Future aquaculture workforce

Results from interviews and modelling

NZIER report to the Ministry for Primary Industries

October 2023

About NZIER

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NZIER was established in 1958.

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Key points

This report provides a range of forecasts for the future workforce in the aquaculture sector

- The sector and the Ministry for Primary Industries (MPI) are interested in understanding the size and make-up of the workforce needed in the future.
- This work is intended to help them understand the current and new initiatives that could support the development of the existing workforce toward those future states.

We collected qualitative and quantitative data to model these future scenarios

- We interviewed informants in the aquaculture sector about current plans, trends and the workforce.
- Aquaculture New Zealand provided data from a workforce census of the sector. We used the data to estimate that there are 3,227 workers in the sector. For comparison, a June 2021 estimate was 3,045 workers.
- Aquaculture New Zealand, MPI and interviews with sector experts provided information for NZIER to create a model of the 2035 workforce and develop several scenarios for future sector growth.

The $3 billion sales goal is achievable

- Industry informants believe that the industry can grow to achieve the $3 billion goal set out in the New Zealand Government's Aquaculture Strategy. There is demand for seafood and declining catch from wild sources, creating an opening for aquaculture products.
- Technology is available overseas that can help New Zealand increase production and productivity. Accessing technology and adapting it to local conditions will be important for achieving the goal. In addition, there are bottlenecks in the aquaculture sector – access to water space, in particular – and people are working on overcoming them.

The workforce will not grow as fast as sector revenue

- Our model estimates the workforce required to achieve different levels of revenue under different assumptions.
- We consider four scenarios with different levels of outputs, price growth and efficiency gains. They show that New Zealand can achieve the $3 billion goal – four times the level of current revenue – by approximately doubling the workforce. In some scenarios, the workforce growth is even less.
- The interviews and modelling results suggest a shift toward roles requiring greater skills and training, such as ones with more automated and computer-aided remote tasks, compared to today. Nevertheless, the workforce is still dominated by frontline roles performing relatively manual tasks.

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1 Introduction

1.1 The project focused on the aquaculture workforce in 2035

The New Zealand Government's Aquaculture Strategy has the goal of reaching $3 billion in annual sales from the sector by 2035. Reaching the goal will require land and water space, technology and investment, as well as the right workforce.

The Ministry for Primary Industries (MPI) commissioned NZIER to investigate the potential workforce that would produce $3 billion in annual sales. This report describes the investigation and discusses its findings.

The focus of the project was the workforce, including the skill levels required and the types of roles that are expected by 2035. The other elements that will be needed – space, capital and technology – are included only to the extent that they are relevant to workforce questions. We understand that other work has considered issues such as the availability of sufficient quality marine space and sources of investment capital; those issues are outside the scope of this report. Also outside the scope is any discussion of the wider Aquaculture Strategy.

1.2 The 2023 aquaculture sector is estimated to sell $737 million, mainly mussels and salmon

Sales from the aquaculture sector for the 2023 calendar year are estimated to total $737 million, according to data provided to us by MPI. For comparison, MPI's *Situation and Outlook for Primary Industries* for June 2023 forecast 2023 revenue of $510 million from aquaculture exports, and domestic consumption is over $200 million annually. The three main products are mussels, salmon and oysters, with the first two providing most of the sector revenue. The industries have both domestic sales and export revenue, and the split between the two varies across the products. Mussels make about 15 percent of its sales domestically, salmon has about an equal split, and oysters make 40 percent of its revenue from domestic sales.

1.3 We conducted interviews with the sector and modelled the workforce

The aim of the project was to provide forecasts of the possible workforce in the aquaculture sector in 2035. We approached the work from two directions.

- We created a spreadsheet model of the sector to estimate future levels of revenue and the associated workforce. The data for the model was provided by MPI and Aquaculture New Zealand (AQNZ). The model allowed us to test the impact of several assumptions about growth rates, prices and labour efficiency in the sector.
- We interviewed many people from the aquaculture sector to understand their views on future development. We then used the information they provided to underpin the scenarios we developed. We also asked them about their workforces, which provided additional information to 'sense-check' the modelling.

The output from the work is this report and the spreadsheet model.

1.4 The report provides data and results

The balance of this report provides the data, analysis and results from the project. Section 2 describes the interviews and their findings. Section 3 describes the data used in the modelling. Section 4 describes the model and how it works, as well as the scenarios modelled. Finally, section 5 describes the results from the scenarios.

An important caveat is that this work has not investigated differences between Māori-owned or Māori-controlled operations and other operations. Therefore, we cannot draw any conclusions on associated workforce or labour topics.

2 Interviews and their findings

2.1 Approach taken for the interviews

The aim of the interview process was to understand the views of the stakeholders within the aquaculture industry on the likely workforce needs if they were to strive to achieve the $3 billion sales target set for 2035. We were particularly interested in the type of workforce required to meet the $3 billion sales goal.

The approach taken here was to use AQNZ's contact list and ask a series of questions about the sales goal, the issues they faced, the current workforce (briefly) and what type of workforce will be required by 2035. The approach was to:

- Have an initial interview with Aquaculture New Zealand to set the context
- E-mail the potential respondents. Aquaculture New Zealand had already contacted each of the participants, which assisted with introductions
- Set up online videoconference interviews. The people who participated are listed in Appendix A, and the interview guide is provided in Appendix B
- Follow up with respondents.

The individual meetings yielded a greater amount of extra information and context relative to written questionnaire responses only. The responses were supplemented with information from web pages and other documentation about developments in the aquaculture industry.

The approach and survey sample reflect the resources available. The survey sample was not designed with any statistical method in mind. Instead, the aim was to talk to key stakeholders within the industry to paint a picture of workforce trends.

The sample contained stakeholders within the salmon, mussel and oyster industries and covered the more novel products and technologies being considered. We spoke to 11 senior executives within their respective organisations. We thus believe we interviewed the majority of key people who will drive the industry over the next five years at least.

Respondents could not or did not, answer all questions. They were also light on the specific roles that might be required. However, they were able to paint a picture of where they were driving the business and where the workforce would fit into that strategy.

2.2 What did we find?

The interviews tended to be in four parts:

- Their attitudes to the $3 billion strategy and the current constraints on their business
- Their current workforce (briefly)
- How they were thinking about the workforce to 2035, painting a picture of what workforce they might need (numbers and composition)
- Any other issues that might impact on the workforce.

2.2.1 The strategy is achievable

All interviewed participants think the $3 billion strategy is achievable if consent processes are timely and the capital is forthcoming. The confidence is based on what they see happening overseas (salmon farming in Tasmania and Norway), which they believe can be replicated in New Zealand and advances in the mussel business domestically. Respondents believe a durable industry can be created that delivers for businesses, workers and the economy while ensuring a healthy aquatic environment.

Importantly, MPI has developed the strategy but also relied on participation and advice from industry stakeholders. In particular, AQNZ and senior executives of aquaculture companies have all had input.

While companies are out there competing hard, all have slightly different approaches to growing their business. For example, some have a strong need to provide employment for their local catchment of workers, while others are focused on automation. Employing locals is a strong driver for iwi investment in aquaculture, particularly in areas such as Opotiki.

The drivers toward the $3 billion in annual sales outcome by 2035 are:

- Increasing scale, particularly in salmon, but also much smaller increases in other species (mussels and oysters). Novel products are not expected to be a major contributor to the strategy but are likely to play a part in the long-term growth of the industry
- Volume increases in nearly all species – but particularly salmon
- Value increases – demand is expected to remain strong.

The regional importance of aquaculture, iwi involvement and iwi settlements were also seen as a positive contributor to the industry. It also fell squarely into government regional growth objectives.

Two caveats were stipulated:

- Being able to get access to overseas workers
- The need to streamline the consent processes, i.e. in terms of:
  - time taken
  - the very large costs involved

- increased certainty in the consenting process, particularly to access new growing water space.[1]

While these caveats are front of mind for interviewed participants, it is **important to state that the forecasts provide an indication of potential demand** and do not provide any insights on 'supply' (e.g. issues such as consent processes). The aim has been to illustrate how the projected labour and skill growth will be met given possible demand scenarios.

The strategy is based on three species: salmon, mussels and, to a lesser extent, oysters. New species are not expected to rival the production and revenue of these core species in the near to medium term.

2.2.2 Demand is likely to remain strong for aquaculture products

Industry informants expect aquaculture to play a critical role in global food production for the foreseeable future. With the world population growing and stocks of wild-caught fish shrinking, further growth is expected.

Most in the industry believe that demand will be strong enough to meet the expectations of the MPI strategy. Industry expects strong demand from industrialised markets – particularly Australia and the United States and other growth markets in Asia. Currently, constraints on exports are driven not by demand but by an inability to supply.

There is always a fear that when limited volumes command high prices on international markets, producers will over-produce and prices will crash. This does not appear to be the case with aquaculture. The New Zealand product offering (particularly salmon) appears to have strong demand in traditional and growth markets. This is likely to be sustained over the long term.

2.2.3 Each sub-sector has different drivers that dictate levels of growth and workforce required

Each sub-sector participant has different production constraints and different approaches to overcoming those constraints.

2.2.4 Salmon production will become more automated

Salmon expansion will rely on the ability to obtain consents for new space in open water and the ability to automate many of the functions now done onsite, e.g., use of automatic feeding from an on-shore site. While details have yet to be worked through, industry expects to reduce the workforce working on the water by half and increase production to 20,000 tonnes per farm per year. This is contingent on acquiring water space and replicating automation processes either being trialled or in use overseas.

Farms of the current size produce anywhere between 200 tonnes and 2,000 tonnes per annum and are located in sheltered and inshore sites. Staff numbers are approximately 25 workers per farm.

What is envisaged is automated open ocean farming on a bigger scale. On the open ocean, having current staffing levels used in sheltered waters presents a health and safety risk. The

1 Further space is required and consenting for that space is the main bottleneck, e.g. see https://www.mpi.govt.nz/dmsdocument/50131-Open-Ocean-Salmon-Farming-in-New-Zealand-Aquaculture-Strategy

aim will be to use automation to reduce staff numbers on the water (by half) and dramatically increase production (to approximately 20,000 tonnes).

Firms involved in aquaculture currently tend not to contract work out, mainly because it is cheaper at the current scale of operation to perform all the tasks associated with their aquaculture operations. As the industry grows, this could change, as it has done in Norway. Respondents expect that there will be more contractors used as the industry grows. Currently, there are very few contractors in the salmon business. If New Zealand follows the Irish or Norwegian model, we expect companies to be formed that will perform specific maintenance tasks, clean nets, etc. These types of ancillary services would be developed as scale increases. While the number of company employees on the water will drop considerably, the number of contractors will grow.[2]

The interviews we conducted, and the workforce census from AQNZ did not provide a clear picture of when a transition to contracting arrangements might happen or how large the shift might be. The forecasts provided in this report are derived from current workforce counts and projections of efficiency gains. We have not split out contractors versus employees in the analysis since it is difficult to pinpoint what jobs will be contracted out and what will be kept in-house in aquaculture companies.

These changes will require large amounts of capital to achieve their aims. They will also require a different type of worker. Rather than performing onsite tasks as they do at present, they will be more able to work remotely or monitor automated processes on the water. The off-site tasks are expected to be connected with feeding and health monitoring. This means that the work can be done from any location, increasing the attractiveness of the jobs on offer. Other activities, such as net cleaning, will still be onsite.

Those jobs that involve regular visits (e.g. health checks) will require onsite checking from time to time. Further, while many of the manual jobs will be eliminated, the increased use of capital equipment will require checking and maintenance, creating a different set of roles.

The type of salmon processing depends on the demand from the markets. Some markets may wish to purchase the whole fish, while others will require specific fillets. This determines the level of processing required.

Over time, the degree of automation of whole fish operations will increase dramatically and be relatively straightforward. There are two distinct activity areas: gutting and packaging/distribution. Most of this can be achieved with the purchase of off-the-shelf equipment.

Further processing requires a number of steps which, among other things, include deheading, desliming, filleting, pin bone removal, inspection and grading. To perform these tasks, there is already a large amount of automatic or partially automatic equipment on the market that potentially can be used.

The workforce in processing is likely to remain stable or increase by up to 25 percent, but its composition will change as automation increases and volumes increase dramatically. The need for technical workers and maintenance workers will increase and come to dominate the workforce – as much as 40 percent or more.

[2] This is also the case for horticulture in New Zealand, where contracting is an important part of the industry.

Currently, there is potential for further utilisation of the remaining raw material from salmon processing. One respondent's company has now opened a processing centre whose job it will be to investigate how the waste can be turned into value. Potentially, any processing of waste is likely to be highly automated with a small but skilled workforce.

2.2.5 On-water mussel farming is mechanised, but processing will require more investment in automation

For mussels, the farming part of the business is a mix of manual and mechanised operations. Declumping, size grading, bagging and colour grading were all reasonably well automated, whereas handling floats and tying lines are manual repetitive tasks. There are fewer automated services on land (e.g. rope yards and workers who maintain vessels). While automation is increasing, the impact will only be incremental. The number of workers will likely increase as more water space is utilised. However, the number of workers will not double if the volume doubles, given advances in automation.

Processing of mussel products such as half-shell mussels will require more automation. Automation is seen as a critical part of the industry over the next 15 years. For mussel processing, a critical choke point is mussel openers. Some operators are using automatic openers, while others depend on frontline labour. Having automatic mussel openers of increasing reliability will assist the industry in its automation quest.

Other operations, such as bagging and packing, were also not that straightforward. More work will be required before these operations are fully automated.

Still, one respondent did have a full complement of workers and was reluctant to replace workers with automated processes. They had social as well as economic considerations, and what they automated needed careful consideration.

Overall, respondents thought the number of workers would either stay constant or increase by 25 percent. However, the nature of the jobs will change. More technical and maintenance workers will be required. These are likely to grow from 10 percent of the workforce to 40 percent of the workforce over the next 15 years.

Nutraceutical processing does not require a large workforce. Most processes are automated, and automation is likely to continue incrementally. Respondents expect the size of the workforce to increase marginally as the volumes increase.

Respondents mentioned that the more scale was achieved, the more opportunities there were for nutraceuticals.

2.2.6 Oyster farming and processing is focused on increasing automation

A clear consideration for oyster growers was the inability to find workers to assist in on-water operations. Most of their oyster farms were struggling to attract workers. There is a range of oyster farming systems in operation, from highly manual traditional wild 'stick' culture to floating baskets and hatchery-sourced stock. Some oyster farming entities are investing heavily in automation and partial mechanisation. Prior to further investments in the farms, workers still work outside on barges but do not need to be in the water to such an extent.

Of overriding importance is to find leaders who can motivate staff on the farms. Ideally, this means having leaders who can capture the necessary data to drive productivity, create the right environment, and ensure that workers have access to services that keep them coming to work day-in day-out. Finding these people is difficult because of the skills required. They have to be not only self-starters and technically proficient but also good managers of staff.

Processing oysters also requires more frontline workers, particularly when the most valuable product form is the half shell. They will continue to invest in automation operations to reduce their reliance on scarce labour. One respondent expected that as mechanisation increased, the number of workers would grow but only slowly. However, the type of work would change, reducing manual labour and increasing the demand for more technical skills. Challenges such as the irregularity of oyster production, especially wild-sourced, complicate the automation process.

Unlike other parts of the oyster operation, the ability to recruit in the hatchery for technical roles was relatively straightforward. This was attributed to the location of the hatchery (Nelson) and the strong availability of skilled people in the region.

2.2.7 Salmon volumes and value could potentially dominate the industry

Most of the volume and value growth for the strategy is expected from open ocean farming of salmon. Respondents are relatively confident that this can be done since most of the equipment needed is already available from places like Tasmania, Scotland and Norway.

The demand-focused strategy revolves around six or more medium-sized offshore salmon farms, potentially producing up to 70,000 tonnes. Two-thirds of the strategy value ($3 billion in sales) is expected from salmon, perhaps more.

Shellfish production and processing could potentially double in size but can't really compete with the potential volumes and values produced by salmon.

The challenge for the salmon industry is to reinvent itself as an ocean-going business, which requires a skilled workforce to make it happen. To do this will require the employment of senior overseas experience – at least in the initial stages – to get the industry up and running.

With increased growth, another critical area will likely be the supply chain infrastructure outside the aquaculture industry. Ports, the wharf capacity and other cold chain logistics will be more important and perhaps even more difficult to operationalise. The challenge is whether New Zealand can move product through the supply chain efficiently given the amount of product envisaged in the strategy.

2.2.8 Automation is already driving productivity

With a shortage of frontline workers already a major concern for respondents, automation has become a major area of on-going investment and management focus. One respondent mentioned that they had already disestablished 100 jobs in the last 18 months due to automation improvements in their systems.

It was universally agreed among respondents that automation is likely to have the biggest impact on the salmon industry. The scope to introduce automation is high. Even now, AI (artificial intelligence) has the potential to assist in estimating fish weight, identifying potential diseases, and understanding the feed intake of salmon.

One respondent gave an example of what was required to estimate a fish's weight. It had to be caught, and anaesthetics applied, and then it could be weighed. Potentially, 100 fish could be weighed in a day by one person. This is in a pen of 10,000 fish, so the accuracy is not high. Now, a camera can be put in the fish pen, and using AI algorithms, it can estimate the size of 3,000 fish in a day. This approach is a big advance in what is an important function of salmon farming, and it is saving labour and enhancing accuracy.

Automation in open ocean salmon has many applications. The potential for rough weather is high, and a salmon farm may not be accessible by staff for at least a week. Automatic processes will need to be used regularly. Currently, many of the jobs on salmon farms involve manual labour. Many of these functions will have to be eliminated, e.g. there will be a need for automatic feeding operated from onshore. Despite functions being withdrawn, overseas examples suggest that staff numbers will remain stable. There is likely to be a shift toward more skilled (higher paid) roles to operate and maintain the systems.

By far, the largest land-based activity is Mt Cook Alpine salmon. They are planning to double production from 2,500 tonnes today to 5,000 tonnes over the next 15 years. While this is a significant operation in the region – they are the biggest employer in Twizel – nationally, it is relatively small. They expect to increase their workforce from the current 90 to approximately 130 and face similar issues as other aquaculture companies. Their workforce will need to change to reflect the need for further automation, and they will need to attract that staff potentially from other regions or overseas.

2.2.9 Workforce composition

A critical factor for the workforce is the need for technical, quality control, and skilled maintenance staff. Like every other primary industry and manufacturing operation, their skills will be transferable and in heavy demand. The ability to hold and attract staff to the industry is critical.

In most cases, the need for this type of worker – not necessarily university-trained – would grow significantly from a small part of the workforce to a stage where they dominate the workforce. In some respects, this mirrors what is happening in other primary industries: dairy processing and post-harvest horticulture are all moving in this direction.

One respondent suggested that the Government could assist this process by putting in place a scholarship for an industry specialist to study/work in the Northern Hemisphere salmon industry.

2.2.10 Other species are likely to be a small part of the value creation

While other aquaculture activities are underway, they are unlikely to be a major contributor to the Government's $3 billion strategy. Longer term, however, novel products will feature in the industry, coming to fruition after 2035.

These include land-based operations such as kingfish and sea-based operations around seaweed. We should note that one respondent with a large amount of water space was considering experimenting with seaweed.

In Table 1, we summarise industry views on the future workforce. Of overriding importance is the need to attract and hold skilled workers who can drive industry automation.

Table 1 Information gained from interviews on the future workforce

Segment	Current workforce	Future workforce
Salmon		Will require overseas senior leadership with experience in open-ocean farming
On-farm	25 workers on current farms. A lot of manual labour producing around 2,000 tonnes per farm per annum	A reduction in staff is expected (potentially by half, i.e. 12–13 workers) on farms producing 20,000 tonnes (10 times the current production level). Staff will be more technically skilled. Increased numbers of contractors will be required to do specific tasks. Much of the technology is already being used or tested overseas.
Processing	Frontline workers used and relatively labour intensive. Higher-skilled staff currently represent approximately 10 percent of the workforce.	More automated with more technical staff. More technical staff required, and total staff numbers increasing by approximately 25 percent or more. Changing staff mix with approximately 30 to 40 percent having higher skills. Volumes will increase substantially by 7- to 10-fold. Much of the technology is already being used or tested overseas.
Other products/by-products	Relatively well automated	Scale will mean the workforce increases slightly for oil and pet food. Processes will be highly automated.
Mussels		Automation is a key driver from most operations. Most of the critical technology is domestically developed.
On-farm	Processes are semi-automated	Number of workers will increase incrementally as volumes increase. Many of the processes are already automated. Volumes could potentially double.
Processing	Processing is labour-intensive, and there is, in most areas, a shortage of workers	Large focus on automation will mean that worker numbers will increase by up to 25 percent. Composition of skills needed will change and skilled workers will become a much larger part of the workforce (40 percent or more of the workforce). Automation will occur, providing steady productivity improvements around opening mussels, grading, and packing.
Nutraceuticals	Already automated	Incremental advances as new technology becomes available.
Oysters		Key will be obtaining the right leadership qualities.
On-farm	Struggling to attract workers and leaders	Automation has occurred in the industry, reducing the difficulty of harvesting. These technical improvements will need to be backed up by improved leadership on-farm.
Processing	Worker availability is dependent on location. Regional processing more difficult than sites close to bigger urban centres	Will incrementally increase automation efforts. Need overseas expertise to drive further change within the industry. Automation focused on opening, sorting, grading and packing will also assist in driving incremental productivity.
Novel products	Not known	Not known but unlikely to be a major contributor to the $3 billion target.

Source: NZIER

2.3 Assumptions on workforce drivers

As part of the interview process, we asked respondents about their views on how the composition of the workforce might change over time as volumes increased and automation became more important.

We recognise that there are multiple roles, job titles, job descriptions and skill levels between different roles.

We also recognise that job descriptions and formal qualifications may provide an indication of skill, but we also know that there are many skilled people within the sector who have developed their skills through experience and on-the-job training.

We particularly wanted to further understand:

- The numbers of frontline workers. This workforce is involved mainly in manual tasks. These workers are supervised. We expect these workers to have varying degrees of skill and experience, and some will be doing entry-level jobs. We also expect them to be offered opportunities to grow their skills, given ongoing and persistent staff shortages. As technology is introduced, this group of workers are strong candidates to fill the newly created jobs by accessing tailored courses and on-the-job training.
- Semi-autonomous workers who will be responsible for running the automation process and fit into a management structure but are not closely supervised. This group may have specialist skills and could be relatively new to the company or have come up through the ranks through a combination of training courses and on-the-job training.
- Managers who are responsible for running different parts of the business.

Respondents did not provide clear descriptions of the future workforce composition. Many were understandably preoccupied with current workforce issues and did not have a detailed picture of how the workforce would grow and change over time. However, they were able to paint an overall picture of their views on the future composition of the workforce.

Of critical importance is the development of the semi-autonomous workforce since they will drive the automation processes across all parts of the business. With transferable skills, it is these workers that will be in high demand across all primary industries and manufacturing businesses.

- For mussels:
  - Hatchery jobs are already dominated by semi-autonomous workers. This is unlikely to change. Some incremental growth in semi-autonomous workers will be required per hatchery, but the main growth will occur with the development of more hatcheries. The closer hatcheries are to population centres, the easier recruitment will be
  - Farming is already highly automated, but there is still further room for some automation, although not as much as processing
  - Processing is an area where automation is growing. Currently, processing of mussels has been challenging, with large numbers of frontline workers required. Progress in some has proved difficult to automate (up until now). This includes mussel shell opening and packaging. Advances in this area could see further automation. As volumes potentially double, many of the frontline workers'

manual activities are expected to disappear. This does not mean that the workforce decline. We expect workforce growth driven by volume; however, the jobs will become more highly skilled as new generations of openers are developed and packing and sorting become more mechanised. The pace of adoption is a major question, although industry are investing to overcome these obstacles

  - Support functions will likely be stable with only incremental increases in the semi-autonomous workforce.

- For salmon:
  - Hatchery jobs are already dominated by semi-autonomous workers. This is unlikely to change. Respondents expected some incremental growth per hatchery, but the main growth will occur with the development of more hatcheries as salmon volumes rise dramatically
  - Farming will become much more highly automated. Respondents expect around half the number of workers needed that are currently working on farms. Most functions would be automated, lessening the need for manual labour. Almost all aspects of farming will utilise automation processes. Farms will have a mixture of onshore and offshore staff; therefore, the numbers of staff may not change, but the composition of staff will. Farming will be dominated by semi-autonomous workers. Increased numbers of contractors are likely
  - Processing is an area where automation is likely to increase. This is already occurring in processing facilities overseas. The semi-autonomous workforce could grow to around 40% of the total processing workforce
  - Support functions will be stable. Some incremental increases in the semi-autonomous workforce are likely.

- For oysters:
  - Hatchery jobs already have significant numbers of semi-autonomous workers, which will grow incrementally as some processes are further automated. The number of semi-autonomous workers will grow but only slowly in percentage terms
  - Farming of oysters will see growth in mechanisation/automation. However, the ability to automate is constrained (relative to salmon). Respondents do see that further automation is required to ensure industry profitability. This will require workers with semi-autonomous skill sets to drive further productivity
  - Processing will see some growth in semi-autonomous workers over time. Growth will likely be more incremental since the opportunities for automation are constrained by the product characteristics, e.g. we have not seen the development of automatic openers in the same way they are being developed in the mussel industry
  - Support functions are likely to remain at current levels. Some innovation is expected, but it will be incremental; therefore, the need for semi-autonomous workers will increase albeit slowly.

For novel products, we have assumed that seaweed will follow mussel workforce trends and kingfish will follow salmon staffing levels and workforce composition.

Table 2 below describes the estimated skill level of the mussel, oyster and salmon industries in 2023. Table 3 and Table 4 provide estimates of the skill levels in 2035 when the aquaculture sector has a large adoption of new technologies (Table 3) and lower adoption of new technologies (Table 4).

Both the highly technical and lower technical aquaculture skill scenarios will still result in a high degree of change between frontline workers and semi-autonomous workers as new technologies are implemented and require more technical skills. The highly technical workforce in Table 3 has been used in scenarios 1 and 3, while the less technical workforce in Table 4 has been used in scenarios 2 and 4. The skill level breakdowns for each scenario can be found in Appendix C.

We developed two sets of adoption scenarios because of the uncertainty around the pace of technological change and adoption in the New Zealand aquaculture industry. While many in the industry are optimistic about the ability to adopt new technology, the actual rate of adoption is sometimes slower than anticipated. In the modelling, we reflected the two different rates of adoption by adjusting the annual efficiency growth for each industry.

We have taken advice from interviewees on the split between the various roles within each industry for frontline workers, semi-autonomous workers and managers. The salmon skill level split is informed by what is happening overseas, particularly in Norway and Tasmania. For oysters and mussels, the skill level split is more focused on the incremental technology gains occurring domestically.

Points to note include:

- For mussels, most of the on-farm and processing capital has been developed domestically. Bottlenecks have been around the development of automatic openers, grading, and packing. How quickly automation occurs depends on the effectiveness and efficiency of the processes developed – which is still unclear. Scenarios have been developed to further understand the impact in the following tables.
- For oysters, incremental gains across farming and processing are expected to occur. We are expecting the volume of oysters produced to double. Expanding further will be hampered by the difficulty in applying off-the-shelf capital and sourcing skilled labour on farms and in processing. Some uncertainty exists on how this might play out in terms of the type of technologies used and the ability to attract a skilled workforce.
- For salmon, we expect major changes both on-farm and processing. We are confident of this because most of the equipment is being used or tested overseas in big salmon farming operations. The uncertainty relates to how quickly technology can be adapted to salmon production in New Zealand and the capabilities of the workforce. New Zealand has little experience in open ocean farming, and the workforce required for senior positions will be needed from overseas. Processing will have to be totally reorganised to cope with the large volumes expected (i.e. production will increase nearly 10-fold). Uncertainty about how this might affect future production is examined in the following tables.
- For other potential industries, it is not known how the workforce composition will grow and change. Therefore, we have based those composition changes on other aquaculture industries.

Table 2 Current aquaculture skill level percentage make-up in 2023

Industry	Skill level	Hatchery	Farming	Processing	Support functions
Mussels	Frontline	55%	80%	85%	55%
	Semi-autonomous	40%	15%	10%	40%
	Managers	5%	5%	5%	5%
Oysters	Frontline	52%	80%	80%	50%
	Semi-autonomous	30%	10%	8%	20%
	Managers	18%	10%	12%	30%
Salmon	Frontline	60%	76%	81%	85%
	Semi-autonomous	25%	17%	12%	8%
	Managers	15%	7%	7%	7%
Kingfish	Frontline	60%	76%	81%	85%
	Semi-autonomous	25%	17%	12%	8%
	Managers	15%	7%	7%	7%
Seaweed	Frontline	55%	80%	85%	55%
	Semi-autonomous	40%	15%	10%	40%
	Managers	5%	5%	5%	5%

Source: NZIER

Table 3 Highly technical scenario aquaculture skill level percentage make-up in 2035

Industry	Skill level	Hatchery	Farming	Processing	Support functions
Mussels	Frontline	10%	50%	55%	0%
	Semi-autonomous	85%	45%	40%	95%
	Managers	5%	5%	5%	5%
Oysters	Frontline	18%	60%	68%	25%
	Semi-autonomous	64%	30%	20%	45%
	Managers	18%	10%	12%	30%
Salmon	Frontline	30%	15%	53%	73%
	Semi-autonomous	55%	78%	40%	20%
	Managers	15%	7%	7%	7%
Kingfish	Frontline	30%	15%	53%	73%
	Semi-autonomous	55%	78%	40%	20%
	Managers	15%	7%	7%	7%
Seaweed	Frontline	10%	50%	55%	0%
	Semi-autonomous	85%	45%	40%	95%
	Managers	5%	5%	5%	5%

Source: NZIER

Table 4 Less technical scenario aquaculture skill level percentage make-up in 2035

Industry	Skill level	Hatchery	Farming	Processing	Support functions
Mussels	Frontline	52.5%	72.5%	75%	47.5%
	Semi-autonomous	42.5%	22.5%	20%	47.5%
	Managers	5%	5%	5%	5%
Oysters	Frontline	50%	75%	78%	47.5%
	Semi-autonomous	32%	15%	10%	22.5%
	Managers	18%	10%	12%	30%
Salmon	Frontline	57.5%	54%	73%	83%
	Semi-autonomous	27.5%	39%	20%	10%
	Managers	15%	7%	7%	7%
Kingfish	Frontline	57.5%	54%	73%	83%
	Semi-autonomous	27.5%	39%	20%	10%
	Managers	15%	7%	7%	7%
Seaweed	Frontline	52.5%	72.5%	75%	47.5%
	Semi-autonomous	42.5%	22.5%	20%	47.5%
	Managers	5%	5%	5%	5%

Source: NZIER

3 Data on the workforce and sector

3.1 Price and quantity shifts to reach $3 billion revenue in 2035

We received a table of data from MPI that was output from their model of forecast production for the aquaculture sector, contingent on certain assumptions holding true and growth happening according to certain timeframes. The table provided figures that disaggregated the Aquaculture Strategy's goal of reaching $3 billion in revenue in 2035. The table covered mussels, oysters and salmon. It contained tonnage figures, divided into tonnage in 2023, which was held constant through to 2035, and estimated new tonnage to be added between 2023 and 2035 from new farms and additional production on existing farms. The table also contained forecast prices per kilogram for exported and domestically sold mussels, oysters and salmon, and the percentage of each that is exported each year. Combining these data with the estimated fraction of initial volume lost in processing, also provided by MPI, yielded the projected revenue for each industry from 2023 to 2035. The table also showed that the main contributor to the increase in aquaculture revenue in New Zealand is expected to be salmon, with mussels and oysters contributing the remainder of the $3 billion.

If the assumptions that form the basis for MPI's aquaculture demand model eventuate, production of mussels could increase from 92,265 tonnes in 2023 to 144,933 tonnes in 2035, an increase of 52,667 tonnes or 57 percent. The price per kilogram of mussels could increase from $11.69 in 2023 to $20.85 in 2035 for exported mussels (mainly processed half-shell format) and from $9.36 to $14.99 for domestic mussels (live and marinated formats). The percentage of mussels exported is predicted to rise from 85 percent in 2023 to 90 percent in 2035. The total revenue for mussels could increase from $375 million in 2023 to $1.04 billion in 2035, increasing by 177 percent or $663 million.

Oyster production is projected to increase from 1,849 tonnes in 2023 to 4,255 tonnes in 2035, an increase of 130 percent or 2,405 tonnes. The price per kilogram of oysters could increase from $22.90 in 2023 to $37.66 in 2035 for exported oysters, while the price per kilogram of domestic oysters is projected to increase from $34.38 in 2023 to $55.04 in 2035. The percentage of oysters exported is predicted to increase from 60 percent in 2023 to 83 percent in 2035, with these increases causing the projected revenue for oysters in 2035 to increase to $135 million from $31 million in 2023, an increase of $112 million or 363 percent.

As part of achieving $3 billion in sales, salmon production is projected to increase from 15,118 tonnes in 2023 to 45,718 tonnes in 2035, an increase of 202 percent or 30,600 tonnes. This amount is within the potential increase in total farm capacity of 70,000 tonnes. The price per kilogram of salmon is projected to increase from $26.17 in 2023 to $52.96 in 2035 for exported salmon, and the price per kilogram of domestic salmon is expected to increase from $32.24 in 2023 to $51.62 in 2035. The percentage of salmon exported is predicted to increase from 50 percent in 2023 to 83 percent in 2035. These projected increases cause the total revenue for salmon to increase from $331 million in 2023 to $1.81 billion in 2035, an increase of 446 percent or $1.48 billion.

Across these three industries, the aquaculture sector is expected to increase its revenue by 305 percent from $737 million in 2023 to $2.99 billion in 2035. These projected increases are contingent upon, amongst other factors, the development and adoption of new technologies, availability of on-water and off-water space and availability of an appropriately skilled workforce in a highly competitive market.

3.2 Current workforce breakdown

We received the results from Aquaculture New Zealand's census of their industry members to gather data on the number of employees. The instrument used for the questionnaire divided employees into four activities – hatchery, farming, processing and support functions – and 27 positions or job titles. The census also gathered information about type of employment, part-time or full-time, seasonal dates of employment and demographic information, including age group, gender, ethnicity and residency status. We used the results of the census to create a model of the sector workforce.

The census had a target of gathering data from respondents who represented 80 percent of the output for the mussel, oyster and salmon industries. For the mussel industry, the census reached 80 percent, and for oysters and salmon, it reached 87 percent and 93 percent, respectively. The census recorded 2,770 people currently employed in the aquaculture industry in New Zealand, as well as their activity and positions. We estimate the total number of people employed is 3,327 after accounting for the percentages of total production covered by the census: 80 percent for mussels, 87 percent for oysters and 93 percent for salmon.

The total figure is similar to the workforce of 3,045 estimated for June 2021 in the Aquaculture New Zealand submission to the workforce inquiry into the seafood workforce.

Although the census instrument asked for information about 27 positions, respondents used more position titles to describe their workforce. We have not included the full details of the position titles collected. Instead, most were assigned to one of the existing categories. Some – less than five percent of employees – were placed in a miscellaneous category. Table 5 shows the reclassification of Aquaculture New Zealand census results to position descriptions in our model. Table 6 provides the estimated number of people currently in each role for each species/product.

Table 5 Changes to position categories from AQNZ census to workforce model

Industry	AQNZ activity	Positions in AQNZ census	Position moved to in model
Mussels	Support functions	HR/Training/Wellbeing/Coordinators, Administration/Business Support/Payroll, Supply Chain Mgr, Logistics/Supply Chain, Finance Mgr/Business Mgr, Business Analyst	Misc
Mussels	Support functions	Enviro Sustainability	Farming – Environmental Specialist
Mussels	Support functions	Engineers (Site), Maintenance	Farming – Engineer/Maintenance
Oysters	Hatchery	Nursery Technician	Hatchery Crew
Oysters	Hatchery	Technical Specialist - Spat Tech/Tech project Manager	Hatchery Manager
Oysters	Farming	Farm Supervisor/Live Team Supervisor/Shore Supervisor/Juvenile and Farm Supervisor	Harvest Coordinator/Manager
Oysters	Farming	National Farm Manager	Operations Manager
Oysters	Support functions	National Farm Manager	Farming – Operations Manager
Oysters	Support functions	Admin Mgr and Assistant, Data Technician, Sales and Mktg, Finance	Misc
Salmon	Farming	Maintenance/Maintenance Mgr	Engineer/Maintenance
Salmon	Support functions	Health and Safety Advisors/Managers	Health and Safety Advisors, Health and Safety Managers Split evenly
Salmon	Support functions	HR/HR Mgr, Marketing/Mkt Mgr, IT, Finance/Finance Mgr, Administration/Business Support/Call Centre, Business Support Manager, Director of Aquaculture	Misc
Salmon	Support functions	Environmental Manager	Farming – Environmental Specialist
Salmon	Support functions	Environmental Technician/Production Analyst	Farming – Environmental Specialist Misc Split evenly
Salmon	Support functions	Engineer team	Farming – Engineer/Maintenance

Source: NZIER

Table 6 Aquaculture workforce in 2023 by position

Activity	Position	Mussels	Oysters	Salmon	Total
Hatchery	Hatchery crew	6	2	29	38
	Hatchery technician	35	6	10	50
	Technical specialist	21	2	9	32
	Hatchery manager	4	2	6	13
	Misc				
Farming	Aquaculture yard worker	51	25	6	83
	Aquaculture farmer/harvest crew		55	110	165
	Harvest coordinator/manager	4	11	30	45
	Aquaculture farm diver			8	8
	Deckhand	139	9	17	165
	Senior deckhand/bosun	14			14
	Skipper (Aquaculture)	83	24	6	113
	Engineer/maintenance	33	2	38	72
	Operations manager	13	6	6	25
	Environmental specialist	1		2	3
	Misc				
Processing	Process operator – grader	254	9	314	577
	Process operator – opener/shucker	1,000	51		1,051
	Process operator – packing	293	20	18	330
	Hygiene team (Cleaning and sanitation)	175	3	11	189
	Line supervisor/team leader	203	9	11	122
	Production coordinator/manager	21		4	26
	Quality controller (QC/QA)	46	2		49
	Quality assurance manager	8	1	2	11
	Factory manager	11	8	3	23
	Operations manager	9	2	2	13
	Misc				
Support functions	Quality controller (QC/QA)				
	Quality assurance manager				
	Health and safety advisors	6		2	8
	Health and safety managers	1		2	3
	Misc	49	5	46	100
Total		2,378	256	694	3,327

Source: Aquaculture New Zealand, NZIER

There are official statistics on the seafood industry, collected by Statistics NZ. Data are collected by industry using the Australian and New Zealand Standard Industrial Classification (ANZSIC) system. In the ANZSIC system, aquaculture and wild-catch fishing are treated separately for production activities (farms and fishing vessels) but combined into a single seafood category for processing activities. The ANZSIC06 class codes and descriptions included in aquaculture production are: A020100 – Longline and Rack (Offshore) Aquaculture, A020200 Caged (Offshore) Aquaculture and A020300 – Onshore Aquaculture. Table 7 provides the available data. Comparing workforce numbers for aquaculture production from the two data sources, we see that the 2023 AQNZ figure is less than the 2019 ANZSIC figure. The most likely reason for the difference is that ANZSIC classifies businesses rather than roles, so all employees of an aquaculture production business are included in the count. By contrast, the AQNZ census collected more granular data about the roles performed by staff.

Table 7 also provides data on workforce counts for processing. For ANZSIC, processing includes all seafood, whereas the AQNZ figures are just for aquaculture. Comparing the two numbers, we find that aquaculture accounts for about half of all seafood processing jobs in New Zealand. The figures confirm that aquaculture processing is labour-intensive. Opening half-shell mussels, sorting, grading, and packing are labour-intensive jobs. As one respondent said: "*if you could automate shell opening, grading and packing you could cut the workforce by half*". It is a similar story for oysters. In salmon processing, filleting is a labour-intensive business.

There is potential for job classification error in these figures. Some processing for wild-catch fish occurs on fishing boats. If the businesses are classified as fishing businesses, then the employees will not be included in the count of seafood processing jobs.

Nevertheless, comparing AQNZ figures with those from Statistics NZ gives us confidence that the data used for building the workforce model are correct.

Table 7 Aquaculture workforce comparison

Activity	Seafood, ANZSIC 2019	Aquaculture, ANZSIC 2019	Aquaculture, AQNZ 2023
Production	6,075	1,002	826
Processing	4,808		2,390

Source: MPI using Statistics NZ's Integrated Data Infrastructure (IDI) and Aquaculture New Zealand workforce survey

The labour-intensive nature of aquaculture processing combined with the difficulty in automating some processing activities (half-shell opening for mussels and oysters and packing, for example) means that frontline staff dominate the workforce. In addition, mussel and oyster processing are not major activities overseas, unlike salmon processing. There are few 'off-the-shelf' automation processes that can be readily used.

Potentially, one of the reasons that salmon farming and processing is likely to become more dominant is the availability of purpose-built capital equipment and automated processes from overseas that can be readily adapted for New Zealand conditions.

4 Workforce modelling and scenarios

4.1 The workforce model

We created a spreadsheet model of production and employment in the aquaculture sector using Microsoft Excel. The model calculates the expected value of production for the sector and five component industries and then uses productivity assumptions to calculate the expected workforce in 2035.

The model works by utilising two major sources of data: the output from the MPI aquaculture production model and the results of the Aquaculture New Zealand census. The data are contained in model worksheets *Data – production* and *2023 workforce*. From these inputs, the tonnes per person per year are calculated across the mussel, oyster and salmon industries for each activity and position from the Aquaculture NZ survey (worksheet *2023 workforce*). With the ratios of tonnes per person and the projected tonnes of volume in 2035, the model calculates the aquaculture workforce in 2035. Those calculations are in the worksheet *2035 workforce*.

There are several levers that can be pulled in the model to adjust production and workforce figures. The assumptions that drive the model are shown in the worksheet *Main model*, in the 'Inputs for sector growth' section. They are:

- **Loss fraction** – The loss fractions received from MPI allow the conversion between the raw volumes produced for each industry and the finished volumes sold and revenue generated by them. The current loss fractions of 64.6 percent, 17.5 percent and 25 percent for mussels, oysters and salmon, respectively, allow the volumes in the MPI aquaculture production model to be converted into revenue and align with the revenue figures generated.
- **Production volumes** – The volume of production for each species is a combination of growth from current production methods and an assumption about production from future methods. The model allows the user to specify an annual growth percentage for current methods and a total volume from new methods in tonnes. Future growth cannot be specified as a percentage term because it begins from zero. The inputs are labelled 'Growth, current, annual' and 'Final volume, new'.
- **Efficiency growth** – Once production in 2035 is estimated based on the above, it can be used to estimate the future workforce. The efficiency growth assumptions are related to the economic concept of labour productivity: the growth in production per unit of labour. In the model, the annual efficiency growth for current production methods can be specified for each species and each activity (hatchery, farming, processing and support functions). These are shown under the heading 'Annual efficiency growth, current approaches'. Next, the relative efficiency of new farming methods can be specified. This parameter relates the output from future farming methods to the output from current methods in terms of labour efficiency. If a new method is expected to need one-half the labour, that can be shown as a 200 percent relative efficiency gain under the header 'Relative efficiency, new'.
- **Market factors** – Under the header 'Market factors, annual growth' are inputs that allow the user to adjust the revenue received per unit of volume. They are the annual percentage change in both domestic and export prices, as well as the share of volume

that is exported. The 'Domestic price', 'Export price' and 'Export share' are all currently using the data from the MPI aquaculture production output. This approach has calibrated the workforce model to the production data output from MPI.

- **New industries** – The model includes two new industries, currently specified as kingfish and seaweed. The value of production is generated by inputs specifying their volumes and prices in 2035. For calculating their workforce requirements, a reference industry must be chosen from the current industries: mussels, oysters and salmon. The 'Reference industry' uses the figures from current industries to calculate the workforce required to produce the production specified for the new industries.

With the above inputs, the workforce required for each position and industry is calculated in the worksheet *2035 workforce*. First, the production in 2035 is calculated based on current production levels, growth in the current production approaches, and the assumed level of production using new approaches. Then, current labour productivity is adjusted using the efficiency growth inputs to calculate labour productivity in 2035. Finally, the 2035 production and 2035 labour productivity are used to calculate the workforce requirements for each activity and position in the Aquaculture New Zealand census data.

The *Main model* worksheet provides outputs from the model. One section contains the industry-level data for mussels, oysters, salmon, kingfish and seaweed, including total volume and value, export volume and value, and total workforce. In the 'Workforce' section are the expected workforce requirements by species, activity and position, pulled into the *Main model* worksheet from the *2035 workforce* worksheet.

4.2 Key limitation of the model

An important feature to understand about the workforce model is that it does not include economic calculations of market drivers. There is no price response and no cost response underlying production data. That is, the industries do not produce more when the price goes up (or less when it falls), and they do not increase production as labour efficiency improves. The model is a calculator of expected workforce requirements given assumptions about market growth and efficiency growth.

4.3 Description of scenarios

Working with Aquaculture New Zealand and MPI, we developed four scenarios for how the aquaculture industry might develop to reach the $3 billion goal. The scenarios are summarised in Table 8.

Table 8 Summary of scenarios

Scenario	Description
Scenario 1	Salmon dominated sector, highly technical workforce • Requires a high capital investment to achieve technical gains. • A highly technical workforce will be required. • There will be a reduction in the share of manual labour due to automated processes. • Changes to workforce will apply both on and off-water.
Scenario 2	Salmon dominated sector, less technical workforce • Requires some investment but not as much as scenario 1. • Technical workers will increase somewhat with the adoption of new technology. • Increase in workforce is largely driven by production volume.
Scenario 3	Mussel dominated sector, highly technical workforce • Requires a high level of capital investment, but lower than the capital investment required for the salmon dominated, highly technical scenario due to capital investment in processing rather than farming. • A highly technical workforce will be required, particularly in processing.
Scenario 4	Mussel dominated sector, less technical workforce • Requires some investment but not as much as in scenario 3. • Technical workers will increase somewhat with the adoption of new technology. • Will require a significant increase in the area used for farming due to the increase in mussel volume needed to reach $3 billion.

Source: NZIER

4.3.1 Scenario 1 – Salmon dominated, highly technical workforce

Scenario 1 is dominated by salmon production and has a highly technical workforce from modelling the efficiency gains described in the interviews and are achieved gradually between 2023 and 2035 when the full efficiency gains are realised. The technical gains needed for this scenario will require an increased capital investment and reduced manual labour due to automated processes both on-water and off-water.

For modelling, the scenario includes a 1 percent annual efficiency growth in current mussel, oyster and salmon farming; a 2 percent annual efficiency growth in processing for mussels, oysters and salmon; a 200 percent relative efficiency gain for new mussel and oyster farming roles; and a 2,000 percent relative efficiency gain for new salmon farming roles (a combination of fewer farm roles and greater production). It also includes 1,000 tonnes of kingfish production, using the salmon workforce as a reference for role delineation, and 500 tonnes of seaweed production, which uses the mussel industry as a reference for role delineation.

Scenario 1 reaches the $3 billion revenue goal for the aquaculture sector. The mussel industry contributes 34 percent of the total revenue at $1.04 billion, the oyster industry contributes 5 percent of the aquaculture revenue at $143 million, the kingfish industry contributes $20 million or 1 percent of the aquaculture revenue, the seaweed industry contributes less than 1 percent of the total revenue at $15 million and the salmon industry contributes the largest share at $1.81 billion or 60 percent of the total revenue.

4.3.2 Scenario 2 – Salmon dominated, less technical workforce

Scenario 2 is also dominated by salmon production but has a less technical workforce compared to scenario 1. It assumes that only half of the efficiency gains described in the interviews and are achieved gradually between 2023 and 2035. This scenario will require capital investment into aquaculture, as in scenario 1, and the workforce skill level will remain at the same proportions as they are currently.

It includes a 0.5 percent annual efficiency growth in current mussel, oyster and salmon farming; a 1 percent annual efficiency growth in processing for mussels, oysters and salmon; a 150 percent relative efficiency gain for new mussel and oyster farming roles; and a 1,000 percent relative efficiency gain for new salmon farming roles. It also includes 1,000 tonnes of kingfish production, using the salmon workforce as a reference for role delineation, and 500 tonnes of seaweed production, which uses the mussel industry as a reference for role delineation.

Scenario 2 reaches the $3 billion revenue goal for the aquaculture sector, with the revenue contributions remaining the same from each industry as in scenario 1.

4.3.3 Scenario 3 – Mussel dominated, highly technical workforce

In scenario 3, salmon production only increases to 30,418 tonnes, which could be due to warming waters or difficulties in open ocean farming. In order to still achieve $3 billion revenue, mussel production needs to increase by 143 percent (the growth in new mussel production is two and a half times that of scenarios 1 and 2). The result is a mussel-dominated aquaculture sector. Scenario 3 has a highly technical workforce from modelling the same efficiency gains as scenario 1. The technical gains needed for this scenario will also require capital investment, but lower than the investment required in scenario 1 due to the capital investment occurring predominantly in processing. The investment will result in a reduction in manual labour due to automated processes both on-water and off-water. This scenario will also require a significant increase in the area used for farming due to the increased mussel production.

The scenario includes a 1 percent annual efficiency growth in current mussel, oyster and salmon farming; a 2 percent annual efficiency growth in processing for mussels, oysters and salmon; a 200 percent relative efficiency gain for new mussel and oyster farming roles; and a 2,000 percent relative efficiency gain for new salmon farming roles. It also includes 1,000 tonnes of kingfish production, using the salmon workforce as a reference for role delineation, and 500 tonnes of seaweed production, which uses the mussel industry as a reference for role delineation.

Scenario 3 reaches the $3 billion revenue goal for the aquaculture sector. The mussel industry contributes 54 percent of the total revenue at $1.6 billion, the oyster industry contributes 5 percent of the aquaculture revenue at $0.143 billion, the kingfish industry contributes $20 million or 1 percent of the aquaculture revenue, the seaweed industry contributes 0 percent of the total revenue at $15 million and the salmon industry contributes $1.2 billion or 40 percent of the total revenue.

4.3.4 Scenario 4 – Mussel dominated, less technical workforce

Like in scenario 3, salmon production only increases to 30,418 tonnes, which could be due to warming waters or difficulties in open ocean farming. In order to still achieve $3 billion revenue, mussel production needs to increase by 143 percent as in scenario 3, leading to a mussel-dominated aquaculture sector. Scenario 4 has a less technical workforce than scenario 3, assuming that only half of the efficiency gains described in the interviews are achieved gradually between 2023 and 2035, as in scenario 2. This scenario will require less capital investment than scenario 3, and the workforce skill level will remain at the same proportions as they are currently. This scenario will also require a significant increase in the area used for farming due to the increased mussel production.

The scenario includes a 0.5 percent annual efficiency growth in current mussel, oyster and salmon farming; a 1 percent annual efficiency growth in processing for mussels, oysters and salmon; a 150 percent relative efficiency gain for new mussel and oyster farming roles; and a 1,000 percent relative efficiency gain for new salmon farming roles. It includes 1,000 tonnes of kingfish production, using the salmon workforce as a reference for role delineation, and 500 tonnes of seaweed production, which uses the mussel industry as a reference for role delineation.

As scenario 4 uses the same volumes and prices as scenario 3, it also reaches the $3 billion revenue goal for the aquaculture sector, with the revenue contributions remaining the same as scenario 3 for each industry.

5 Results – workforce required for 2035

Some of the workforce numbers below in the skill level tables may not add up to the numbers described in the scenarios below due to rounding or a small total workforce number, particularly for kingfish and seaweed.

5.1 Scenario 1 – Salmon dominated, highly technical workforce

Scenario 1 assumes that the efficiency gains for mussels, oysters and salmon that were mentioned in the interviews are implemented between 2023 and 2035 when they are fully realised, and the aquaculture sector is dominated by salmon.

In this section, the workforce figures are provided by species/product (mussels, oysters, etc.) and by activity (hatchery, farming, etc.), further disaggregated by skill level. The three levels – frontline, semi-autonomous and managerial – match the three levels used in prior MPI work on the workforce across all the food and fibre sectors. In addition, the results by position title used in the Aquaculture New Zealand census are provided in Appendix C. Table 20 in Appendix C also provides results for the salmon industry by activity and position title for both current approaches to salmon farming (in-shore and land-based) and new approaches (open ocean). That breakdown is available in the spreadsheet model in the *2035 workforce* tab for any scenarios that are modelled.

In 2035, under scenario 1:

- The $3 billion revenue target is achieved.
- The total aquaculture workforce required is 4,835, increasing by 1,508 or 45 percent from the 2023 workforce of 3,327.
- The mussel industry requires a workforce of 2,953, an increase of 575 or 24 percent from the 2023 workforce of 2,378.

- The oyster industry requires a workforce of 440, an increase of 184 or 72 percent from the 2023 workforce of 256.
- The salmon industry requires a workforce of 1,406, an increase of 712 or 103 percent from the 2023 workforce of 694.
- The kingfish industry requires a workforce of 28.
- The seaweed industry requires a workforce of 9.

Table 9 Aquaculture workforce in 2035 – scenario 1

Salmon dominated industry, highly technical workforce

Industry	Skill level	Hatchery	Farming	Processing	Support functions	Total
Mussels	Frontline	10	192	1,307		1,509
	Semi-autonomous	88	173	951	84	1,296
	Managers	5	19	119	4	148
Oysters	Frontline	5	120	135	3	263
	Semi-autonomous	19	60	40	5	124
	Managers	5	20	24	3	53
Salmon	Frontline	49	33	462	112	655
	Semi-autonomous	89	170	349	31	39
	Managers	24	15	61	11	111
Kingfish	Frontline	1		10	2	14
	Semi-autonomous	2	1	8	1	11
	Managers	1		1		2
Seaweed	Frontline			5		5
	Semi-autonomous			3		4
	Managers					0
Total		301	804	3,474	256	4,835

Source: NZIER

Table 10 Aquaculture workforce percentage change from 2023 – scenario 1

Salmon dominated industry, highly technical workforce

Industry	Skill level	Hatchery	Farming	Processing	Support functions	Total
Mussels	Frontline	-71%	-29%	-20%	-100%	-23%
	Semi-autonomous	234%	242%	395%	273%	345%
	Managers	57%	14%	24%	57%	24%
Oysters	Frontline	-18%	13%	60%	19%	31%
	Semi-autonomous	408%	350%	369%	436%	367%
	Managers	138%	50%	88%	138%	77%
Salmon	Frontline	51%	-81%	56%	160%	21%
	Semi-autonomous	565%	348%	695%	656%	543%
	Managers	202%	-2%	138%	202%	111%
Total		124%	16%	44%	126%	44%

Source: NZIER

5.2 Scenario 2 – Salmon dominated, less technical workforce

Scenario 2 assumes that only half of the efficiency gains for mussels, oysters and salmon that were mentioned in the interviews can be implemented between 2023 and 2035, and the aquaculture sector is dominated by salmon.

This section provides the workforce figures by species/product and activity, disaggregated by skill level. The results by position title used in the Aquaculture New Zealand census are provided in Appendix C. Because this is a salmon-dominated scenario, Table 22 in Appendix C also provides results for the salmon industry for both current approaches to salmon farming (in-shore and land-based) and new approaches (open ocean).

In 2035, under scenario 2:

- The $3 billion revenue target is achieved.
- The total aquaculture workforce required is 5,408, increasing by 2,081 or 63 percent from the 2023 workforce of 3,327.
- The mussel industry requires a workforce of 3,304, an increase of 926 or 39 percent from the 2023 workforce of 2,378.
- The oyster industry requires a workforce of 506, an increase of 250 or 98 percent from the 2023 workforce of 256.
- The salmon industry requires a workforce of 1,550, an increase of 856 or 123 percent from the 2023 workforce of 694.
- The kingfish industry requires a workforce of 37.
- The seaweed industry requires a workforce of 11.

Table 11 Aquaculture workforce in 2035 – scenario 2

Salmon dominated industry, less technical workforce

Industry	Skill level	Hatchery	Farming	Processing	Support functions	Total
Mussels	Frontline	55	317	2,006	42	2,420
	Semi-autonomous	44	98	535	42	720
	Managers	5	22	134	4	165
Oysters	Frontline	15	181	174	5	375
	Semi-autonomous	10	36	22	2	71
	Managers	5	24	27	3	60
Salmon	Frontline	93	137	716	127	1,073
	Semi-autonomous	45	99	196	15	355
	Managers	24	18	69	11	121
Kingfish	Frontline	2	2	16	3	23
	Semi-autonomous	1	2	4		7
	Managers	1		2		3
Seaweed	Frontline			7		8
	Semi-autonomous			2		2
	Managers					1
Total		301	941	3,910	256	5,408

Source: NZIER

Table 12 Aquaculture workforce percentage change from 2023 – scenario 2

Salmon dominated industry, less technical workforce

Industry	Skill level	Hatchery	Farming	Processing	Support functions	Total
Mussels	Frontline	50%	18%	23%	36%	23%
	Semi-autonomous	67%	95%	179%	87%	147%
	Managers	57%	30%	39%	57%	39%
Oysters	Frontline	129%	70%	106%	126%	88%
	Semi-autonomous	154%	171%	164%	168%	166%
	Managers	138%	81%	111%	138%	101%
Salmon	Frontline	190%	-20%	142%	195%	84%
	Semi-autonomous	233%	160%	347%	278%	257%
	Managers	202%	13%	168%	202%	130%
Total		124%	34%	62%	126%	61%

Source: NZIER

5.3 Scenario 3 – Mussels dominated, highly technical workforce

Scenario 3 assumes that the efficiency gains for mussels, oysters and salmon that were mentioned in the interviews are implemented between 2023 and 2035 when they are fully realised, and the aquaculture sector is dominated by mussels.

This section provides the workforce figures by species/product and activity, disaggregated by skill level. The results by position title used in the Aquaculture New Zealand census are provided in Appendix C.

In 2035, under scenario 3:

- The $3 billion revenue target is achieved.
- The total aquaculture workforce required is 5,955, increasing by 2,628 or 79 percent from the 2023 workforce of 3,327.
- The mussel industry requires a workforce of 4,481, an increase of 2,103 or 88 percent from the 2023 workforce of 2,378.
- The oyster industry requires a workforce of 440, an increase of 184 or 72 percent from the 2023 workforce of 256.
- The salmon industry requires a workforce of 998, an increase of 304 or 44 percent from the 2023 workforce of 694.
- The kingfish industry requires a workforce of 28.
- The seaweed industry requires a workforce of 9.

Table 13 Aquaculture workforce in 2035 – scenario 3

Mussels dominated industry, highly technical workforce

Industry	Skill level	Hatchery	Farming	Processing	Support functions	Total
Mussels	Frontline	16	256	2,020		2,291
	Semi-autonomous	137	230	1,469	130	1,965
	Managers	8	26	184	7	224
Oysters	Frontline	5	120	135	3	263
	Semi-autonomous	19	60	40	5	124
	Managers	5	20	24	374	53
Salmon	Frontline	32	31	307	20	445
	Semi-autonomous	59	163	232	7	474
	Managers	16	15	41	2	79
Kingfish	Frontline	1		10	1	14
	Semi-autonomous	2	1	8		11
	Managers	1		1		2
Seaweed	Frontline			5		5
	Semi-autonomous			3		4
	Managers					
Total		303	922	4,478	253	5,955

Source: NZIER

Table 14 Aquaculture workforce percentage change from 2023 – scenario 3

Mussels dominated industry, highly technical workforce

Industry	Skill level	Hatchery	Farming	Processing	Support functions	Total
Mussels	Frontline	-56%	-5%	24%	-100%	16%
	Semi-autonomous	416%	356%	665%	476%	575%
	Managers	143%	52%	91%	143%	88%
Oysters	Frontline	-18%	13%	60%	19%	31%
	Semi-autonomous	408%	350%	369%	436%	367%
	Managers	138%	50%	88%	138%	77%
Salmon	Frontline	1%	-82%	4%	73%	-18%
	Semi-autonomous	343%	328%	429%	403%	377%
	Managers	101%	-7%	59%	101%	49%
Total		125%	33%	86%	124%	78%

Source: NZIER

5.4 Scenario 4 – Mussels dominated, less technical workforce

Scenario 4 assumes that only half of the efficiency gains for mussels, oysters and salmon that were mentioned in the interviews can be implemented between 2023 and 2035, and the aquaculture sector is dominated by mussels.

This section provides the workforce figures by species/product and activity, disaggregated by skill level. The results by position title used in the Aquaculture New Zealand census are provided in Appendix C.

In 2035, under scenario 4:

- The $3 billion revenue target is achieved.
- The total aquaculture workforce required is 6,696, increasing by 3,369 or 101 percent from the 2023 workforce of 3,327.
- The mussel industry requires a workforce of 5,048, an increase of 2,670 or 112 percent from the 2023 workforce of 2,378.
- The oyster industry requires a workforce of 506, an increase of 250 or 98 percent from the 2023 workforce of 256.
- The salmon industry requires a workforce of 1,095, an increase of 401 or 58 percent from the 2023 workforce of 694.
- The kingfish industry requires a workforce of 37.
- The seaweed industry requires a workforce of 11.

Table 15 Aquaculture workforce in 2035 – scenario 4

Mussels dominated industry, less technical workforce

Industry	Skill level	Hatchery	Farming	Processing	Support functions	Total
Mussels	Frontline	84	448	3,100	65	3,697
	Semi-autonomous	68	139	827	65	1,099
	Managers	8	31	207	7	252
Oysters	Frontline	15	181	174	5	375
	Semi-autonomous	10	36	22	2	71
	Managers	5	24	27	3	60
Salmon	Frontline	62	125	477	84	748
	Semi-autonomous	30	90	131	10	261
	Managers	16	16	46	7	85
Kingfish	Frontline	2	2	16	3	23
	Semi-autonomous	1	2	4		7
	Managers	1		2		3
Seaweed	Frontline			7		8
	Semi-autonomous			2		2
	Managers					1
Total		303	1,100	5,040	253	6,696

Source: NZIER

Table 16 Aquaculture workforce percentage change from 2023 – scenario 4

Mussels dominated industry, less technical workforce

Industry	Skill level	Hatchery	Farming	Processing	Support functions	Total
Mussels	Frontline	132%	67%	90%	110%	88%
	Semi-autonomous	158%	176%	331%	188%	277%
	Managers	143%	84%	115%	143%	112%
Oysters	Frontline	129%	70%	106%	126%	88%
	Semi-autonomous	154%	171%	164%	168%	166%
	Managers	138%	81%	111%	138%	101%
Salmon	Frontline	93%	-26%	61%	96%	38%
	Semi-autonomous	121%	138%	198%	152%	163%
	Managers	101%	4%	79%	101%	61%
Total		125%	57%	110%	124%	100%

Source: NZIER

5.5 Summary of scenarios

All four scenarios assume that the sector reaches the $3 billion revenue target of the Aquaculture Strategy in 2035. The estimated workforce requirements for meeting the target range from 4,835 to 6,696. The range depends on how much efficiency in farming and processing is achieved and whether salmon or mussels dominate the aquaculture sector. Scenario 4 requires the largest workforce: fewer efficiency gains are made, and the sector is dominated by the mussel industry, which doesn't have the large increases in farming efficiency expected with open-ocean salmon aquaculture. Scenarios 2 and 3 require similar-sized workforces. Scenario 3 requires a smaller workforce due to increased efficiency gains compared to scenario 4. Scenario 2 has the same efficiency gains as Scenario 4, but is a salmon-dominated aquaculture sector, which sees higher levels of efficiency gains compared to the mussel industry. Scenario 1 has the lowest workforce requirement for the aquaculture sector as it is a salmon-dominated industry and models the full efficiency gains described in the interviews.

Table 17 Aquaculture workforce and revenue scenario comparison

Industry/sector	Measure	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Aquaculture	**Total revenue**	**$3,024 m**	**$3,024 m**	**$2,985 m**	**$2,985 m**
	Total workforce	**4,835**	**5,408**	**5,955**	**6,696**
Mussels	Revenue	$1,038 m	$1,038 m	$1,604 m	$1,604 m
	Workforce	2,953	3,304	4,481	5,048
Oysters	Revenue	$143 m	$143 m	$143 m	$143 m
	Workforce	440	506	440	506
Salmon	Revenue	$1,808 m	$1,808 m	$1,203 m	$1,203 m
	Workforce	1,406	1,550	998	1,095
Kingfish	Revenue	$20 m	$20 m	$20 m	$20 m
	Workforce	28	37	28	37
Seaweed	Revenue	$15 m	$15 m	$15 m	$15 m
	Workforce	9	11	9	11

Source: NZIER

The modelled results suggest a few trends:

- It is possible to achieve $3 billion in revenue from the aquaculture industry with different mixes of species, and the model provides a tool for understanding the required growth rates.
- The sector can expect to need a larger workforce, even with gains in efficiency. In the modelling, the growth in the workforce results from the large increase in output.
- In all scenarios, the mussel industry has the largest workforce. Even in the salmon-dominated scenarios, the mussel industry still has more workers.
- Achieving the revenue target by growing the mussel industry requires a larger workforce than if growth is achieved through the salmon industry. The mussel industry

requires a greater input of labour and is not expected to have the same level of mechanisation or automation as salmon.

- There is expected to be growth in roles for all skill levels. The aquaculture sector will need, for example, more managers to achieve the target growth. However, the labour force will still be dominated by frontline staff with relatively manual jobs in 2035, particularly in farming and processing.
- New products – kingfish and seaweed in this modelling – remain small parts of the workforce.

Appendix A Key informants for the project

Table 18 Key informants for the project

People interviewed, based on recommendations from Aquaculture New Zealand

Name	Position/organisation
Jon Bailey	Mount Cook Alpine Salmon
Tony Hazlett	Talleys
Gary Hooper	CEO of Aquaculture New Zealand
Steph Hopkins	Aquaculture New Zealand
Mike Mandeno	Sanford (Mussels)
Richard Miller	Sanford (Salmon)
Andrew Selby	OP Columbia
Che Todd	Whakatōhea Mussels
Fiona Wikaira	Moana

Source: NZIER

Appendix B Semi-structured interview guide

Identification of interviewee

Name:

Firm/entity:

Industry:

Date interviewed:

Issue to be discussed:

Overview: existing information/data

Information on the existing workforce in each industry is variable. The NZIER needs to identify what is known and establish the factual basis to work from.

Key participants can assist this process by:

- Pointing to key information/data
- Granting access to key informants and information/data
- Detailing the gaps in information/data
- Pointing to the strengths and weaknesses of information/data.

Questions include:

- What workforce data/information is available?
- Does it show how the industry/workforce change over time?
- How detailed or fine grained is the data? i.e.:
  - Are the specific job categories described along with numbers employed in each job category?
  - Are skill levels identified (these may or may not be based on qualification standards)[3]
- How many people work in your sector?
  - How do you know that? What is the source of that information?
  - How does that number break down in terms of roles skills and periods of employment (i.e. part year roles compared to full year roles)?

Workforce numbers

1 How are you planning for the future (in general) specifically around price and volumes. And how does workforce planning fit into your thinking (in general)?

2 The Government have a strategy of increasing aquaculture value to $3 billion by 2035. In your specific area (species type) what are the volume and price increases you expect over that period?

[3] https://www.careers.govt.nz/courses/find-out-about-study-and-training-options/qualifications-and-their-levels/

a Do you have any supporting documents or spreadsheets that support this?

3 What information do you have on the number of people employed in your industry now and in the future?

4 Can you please clarify what these numbers represent?

a Total number employed in the industry in general terms

i How will the workforce change over time?

ii What will drive that change?

iii Do you have any documentation on the likely workforce composition?

b What time period do these numbers represent?

c If you have an annual count are these numbers:

i Peak workforce

ii At a point in time e.g. 31 March

iii Averaged over the year

iv How will these counts change over time?

d How are they measured:

i Head count

ii Full time equivalent (FTE)

e How will these figures change over the life of the strategy?

f What is the source of the data?

5 Do you have break downs of the roles and skills associates with those roles?

a Do you have documents spreadsheets that support this?

b How are these roles and skills going to change in the future?

6 What impact will increased automation have on these roles/skills?

Definition of the Sector

7 How do you define/describe the sector? e.g.:

a People involved in production

b Processing

c Support services

Discussion of different data

The above questions and discussion are designed to understand the interviewee's data and workforce structure and dynamics. We will need to triangulate this data with other information and data.

Roles

We are also interested in roles and skills within aquaculture industries and how these may change over time as businesses/entities respond to market incentives, technology, and how people like to work.

We recognise that there are multiple roles, varying job titles and job descriptions, and varying skill levels between different roles.

We also recognise that job descriptions and formal qualifications may provide an indication of skill, but we also know that there are many skilled people within the sector who have developed their skills through experience and on-the-job training.

We are interested in what information you may have on the breakdown of your workforce by roles/skill levels?

One potential way to think about this is by:

- Number of people who are semi-skilled or work under supervision – and the type of jobs they are doing
- Number of people who are skilled and can work independently – and the type of jobs they are doing
- Number of people who are highly skilled or work in managerial roles – and the type of jobs they are doing.

Is this a good way of thinking about the roles and skills in your industry? Do industries have data on this? Or can industries make approximations on the relative numbers in each of the categories set out above (if these are the right categories).

Could we also breakdown data and distinguish between skill levels for people who work all year vs those who only work part of the year?

Another approach could be to focus on the structure of the firm workforce, e.g. the typical labour structure of a small, medium and large entity. This may change from aquaculture industry to aquaculture industry.

Other people to talk to about workforce numbers and roles

Can you identify knowledgeable people in your industry that we can talk to about:

- Workforce numbers
- Structure of workforce
- Skills
- Industry dynamics.

Strategy

We are also interested in forecasting what the workforce may need to be in the future, both in terms of numbers and skills.

To help with this, we are interested in obtaining any strategic documents and insights you may have about how the sector may look like in the future.

Are there any documents you recommend we access, and who else should we talk to?

Next steps

Thank you for your help today. The information will be very helpful in trying to better understand the workforce in greater detail.

We will also be drawing on other sources of information, such as the data from Statistics NZ. From this, we will develop a baseline set of numbers to help with the forecasting.

We will be working closely with the aquaculture to ensure that the numbers are as consistent and robust as possible.

How would you like to be involved going forward and are we able to contact you if we have further questions or clarifications?

Appendix C Aquaculture workforce required in 2035 by position

Table 19 Aquaculture workforce in 2035 by position – scenario 1

Activity	Position	Mussels	Oysters	Salmon	Kingfish	Seaweed
Hatchery	Hatchery crew	10	5	88	2	
	Hatchery technician	55	14	29	1	
	Technical specialist	33	5	26	1	
	Hatchery manager	6	5	20		
	Misc					
Farming	Aquaculture yard worker	58	38	6		
	Aquaculture farmer/harvest crew		83	107	1	
	Harvest coordinator/manager	4	17	29		
	Aquaculture farm diver			7		
	Deckhand	158	14	17		
	Senior deckhand/bosun	16				
	Skipper (Aquaculture)	94	36	6		
	Engineer/maintenance	37	3	37		
	Operations manager	14	9	6		
	Environmental specialist	1		2		
	Misc					
Processing	Process operator – grader	314	17	749	16	1
	Process operator – opener/shucker	1,239	95			4
	Process operator – packing	362	37	44	1	1
	Hygiene team (Cleaning and sanitation)	217	6	26	1	1
	Line supervisor/team leader	127	17	26	1	
	Production coordinator/manager	26		10		
	Quality controller (QC/QA)	57	4			
	Quality assurance manager	9	2	5		
	Factory manager	14	15	8		
	Operations manager	11	4	5		
	Misc					
Support functions	Quality controller (QC/QA)					
	Quality assurance manager					
	Health and safety advisors	10		7		
	Health and safety managers	2		7		
	Misc	77	11	140	3	

Source: NZIER

Table 20 Salmon workforce in 2035 by farming practice – scenario 1

Activity	Position	Current practices	New practices (open ocean)
Hatchery	Hatchery crew	29	59
	Hatchery technician	10	20
	Technical specialist	9	17
	Hatchery manager	6	13
	Misc		
Farming	Aquaculture yard worker	6	1
	Aquaculture farmer/harvest crew	97	10
	Harvest coordinator/manager	27	3
	Aquaculture farm diver	7	1
	Deckhand	15	2
	Senior deckhand/bosun		
	Skipper (Aquaculture)	6	1
	Engineer/maintenance	33	3
	Operations manager	6	1
	Environmental specialist	2	
	Misc		
Processing	Process operator - grader	248	501
	Process operator - opener/shucker		
	Process operator – packing	14	29
	Hygiene team (Cleaning and sanitation)	8	17
	Line supervisor/team leader	8	17
	Production coordinator/manager	3	7
	Quality controller (QC/QA)		
	Quality assurance manager	2	3
	Factory manager	3	5
	Operations manager	2	3
	Misc		
Support functions	Quality controller (QC/QA)		
	Quality assurance manager		
	Health and safety advisors	2	4
	Health and safety managers	2	4
	Misc	46	94

Source: NZIER

Table 21 Aquaculture workforce in 2035 by position – scenario 2

Activity	Position	Mussels	Oysters	Salmon	Kingfish	Seaweed
Hatchery	Hatchery crew	10	5	88	2	
	Hatchery technician	55	14	29	1	
	Technical specialist	33	5	26	1	
	Hatchery manager	6	5	20		
	Misc					
Farming	Aquaculture yard worker	67	46	7		
	Aquaculture farmer/harvest crew		100	124	4	
	Harvest coordinator/manager	5	21	34	1	
	Aquaculture farm diver			9		
	Deckhand	180	17	19	1	
	Senior deckhand/bosun	18				
	Skipper (Aquaculture)	107	44	7		
	Engineer/maintenance	42	4	43	1	
	Operations manager	16	10	7		
	Environmental specialist	2		2		
	Misc					
Processing	Process operator – grader	354	19	843	18	1
	Process operator – opener/shucker	1,394	107			5
	Process operator – packing	408	41	49	1	1
	Hygiene team (Cleaning and sanitation)	244	7	29	1	1
	Line supervisor/team leader	143	19	29	1	
	Production coordinator/manager	30		12		
	Quality controller (QC/QA)	64	5			
	Quality assurance manager	10	2	6		
	Factory manager	16	17	9		
	Operations manager	12	5	6		
	Misc					
Support functions	Quality controller (QC/QA)					
	Quality assurance manager					
	Health and safety advisors	10		7		
	Health and safety managers	2		7		
	Misc	77	11	140	3	

Source: NZIER

Table 22 Salmon workforce in 2035 by farming practice – scenario 2

Activity	Position	Current practices	New practices (open ocean)
Hatchery	Hatchery crew	29	59
	Hatchery technician	10	20
	Technical specialist	9	17
	Hatchery manager	7	13
	Misc		
Farming	Aquaculture yard worker	6	1
	Aquaculture farmer/harvest crew	103	10
	Harvest coordinator/manager	28	3
	Aquaculture farm diver	7	1
	Deckhand	16	2
	Senior deckhand/bosun		
	Skipper (Aquaculture)	6	1
	Engineer/maintenance	35	3
	Operations manager	6	1
	Environmental specialist	2	
	Misc		
Processing	Process operator – grader	279	564
	Process operator – opener/shucker		
	Process operator – packing	16	33
	Hygiene team (Cleaning and sanitation)	10	19
	Line supervisor/team leader	10	19
	Production coordinator/manager	4	8
	Quality controller (QC/QA)		
	Quality assurance manager	2	4
	Factory manager	3	6
	Operations manager	2	4
	Misc		
Support functions	Quality controller (QC/QA)		
	Quality assurance manager		
	Health and safety advisors	2	4
	Health and safety managers	2	4
	Misc	46	94

Source: NZIER

Table 23 Aquaculture workforce in 2035 by position – scenario 3

Activity	Position	Mussels	Oysters	Salmon	Kingfish	Seaweed
Hatchery	Hatchery crew	15	5	58	2	
	Hatchery technician	85	14	19	1	
	Technical specialist	52	5	17	1	
	Hatchery manager	9	5	13		
	Misc					
Farming	Aquaculture yard worker	78	38	6		
	Aquaculture farmer/harvest crew		83	102	1	
	Harvest coordinator/manager	6	17	28		
	Aquaculture farm diver			7		
	Deckhand	211	14	16		
	Senior deckhand/bosun	21				
	Skipper (Aquaculture)	125	36	6		
	Engineer/maintenance	49	3	35		
	Operations manager	19	9	6		
	Environmental specialist	2		2		
	Misc					
Processing	Process operator – grader	486	17	498	16	1
	Process operator – opener/shucker	1,914	95			4
	Process operator – packing	560	37	29	1	1
	Hygiene team (Cleaning and sanitation)	335	6	17	1	1
	Line supervisor/team leader	196	17	17	1	
	Production coordinator/manager	41		7		
	Quality controller (QC/QA)	89	4			
	Quality assurance manager	14	2	3		
	Factory manager	22	15	5		
	Operations manager	17	4	3		
	Misc					
Support functions	Quality controller (QC/QA)					
	Quality assurance manager					
	Health and safety advisors	15		4		
	Health and safety managers	3		4		
	Misc	118	11	93	3	

Source: NZIER

Table 24 Aquaculture workforce in 2035 by position – scenario 4

Activity	Position	Mussels	Oysters	Salmon	Kingfish	Seaweed
Hatchery	Hatchery crew	15	5	58	2	
	Hatchery technician	85	14	19	1	
	Technical specialist	52	5	17	1	
	Hatchery manager	9	5	13		
	Misc					
Farming	Aquaculture yard worker	94	46	7		
	Aquaculture farmer/harvest crew		100	114	4	
	Harvest coordinator/manager	7	21	31	1	
	Aquaculture farm diver			8		
	Deckhand	255	17	18	1	
	Senior deckhand/bosun	25				
	Skipper (Aquaculture)	152	44	7		
	Engineer/maintenance	60	4	39	1	
	Operations manager	23	10	7		
	Environmental specialist	2		2		
	Misc					
Processing	Process operator – grader	547	19	561	18	1
	Process operator – opener/shucker	2,154	107			5
	Process operator – packing	630	41	33	1	1
	Hygiene team (Cleaning and sanitation)	377	7	19	1	1
	Line supervisor/team leader	221	19	19	1	
	Production coordinator/manager	46		8		
	Quality controller (QC/QA)	100	5			
	Quality assurance manager	16	2	4		
	Factory manager	24	17	6		
	Operations manager	19	5	4		
	Misc					
Support functions	Quality controller (QC/QA)					
	Quality assurance manager					
	Health and safety advisors	15		4		
	Health and safety managers	3		4		
	Misc	118	11	93	3	

Source: NZIER