TAR MANAGEMENT STRATEGY

2018–2021

CONTENTS

EXECUTIVE SUMMARY

This management strategy is a commitment by industry to increase the status of the eastern Tarakihi fishstocks towards "real world" B_{MSY} before the next TAR stock assessment proposed for 2020/21.[1] There will be an iterative process of collecting more information to better inform the next TAR stock assessment.

The management strategy is a commitment to enabling the best-informed fishery management decisions whilst moving the stock towards B_{MSY} in line with the requirements of the Fisheries Act.

Following the outcomes of the first fully quantitative assessment for east coast TAR, there is an acknowledgement by the commercial industry that a management strategy is required. This needs to address the outcome of the assessment while also addressing the uncertainties associated with the stock assessment model.

The management strategy objectives are to:

1. Increase the east coast TAR biomass by at least 12% by the next stock assessment (and in doing so increase the stock status to circa 20% B_0 within three years); and

2. Improve the knowledge about the stock to reduce uncertainties, fine tune management measures to ensure their effectiveness and allow more informed management decisions in future.

The objectives will be achieved through a commitment to implement a suite of management and research measures. These include collectively reducing catch in designated areas as well as research and monitoring programmes to ensure that fishery management decisions are made with increasing certainty.

The complexities associated with east coast TAR mean that a range of management measures and research is required to provide an appropriate management package—particularly regarding the relationship between stock structure and QMAs.

We see this strategy as a package of measures that will collectively deliver robust management of TAR fisheries. This package represents a multi-year management approach rather than a one-off management event; we consider this represents the most appropriate way to manage inshore fisheries and support similar such management plans being replicated in other important inshore fisheries.

This management strategy reflects the combined views of Fisheries Inshore New Zealand Ltd and Southern Inshore Fisheries Management Company Ltd.

[1] Real world, or stochastic B_{MSY} is preferred to a target of deterministic B_{MSY}. The latter is currently estimated to be 21.5% B_0 and has the disadvantage of not appropriately incorporating the natural variability in various stock parameters.

1 STOCK ASSESSMENT

The first fully quantitative assessment for east coast TAR (Project TAR2016-01) was completed in November 2017 and adopted at the November Plenary.

The stock assessment assumes that tarakihi spawn in three main spawning grounds: Cape Runaway to East Cape, Cape Campbell to Pegasus Bay, and the west coast of the South Island near Jackson Bay. It is thought that significant numbers of these larvae then move southward by some unknown mechanism to recruit into the nursery for east coast TAR fishery found south of Banks Peninsula.[2]

The current stock hypothesis is that the Canterbury Bight/Pegasus Bay area represents the main nursery area for the eastern stock unit. The hypothesis regarding stock structure is that there is considerable northward movement of fish from the east coast of the South Island to the Wairarapa coast, East Cape and Bay of Plenty.

This hypothesis is supported by the available age composition data that shows a progressive increase in the proportion of older fish in the catches as you move north. CPUE analysis indicates a time lag in CPUE trends that support the observed age composition.[2]

The results of the stock assessment also indicate that the stock biomass has been reasonably stable with a moderate declining trend for over 40 years since 1975. It also now shows that the spawning biomass (SB) has remained below the default soft limit since the mid-2000s and reached its peak of c. 27% B_0 in the mid-1980s. The spawning biomass has increased slightly from its lowest level in 2014 following above average recruitment in 2011–2012 (Figure 1).

Current (2015/16) spawning biomass is estimated to be at 17% of the unexploited, equilibrium biomass level (SB_{2016}/SB_0 = 0.170) from the base case model.

There is a low probability (12.6%) that the spawning biomass is above the soft limit (20% SB_0). There is no risk that the spawning biomass is below the hard limit (10% SB_0).

An update to the 2017 assessment model and the associated CPUE analysis to include 2016/17 fishing year was completed in April 2018 to ensure the most up to date information is available.[3] The same base model for the assessment was used: a single region model starting in 1975. This indicates the current state to be 17.3% B_0.

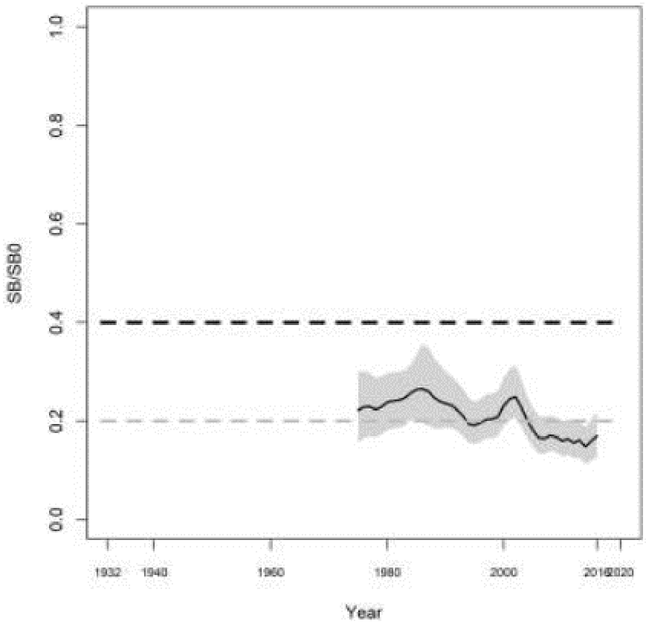


Figure 1: Spawning biomass (SB) as a proportion of unfished biomass (SB_0).

[2] New Zealand Fisheries Assessment Report 2018/05 Langley, A.D (2018) Stock assessment of tarakihi off the east coast of mainland New Zealand. March 2018. ISBN 978-1-77665-797-1.

[3] SINS-WG-2018-18. Langley, A.D (2018) Stock assessment of east coast tarakihi – an update for 2018. 24 April 2018.

2 MANAGEMENT CONTEXT

Principal Legal Guidance

This management strategy reflects the legal framework provided in the Fisheries Act 1996 (the Act). The core sections Act are:

Section 8(1)
The purpose of this Act is to provide for the utilisation of fisheries resources while ensuring sustainability.

Section 13(2)
The Minister shall set a total allowable catch that—

(a) maintains the stock at or above a level that can produce the maximum sustainable yield, having regard to the interdependence of stocks; or

(b) enables the level of any stock whose current level is below that which can produce the maximum sustainable yield to be altered—

  (i) in a way and at a rate that will result in the stock being restored to or above a level that can produce the maximum sustainable yield, having regard to the interdependence of stocks; and

  (ii) within a period appropriate to the stock, having regard to the biological characteristics of the stock and any environmental conditions affecting the stock; or

(c) enables the level of any stock whose current level is above that which can produce the maximum sustainable yield to be altered in a way and at a rate that will result in the stock moving towards or above a level that can produce the maximum sustainable yield, having regard to the interdependence of stocks.

Section 13(3)
In considering the way in which and rate at which a stock is moved towards or above a level that can produce maximum sustainable yield under subsection (2)(b) or (c), or (2A) (if applicable), the Minister shall have regard to such social, cultural, and economic factors as he or she considers relevant.

Section 10
All persons exercising or performing functions, duties, or powers under this Act, in relation to the utilisation of fisheries resources or ensuring sustainability, shall take into account the following information principles:

(a) decisions should be based on the best available information:

(b) decision makers should consider any uncertainty in the information available in any case:

(c) decision makers should be cautious when information is uncertain, unreliable, or inadequate:

(d) the absence of, or any uncertainty in, any information should not be used as a reason for postponing or failing to take any measure to achieve the purpose of this Act.

Policy context

The stock assessment of tarakihi off the east coast of mainland New Zealand will require the Minister to take action to ensure the stock rebuilds to the level that can produce the maximum sustainable yield.

MPI use its Harvest Strategy standard (HSS) as the default policy guidance document to develop a rebuild plan for a fishery in this position.[4]

[4] Harvest Strategy Standard for New Zealand Fisheries (2008). Ministry of Fisheries – October 2008 at [24].

Acceptable Proxy for B_{MSY}

No single target is applicable for all species and stocks.[5] Management targets for individual stocks have to be specific on the biological characteristics of the stock.

The HSS uses a default position of 40% B_0 for all 'low' productivity stocks. However, it is acknowledged deterministic B_{MSY} may be inappropriate at 21.5% B_0 and that stochastic B_{MSY} for the TAR stock is not known.

Acknowledging the previous point, an appropriate priority management measure is to develop a Management Strategy Evaluation (MSE) to determine stochastic B_{MSY} for east coast TAR. The HSS guideline recognises that "MSEs are fully-compatible with the Harvest Strategy Standard".[6]

Noting that the fishery has never been above 27% B_0 since 1975 (the entire time period used for the stock assessment), it is considered appropriate to conduct the necessary work to determine an appropriate estimate of real-world B_{MSY}.

Way and Rate

In addition, the Act does not require that measures are only taken based on the biology and state of the fishery, it provides that in addition to this, the Minister should have regard to the relevant economic, social and cultural impacts when deciding upon the way and rate at which a stock is rebuilt to the target level.[7]

The two above points have been addressed in Section 0 of this management strategy.

5 Operational Guidelines for New Zealand's Harvest Strategy Standard (2011). Ministry of Fisheries June 2011 at page 2.

6 Harvest Strategy Standard for New Zealand Fisheries (2008). Ministry of Fisheries – October 2008 at [25].

7 Fisheries Act, section 13(3).

3 SCIENTIFIC UNCERTAINTIES

The stock assessment is considered the best available science. However, there are recognised scientific uncertainties within the model.

Specifically, the stock hypothesis still has a range of assumptions that need more research to increase certainty. The proposed additional research and analysis that form part of this management strategy are addressed in the following section.

This additional science is required to address these uncertainties and ensure that management decisions are consistent with section 10 of the Act, regarding the need to ensure "decisions are based on the best available information", and that "decision makers should consider any uncertainty in the information available in any case".

Connectivity

A key hypothesis in the assessment is that the larvae from spawning fish on the east coast make their way back to South of Banks Peninsula and subsequently recruit into the fishery.

Despite this being the core hypothesis of the stock assessment, the mechanism that supports this is not understood or proven.[8] Annala (1987) noted that larvae from the west coast South Island spawning grounds may be transported north or south. Behringer & Xue (2004) noted that passive drift from spawning locations (off the east Northland, the Bay of Plenty and East Cape) resulted in eastward displacement well offshore from the east coast of the North Island.

There is a lack of direct observations to support this hypothesis. The 2017 WG report states "Few larval and post-larval tarakihi have been caught and identified".[9] Further research is required to provide additional data to either prove or disprove this hypothesis (see section 0).

CPUE

The stock assessment was strongly dependent on CPUE indices as the primary index of stock abundance. CPUE indices in the model provide "a reasonable index of stock abundance".[10]

Concerns have been raised however that the CPUE data in the model does not accurately reflect fishing practice, with fishers highlighting numerous uncertainties regarding the utility of the CPUE data. Specific CPUE uncertainties identified were associated with gear specifications.

For example, in TAR3 new vessels have entered the fishery that are fishing in different locations and have different configurations to the vessels they have replaced. As these vessels have entered the fishery less than five years ago, they are not included in the core vessel fleet that is used in the CPUE analysis. Similarly, vessels using PSH technology have also been excluded – the use of this technology is expected to be an ongoing feature in this fishery.

In recognition of the uncertainty in the CPUE accurately reflecting the fishery, it is important that further research is conducted. Further scientific research is required to ensure the CPUE analysis accurately reflects the east coast TAR fishery (see section 0).

Age Composition Data

The model results are strongly informed by the age composition data from the commercial fishery. The stock assessment assertion is that "The fisheries in Canterbury Bight/Pegasus Bay are dominated by younger fish and

8 New Zealand Fisheries Assessment Report 2018/05 Langley, A.D (2018). Stock assessment of tarakihi off the east coast of mainland New Zealand. March 2018. ISBN 978-1-77665-797-1.

9 *Ibid*.

10 *Ibid*. at – Section 6.

there is a progressive increase in the proportion of older fish in the catches from TAR2, the Bay of Plenty and east Northland."[11]

However, the representativeness of the age composition data used to support the model's hypothesis of connectivity has been questioned by fishers from all QMAs:

- TAR1 fishers proposed an alternative hypothesis that the Bay of Plenty and East Cape were receiving juveniles from the Kermadecs, this was based on historical observations of juvenile TAR catches from fishers fishing on the way to the Kermadecs
- TAR2 fishers highlighted that the presence of significant juvenile TAR grounds has not been reflected in the model
- TAR3 fishers identified that the catch sampling does not reflect the higher proportion of older fish in the TAR3 fishery

Industry is committed to collecting new age composition data and will be actively engaged in this process to ensure that the concerns raised in the previous bullet points are addressed in the proposed catch sampling programme (see section 0).

Recruitment

The most recent TAR FAR acknowledges the uncertainty around recruitment: the "estimates of recruitment in the most recent years (2013–2015) were poorly determined."[12] The uncertainty around recruitment is confirmed by the statement "estimates of recent potential yields are relatively uncertain due to the uncertainty associated with estimates of recent recruitment."

Figure 2 emphasises that uncertainty. The biennial ECSI trawl survey is the only early source of recruitment information. Further work is required to address the uncertainty associated with TAR recruitment (see Section 7).

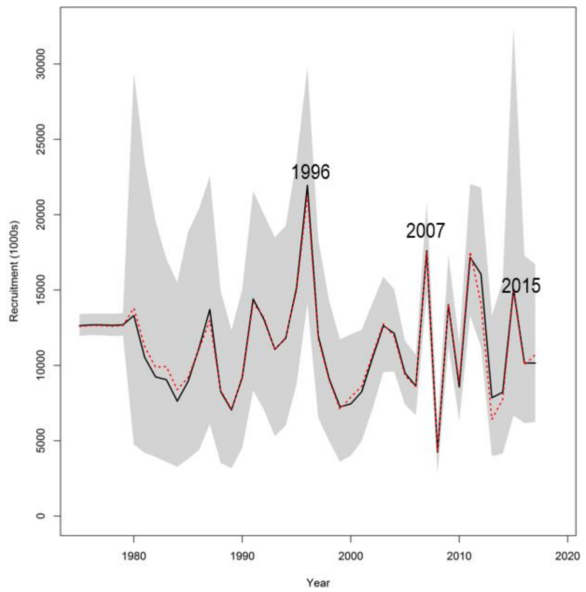


Figure 2. Modelled TAR recruitment.

[11] New Zealand Fisheries Assessment Report 2018/05 Langley, A.D (2018) Stock assessment of tarakihi off the east coast of mainland New Zealand. March 2018. ISBN 978-1-77665-797-1 at – Section 4.6 [27].

[12] *Ibid*. at Section 5.5.5 [55].

Selectivity

There is the potential for improvement in survivorship of juvenile tarakihi via reductions in sub-MLS catch due to changes to both spatial and temporal distribution of fishing (vs historical) and use of larger mesh (125 mm) cod ends. Potentially represents an increase in recruitment from estimated average level (R_0).[13]

Indicative results from the provisional work contracted by industry demonstrates that the annual estimate of sub-MLS TAR catch from the Canterbury Bight has remained reasonably stable since 2007. At the same time, the ratio of sublegal to landed catch has reduced. This can only mean there is less sub-MLS catch in relation to legal catch in 2016 than in 2008.

These results support anecdotal information from TAR3 fishers that the CPUE data do not reflect recent changes in fishing practices in TAR3. This emphasises the need for further research to accurately understand selectivity and its impacts on recruitment (see section 0).

Projections

As a result of the biological characteristics of TAR, the default rebuild period under the HSS is 10 years. Projected stock biomass over 10 years has been used to model the state of the fishery for a variety of reductions in catch.

These 10-year stock projections (as shown in Figure 3) identify that long-term projections for TAR have such variance that the fishery could achieve either of two extremes – rebuild to 40% B_0 or be extinct—if measures were simply adopted now with no further refinement within the 10 years.

It is considered inappropriate fisheries management to manage to these levels of uncertainty in the projections. This management strategy provides a timeframe for implementing measures that addresses the level of uncertainty in projections whilst also providing for an appropriate stock rebuild.

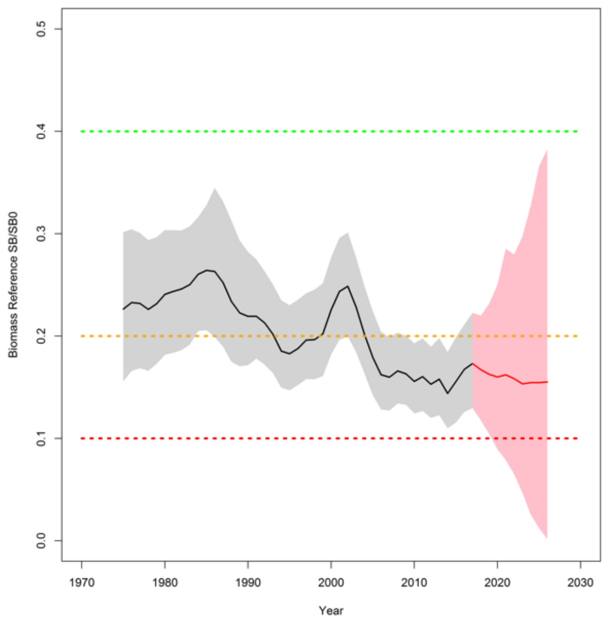


Figure 3. Stock projections from 2018 model.

[13] SINS-WG-2018-18 Langley, A.D (2018) Stock assessment of east coast tarakihi – an update for 2018. 24 April 2018.

4 MANAGEMENT COMPLEXITIES

Disconnect Between Management Areas and Stock Structure

The stock assessment includes four QMAs. However, two of those QMAs are only partially represented in the model: TAR1E (circa 60% of TAR1) and TAR7E (circa 25% of TAR7). TAR1W catches are not included in the model, whilst the TAR7 catches in the model only relate to the eastern Cook Strait.

Further to this, the stock structure used in the model combines TAR2 and TAR caught in BPLE into the same region. From a management perspective this is a problem as any changes to TAR2 are being impacted by the difference CPUE trend seen in BPLE (which is part of TAR1E). These areas are managed separately and the combining of these areas scientifically does not address the management differences (Figure 4).

The Minister is required to manage at the QMA level. Given this, to make management changes to TAR1 or TAR7 there are three options:

1. Apply the cut across the whole QMA;
2. Change to regulations to split the QMAs;
3. Voluntary catch spreading agreements promoted and enforced by industry.

Option 1 would mean applying cuts to areas outside of the stock assessment which is not an equitable approach. Option 2 is not feasible because the timeframes required to achieve a regulatory change mean that this is not possible before the 1 October 2018.

An assessment of implementing voluntary catch spreading arrangements that can be put into place by industry is required as part of finalising this management strategy.

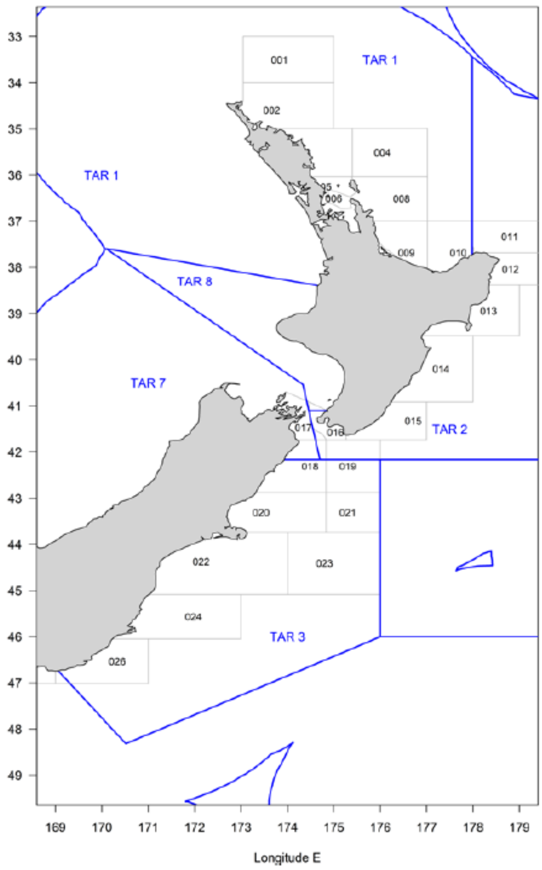
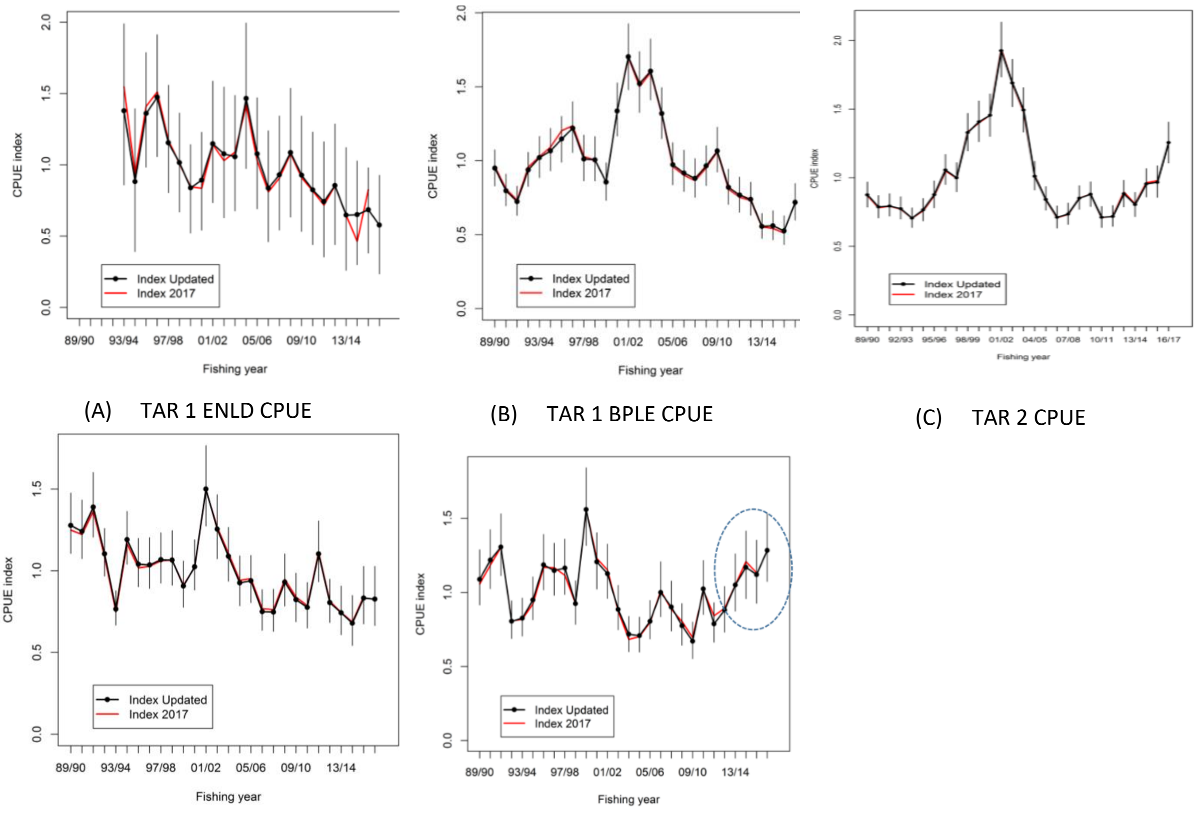


Figure 4. Tarakihi fish-stock areas and Statistical Areas that constitute the domain of the east coast TAR assessment.

CPUE indices demonstrating different regional trends

There is no uniform state for the fishery across the QMAs. Each management area displays a different CPUE trend that demonstrates the importance of spatial management to address the disconnect between scientific and management boundaries (Figure 5).



(A) TAR 1 ENLD CPUE

(B) TAR 1 BPLE CPUE

(C) TAR 2 CPUE

(D) TAR 3 SN CPUE

(E) TAR 3 BT CPUE

Figure 5. CPUE trends observed in the TAR stock assessment model.

28N rights

When the QMS was first established, quota holders had rights to fish set tonnages of quota rather than a proportion of the TACC. If a sustainability assessment indicated more catch was available, the Government sold more quota on the open market. If a decrease was required, the Government bought quota back from quota holders. However, in the early days of the QMS, it was recognised that several fish stocks required substantial catch reductions. Quota owners were offered compensation for these reductions through tendered buyback – not market rates. Those quota owners who did not accept this option obtained rights under 28N of the Fisheries Act 1983 to fish at the lower level demanded but with the ability of returning their quota to its original limit when/if the fishery recovered. Under that regime, 28N rights holders had preferential access to quota when TACCs were increased.

The '28N' rights continue to exist under the QMS today, but the regime has been modified. Quota is now based on proportionality. To allow 28N rights holders to gain additional catch when the TACC is increased (over and above the rights for their exercised quota), quota shares in the fishery are taken from all other quota owners (including iwi) and reallocated to 28N rights holders. This use of iwi settlement assets to satisfy the Crown's liability was not a part of the agreement in the "full and final" settlement of Māori Fishing Rights under the Deed of Settlement. In fisheries that still have 28N rights, iwi oppose the use of quota cuts if other options to recover the fishery are available, because any cut will automatically invoke the readjustment of the 28N rights (and in doing so strip settlement rights from iwi) as the fishery recovers and the TACC is increased.

Socio-economic factors

East coast tarakihi is a very important component of inshore fisheries and is predominantly caught as part of a mixed species fishery. Management measures affecting TAR need to reflect the interdependent effects that any cut in catch will have on the ability of fishers to then catch other species.

90% of TAR is domestically sold, forming an important part of the domestic market. This domestic market identifies that socio-economic factors need to reflect not just the direct impacts on the fishing industry but also the flow on effects to the wider seafood sector within New Zealand.

Commercial catch varies but all stocks are well utilised with no significant or consistent under-catch.

5 MANAGEMENT STRATEGY

Overview

The management strategy:

- aligns with the requirements of the Act and is not inconsistent with the HSS guideline
- acknowledges that industry needs to take action to address the outcomes of the 2017/18 Stock Assessment
- recognises that any action should reflect the complexity of the model and the associated scientific uncertainties
- will, given the associated complexities, require a combination or regulatory and non-regulatory measures that are implemented in an innovative, collaborative manner to achieve an optimal response
- must be cognisant of the history of the fishery and reflect the socio-economic importance of the east coast TAR fishery
- will provide for an iterative process of collecting more information to better inform the next TAR stock assessment. This is consistent with the HSS which states that "Targets will be set by fisheries managers based on estimates of MSY-compatible reference points, but modified by relevant factors"

Aim

To improve the stock status and move it towards real world B_{MSY} before the next TAR stock assessment, while iteratively collecting more information to better inform the next TAR stock assessment.

This management strategy is a commitment to enabling the best-informed fisheries management decisions whilst moving the stock towards B_{MSY} in line with the requirements of the Fisheries Act.

Objectives

The management strategy objectives are to:

1. Increase the east coast TAR biomass by at least 12% by the next stock assessment (and in doing so increase the stock status to circa 20 % B_0 within three years); and

2. Improve the knowledge about the stock to reduce uncertainties, fine tune management measures to ensure their effectiveness and allow more informed management decisions in future.

The management strategy objectives would be achieved through a commitment to implement an innovative suite of management and research measures to inform fishery management decisions.

Management Strategy Target 1 and 2

The management strategy timeline of three years is considered an appropriate management period in order to align with the next scheduled east coast TAR stock assessment in 2020/21. Three years allows for additional science to be collected to inform the next stock assessment and address the uncertainties outlined in Section 3.

Table 1 demonstrates how the management strategy target reverses the current stock trajectory and turns this into a positive trajectory that is moving towards B_{MSY} compared to the status quo (Table 2). The projections have been provided in the context of both percentage biomass increases compared to the 2016/2017 level and the projected stock status in 2020/21.

Table 1. Model outputs based on a 20% catch reduction from the projected 2018/19 catch levels.

Project Year	1	2	3
Model Year	Year 1	Year 2	Year 3
Fishing year	2018/19	2019/20	2020/21

Probability of being above 10% SB_0 ($SB>10\%SB_0$)	0.986	0.978	0.978
Probability of being above 20% SB_0 ($SB>20\%SB_0$)	0.202	0.291	0.406
SB_ratio Median SB/SB_0	0.171	0.177	0.187
Delta SB_ratio (Yr[x]/Yr[2018])	1.024	1.060	1.120

Table 2. Status quo without any catch reductions – continuation of 100%**.**

Project Year	1	2	3
Model Year	Year 1	Year 2	Year 3
Fishing year	2018/19	2019/20	2020/21

Probability of being above 10% SB_0 ($SB>10\%SB_0$)	0.971	0.928	0.882
Probability of being above 20% SB_0 ($SB>20\%SB_0$)	0.141	0.174	0.217
SB_ratio Median SB/SB_0	0.162	0.157	0.155
Delta SB_ratio (Yr[x]/Yr[2018])	0.970	0.940	0.928

6 PROPOSED MANAGEMENT MEASURES

Confirmation of agreed management measures is required as part of the management strategy development and agreement between industry and government.

Voluntary reductions in catch

Voluntary TACC reductions are proposed as part of the management strategy reflecting the results of the recent stock assessment and associated projections, whilst recognising the scientific uncertainty associated with the assessment and the socio-economic considerations required by the Act.

The mechanism proposed to implement the voluntary TACC reductions that reduce catch from 1 October 2018 is through formal voluntary shelving to achieve an overall *c*. 20% B_0 of overall East Tarakihi in order to increase the east coast TAR biomass by 12% biomass by the next stock assessment.

Acknowledging the complexity of different management areas and the differing CPUE trends and observations of these fisheries, a differential voluntary TACC reduction is proposed to achieve the overall 25% TACC reduction required to achieve the management target. This differential reduction is still being finalised within industry.

Catch spreading

To address management complexities around TAR1E and TAR1W, and TAR7 eastern Cook Strait, industry is proposing to advance voluntary catch spreading measures. This will allow catches to be reduced in the areas covered by the assessment whilst not adversely affecting those areas not incorporated into the stock assessment. Precedent exists for industry to conduct catch spreading agreements.

Deemed Values Review

Reflecting the fact that TACCs will have been voluntary reduced, it will be necessary to conduct a deemed value review. The aim of this review will be to provide a deemed value system that appropriately reflects the changes in the TACC accounting for:

1. the increased difficulty for fishers to avoid TAR, especially in areas where the CPUE is increasing
2. the potential constraints on ACE availability
3. the need to act as a deterrent to over-catch of the new voluntary TACCs
4. the need to incentivise accurate recording of catches and disposals so as to better inform the model.

Voluntary closed areas

To address the uncertainty around recruitment, industry is committed to temporary voluntary closures to reduce the levels of juvenile TAR caught. The appropriate areas for temporary voluntary closures to protect juvenile TAR will be determined through information provided by the proposed research project below.

Recording of undersize TAR

Industry is proposing to collect additional data on catches of sub-legal TAR to '*enable an evaluation of the sensitivity of the model results to this source of mortality.'* This is an important data source to address the key uncertainty about recruitment in the next stock assessment. The FAR acknowledges that *'There is anecdotal evidence that the trawl fisheries off the east coast of the South Island may catch substantial quantities of tarakihi below the Minimum Legal Size (MLS) of 25 cm (F.L.). These catches are discarded and their magnitude has not been quantified. Thus, no information was available to explicitly account for this additional source of mortality in the assessment models'.*

Voluntary reporting of sub-legal fish will provide data on a portion of the fishery that the model currently does not account for and has had to assume is constant over time. The preliminary analysis conducted at industry's request demonstrates this has not been constant.

If large catches of small TAR are recorded, it will identify the need for improved management to reduce the levels of this undersize catch. The location of small juveniles would be an additional data source to address uncertainty around connectivity.

Review of the MLS for TAR

A review of the MLS is proposed to determine why it is not currently in line with the size at first maturity. There appears to be a disconnect between the two and the historical rationale for this is not clear. This would need to be assessed and the impacts of such a change would need to be analysed and discussed as part of this review.

7 PROPOSED RESEARCH PROJECTS

These research projects will collect further data to address the scientific uncertainties identified in Section 0. They align with the scheduled 2020/21 stock assessment and will be completed in time to inform that assessment.

The *primary research projects* are those industry has identified as key components of this management strategy. The *supplementary research projects* are projects that can provide useful information on the east coast TAR but are not necessary within the next three-year period before the next stock assessment.

Primary research projects

Management Strategy Evaluation (MSE)

The MSE is a simulation analysis using outputs from the stock assessment to determine the real world B_{MSY}. It is anticipated that the preliminary development of an MSE for TAR can be done in a relatively short timeframe and is a priority research action for the management strategy.

The results of this work will then be used as the B_{MSY} target for the next stock assessment to determine where the stock is in relation to the management target. Industry has identified this as a priority piece of research—this research aims to address uncertainty about B_{MSY} for east coast TAR.

TAR genetic research (information provided by Victoria University)

The overall objective of the work is to use genetic markers to determine New Zealand tarakihi stock structure. Specific details of this project are provided in section 0. This research will provide information to prove or disprove the current stock assessment hypothesis regarding the connectivity of east coast TAR (see section 0).

The project is in two phases in line with the specific objectives:

1. determine the mitochondrial DNA (mtDNA) sequence using DNA from a broad range of tarakihi samples and conduct a “first look” test of stock structure; and subsequently
2. determine the whole genome sequences of a range of tarakihi samples and based on the results of the mtDNA study, conduct a high-resolution test of the stock structure.

Additional funding for this work will increase the sample size that can be used and increase the statistical rigour of results. Industry have identified this as a priority piece of research and would, as part of the management strategy, identify funding options to assist scientists in achieving a higher level of statistical rigour i.e. provide funding for more samples.

ECSI trawl survey

Industry is committed to the ongoing ECSI trawl survey. The ECSI survey provides a valuable time series of data that informs the stock assessment model.

Catch sampling

Industry is committed to a cost effective, representative catch sampling project. It is acknowledged that the catch sampling provides a valuable data source to the assessment model. Industry will be actively engaged to work collaboratively with research providers to ensure representative sampling is achieved. This will thereby deal with the areas of concerns raised around the previous catch sampling project.

Improve CPUE analysis

Engagement with industry had highlighted to both scientists and managers that there is a disconnect between the CPUE analysis used in the stock assessment and the nature of the fishery. There have been some subtle changes in the fishery that need to be better understood. To achieve this, a research project is required for scientists to engage with fishers and identify the data fields that are currently not collected that would better inform CPUE analysis. For those fields already collected, it will provide assurances that the correct information is being collected and analysed. This work will ensure that the CPUE used in the upcoming TAR assessment (2020/21) has accounted for the uncertainties outlined Section 3 of this paper.

Analysis of undersize TAR catches

In conjunction with the recording of undersize catch, a research project is proposed that will assess the location and scale of undersize TAR catches as well as investigate temporal changes to provide data that is potentially beneficial in identifying recruitment pulses in the fishery. The proposed research will provide detailed analysis of the latest trawl survey data. This will include the ECSI trawl survey and potentially incorporate data from the INT2018-03 research proposal (if this project proceeds). The proposed WCNI survey may be used to provide supplementary data. This work has been identified to address the uncertainties raised in Section 3 of this paper.

Supplementary research projects

Otolith chemistry (information provided by NIWA)

This is supplementary project that would complement the genetics research previously outlined above. The work investigates a subset of the fish being using to assess the genetics of New Zealand tarakihi (collaboration with Peter Ritchie, Yvan Papa, Alex Halliwell; Victoria University of Wellington), supported by the current Bottlenecks programme. The intention being, where possible, to use the same individual fish for both the otolith and genetics research, as this will increase the collective power of the work.

The project is looking at the elemental chemistry of these fish otoliths and for TAR has two research objectives:

1. To assess the otolith chemistry of the inner part of the adult fish otolith, which represents that part of the otolith laid down during their small juvenile life phase. If we can identify distinct separate groups of fish, this may in turn represent fish produced in different natal nursery areas. By looking at how these proportions vary around New Zealand, it may give us an idea of what putative nurseries are linked to what regions. It does not tell us what/where those nurseries are, but it does give us a better handle on likely stock structure; and this also helps us in later going out to physically find and map out those nurseries.

2. To look at the environmental history of adult fish, by quantifying how the elemental chemistry varies from the centre out to the edge of otoliths, which is effectively a time series, 'time-stamped' using annual growth rings. Here we are looking for evidence of distinct separate groups of fish making large scale seasonal spawning (or other time scale) migrations each year, where these large spatial movements are likely to pass through areas with different background environmental chemistries and be 'captured' as such in the otolith elemental records.

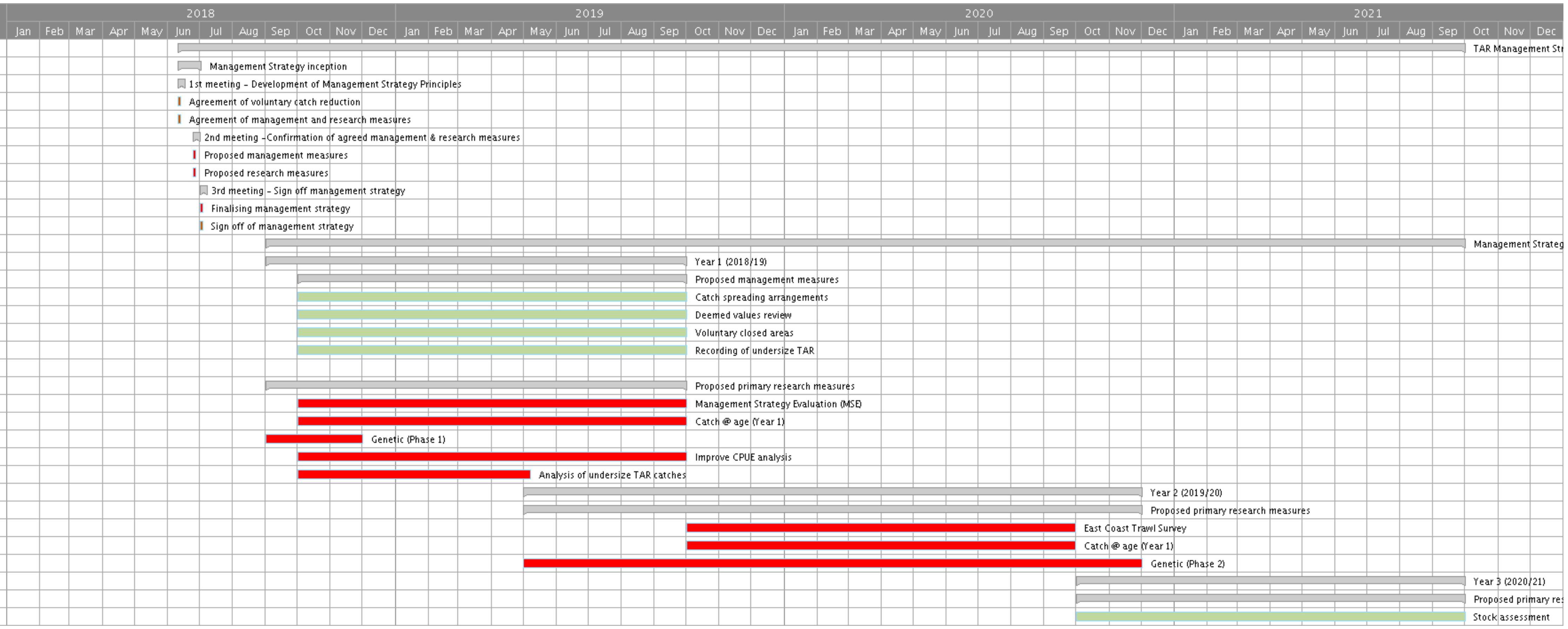
Trawl Gear Selectivity Modelling project (information provided by NIWA)

This is a supplementary project that would complement the genetics research previously outlined above. This would be a TAR-focussed project that is part of a wider collaboration between NIWA and SINTEF to use SINTEF software tools and expertise to develop predictive models of trawl cod-end selectivity for New Zealand species to help inform commercial fishing practices and management decisions. This work has been identified to address the uncertainties raised in Section 3 of this paper.

8 MANAGEMENT STRATEGY IMPLEMENTATION TIMEFRAME

The timeline outlines the process required to reach an agreement management strategy including determining that most effective management and research measures to achieve the management strategy target.

	Task Name	Start	Finish
1	TAR Management Strategy	06/11/18	09/30/21
2	Management Strategy inception	06/11/18	07/02/18
3	1st meeting – Development of Management Strategy Principles	06/11/18	06/11/18
4	Agreement of voluntary catch reduction	06/11/18	06/11/18
5	Agreement of management and research measures	06/11/18	06/11/18
6	2nd meeting –Confirmation of agreed management & research measures	06/25/18	06/25/18
7	Proposed management measures	06/25/18	06/25/18
8	Proposed research measures	06/25/18	06/25/18
9	3rd meeting – Sign off management strategy	07/02/18	07/02/18
10	Finalising management strategy	07/02/18	07/02/18
11	Sign off of management strategy	07/02/18	07/02/18
12	Management Strategy implementation	09/01/18	09/30/21
13	Year 1 (2018/19)	09/01/18	09/30/19
14	Proposed management measures	10/01/18	09/30/19
15	Catch spreading arrangements	10/01/18	09/30/19
16	Deemed values review	10/01/18	09/30/19
17	Voluntary closed areas	10/01/18	09/30/19
18	Recording of undersize TAR	10/01/18	09/30/19
19	Review of the TAR MLS		
20	Proposed primary research measures	09/01/18	09/30/19
21	Management Strategy Evaluation (MSE)	10/01/18	09/30/19
22	Catch @ age (Year 1)	10/01/18	09/30/19
23	Genetic (Phase 1)	09/01/18	11/30/18
24	Improve CPUE analysis	10/01/18	09/30/19
25	Analysis of undersize TAR catches	10/01/18	05/06/19
26	Year 2 (2019/20)	05/01/19	12/01/20
27	Proposed primary research measures	05/01/19	12/01/20
28	East Coast Trawl Survey	10/01/19	09/29/20
29	Catch @ age (Year 1)	10/01/19	09/29/20
30	Genetic (Phase 2)	05/01/19	12/01/20
31	Year 3 (2020/21)	10/01/20	09/30/21
32	Proposed primary research measures	10/01/20	09/30/21
33	Stock assessment	10/01/20	09/30/21



9 APPENDICES

Genetic analysis of New Zealand tarakihi: Testing the stock structure model ((Information provided by Victoria University)

Project supervisor: Associate Professor Dr. Peter Ritchie (E-mail: Peter.Ritchie@vuw.ac.nz)
PhD Student: Yvan Papa (E-mail: Yvan.Papa@vuw.ac.nz) MSc student: Alex Halliwell

Overall objective: Use genetic markers to determine New Zealand tarakihi stock structure

Specific objectives:

1) Determine the mitochondrial DNA (mtDNA) sequence using DNA from a broad range of tarakihi samples and conduct a "first look" test of stock structure
2) Determine the whole genome sequences of a range of tarakihi samples and based on the results of the mtDNA study, conduct a high-resolution test of the stock structure

Project 1 Mitochondrial DNA (low resolution) small genome analysis – MSc

Preliminary results: 1 September 2018 *Completion date: 1 November 2018*

This study will provide a low-resolution test of the tarakihi stock hypotheses and we expect a preliminary assessment of the genetic data by the end of 2018. Mitochondrial DNA is a genetic sample of the small genome in animal cells. This marker is used to conduct a 'first look" type study, which enables hypotheses about stock structure to be rapidly tested. A finding of genetic difference between two populations is usually strong evidence for a lack of successful migration and reproduction between two areas. If no genetic difference is detected it could mean that higher resolution markers are required to find the difference. An important component of testing for genetic differences is to have samples analysed from a broad range of locations, which enable us to define a reference point for the geographic scale that a genetic difference can be detected. We have 1300 samples of NZ tarakihi, but our current funding limits us to analyzing 400 specimens. This constraint reduces our ability to properly test all of the locations implicated in the stock model and obtain the requirement broad-scale reference points to "calibrate" the data analysis.

Constraint: Funding limited to analyzing 400 specimens which restricts the statistical power of the method. To satisfy the statistical requirements an additional $12,500 (approximately) would be needed to complete the DNA sequencing of the 1,300 samples.

Project 2 Full genome (high resolution) analysis – PhD

Preliminary results: mid-2019 *Completion date: 1 December 2020*

The second study will use the high-resolution approach of whole-genome sequencing (WGS) to target a massive number of genetic markers across the genome. This method allows the detection of stock structure that could be missed with the single-marker method of mtDNA.

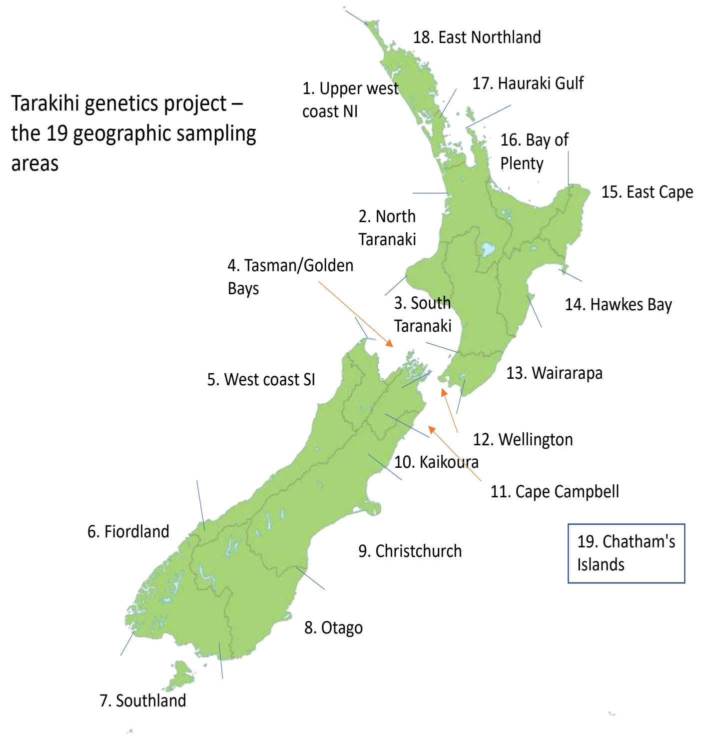
With a comprehensive sample size, the WGS has the potential to provide a definitive answer about the genetic stock structure of tarakihi. The key to the success is being able to collect data from a broad range of samples and wide geographical coverage. With our current funding we will only be able to analysis 230 of the 1300 samples that we have available. An additional $60,000 of funding would enable us to considerably increase the statistical power. This would reduce the risk of underestimating the levels of genetic variability and avoid sub-sampling bias and the potential for false positive findings. This increase in the statistical confidence would transform our study into a robust genetic-based test of the fish stock model.

Constraint: Current funding restricts us to analysing 230 samples and hence limits the statistical power and level of confidence in findings. Additional $60,000 of funding would double sample size and enable a proper test of the model.

The work currently underway is funded by a VUW Doctoral Scholarship to Yvan Papa; combined with a sub-contract from NIWA, as part of the MBIE Endeavour Fund Research Programme “Juvenile Fish Habitat Bottlenecks’ (CO1X1618). This research is being conducted in collaboration with Dr. Mark Morrison (NIWA) and Dr. Maren Wellenreuther (Plant and Food Research).

Supplemental information: Sample Collections Available

Tissue samples from more than 1300 specimens from 19 areas, including spawning grounds, have already been collected (see sampling area map below).



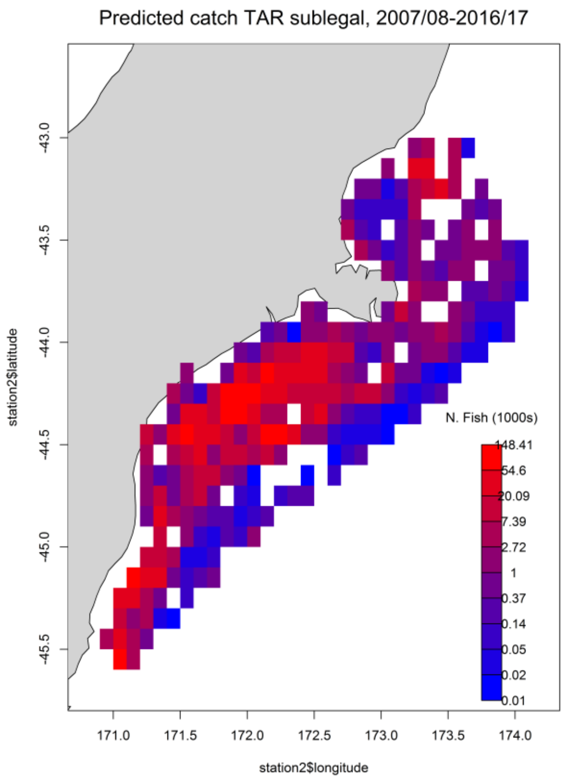
19 areas where tarakihi have been sampled between November 2017 and March 2018 (60 fish/area).

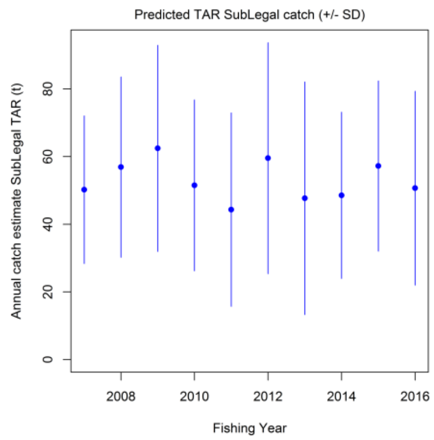
Three of these areas (East Cape, Cape Campbell and West Coast SI) have been sampled for 60 additional fish during the spawning season.

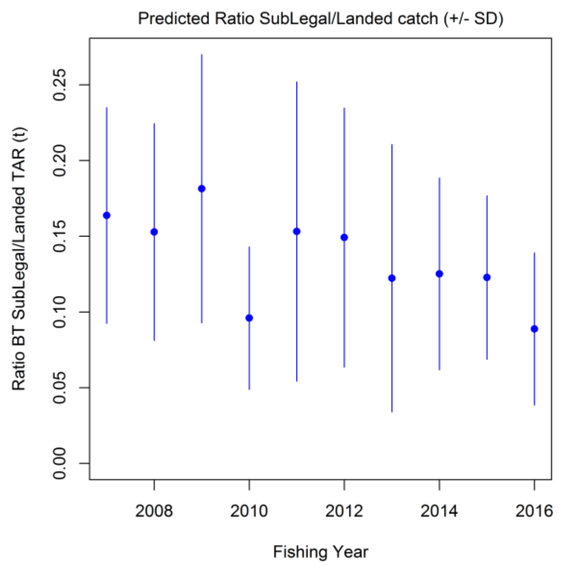
Additional samples include 40 King tarakihi from 3 Kings Islands and 60 tarakihi from Australian waters.

Preliminary analysis of sublegal TAR catches (Canterbury Bight – Pegasus Bay)
Summary

- ECSI Kaharoa trawl stations with (and without) associated TAR length frequency data. All surveys combined (to 2014) (N stations = 1547, Nfish = 158,385).
- For each trawl station derive TAR LF.
- Apply 100 mm trawl selectivity to LF (=vulnerable to commercial gear).
- Truncate length frequency at 25 cm (F.L.) = sublegal fish.
- Derive sublegal TAR density (number of fish) for each trawl (sum of fish divided by area swept).
- Determine average distribution of sublegal fish using (ordinary) Kriging approach (combined over surveys, years, seasons).







Acknowledgement of uncertainties in provisional work

- Range of assumptions required for analysis.
- Does not account for variation in distribution and relative abundance amongst years (variable recruitment).
- Assumption of trawl selectivity (100 mm mesh).
- Reliability of Kriging approach – further evaluation required.
- Trawl records are based on start location only.
- Uncertainty is under-estimated but is still high – catch estimates are poorly determined.
- Highlights main areas of highest sub-MLS catches. Fishing appears to be low in the areas of highest abundance.
- Suggests moderate catch of sub-MLS TAR, although indicates that catches are not excessively high.

Trawl Gear Selectivity Modelling project (information provided by NIWA)

Overall Project Aim
Collaborate with SINTEF to use their software tools and expertise to develop predictive models of trawl codend selectivity for New Zealand species to help inform commercial fishing practices and management decisions. We aim to be able to give predicted selectivity information over a range of codend mesh sizes and shapes: from 100 – 200mm (cover 4 – 6”) for diamond, T90 and square orientated mesh.

Current funding sources: MBIE Catalyst Seeding Fund (until Feb 2019), and NIWA Core Fisheries programme (until June 2019).

Project leaders: Ian Tuck & Emma Jones, NIWA

Progress to date
In 2017 we sponsored a visit by overseas fisheries selectivity expert to come to NZ for the ICES meeting, and to help set up and run the first set of trials.

Co-funded with MPI a 9-day charter onboard 11.5m vessel in Hawkes Bay. Used vessel’s standard net with a 5’ diamond mesh codend with and without a small mesh liner. Completed up to 4 tows a day, aiming for 2 pairs, although not all tows were paired. Completed 24 tows, 9 sets of paired tows and 6 unpaired tows. Collected length frequency data for selectivity analysis and morphometric data for 3 species: snapper, red gurnard and English sole.

Proposed work for 2018/2019

Planned return visit to SINTEF to complete data analysis and develop the models in May 2018 and attend ICES FTFB meeting in early June

Propose a second round of data collection to add 2–3 species for which we can develop models sometime between July 2018 and Feb 2019.

Allowing a minimum of 3 days per species for morphometric data collection, so suggest would need 4–9 days of vessel time depending on resources available.

Funding provided
NIWA propose to cover the costs of providing science staff and specialized equipment to collect these data. In addition to this, NIWA have already and will continue to support the cost of data analysis, provision of reports and presentation of results to Industry forums, and if desired, development of an interactive tool that could be made available on a website to easily demonstrate the effect on selectivity of changing mesh sizes / shapes (as discussed).

Funding requested:
We request in-kind funding and support to enable the charter of a vessel for up to 9 days to collect morphometric and selectivity data for 2 -3 species as per Option 1 (see below)

The size of vessel and scope of work can be determined in consultation with Talley’s / Southern Inshore Fisheries Management / FINZ. Species already discussed include tarakihi, elephant fish and red cod. Ideally, we would need to use a vessel fishing in an area where all the target species occur across the relevant size range – this may be a challenge and we will need to be guided by your knowledge on this. We have operated successfully on an 11m **day** boat in Hawkes Bay, but this was absolute minimum size.

Commercial vessel chartered with in-kind Industry support

Data collection: Agree target species and a fishing ground where we can catch a suitable mix of the target species.

Carry out paired selectivity tows (i.e. 2 tows fished side-by-side) using a 5" diamond or other Industry-specified configuration codend with and without a small mesh liner. Tows likely to be shorter than standard commercial tows, e.g. 1.5 – 2 hrs. This enables more pairs to be achieved per day for the selectivity data.

After each haul, sort catch and collect length frequency data for target species. Sub-sample of fish held in an onboard tank to keep alive for morphometric data collection using the fall-though mesh templates for those target species. Samples need to include the entire relevant size range, ie including small fish that we know will pass through the smallest mesh size, and large fish that would have 100% retention even in the largest mesh size. Eg for snapper, we collected fish from 13/14/15cm up to 40+cm.

Processing and fate of catch: the vessel would need a special permit to use the small mesh liner. Sub-legal fish would be disposed of at sea asper the permit requirements. Legal fish would be landed against the vessel's quota and sold. Would need to agree whether profit from fish sales are subtracted from the agreed charter fee, or charter fee reflects that the catch is being sold in addition.

Staffing: we would need a minimum of 2, ideally 3 scientists onboard. 1 to collect length frequency data and 2 to collect morphometric data. On our previous charter we also had the help of a crew member to form a second team of 2 people to collect l-f and morphometric data.

Space: would require an area, preferably under some sort of cover to set up mesh templates and collect those data. Templates are approx. 50 x 60cm in size and we would need to install a table/frame into a space where they can be used. Ideally this would be close to a holding tank big enough to maintain 10 – 15 fish alive at a time. Also space for someone with a measuring board to collect LFs.