catch a feed or gather shellfish. It is almost impossible for young people to become fishermen and earn a livelihood. The mana derived from fishing, sustaining the whanau and community, has been lost as the fish that are landed are trucked away from our small towns. All the benefits seem to be for someone far away.

LegaSea's alternative management structure is designed to benefit Maori in the following ways.

- To buy back the quota shares that Iwi own at fair value. One essential step is to end the Quota Management System. Reparations for Treaty breaches in cash from the buyback is more useful than shares in Total Allowable Commercial Catches (TACCs) that are destroying inshore fish stocks.
- To create a Rununga that exercises the highest chieftainship over fisheries by setting Total Allowable Catches (TACs), the maximum catch that allows the stocks to always be above 50% of the unfished, natural size. The Rununga would comprise equal members of Maori and the Crown to reflect the principles of the Treaty of Waitangi.
- Fulfilment of the intention of those who signed the Treaty of Waitangi (Fisheries Claim) Settlement Act 1992. The original intent was to use

Settlement cash to support “the development and involvement of Maori in fishing”.

- To regulate commercial fishing to encourage and enable small scale fishing along the coast. Aspiring commercial fishers would apply for a permit, with maximum catches and maximum fishing days applying to each permit. This is to provide employment opportunities and again encourage young Maori to get their hands wet.
- A new Fisheries Act based on a clear set of principles will be required to ensure the fish stock abundance targets are met. The best results come from having the minimum stock size set in law and not able to be changed as a result of lobbying. The Rununga will exercise Kaitiakitanga and ensure our mokopuna can also exercise their customary fishing rights by having fish again plentiful in inshore areas.
- Local area management will occur in each rohe, with each management area having a Kaitiaki board comprising mainly representatives of Iwi, hapu, and the local council. The main role for this local board is to maintain a living spatial plan. They can impose rahui, protect areas of high significance, for example habitats that are at risk, shellfish beds, and set local rules for local users.
- Another feature of the new system is that those fishing under a permit will pay a resource rental, or resource tax. This is to reflect that the fish are common property and those that catch and sell them should pay something back to the community. All of the resource rental is collected by the Crown. This Crown fund will pay for research and management costs. LegaSea propose that a share of the resource rentals collected each year will be set aside and distributed to Maori. The final amount will be subject to negotiation.
- Maori will be free to invest their income from resource rentals as they see fit. Some Iwi may choose to reinvest in fishing opportunities for their people, others may decide they would generate more income elsewhere.
- Mana will be restored. Prior to the introduction of the Quota Management System the government, in the early 1980s, revoked the permits of fishers who were deemed to be part-timers, not making an annual income from fishing. This had a disproportionate effect on Maori, especially in the regions where it was common for people to spend several months at the freezing works or dairy factory and the rest of the year fishing inshore for flounders, mullet and kahawai. The ability to provide kai moana for the marae and community enhanced the mana of these fishers and their families. The removal of their fishing permits not only diminished their ability to work, it reduced the mana of the fisherman and his family amongst their community.
- As fisheries rebuild Maori will benefit from the resource rentals generated from the commercial use of fisheries. In the short term there will need to be catch reductions to achieve the desired level of abundance. In the governance role Maori will be part of the process to apply the necessary catch reductions in some areas to enable fish stocks to rebuild.

- Non-commercial fishing will improve with more fish in the water. Maori customary interests will be paramount and best served by having kai moana readily available in the places traditionally fished. Fishing to feed the whanau without a permit is classed as 'recreational' fishing. At 26% of the total, Maori adult men represent the largest ethnic group participating in recreational fishing . And research shows that 52% of Maori who fish in the sea say they rely on fishing to feed their families, compared with 27% of the adult population overall. Abundance is the key to providing for Maori's interests in fisheries.

Appendix D Modelling the transition

This appendix describes the methodology NZIER and LegaSea has developed to model the financial consequences of the proposed transitional regime set out in the main body of this report.

A.1 Modelling objective

The objective of the model is to estimate the expenditure and revenue implications to the Crown of the transitional rule. We are seeking to quantify the fiscal effects of the different parts of the transitional rules:

- The one-off up-front payment by the Crown to current ITQ owners to compensate them for the abolition of the current ITQ regime
- The revenue streams over future years that will be earned from the tendering of permits under the new regime
- The replacement of levy-based funding of administration and research with the funding, from tendering proceeds, of a new entity to administer the regime

Importantly, this modelling is not an economic assessment of the costs and benefits of the proposed new regime.

A.2 Methodology

We have used the Internal rate of Return (IRR) technique to undertake this costing.

The IRR is the discount rate r at which the net present value of undertaking the buy back and adopting the proposed QMS equates to 0.

$$NPV = \sum_{t=1}^{t} \frac{C_t}{(1+r)^t} - C_0 = 0$$

C_0 = upfront cost

C_t = revenue stream during period t

r = discount rate

t = number of periods[25]

Effectively this is interest rate at which the buy-back of ITQs breaks even with future earnings from TACC under the new regime.

When used as a decision-making tool in firms, the IRR is compared with a "hurdle rate of return" that is set external to the IRR model. This is usually the firms weighted average cost of capital (WACC). The usual decision is that if the IRR is higher than the hurdle rate, then the project will be profitable over its life.

[25] A 25-year period has been adopted for this model, spanning the period of 2021 – 2045.

Determining the appropriate discount rate to use for this exercise is difficult and there are many different views in the literature. By using the IRR approach, we are allowing readers to select their view of the appropriate discount rate. If the IRR is higher than that rate, then the transitional rule will have positive fiscal implications for the Crown over the long term.

D.1 Upfront cost – C_0

The initial cost of LegaSea's proposed transitional rule is the price at which the Crown will pay to buy back all ITQs currently on the market from their respective owners.

In order to value ITQs LegaSea have made the following assumptions:

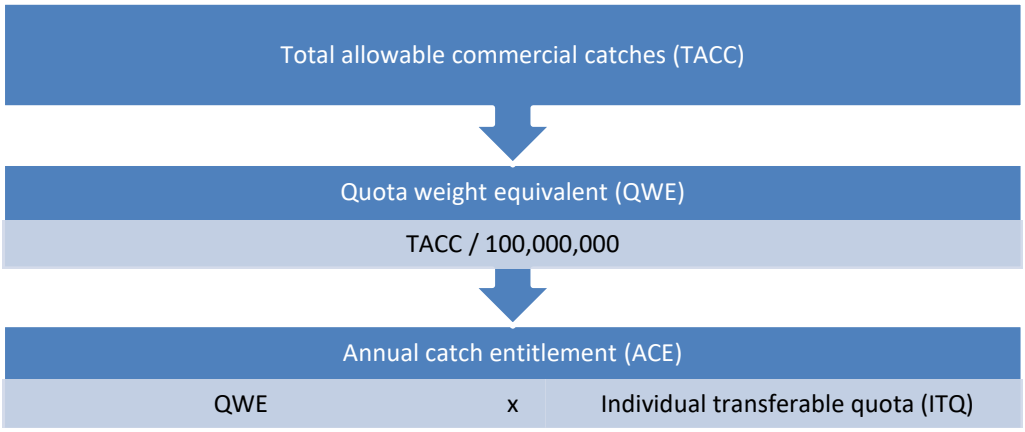
- Earnings from ITQs per fish year are equivalent to the value of ACE they generate in that respective year.
- ACE hold an equivalent value to the quantity of fish stock that can be caught and the price at which they are sold for.
- The value of ITQs can be estimated by applying a valuation ratio on the value of ACE it generates per fish year.
- The reported catch is the appropriate measure on which to value the ITQs.

Given the lack of pricing information for ITQs, a valuation ratio of 10 has been adopted to provide an estimate of the value of an ITQ across each fish stock classification[26].

ACE based on catch quantity and not the catch quantity entitled under each ACE. This distinction recognises that for some fish stock, the TACC is set at an unattainable level. This assumes that the total quantity of all ACE is only as valuable as the total quantity of all landings.

Figure 15 shows how ITQs are related to ACE under the current QMS, via the idea of quota weight equivalents (QWE).

Figure 15 ITQ earnings are based on the value of ACE

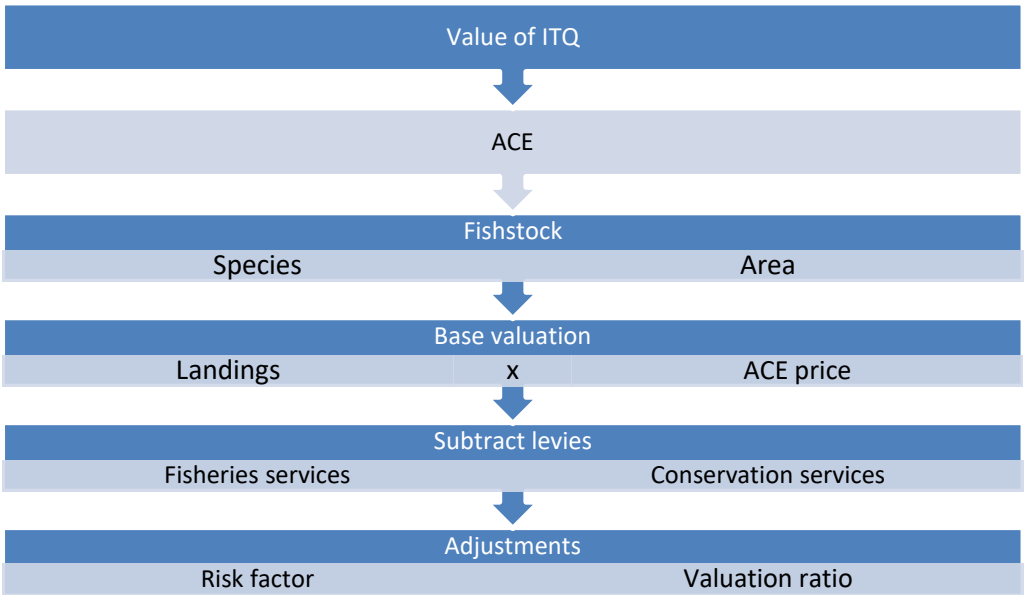


[26] This is based on typical price to earnings ratios of publicly traded businesses. While these are can vary significantly between business, 10 was chosen as a fair offer. This ratio can be sensitivity tested by adjusting the `valuation_ratio` in `global_assumptions` sheet.

As at May 2019, the average earnings per share of Air New Zealand for the previous 12-months was 9.87.

- In each fishing year a TACC level is set by the Minister. This figure is a biomass weight limit (Kgs) distinct across each fish stock classification.
- The total number of TACC shares is always 100,000,000. The QWE is calculated to determine the fish year quota for each ITQ share.
- The number of fish stock encompassed by ACE can be determined by multiplying the QWE by the quantity of ITQs.

Figure 16 Valuing ITQ based on current ACE value



The value of ITQs has been estimated for each fish stock using the following method:

Steps 1 - 3 provide an estimate for ITQ earnings per fish year.

1. Determine the quantity of reported landings for each fish stock (set at TACC level if reported as overfished).
2. Multiply reported landings by ACE price (and convert Kg pricing to tonnage).
3. Subtract annual levies of fisheries and conservation services.

Steps 4 – 5 translate ITQ earnings to a net ITQ value.

4. Multiply ITQ earnings per fish year by an assumed valuation ratio.
5. Adjust for foreseeable future risks that will impact the value of ITQs.

The sum of all ACE values across each fish stock after following the steps above equates to the total value of all ITQs. This is the estimated upfront cost to the Crown for the buyback scheme.

D.2 Accounting for risk

Numerous risks factors that may influence the value of ITQs in future reviewed have been rated by LegaSea on a 1 – 9 scale. The average of these rankings forms the risk

index for each fish stock. A risk multiplier is then applied to the initial ITQ valuation for each fish stock to account for upside and downside risks[27].

Table 13 Risk factors[28]

Identified areas of future risk

Risk factor	Description
Near shore contamination	Accumulated contamination of estuarine and near shore habitats cause spill over contamination to saltwater systems affecting inshore marine life.
Ocean acidity	A substantial amount the worlds CO_2 is absorbed by the ocean with lowering pH levels (increasing acidity) being a by-product of this process. Increasing levels of atmospheric CO_2 is leading to an imbalance of this process resulting in increasing ocean acidification affecting marine life in different ways.
Climate change	Increasing ocean temperatures are leading to changes in species ranges. The impacts are varied across different species impacting the ecosystem of marine life.
Ecosystem dysfunction	The combination of all stressors on the ecosystem provide an overarching risk to continued natural species equilibriums.
Excessive exploitation	Future yields are at risk from current excessive exploitation rates.
Market stability	Accounts for volatility within seafood markets.
Ministerial discretion	Under the Fisheries Act the Minister has the discretion in setting TACCs, and directly altering ITQ values.
Regulatory	The ability of government to pass regulations that materially affect the return on assets. Digital monitoring, gear restrictions etc. all comprise a risk to future earnings, as does the ability of foreign governments to deny or condition entry of seafood into markets.
Public opinion	Public opinion can influence regulation as well as purchasing habits on a material level.

Source: LegaSea

[27] The relative impact of each risk level can be sensitivity tested by adjusting `risk_multiplier` values in the `global_assumptions` sheet.

[28] We note that as average has been used as a proof of concept. With more research, it would be expected that the individual contributions of each factor would be weighted based on their influence on the fishing market.

D.3 Revenue stream during period t – C_t

Valuation of future revenue stream for the Crown can be split into two components. For simplicity this can be thought of as changes in price and quantity.

Firstly, regarding quantity, with the changes in fishing quotas to sustainable levels, all fish stock is assumed to experience a decrease in landings. LegaSea have assigned a stock status for each fish stock and assumed changes in fishing quotas with respect to their status.

Table 14 Quota reductions

Transition ratios from current TACC to sustainable catch quotas

Quota reductions	Stock status[29]	Reduction+ in landings[30]
In order to meet sustainable targets, LegaSea have classified each fish species in order of conservation effort. Stock status 1 requires catch quotas to be reduced to 80% of current landings or the TACC, whichever is lowest. Stock status 5 requires catch quotas to be reduced to 1% of current landings or the TACC, whichever is lowest . These reductions also reflect changes to some unrealistic current TACC levels i.e. difficult to catch but high TACC fish stock.	1	80%
	2	60%
	3	40%
	4	20%
	5	1%

Source: LegaSea

It has been assumed after these initial changes to catch quotas, they will be increased at a rate of 1% per annum. This allows for the additional yield to come onstream as stocks replenish.

Second, the price paid for permits will be equal to the value that fishers place on the right to fish which will, at the marginal, equal to resource rent generated by fishing.

Initial wholesale prices have been estimated based on Port Prices (Kgs) sourced from FishServe with an additional price premium of 30 – 50% added to better reflect unreported port overhead costs[31]. The range adopted reflects overseas practice with resource rental regimes and has been set for each fish stock by LegaSea.

Price changes for transitioning away from the existing QMS have been assumed to grow at an average annual rate of 4.8% per annum, with much of that growth happening in initial years. While prices may be expected increase faster during the earlier years of transition, this rate has been adopted for simplicity and can be adjusted within the model.

[29] Stock status for each fish stock are listed in `rr_assumptions`.

[30] The level of fishing quotas reduction for each fish stock can be sensitivity tested by changing the vales of `quota_adj` in the `rr_assumptions` sheet.

[31] Each fish stock has been assigned a category of 1 or 2, which denotes their port price adjustment. Fish stock of category 1 have their wholesale prices set at 150% of reported port prices, while fish stock of category 2 have their prices set at 130% of reported port prices.

This rate reflects the reduction of supply leading to increasing fish prices and its impact on resource rental rates. A secondary impact on prices will come from the abolishment of Licenced fish receivers driving innovation by individual fishers.

Calculating the resultant revenue stream is a matter of multiplying the new catch quotas for each year by the resource rental price.

D.3.1 Payment to Māori

Under the LegaSea proposal, part of the resource rental will be paid to Māori, as the mechanism for carrying-over the Treaty settlement into the new regime.

The proportion of revenue will equal the value of existing quota held by Māori. For the purpose of these calculations, we have assumed this to be 15%.

D.4 Data sources

Data	Provider	Model reference	Comments
Fisheries species codes	**Ministry of Primary Industries**	• Species Name • Species Code • Fisheries management area	The QMS currently in place following The Fisheries Act 1996 is managed by species and area. Under the QMS there are 98 species and 642 individual fish stocks. This refers to the separate areas of which each species has been classified and the legislative areas they reside. It is under these fish stock classifications that ITQ and ACE are based.
Reported landings Annual catch entitlement (ACE) prices	**FishServe**	• Reported Landings • TACC • Low ACE price • Average ACE price • High ACE price	FishServe is the trading name of a privately-owned company called Commercial Fisheries Services (CFS). CFS is a wholly owned subsidiary of Seafood New Zealand (SNZ). FishServe provides administrative services to the New Zealand commercial fishing industry to support the 1996 Fisheries Act. Report landings are for the fish year of 2016/17 ACE prices use in the model are the average of the fish years of 2015/16, 2016/17 and 2017/18 to mitigate for missing data.
Risk factors	**LegaSea**	• Near shore contamination • Ocean acidity • Climate change • Ecosystem dysfunction	In order to account for the level of future risk for valuing ACE. LegaSea have estimated the average risk factor across each classified fish stock.

		• Excessive exploitation • Market stability • Ministerial discretion • Regulatory • Public opinion • Average risk factor • Risk effect	