

---

# Automation and the UK seafood industry

---

Exploring the trade-offs between new technology,  
mechanisation and traditional labour resourcing.  
**September 2019.**

---

**Authors:** Dr Angus Garrett, Lee Cooper, Lewis Tattersall.

# Contents

<b>Summary</b>	<b>1</b>
<b>1. Introduction, requirement and purpose</b>	<b>4</b>
<b>2. UK seafood industry</b>	<b>6</b>
<b>3. Labour and automation in UK seafood</b>	<b>8</b>
3.1 The labour and automation landscape	9
3.2 Labour/automation deployment: trade-offs and influences	12
3.3 Current deployment of labour/automation across the UK domestic seafood industry	16
3.4 Support for automation in the UK seafood industry	21
<b>4. Drivers and change pathways affecting labour and automation in seafood – the long view</b>	<b>22</b>
4.1 Labour pathways	24
4.2 Automation pathways	24
4.3 Projections for labour and automation	26
4.4 Alternative scenarios	28
<b>5. UK seafood, labour and automation – recent and anticipated developments</b>	<b>29</b>
5.1 Digital intelligence driven food production and consumption	30
5.2 Primary production	32
5.3 Processing	35
5.4 Other sectors – logistics, retail and food service	38
<b>6. UK seafood, labour and automation – impacts and response to longer term developments</b>	<b>40</b>
<b>Bibliography and Appendices</b>	<b>43</b>

# Summary

Labour and automation are the means by which essential industry tasks are undertaken. This review is an initial exploration of how developments in labour and automation might affect the UK seafood industry. It looks to identify and understand the current trade-offs between labour and automation and any threats and opportunities that may arise as these trade-offs evolve into the future.

## Labour and automation in the UK seafood industry

The UK seafood industry employs labour, either sparingly or intensively, across all sectors in the supply chain. This involves delivering operational tasks in fishing and aquaculture; ports, markets and logistics; manufacturing; and product preparation, presentation and sales activity in retail and food service outlets. Seafood jobs involve practical and intellectual tasks; may be full time, part time and seasonal; can require generalist, technical specialist, or craft skills; and range from junior to senior roles.

Automation can be defined as *'the application of machines to tasks once performed by human beings or, increasingly, to tasks that would otherwise be impossible.'* It includes mechanical technology, powered machinery, computerised technology and digital technology.

There is a notable difference in the nature of operational tasks, and job roles, across the seafood supply chain. In upstream sectors, there is an emphasis on physical tasks, such as moving and handling large volumes of physical product. In downstream sectors, tasks centre on more complex operations, for example transforming raw material into sophisticated product, or interacting with consumers and anticipating their needs.

The decision to deploy labour or automation depends on the nature of operational tasks – whether they are routine or non-routine and require mental or manual effort – and the contribution, availability and cost of each option.

This is particularly important in the seafood industry where tasks can involve wide variation in material being handled (e.g. shelling, filleting, etc) and judgement and flexibility is required.

Human labour offers *flexibility*; with the ability to learn, build experience and adapt to new situations whilst bringing passion to work tasks. Technology and automation can provide *consistency and predictability* with the potential to undertake tasks entirely as a substitute for labour, offer task support to complement existing labour and deliver new tasks or work that labour can't deliver.

The labour/automation trade-off balances the strengths of automation against the weaknesses of labour in task delivery and vice versa. Traditionally, routine tasks have been a focus for automation through mechanisation and non-routine tasks a focus for labour. However, new developments in digital technology are challenging these traditional trade-offs and opening up opportunities for the use of automation in non-routine tasks.

### Deployment of labour/automation in UK seafood

Successfully deploying automation depends on having fertile investment conditions; the ability to activate longer term investments and secure their returns. In the seafood industry, such conditions often depend on available volume and security of supply and markets.

The level of automation in UK seafood shows clear differences across supply chains, with high volume chains much more automated than low volume chains. High volume chains with continuity of supply have a higher share of standard, routine tasks making them more amenable to automation. These chains include domestic pelagic and salmon, as well as international sourced whitefish, pelagic, shellfish and salmon (particularly high volume frozen). Low volume chains, with inherent variability and a high share of non-routine tasks, tend to be labour intensive. These chains include domestic shellfish and whitefish, and international sourced whitefish, pelagic, shellfish and salmon (particularly low volume fresh).

Different labour/automation choices are associated with contrasting performance in industry productivity and measures of return over cost. For example:

- A number of large whitefish and pelagic vessels with sophisticated automation are highly productive.
- A number of mid-sized processors are highly productive, however a number of large sized companies have lower productivity.

The current labour/automation profile across industry is to be expected, given the balance of drivers across the supply chain in recent years:

- Tasks in seafood supply are both routine and non-routine in nature, with the balance depending on the species being handled and sophistication of final product.
- The availability and cost of labour has been supported by migrant labour.
- The availability and cost of technology has supported mechanical automation.
- Investment conditions for automation in seafood are mixed due to available volume and nature of supply.

### Longer term drivers and anticipated changes

Longer term drivers suggest a number of changes over the next 10 years that could change the labour/automation profile across industry.

- The availability and cost of labour is likely to be more challenging, affected by issues including an ageing population and a shrinking workforce; a tight UK labour market; changing migration conditions slowing a supply of labour ready to fulfil low wage job roles; and ongoing perceptions of the seafood industry as unattractive.
- The availability and cost of technology is likely to improve. New digital technologies, and the so-called 4th industrial revolution, will transform automation making it more suited to supporting non-routine tasks and deliver *efficient but also flexible production*.
- Automation is due to impact considerably on job roles within the next 10-20 years, making some roles obsolete. However, new roles focussed on complex problem solving, creativity and social relationships may also emerge.

It is anticipated that automation could reinvent food supply chains and address a number of challenges facing the food industry. Automation could support co-ordination on a single platform across an ecosystem of different actors in food delivery. This would enable intelligent food production and consumption systems, with: machines connected through the internet to manage production, storage and transportation, manufacture products and adapt to new processes, in response to – and in anticipation of – market demand and sales, with limited human guidance.

The digital transformation from a linear supply chain to an 'autonomous ecosystem of firms' will evolve, following a maturity pathway. In seafood, initial steps in this transformation will include:

- the proliferation of sensors that monitor environmental signals;
- blockchain technology that could improve transparency and traceability;
- automatic identification systems (AIS) that could help reduce illegal, unreported and unregulated (IUU) fishing.

As previously noted, the adoption of automation technologies is dependent on fertile investment conditions. Investment conditions may improve for domestic seafood supply chains due to changes in the scale and nature of supply volumes as a result of the UK's exit from the EU. There may also be scope for technology application, and improvements in productivity, in low volume sectors. For example there are specific opportunities to:

- Improve productivity in mid-sized vessels through technology transfer/new build especially in whitefish with greater share of fish in the UK EEZ.
- Explore further automation in the whitefish and shellfish catching sector, in whitefish and shellfish primary processing, and in secondary processing for whitefish, pelagic and shellfish.

Successfully implementing increased automation and realising the benefits will require long term thinking from industry, certainty from government, support for smaller operators and uptake/ collaboration with universities. Actions to support this could include:

- Providing financial support for research and development, easing smaller company participation through sensible criteria.
- Canvassing industry for research and development project opportunities and provide cost/benefit analyses to incentivise engagement.
- Identifying and engaging with research partners and technology providers for collaborative projects in research and development.
- For Seafish, building on this initial work, engaging industry to further these support actions and explore areas of potential opportunity in low volume sectors, including whitefish, pelagic, and shellfish and secondary processing.

# 1

## Introduction, requirement and purpose

This review is an initial exploration of how developments in labour and automation might affect the UK seafood industry. Labour and automation are the means by which essential industry tasks are undertaken. Of particular interest is an understanding of current trade-offs between labour and automation and any threats and opportunities that may arise as these trade-offs evolve into the future.

Changes in the industry landscape can present longer-term, strategic challenges for the industry (as captured in the Seafish industry change landscape 2017/18). Reflecting on these developments in 2017, strategic priorities included an immediate need to respond to the labour/automation trade-off. More specifically there is a requirement to explore how mechanisation is being used both as a substitute for labour in seafood businesses and as a means to increase the productivity of existing labour forces, to:

- i) identify implications, opportunities and threats for the UK industry; and
- ii) use the findings to undertake a comparative study based on part of the UK sector.

This report is an interim output focussed on implications, opportunities and threats for the UK industry. It aims to support the UK seafood industry in understanding:

- The types of operational problems amenable to technology / a skilled workforce in the seafood chain.
- Areas of technology relevant to seafood, and different stages in the seafood chain.
- Areas of seafood oriented to technology / labour.
- Drivers and possible pathways for technology.
- Opportunities, threats and actions that can be pursued.

This exercise, conducted in 2018, involved desk research and consultation with Seafish staff (see Appendix 1). The review has limitations: the focus of this exercise is on the domestic industry, the scope of consultation is not exhaustive and, in addition, the review does not consider alternative future pathways (scenarios), but is based on 'business as usual' projections.

Further work will be conducted to fulfil the requirement in this priority. This will engage industry stakeholders, and undertake a comparative study based on part of the UK sector to explore automation opportunities further.

This document combines data, opinions and conjecture and is a position paper at the time of press. It is important to bear in mind that evidence today might suggest trends that turn out to be very different in the longer-term.

2

# UK seafood industry

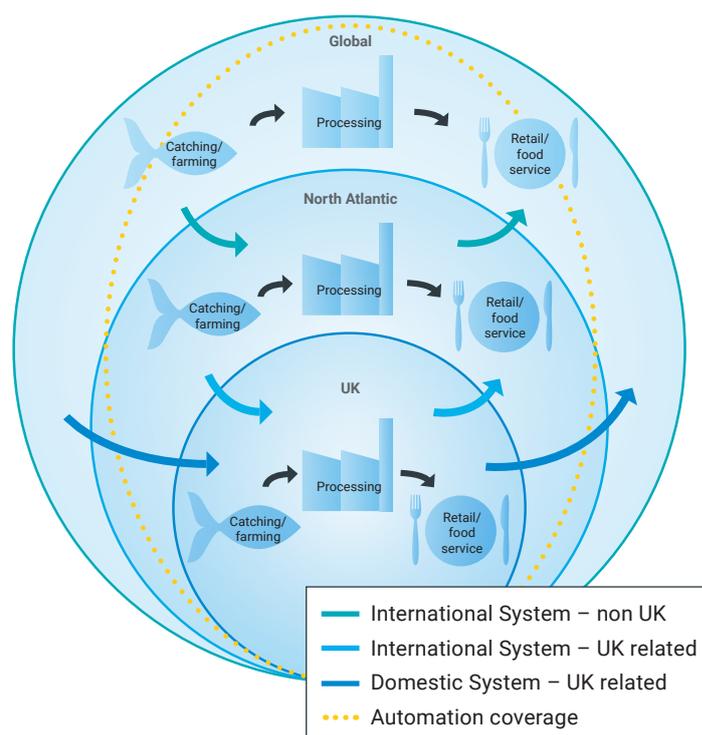
This section provides a representation of the seafood industry landscape and the major regional supplies of relevance to the UK. This representation frames the investigation, discussion and agreement on automation developments relating to the UK seafood industry.

The UK seafood industry, being reliant on wild capture and aquaculture produced raw material, is diverse, complex and dynamic. The seafood industry is considered here to operate as many subsystems (regional, sectoral), of varying degrees of interdependence, nested within one overarching global system.

In the global context, from a UK perspective, there are at least two major seafood systems that, although overlapping, have distinct characteristics:

- A domestic system – defined as a system reliant on domestically sourced fish and shellfish (material caught from stocks in North Atlantic/UK waters and landed in the UK, as well as material farmed in the UK). Within the ‘domestic system’, the key UK actors are: producers (farmers/vessels), agents and merchants in the UK handling fish and shellfish landed/farmed in the UK; UK processors of seafood; and the downstream supply chain in the UK of all of the former including food service companies, retailers and exporters.
- An international system – defined as a system reliant on internationally sourced fish and shellfish (material caught from stocks in the North Atlantic and elsewhere landed outside the UK, or material farmed outside the UK). Within the ‘international system’, the key UK actors are: agents and merchants in the UK importing fish and shellfish that is caught, landed or farmed and possibly processed outside of the UK; UK processors of imported seafood; and the downstream supply chain in the UK of all of the former including food service companies, retailers and re-exporters.

Figure 2.1: Components of the UK international and domestic systems and how they are interrelated (Automation coverage highlighted in yellow)



It is notable that from a UK perspective, imported seafood is largely for UK consumption, whilst seafood originating in the UK is generally exported for overseas consumption. The UK consumer maintains a robust preference for salmonids (farmed salmon), whitefish (cod, haddock and Alaska pollock), pelagics (tunas) and shellfish (cold-water prawn and farmed warm-water prawn). Meanwhile, UK landings volumes are dominated by mackerel and herring (pelagics), Nephrops (shellfish) and cod and haddock (whitefish).

3

# Labour and automation in UK seafood



This section frames what we mean by labour and automation in this review. An overview of typical operational tasks, labour and automation involved in supplying seafood products to the consumer is provided. Labour/automation deployment is explored in relation to immediate trade-offs and wider influences, followed by a profile of labour/automation deployed across the domestic industry. Finally, a list of example sources of support for automation is provided.

### 3.1 The labour and automation landscape

#### 3.1.1. Framing labour and automation

The seafood industry employs labour, either sparingly or intensively, across all sectors in the supply chain. Labour is engaged in: primary production activity in fishing and aquaculture; markets and logistics activity in ports, harbours, and transportation; manufacturing activity in primary and secondary processing of seafood products; and product preparation, presentation and sales activity in retail and food service outlets. The seafood labour force reflects the diversity of operational tasks across industry sectors.

In general terms, jobs:

- include practical and well as intellectual tasks,
- may be full time as well as part-time and seasonal,
- can require generalist, technical specialist, or craft skills,
- can range from junior to senior roles, earning between £8k to over £100k.

The diversity of the seafood labour force is particularly notable in the manufacturing and processing sector. Other sectors, such as primary production and outlet sectors are comparatively limited in the job roles required.

Automation can be defined as *'the application of machines to tasks once performed by human beings or, increasingly, to tasks that would otherwise be impossible'*<sup>1</sup>. Whereas in the past this term was concerned about mechanisation, machines undertaking manual tasks previously undertaken by humans, the term has now expanded to include mental, or knowledge-based, tasks. This review adopts a broad view of automation that includes:

- Mechanical technology that substitutes for artisanal skills or manual effort (machines with moving parts, including engines, cranes, pulleys, winches).
- Powered machinery (including specialised machine tools with interchangeable components, as well as administrative machines such as typewriters, dictaphones, calculators, etc).
- Computerised technology (including industrial robots, self-service technologies – e.g. bar code scanners, personal computers, internet and e-commerce).
- Digital technology (including artificial intelligence – e.g. machine learning and expert systems, 3D printing, etc).

On the basis of this definition, automation can support efficient as well as flexible production. This broad view widens the discussion over how automation can contribute to industry. From a concern about machines replacing people and physical effort to achieve efficient production, the debate can be broadened to consider how automation supports other activities (research and development, design, marketing, etc) to enable flexible production.

---

<sup>1</sup> Encyclopaedia Britannica (<https://www.britannica.com/technology/automation>)

### **3.1.2. Operational tasks, automation and job roles in seafood**

The seafood supply chain involves a number of distinct stages, or sectors. These include primary production (capture and aquaculture); ports; processing (primary and secondary), and outlets (retail and food service). A range of service sectors, such as engineering and logistics, support the industry.

The primary production sector is concerned with sourcing seafood through wild capture fishing and aquaculture. Wild capture fishing is concerned with navigating, catching, on-board handling, and landing of fish and shellfish. Aquaculture production is engaged with hatching, on-growing and harvesting / slaughtering of fish and shellfish.

The port sector is concerned with handling inbound and outbound materials to and from the UK, including seafood landings. There are around 480 ports in the UK with quite a range of sophistication in terms of volumes handled and services provided. High volume facilities can justify a food factory approach and a range of facilities; low volume ports are much more basic. There are three categories of port in the UK:

1. Basic landing stage / concrete jetty (with facilities located on premises outwith the port),
2. Landing and (refrigerated and non-refrigerated) storage huts/warehouses on port premises,
3. Landing, storage and sales facilities.

The processing sector is focussed on manufacturing seafood products, transforming seafood raw material into products for sale to the consumer. This can involve primary processing of relatively simple products that includes; cutting, filleting, chilling, gutting, picking, trimming, shucking, peeling, and washing. This can also involve secondary processing for more sophisticated product formats that includes: freezing, brining, smoking, marinating, canning, deboning, breading, battering, vacuum packing, cooking, and making ready meals.

Outlets are concerned with final sale of seafood products to the consumer. Products are sold either through retail sale for preparation at home, or through food service for consumption out of home (that may involve final preparation before sale).

The sourcing, transformation and sale of seafood to the consumer involves a range of operational tasks at each stage of the supply chain. Although some of these tasks can be automated, all require human involvement, in some cases requiring specific and specialised job roles. Table 3.1 provides examples of operational tasks, automation and job roles by seafood industry sector.

There is a notable difference in the nature of operational tasks, and job roles, across the supply chain. In upstream sectors, there is an emphasis on physical tasks; moving and handling large volumes of physical product. In downstream sectors, tasks centre on more complex operations e.g. transforming raw material into sophisticated product and interacting with consumers and anticipating their needs.

Table 3.1: Example operational tasks, automation and job roles by seafood industry sector

OPERATIONAL TASKS	PRIMARY PRODUCTION		PORTS		PROCESSING		OUTLETS	
	Capture	Aqua			Primary	Secondary	Retail	Food service
	<ul style="list-style-type: none"> <li>• Navigating / finding target species</li> <li>• Catching; shooting, hauling</li> <li>• On board handling: selection, processing / weighing / storing, moving</li> <li>• Landing catch / transferring catch</li> </ul>	<ul style="list-style-type: none"> <li>• Hatching: seeding / smolt rearing, feeding, system monitoring</li> <li>• On growing: transferring to marine cages, feeding &amp; husbandry, system monitoring</li> <li>• Harvesting / slaughtering / dehydrating</li> </ul>	<ul style="list-style-type: none"> <li>• Landing: pre-sale information, landing, grading / sorting / weighing, transporting /holding or storage area</li> <li>• Selling: auction</li> <li>• Post sale transporting</li> </ul>	<ul style="list-style-type: none"> <li>• Moving and storing: loading /unloading, Storing: chilled / frozen</li> <li>• Freezing / Defrosting / Moving</li> <li>• Processing: dehydrating, shelling, gutting, weighing, filleting, skinning, boning, glazing, icing</li> <li>• Quality checking: tracing, quality checking,</li> <li>• Packaging: packing &amp; labelling, boxing</li> </ul>	<ul style="list-style-type: none"> <li>• Moving and storing: loading /unloading, Storing: chilled / frozen</li> <li>• Freezing / Defrosting / Moving</li> <li>• Smoking: slicing, brining, smoking</li> <li>• Coating/breading: portioning, coating, breading, frying</li> <li>• Cooking &amp; pasteurising</li> <li>• Quality checking: tracing, quality checking,</li> <li>• Packaging: packing &amp; labelling, boxing</li> </ul>	<ul style="list-style-type: none"> <li>• Buying</li> <li>• Moving and storing: loading / unloading,</li> <li>• Storing: chilled / frozen</li> <li>• Freezing / Defrosting / Moving</li> <li>• Quality checking: tracing, quality checking, temperature control</li> <li>• Preparation: cutting, shucking/dressing shellfish</li> <li>• Food safety: personal, organisation specific – cleaning schedule.</li> <li>• Selling / customer service: counter display; weighing, packaging and labelling, advice</li> </ul>	<ul style="list-style-type: none"> <li>• Receiving and storing: unloading, storing – chilled / frozen / ambient, defrosting</li> <li>• Preparing: portioning and de-boning, peeling, chipping, soaking, draining, mixing, soaking and draining</li> <li>• Cooking: deep frying, boiling, poaching, grilling</li> <li>• Serving and payment: Eat-in, takeaway</li> <li>• Food safety: HACCP and documentation, cleaning</li> <li>• Marketing: menu displays, social media, online home ordering/ delivery</li> </ul>	
AUTOMATION	<ul style="list-style-type: none"> <li>• AIS signal, radar, GPS systems,</li> <li>• video plotters, net drums</li> <li>• winches, hoppers,</li> <li>• conveyors, cranes, gutting / weighing machines</li> </ul>	<ul style="list-style-type: none"> <li>• Feeding and monitoring systems,</li> <li>• fish pumps, stunning / killing / bleeding systems,</li> <li>• washing, de-clumping, grading system</li> </ul>	<ul style="list-style-type: none"> <li>• Cranes, forklift trucks, weighing and grading machines,</li> <li>• thermostatic control systems,</li> <li>• electronic auction, electronic sales transactions</li> </ul>	<ul style="list-style-type: none"> <li>• Fork lift / pallet truck, freeze / defrost machines/cold storage, storage, shelling / gutting machines, automatic weighing / grading / filleting / portioning / skinning / boning / glazing / traceability systems, X-Ray machines, labelling / packaging machines</li> </ul>	<ul style="list-style-type: none"> <li>• Fork lift / pallet truck, freeze / defrost machines/cold storage, Slicing / brining / smoking / portioning / coating machines, marinade / breading / frying technology, 1st and 2nd stage cooking technology, traceability systems, X-Ray machines, labelling / packaging machines</li> </ul>	<ul style="list-style-type: none"> <li>• Fork lift / pallet truck, chilled / frozen storage, thermostatic control systems (digital fridge/freezer monitoring), electric mixing machines, frying range cooking technology, dishwashers, digital display menus, electronic payment systems, web technology</li> </ul>	<ul style="list-style-type: none"> <li>• Fork lift / pallet truck, chilled / frozen storage, thermostatic control systems (digital fridge/freezer monitoring), electric mixing machines, frying range cooking technology, dishwashers, digital display menus, electronic payment systems, web technology</li> </ul>	
JOB ROLES	<ul style="list-style-type: none"> <li>• Skipper, Mate, Deckhand, Engineer (marine)</li> </ul>	<ul style="list-style-type: none"> <li>• Hatchery/ Farm Manager, Biologist, Engineer, Operative, Farm technician</li> </ul>	<ul style="list-style-type: none"> <li>• Office Administration, Logistics / Port / Market supervisors, Auctioneer, Port / Market / Auction technician</li> </ul>	<ul style="list-style-type: none"> <li>• Food Engineer, Technical manager, Filler, Operative, Supervisor / team leader, Quality assurance, Forklift truck driver</li> </ul>	<ul style="list-style-type: none"> <li>• Food Engineer, Technical manager, Smoker, Operative, Supervisor / team leader, Quality assurance, Forklift truck driver,</li> </ul>	<ul style="list-style-type: none"> <li>• Fishmonger, Delivery driver, Warehouse staff, Website tech team, Cashier</li> </ul>	<ul style="list-style-type: none"> <li>• Chef, Front of House, Kitchen operative, Waiter/ Waitress, Office Administration, Preparation, Shop manager, Fryer, Counter service</li> </ul>	
	<ul style="list-style-type: none"> <li>• Seafood buyer, Technologist, New product development manager, Sector specialist, Packaging technologist, Logistics Marketing / Sales / HR / IT Manager, Management Accountant, PR Officer, Customer insight Executive, Chief Executive</li> </ul>							

### 3.2 Labour/automation deployment: trade-offs and influences

In the near term, deploying labour or automation depends on the nature of operational tasks and the contribution, availability and cost of each option. However, successfully deploying automation is also influenced by the nature of the food industry. Longer term, there are additional drivers and these are considered in section four.

#### 3.2.1. Labour and automation: decision process

In practice operational requirements in the seafood industry need a mix of labour and technology. The exact mix of labour and technology varies across the industry, and within sectors, depending on the situation and nature of the operational tasks. Table 3.2 shows the main dimensions of the labour/automation decision.

#### 3.2.2. Nature of operational tasks

The nature of the work is a key factor in whether work tasks are amenable to labour or automation. Of particular importance are whether operational tasks are routine, non-routine, and require mental or manual effort.

Operational tasks can be routine or non-routine in nature. Routine tasks are standard, repetitive and predictable; fixed rules can be written to guide the delivery of these tasks. Non-routine tasks are variable and unpredictable; it is difficult to apply fixed rules to deliver these tasks, much depends on experience and judgement given the situation at hand.

*Table 3.2: Dimensions of the labour and automation decision*

DIMENSION	SPECIFIC AREAS	EXAMPLES
Nature of task	<b>Non-routine</b>	Manual tasks handling, shelling shellfish or filleting fish. Mental tasks buying, marketing or selling fish
	<b>Routine</b>	Manual tasks moving, transforming, labelling and packaging material Mental tasks grading and sorting material or payment transactions.
Labour	<b>Contribution</b>	Judgement and flexibility to handle variation and non-routine tasks, contributing to greater throughput and financial return
	<b>Availability</b>	Size of local labour pool, skills levels, skills types, attractiveness/perceptions of industry
	<b>Cost</b>	Regulatory requirements, market wage, local competition
Technology	<b>Contribution</b>	Consistency and efficiency to handle standard, routine tasks; potentially offering flexibility to handle variation and non-routine tasks, contributing to greater throughput and financial return.
	<b>Availability</b>	Adaptability of current technologies (highly specific, or standard), ability to interface with other technologies,
	<b>Cost</b>	Cost of technology, but also insurance, servicing, upgrades and retraining

Operational tasks also involve largely manual or mental effort. Manual tasks require some physical movement or transformation of material the task is concerned with. Mental tasks require some thought process which transforms knowledge, ideas and concepts into new forms that can guide action.

In the seafood industry, these tasks can be seen to play out in situations that are relatively:

- Stable:
  - Routine manual tasks e.g. movement of fish, cutting fish blocks, labelling and packaging
  - Routine mental tasks e.g. grading and sorting fish, stock control, payment transactions.
- Changeable:
  - Non-routine manual tasks e.g. shooting and hauling nets, driving vehicles, filleting.
  - Non-routine mental tasks e.g. buying fish, marketing and selling of fish.

In upstream sectors, particularly in primary production activity, tasks can be non-routine to ensure supply availability e.g. coping with natural events that affect wild capture fisheries and influence aquaculture. In downstream sectors, particularly in processing and outlets, tasks can be non-routine to ensure market preferences are met e.g. coping with the variable nature of seafood itself (a foodstuff that is fragile, non-rigid, slippery and often in irregular shapes and sizes) that, if mishandled, can damage product taste; smell; colour; or texture.<sup>2</sup>

### 3.2.3. Labour contribution, availability and cost

The labour option depends on contribution, availability and cost. Humans are suited to tasks that require a degree of judgement but are subject to a number of frailties which can undermine reliability. The contribution of human labour is flexibility; with the ability to learn, build experience and adapt to new situations whilst bringing passion to work tasks. This is particularly important in seafood where tasks can involve wide variation in material being handled (e.g. shelling, filleting etc) and judgement and flexibility is required. In such circumstances human labour can fulfil tasks that cannot be automated, contributing to supplies and returns. This is particularly important in seafood where maximising yield from a finite natural resource is critical. However, human labour has a number of frailties including: bias, habits, requirement for food/rest/stimulation, mental or physical limitations etc. Such frailties mean tasks may not be completed, may not be completed on time or not to the required standard.

Availability of labour is subject to a number of influences. These include: the size of the local labour pool (including workforce age profile); the required skills levels and skill types; and also attractiveness e.g. a willingness to accept prevailing conditions such as seasonal employment or unsociable hours etc.

Costs of labour depends amongst others, on regulatory requirements, for example the statutory national minimum wage, scarcity of qualified individuals, and local competition. In some circumstances the relatively high cost of labour can be addressed by expanding the local labour pool (e.g. through migrant labour), or extending the labour pool (e.g. outsourcing of part-processed materials to overseas markets where labour is relatively cheap and highly skilled – such as Eastern Europe and China).

---

<sup>2</sup> Bader et al (2018)

### 3.2.4. Automation contribution, availability and cost

Automation as an option similarly depends on contribution, availability and cost of the appropriate technology. Technology is suited to tasks for which there are rules and instructions, but can be inflexible and ill-suited to changing circumstances. The contribution of technology is consistency and predictability with the potential to undertake tasks entirely (substituting for labour), offer task support (complementing existing labour) and deliver new tasks (work that labour can't deliver)<sup>3</sup>. In other words, technology can offer a:

- more efficient solution where it is possible to substitute for relatively costly labour, which can then lower sales prices.
- more effective solution where it is possible to complement labour, avoiding human frailties, to deliver a higher quality output.
- brand new solution creating and delivering tasks at a scale humans can't, or tasks that are laborious for humans to undertake (e.g. analysing 'big data').

In so doing, automation can deliver a range of business benefits, including: cost reductions; greater throughput; higher quality; improved safety; reduced variability; reduced waste; and higher customer satisfaction (McKinsey, 2017). In some circumstances, automation can mean sophisticated technology fulfils tasks that humans cannot undertake, e.g. processing small sized seafood species, opening new markets and contributing to supplies and returns.

The availability of technology is subject to the appropriateness of current technologies, the extent to which these are highly specific or standard well-proven components, transferable across tasks or able to interface with other technologies. Given the pace of technology development, availability is also subject to the ongoing maturity of new technologies; where real world promise often needs to be separated from hype.<sup>4</sup>

The cost of the technology is the most visible factor and this extends to cover insurance, servicing and upgrades as well as cost of retraining workers. In seafood, technical solutions for complex non-routine tasks can be very high and being species/size specific can be limited to very particular uses<sup>5</sup>. This can be a level of outlay that is out of reach for smaller companies; larger businesses are better positioned for such a capital outlay and for employing engineers to consider the merits of these technologies and deploy them in the business. In larger seafood businesses, the scale of investment in automated production tends to be small scale and infrequent. However, it should be acknowledged that costs will tend to decline over time as technology is mass produced and become generally adopted / available.

---

<sup>3</sup> See Dellot et al (2017)

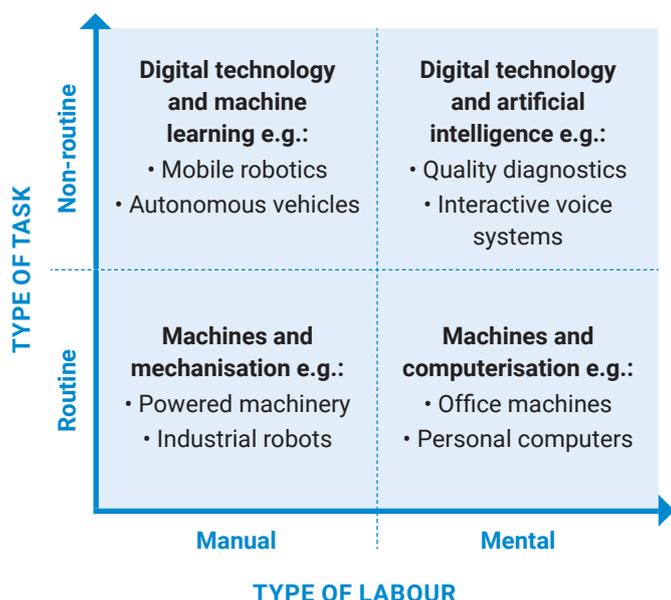
<sup>4</sup> See Gartner hype cycle (<https://www.gartner.com/en/research/methodologies/gartner-hype-cycle>)

<sup>5</sup> The costs of automated filleting machines can exceed £200,000, and intelligent trimming machines can cost over £500,000 (Seafood Industry Alliance, 2018).

### 3.2.5. Labour / automation trade-offs

Traditionally, routine tasks have been a focus for automation (through mechanisation) and non-routine tasks a focus for labour. However, new developments in digital technology are challenging traditional trade-offs and opening up opportunities in non-routine tasks. See Figure 3.3.

**Figure 3.3: Labour / automation trade-off**  
(based on Frey et al, 2013)



A systematic review of operational tasks could support the labour/automation decision<sup>6</sup>. The following steps could help identify tasks and roles that could be supported by automation:

- i. What mental/physical capability could be replicated by machine (current technology)?
- ii. Which of these capabilities perform predictable (routine) / unpredictable (non-routine) tasks and how much labour time is devoted to these?

- iii. Map the task 'activities' to occupational categories, define a hierarchy of jobs more/less susceptible to automation.
- iv. Overlay scenarios for timing of what will be technically feasible (possible solutions) matched by actual technical application (real world solutions).

Beyond this, successfully deploying automation depends on having fertile investment conditions; the ability to activate longer term investments and secure their returns. This is influenced by the nature and challenges of the food industry, including: market imperfections; diversity of actors; information asymmetries; technology infrastructure; immature supply chain networks and the perishable nature of food products<sup>7</sup>. The ability to raise the investment finance and realise business contributions is critical, so that payback can be achieved. This is particularly the case for new technologies where investment can be significant and the payback period long term<sup>8</sup>.

In seafood, fertile investment conditions often depend on there being available volume and security of supply, alongside security of markets. In the catching sector, for example, ownership of fishing quota represents a capital asset that can be used to raise finance as well as guarantee a level of future supply. In processing, ownership – or part-ownership of vessels – and an established customer base, can demonstrate stability in future throughput. It should be noted, however, that seafood operators' profit margins can be very slim and horizons generally near term; this places pressure on investment returns to pay-off within 12-24 months.

The next section provides a high level summary of the extent to which automation is currently deployed in the domestic industry.

<sup>6</sup> Based on McKinsey (2017)

<sup>7</sup> Soosay et al (2018)

<sup>8</sup> Evidence from Iceland suggests a state-of-the-art processing facility can be in excess of £10m, requiring over 5,000t throughput p.a. New technologies deployed in processing can require a 5-10 year, rather than 1-2 year payback. Jonas Vidarsson, Matis and Michael Mitchell, LeanTeamGB at the Scottish Seafood Summit, (2019)

### 3.3 Current deployment of labour/automation across the UK domestic seafood industry

In the UK domestic seafood industry, the current deployment of automation illustrates further differences in the nature of operational tasks, and job roles, across the supply chain. Figure 3.4 provides a high-level overview of labour/automation intensity for domestic supply chains in whitefish, pelagic, shellfish and salmonids.

Much of the variation in deployment is also down to species and supply chain characteristics. A wide variety of fish and shellfish species are sourced at the primary production stage, including: round fish, flat fish, small pelagics, crustaceans, bi-valve molluscs and salmonids. Processors draw on this material to generate a wide portfolio of seafood products (simple, staple products through to high value items) and formats (frozen, chilled, ready to eat, ready to cook, meal centred, ready meal, coated, smoked, marinated etc). Whilst some supply chains will focus on a single species, others handle mixed species from the fishery stage through to multi-species manufacturing lines.

A major asymmetry with the seafood supply chain concerns the high and low volume seafood supply chains. High volume supply is provided mainly through large, often integrated, companies and sold through outlets that are themselves large companies or public institutions. Low volume supply is provided mainly by small companies and through smaller, independent, outlets.

Automation and labour deployment across primary production, processing, and outlets shows a:

- relatively high share of automation in pelagic and salmon chains (low labour intensity);
- relatively low share of automation in shellfish chains (high labour intensity);
- mixed picture in whitefish chains with a high share of automation in some parts and a high labour intensity in others; and
- higher share of automation in primary production and processing.

A review of operators in the catching and processing sectors provides insight into the nature of these chains. Operations can be described in terms of high or low volume, workforce size, and level of productivity – gross value added per full time employee (FTE). See Appendix 2.

#### 3.3.1. Primary production and ports

In the UK catching sector there were 11,692 workers in the UK fleet in 2017<sup>9</sup>. Catching sector workers were geographically distributed as: England and Wales (52%); Scotland (41%); and Northern Ireland (7%). The overall share of overseas workers was 23% with regional and sectoral variation; non-UK crew in Northern Ireland and Scotland was around 50% and 30% respectively. Smaller vessels (under 10m) tend to have mostly UK crew.

At the primary production stage, automation is clearly deployed in those sectors where tasks are more routine. This deployment is largely in vessels and aquaculture that focus on single species at high volume i.e. pelagic capture and salmon farming. Other primary production sectors are often operating at lower volumes, such as shellfish aquaculture, and in lower volume mixed fisheries with a diverse range of species being handled e.g. whitefish and shellfish fisheries. These sectors tend to be more labour intensive, relying on human flexibility and adaptability to undertake tasks.

The balance of labour/automation across fleet segments suggests a clear ranking in automation intensity. The orientation of larger vessels is towards automation whilst that of smaller vessels is towards labour. Large pelagic vessels are leading edge, with innovations cascading through to large whitefish trawlers, followed by prawn trawlers, and then dredgers. Currently, there are a lot of new build vessels, across all segments, with technology evolving over time and crossing over.

---

<sup>9</sup> Marine Management Organisation (2017)

Figure 3.4 Domestic system – current deployment of labour/automation in delivering key seafood species

BROAD SPECIES GROUPING	SPECIES	SOURCE METHOD	FIRST SALE (DIRECT CONTRACT / PORTS / AUCTIONS / MARKETS)	PRIMARY PROCESSING	SECONDARY PROCESSING	FOOD SERVICE OUTLET	RETAIL OUTLET
Whitefish	Cod, haddock, whiting, monkfish, sole, plaice	Whitefish & flatfish (bottom trawl)	Round - Peterhead / Scrabster / Fraserburgh / Lerwick / Grimsby. Flat - Ilfracombe / Milford Haven / Lochinver / Brixham / South coast			Convenience / Specialist	Convenience / Specialist
	Cod, haddock, pollock	Whitefish (gillnets)	Newlyn			Convenience / Specialist	Convenience / Specialist
	Sole, plaice, rays	Whitefish (minority line-caught) Flatfish & rays (beam trawl)	Scrabster / Lerwick / Scalloway / Lochinver Milford Haven / Swansea / Newlyn / Brixham			Convenience / Specialist Convenience / Specialist	Convenience / Specialist Convenience / Specialist
	Herring, mackerel, sardine/pilchard, blue whiting	Small pelagic (purse seine & mid-water trawl)	Mackerel/herring direct contract (Peterhead / Lerwick / Fraserburgh), sardines/sprats (Newlyn, Mallaig)			Large volume (mainstream)	Large volume (mainstream)
Pelagic	Mackerel	Small pelagic (line caught)	Newlyn and small UK ports			Specialist	Specialist
Shellfish	Crabs, lobsters, Nephrops, whelks	Crustaceans (pots)	Direct contracts (Bridlington / Grimsby / Scrabster / UK small ports)	Live	Live	Specialist	Specialist
	Nephrops	Prawn (trawl)	Direct contracts (Fraserburgh / Mallaig / Kilkeel / Portavogie / Ardglass)	Live	Live	Convenience / Specialist Specialist	Convenience / Specialist Specialist
	Mussels, scallops	Molluscs (dredged)	Mussels (Penrhy / Warrenpoint), Scallops (Kircudbright / Douglas / Brixham / Shoreham)	Live	Live	Convenience / Specialist Specialist	Convenience / Specialist Specialist
Salmonids	Mussels, oysters	Molluscs (rope grown/ longlines) Molluscs (bottom grown)	Landing, selling, post sale transporting	Live	Live	Convenience / Specialist Specialist	Convenience / Specialist Specialist
	Atlantic salmon, Rainbow trout (aqua)	Marine cage farming Freshwater ponds/raceways	Landing, selling, post sale transporting			Large volume (mainstream) / Convenience / Specialist Specialist	Large volume (mainstream) / Convenience / Specialist Specialist

High level of automation (low labour intensity)

Labour / automation balance

Low share of automation (high labour intensity)

Pathways for investment, technology and automation reflect:

- An historic period of investing in quota, with operators borrowing to buy quota.
- Having paid off quota, operators borrowing further against this asset.
- Borrowing is used to finance the building of new vessels, justified by the bigger quota.

There is also a pathway for labour and crew. In earlier life stages, fishermen might go to sea on longer more challenging trips. As fishermen hit a mid-life period, they might opt to work on vessels doing shorter trips. As fishermen get older, sometimes into their seventies, they might operate a much smaller inshore vessel; fishing in a very small scale artisanal fashion.

The nature of the catching sector is such that there are a small number of large vessels and large number of small vessels. The largest vessels have the highest levels of turnover and productivity in the fleet (1% of vessels account for 32% of UK landings) with some of these vessels having a very sophisticated level of automation.

The whitefish fleet contains a relatively low number of small vessels and a higher number of medium to large sized vessels with the majority of the latter landing into NE Scotland ports. In whitefish, there may be opportunities to improve the limited productivity of medium-sized vessels. This might include knowledge transfer from the largest vessels (that have a four-fold difference in productivity).

The pelagic fleet contains a limited number of either small vessels or very large vessels with the majority of the latter landing into NE Scotland ports. There are limited opportunities to improve vessel productivity amongst the largest vessels that are highly efficient, or the smallest vessels that are already highly specialised and fill a distinct niche.

The shellfish fleet contains a large number of small and medium sized vessels landing into a range of small, medium and large ports around the UK. Differences in productivity between medium-sized vessels would suggest opportunities to improve productivity through knowledge transfer within that group.

The balance of labour/automation across aquaculture also suggests a clear ranking in automation intensity. The orientation of medium and larger sized salmon producers is towards automation, investing in hatchery automation, and automated systems on cages. Smaller operators are oriented towards labour, majoring on labour intensive aspects e.g. 'hand reared', 'someone at sea every day'. Farmed shellfish operators tend to be small family businesses, and tend to be labour intensive.

Within farmed seafood, there are a relatively small number of salmon farms located in Scotland and a large number of shellfish farms located around the UK. Farmed salmon provides large volumes, with much greater consistency, of supply over the year, in pre-specified fish sizes. Shellfish production delivers smaller volumes with more variability of supply over the year.

### **3.3.2. Processing**

In the seafood and salmon processing sector there were 17,999 full time equivalent (FTE) jobs in 2016<sup>10</sup>. Processing sector FTE jobs were geographically distributed as: England and Wales (51%); Scotland (47%); and Northern Ireland (2%). Around half of workers in the processing sector were from overseas, but with strong regional differences in the share of overseas workers: Grampian (71%); South West England (58%); and Humberside (39%).

---

<sup>10</sup> [Seafish Processing sector report \(2016\)](#)

Automation offers a trade-off in processing operations. With the intrinsic variation in seafood, mechanisation can actually reduce efficiency (lower yield/lower quality product) but increase throughput, enabling a high volume of lower price product to a different part of the market. Automation is suited to manufacturing lines processing high volumes with long runs which have a greater share of routine tasks – these are largely in the primary processing or frozen sectors. Labour, as a flexible and adaptive resource, is suited to manufacturing lines processing lower volumes with shorter runs which have a greater share of non-routine tasks e.g. chilled sector where product formats are diverse, design and assembly can be very complex, and product requirements can change frequently. Large companies undertake high and low volume production, smaller companies undertake low volume production.

The balance of labour/automation across processing suggests a clear ranking in automation intensity with larger companies oriented towards automation and smaller companies towards labour. Large companies have complex manufacturing systems with high and low volume lines involving routine and non-routine tasks. The orientation of these large manufacturing sites is towards automation with machines doing much of the work supported by highly skilled production workers (required to oversee what is going into the manufacturing line, what is coming out, and quality control throughout the process). Manufacturing lines can either be an evolved line (built over time with different components) or a more efficient integrated line (with aligned components). Smaller company manufacturing lines have a relatively simpler set of routine and non-routine tasks. The orientation of smaller operators, involving relatively simple manual tasks but requiring expert judgement, tends towards labour. Many of the tasks are concerned with expert judgement, handling of product and also moving product around.

The processing sector has a small number of large companies – often operating multiple processing sites – and a large number of small sites. The smallest operators have few employees, low turnover and low productivity. Medium sized operators, with around 50-100 FTEs, have relatively low turnover but have the highest productivity. The largest companies have the highest share of employment (69%), highest levels of turnover but amongst the lowest productivity levels. That is, productivity increases as size of operation increases but only to a limit (less than 100 FTEs); beyond this size of operation productivity falls.

This productivity profile is mirrored in companies engaged in primary processing as well as those in secondary processing, although the drop-off in productivity for the largest companies is slight in primary, and pronounced in secondary, processing. In 2018 there were 88 primary processing sites which supported 1,977 FTE jobs. There were 51 secondary processors which supported 2,832 FTE jobs.

In whitefish, 60 processing sites supported 1,108 FTE jobs. These sites processed demersal (whitefish) species only: this includes cod, haddock, and flatfish. These processors include a large group of small processing sites and a small group of large processing sites, both with limited productivity; a reasonable number of mid-sized processors have higher productivity than sites at each extreme of the scale. There appears to be a size threshold above or below which productivity decreases. This may be due to differences in product format or supply with large sites dealing with greater volumes of lower value frozen product and small sites affected by variable supply from wild capture fisheries. Furthermore whitefish processing largely reflects batch production set up on the basis of traditionally buying from fish markets, where variable sizes meant sorting into batches that could serve needs of various products and markets.

However, higher volumes of imported frozen are now being produced at higher quality, with new investment in Russia and Norway introducing new technologies into system wide production systems in brand new factories, benefitting from lessons learned in frozen at sea vessel processing. Automation may offer potential opportunity to address productivity at either ends of the size spectrum for whitefish processors.

In pelagic, 16 processing sites supported 1,083 FTE jobs. These sites processed pelagic species only: this includes mackerel, herring, horse mackerel, pilchards and blue whiting. These sites are either the smallest and largest FTE jobs size bands with few mid-sized sites. In the UK pelagic fisheries are generally either low volume/high value (e.g. line caught mackerel) or high volume/ low value (e.g. midwater trawl or purse-seine caught mackerel/ herring). The large pelagic sites are often more automated than other seafood processing sites; made possible by the consistency of species composition and supply of pelagic fish raw material. In addition the pelagic supply chain often has a greater degree of vertical integration between catching and processing than other sectors with some companies operating both fishing vessels and processing facilities. With productivity highest in the largest processing sites, opportunities for productivity gains lie with medium sites.

In shellfish, 75 processing sites supported 2,929 FTE jobs. These sites processed shellfish only: this includes crustaceans (crab, lobster, and Nephrops) and molluscs (mussels, oysters, scallops, and squid). Processors can be categorised as a large group of small processing sites (over half of sites are in the smallest 1-10 FTE jobs size band) and a small group of large processing sites (nine sites in the largest jobs size band supported 65% of FTE jobs).

These sites can be broadly categorised as follows:

- A large group of small processing sites with reasonable productivity,
- A small group of mid-sized processing sites with reasonable productivity, and
- A small group of large processing sites with lower productivity.

There is potential opportunity to address productivity at either end of the size spectrum, but particularly at sites in the 100+ FTE jobs band where high value sales of shellfish could justify investment.

In salmonids, 34 salmon and trout processing sites supported 2,090 FTE jobs. The size profile of this sector is polarised with the smallest sites (1-10 FTE jobs size band) supporting 3% of FTE jobs whilst the largest sites (100+ FTE jobs size band) support 65% of FTE jobs. Parts of the salmon and trout industry have a greater degree of vertical integration between primary production and processing than other areas of the industry with some companies operating both aquaculture and processing facilities. As salmon production has developed in relatively recent times, it has done so alongside the development of new technologies. This has allowed the introduction of continuous production facilities in brand new factories. Productivity is highest in medium sized sites (50-100 FTEs), there is potential opportunity to address the drop in productivity at the largest salmon and trout processing sites.

There are many processors that process a mix of the above species; 211 processing sites supporting 14,370 FTEs. The size profile of this group is broadly similar to the overall group, as is the productivity profile; with the notable high productivity of the mid-sized group (50-100 FTEs) and lower productivity of the largest size group (100+ FTEs).

### 3.4 Support for automation in the UK seafood industry

This section provides a number of example mechanisms oriented to supporting automation. Mechanisms include government initiatives, research expertise and commercial consultancy and manufactured products.

#### Government initiatives

- Innovate UK (aiming to support technology adoption by supporting the development of technology solutions, funding partnerships, funding research).
- Research centres
- National Centre for Food Manufacturing – Lincoln University.
- Edinburgh Centre of Robotics – Heriot-Watt University and Edinburgh University.
- Centre for Sustainable Manufacturing & Recycling Technologies – Loughborough University.

#### Commercial consultancy services

- High value manufacturing catapult (advisory services and independent consultancy).
- LeanTeamGB.

#### Robotics manufacturing companies

- ABB
- Bosch
- Comau
- Delta Electric
- Denso Robotics
- Doosan Robotics
- Epson Robots
- Foxconn
- Franka
- Funac
- Hanwha Techwin
- HRG
- Hyundai Robotics
- Kawada
- Kawasaki
- Kinova Robotics
- Kuka
- Mecademic
- Mitsubishi Robotics
- Nichi-Fujikoshi
- Omron Adept
- Yaskawa Motoman
- Rethink Robots
- Siasun
- ST Robotics
- Staubli
- Techman Robot
- Toshiba Robotics
- Universal Robot

#### Seafood electronics and equipment manufacturers

- Echomaster marine ([echomastermarine.co.uk/](http://echomastermarine.co.uk/))
- Euskan fish handling ([euskan.com/](http://euskan.com/))
- Furuno, UK ([www.furuno.co.uk/](http://www.furuno.co.uk/))
- Havfront – Norway ([havfront.no/](http://havfront.no/))
- Hondex electronics USA ([hondexne.com/](http://hondexne.com/))
- MacMinn Marine ([www.mcminnmarine.co.uk/](http://www.mcminnmarine.co.uk/))
- Mantsprite Marine ([www.mantsbrite.com/](http://www.mantsbrite.com/))
- Notus electronics ([www.notus.ca/](http://www.notus.ca/))
- Scanmar ([www.scanmar.no/en/](http://www.scanmar.no/en/))
- Seafeld Navigation ([www.seafeldnavigation.co.uk/](http://www.seafeldnavigation.co.uk/))
- Simrad marine electronics ([www.simrad-yachting.com/en-gb/](http://www.simrad-yachting.com/en-gb/))
- Stadpipe Norway ([www.stadpipe.no/](http://www.stadpipe.no/))
- Tecmarine ([www.tecmarine.co.uk/](http://www.tecmarine.co.uk/))
- Ulvesund Elektro AS ([ulvesund-elektro.no/english/](http://ulvesund-elektro.no/english/))
- Ziegra Ice machines ([www.ziegra.co.uk/](http://www.ziegra.co.uk/))
- Baader ([www.baader.com/en/products/fish\\_processing/](http://www.baader.com/en/products/fish_processing/))
- Cabinplant ([www.cabinplant.com/solutions/fish-seafood/](http://www.cabinplant.com/solutions/fish-seafood/))
- Curio (<https://curio.is/en/>)
- KM Fish machinery ([km-fish.dk/products/fish-processing-solutions/](http://km-fish.dk/products/fish-processing-solutions/))
- Marel processing ([marel.com/fish/](http://marel.com/fish/))
- Polar systems ([www.polar-systems.co.uk/](http://www.polar-systems.co.uk/))
- Samey ([www.samey.is/en\\_index.htm](http://www.samey.is/en_index.htm))
- Skaginn 3X ([www.skaginn3x.com/](http://www.skaginn3x.com/))
- Snorre Group ([www.snorregroup.com/](http://www.snorregroup.com/))
- Valka ([valka.is/](http://valka.is/))

# 4

## Drivers and change pathways affecting labour and automation in seafood – the long view

This section summarises the main drivers and change pathways affecting the seafood industry over the long term, with a focus on automation and labour in particular. This draws on pathways that are both observed (by 3rd parties) and experienced (by industry operators).

Table 4.1 shows the long view of drivers and change pathways affecting the labour/automation trade-off, experienced or observed in the period 1997-2008 through to those anticipated in 2019-2030.

*Table 4.1: The long view: 1997/2007 – 2008/2018 – 2019/2030*

DRIVER	CHANGE PATHWAYS	
	FROM	TO
Economic developments	UK economic growth, with premiumisation convenience and added value products	Limited economic growth, expanding overseas markets with greater focus on convenience and added value products
	Constrained supply in traditional supplies with opening up of new supply sources	Broadening of species and supply sources with traditional supplies potentially constrained
	Expanded middle – ‘we’re all middle class now’ (disposable income/debt increasing)	Squeezed middle (low wage economy, reduced disposable income) and savvy shopper
	Increased labour movement / immigration	Migration crises / tightening immigration policies
Trade developments	Diminishing tariffs (new sources of protein)	Free trade agreements (UK won’t run out of food, but higher prices, less choice)
	Sporadic supply disruptions in producing countries	Competitive pressure to secure supply, more processing in third countries (outside UK control)
Population	Growing UK population, globalisation, tourism	Growing population that is diverse and ageing
	Erosion of family as stabiliser	Fragmented, greater demands on individual (work, leisure, caring)
Scrutiny/regulation	Introduction/growth in scrutiny (medical community ‘don’t eat’ lists), increased testing	Forensic testing (allergies etc)
Media influence (Incl. NGOs)	Emergence of celebrity chefs	Influence of social media (trusted advocates)
Technological developments and outliers	Static web information (1st generation)	Dynamic internet (2nd generation) and “internet of things” (3rd generation)
	Technical innovations driving aquaculture (making salmon, prawns, pangasius, available in volume)	Technical innovations driving aquaculture (making new species available in volume)

## 4.1 Labour pathways

Longer term drivers can have a direct bearing on labour availability to the industry. These drivers include:

- **An ageing population and a shrinking workforce generally.** There is an emerging labour crisis in developed countries as a result of demographic changes; 12 out of 15 of the world's largest economies (accounting for 70% of global GDP) are expected to face labour shortages by 2030<sup>11</sup>.
- **Robust economic performance continuing to sustain a tight UK labour market, meaning labour is often not available.** UK employment is at historically high levels, and is high in key UK regions relevant to seafood. UK unemployment is 4.1% and in key regions (Peterhead/Fraserburgh, 2.8%; South West England, 2.9%; Scotland, 3.8%; and Humberside, 5%)<sup>12, 13</sup>.  
Where labour is available competition can be intense, with seafood competing with other 'low skilled' employers in wider primary production, food manufacturing, retail and tourism.
- **Changing migration conditions that is now slowing a supply of labour ready to fulfil low wage job roles.** For many years the industry has been able to rely on a steady supply of migrant labour from EU member states, particularly since the accession of Eastern European countries. The UK departure from the EU, combined with improving economic conditions in Eastern Europe, has contributed to the slowing of this labour supply. Migration Advisory Committee (MAC) recommendations to UK Government, that include restrictions on migration of 'low-skilled' workers, are likely to sustain this slowdown<sup>14</sup>.

- **Ongoing perceptions of the seafood industry as unattractive, meaning seafood jobs are regarded as a last resort option<sup>15</sup>.** Seafood is perceived as being low paid, with unpleasant working conditions (cold, wet, foul smelling, and dangerous – particularly in the catching sector) which disadvantages the industry when recruiting.

These drivers, individually and in combination, present significant difficulties for the availability and cost of labour to the seafood industry. These difficulties can be acute, particularly in rural areas where labour is already scarce.

## 4.2 Automation pathways

Advances in technology and automation can accelerate drivers in longer term pathways.

These include those drivers relating to:

- consumers (the need for flexible products, catering to diversity in tastes and foods, provision of customised food products – to meet specific preferences, and personalised food products – to meet dietary requirements);
- government (improving traceability, employee safety, consumer safety, sustainability and waste); and
- industry (addressing labour and skills shortages, improving productivity, efficiency and quality).

Ongoing technological advances, the so-called 4th industrial revolution, will have – as with other sectors of the economy – a profound effect on the seafood industry. These advances will transform automation; moving it beyond routine operational tasks to cover many non-routine tasks, and in the longer term to undertake tasks not yet envisaged.

---

<sup>11</sup> ICF Global Consulting (2018)

<sup>12</sup> Office for National Statistics (2018)

<sup>13</sup> Aberdeenshire Council (2017)

<sup>14</sup> Migration Advisory Committee (2018)

<sup>15</sup> Seafish Processing sector labour reports (2018)

The 4th industrial revolution is the latest wave in a history of change<sup>16</sup> (see Box 4.2):

- **1st industrial revolution (from late-18th century): Mechanical production**
- **2nd industrial revolution (from late-19th century): Mass production**
- **3rd industrial revolution (from mid-20th century): Computerisation**
- **4th industrial revolution (from early 21st century): Digital technology and innovation**

However, compared to previous revolutions, current changes are progressing at a notable difference in: *speed* (evolving at an exponential, rather than linear, pace); *breadth and depth* (affecting individuals but also businesses, economy and wider society); and *impact* (transforming entire systems within and across countries).

#### **Box 4.2 Industrial revolutions as they relate to the food industry**

- **1st industrial revolution (from late-18th century): Mechanical production** in which water/steam powered technology substituted for manual craft skills to support manufacturing. Tasks were simplified into a set of smaller tasks that could be sequenced and automated. More, albeit less skilled, workers were required to oversee greater production output. This resulted in shorter production times, larger volumes and lower priced outputs e.g. large scale production of staple ingredients such as sugar and flour
- **2nd industrial revolution (from late-19th century): Mass production** in which electrification and further automation in the assembly line, supported higher volume production; either as continuous process or batch production. New automation in assembly lines reduced the need for manual production tasks as well as hauling, and conveying, of materials. This reduced the requirement for unskilled workers but needed more skilled workers who could operate the machinery, and highly educated staff providing managerial services to oversee complex operations. This resulted in much shorter production times, high volume production, lower priced outputs with expanded markets e.g. mass production of a limited range of products and, as technologies advanced, commercial production of canned and pasteurized foods with longer shelf lives.
- **3rd industrial revolution (from mid-20th century): Computerisation** in which computing and internet technologies further automated routine knowledge tasks in labour and managerial services. This complemented the provision of more abstract and creative services expanding high skilled employment. This has recently contributed to a polarised labour market; a growth in high-income knowledge jobs and low-income manual workers, and a hollowing out of middle-income workers. This has supported mass production of composite food products such as ready-to-eat meals and energy dense foods fortified with vitamins and minerals.
- **4th industrial revolution (from early 21st century): Digital technology and innovation** are driving the emergence and fusion of technology breakthroughs, including: artificial intelligence, robotics, the Internet of Things, autonomous vehicles, 3D printing, nanotechnology, biotechnology, materials science, energy storage, and quantum computing. The Internet of Things combined with sophisticated control systems, advanced software and advanced sensory technologies, is enabling the automation and control of all operations in one cyber-physical industrial system (an 'autonomous ecosystem of firms' rather than a linear supply chain) capable of moving towards mass customisation e.g. customised and personalised food products with improved traceability, safety and quality.

<sup>16</sup> Bader et al (2018), Soosay et al (2018), Schwab (2017), Frey et al (2013)

### 4.3 Projections for labour and automation

In 2013, McKinsey reviewed over 100 prospective technologies to identify 12 technologies that matter; those having most disruptive potential by 2025.

Table 4.3 shows these 12 technologies ranked by potential economic impact.

The 4th industrial revolution is enabling digital technologies to increasingly take on non-routine tasks and roles that have long belonged to humans alone<sup>17</sup>. Operational tasks have different automation potential, those with significantly:

- **Higher potential** include tasks that involve: collecting data; processing data; and performing physical activities and operating machinery in predictable situations.

- **Lower potential** include tasks that involve: managing and developing people; applying expertise to decision-making, planning, and creative tasks; interfacing with stakeholders; performing physical activities and operating machinery in unpredictable situations<sup>18</sup>.

Operational tasks that are likely to be automated earliest are those with predictable physical activities (particularly those prevalent in manufacturing and retail), and those that involve collecting and processing data (across all sectors, skills and wages).

*Table 4.3: Twelve potentially economically disruptive technologies, ranked by potential economic impact to 2025<sup>19</sup>*

RANK	TECHNOLOGY	DESCRIPTION
1	Mobile Internet	Increasingly inexpensive and capable mobile computing devices and Internet connectivity
2	Automation of knowledge work	Intelligent software systems that can perform knowledge work tasks involving unstructured commands and subtle judgments
3	The Internet of Things	Networks of low-cost sensors and actuators for data collection, monitoring, decision making, and process optimization
4	Cloud technology	Use of computer hardware and software resources delivered over a network or the Internet, often as a service
5	Advanced robotics	Increasingly capable robots with enhanced senses, dexterity, and intelligence used to automate tasks or augment humans
6	Autonomous and near-autonomous vehicles	Vehicles that can navigate and operate with reduced or no human intervention
7	Next-generation genomics	Fast, low-cost gene sequencing, advanced big data analytics, and synthetic biology ("writing" DNA)
8	Energy storage	Devices or systems that store energy for later use, including batteries
9	3D printing	Additive manufacturing techniques to create objects by printing layers of material based on digital models
10	Advanced materials	Materials designed to have superior characteristics (e.g., strength, weight, conductivity) or functionality
11	Advanced oil and gas exploration and recovery	Exploration and recovery techniques that make extraction of unconventional oil and gas economical
12	Renewable energy	Generation of electricity from renewable sources with reduced harmful climate impact

<sup>17</sup> Brynjolfsson and McAfee (2012, 2016)

<sup>18</sup> McKinsey (2017)

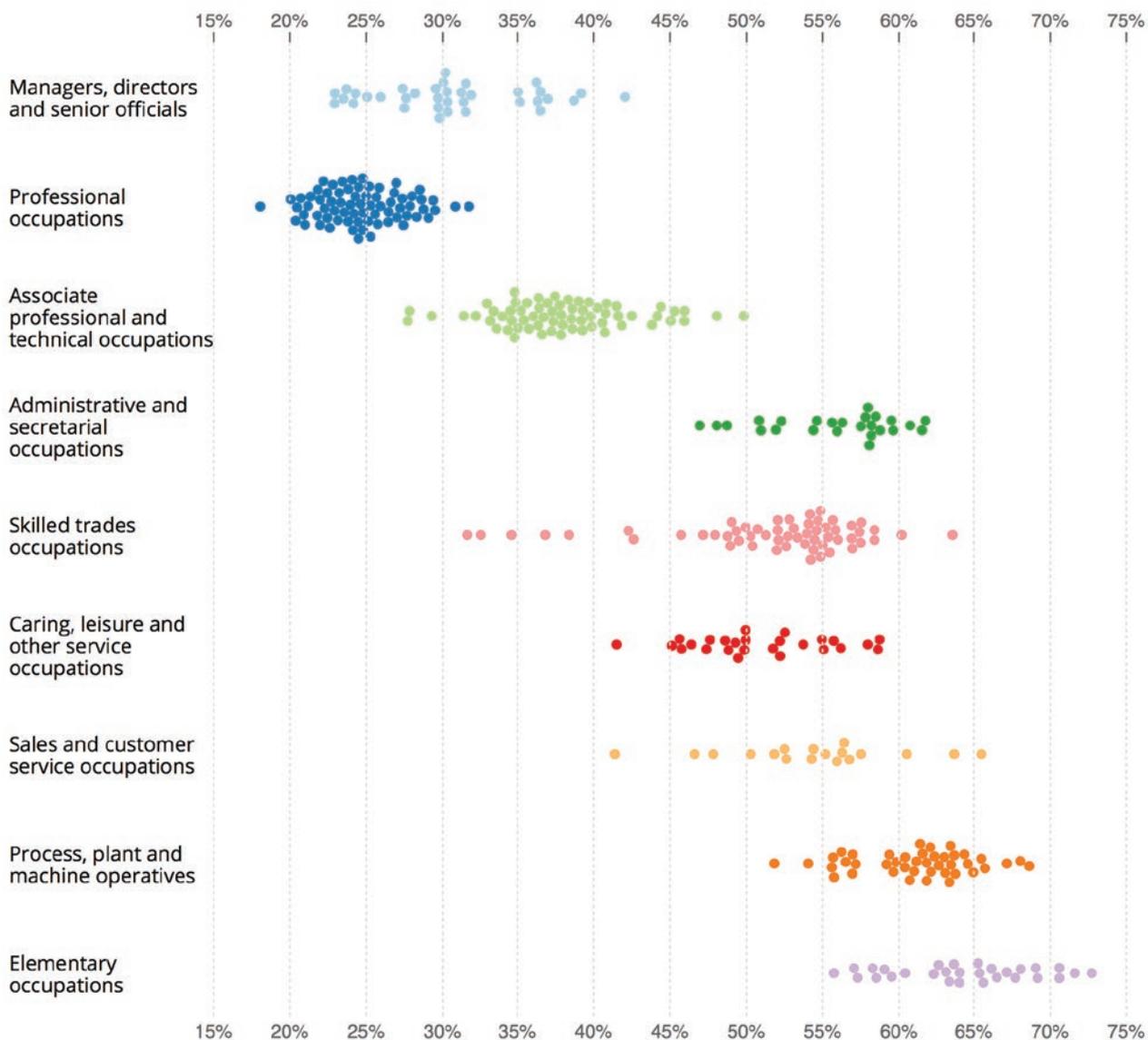
<sup>19</sup> McKinsey (2013)

On the basis of currently demonstrated technologies, McKinsey (2017) estimate:

- Very few job roles are likely to be full automated today (i.e. all activities in the job role is automated) – less than 5 percent, however
- Almost every job could be partially automated (i.e. a significant percentage of its activities could be automated).
- About half of all the activities undertaken by the global workforce could potentially be automated by adapting currently demonstrated technologies.

Automation derived from artificial intelligence and machine learning is due to impact considerably on job roles in the next 10 to 20 years. According to some estimates, 47% of jobs in the United States, and 35% of jobs in the UK, are at high risk of being automated<sup>20</sup>. As an indication, Figure 4.4 shows the recently produced probability of automation across major occupations in England (in other areas of the UK sample sizes are too small).

Figure 4.4: The probability of automation in England: 2011 and 2017<sup>21</sup>



<sup>20</sup> Frey et al (2013, 2015), Nedelkoska et al (2018)

<sup>21</sup> Office for National Statistics (2019)

The type of job roles likely to be in demand in future will be those involving tasks difficult to automate; those involving complex problem solving, and social and systems skills. These include job roles based on: **social intelligence** (e.g. navigating and negotiating complex social relationships); **cognitive intelligence** (e.g. creativity and complex reasoning); and **perception and manipulation** (e.g. conducting physical tasks in changeable environments)<sup>22</sup>.

However, those technologies that can automate operational tasks are not expected to be taken up immediately. For McKinsey (2017), the pace/extent of automation will be influenced by five key factors:

- **Technical feasibility**; including invention and adaptation into automating solutions.
- **A business case for adoption**; including the cost of developing and deploying solutions.
- **Labour market conditions**; the supply, demand, and cost of human labour as the main substitute option to automation.
- **Economic benefit**; including higher throughput or quality, and reduced labour cost.
- **Regulatory and social acceptance**; issues including safety, liability, privacy, job security, etc can create barriers.

If all five factors act against automation then full potential could be achieved by 2055, if they are supportive of automation then full potential could be as early as 2035 i.e. *the next 15 years*.

#### 4.4 Alternative scenarios

The above projections take the view that automation is necessary, and will be broadly positive. For McKinsey (2017), automation will be a necessary support to a smaller workforce having to support an ageing population. However, alternative scenarios<sup>23</sup> suggest:

- more dramatic change (alarmists, dreamers);
- change will be more limited (incrementalists, sceptics);
- more pessimistic outcomes – where automation leads to technological unemployment on a massive scale, growing inequality with prosperity declining for labour providers but increasing for those providing capital generating widespread social and political unrest; or
- more optimistic outcomes – where automation displaces workers but reduces prices (sometimes to zero), increases productivity and digital innovation, and generates new jobs for displaced workers, ushering in a new era of prosperity.

Finally, systemic global change, notably food security and climate change, also act as multipliers to amplify the above change pathways and their impacts (threats and opportunities). Food security tensions may drive investment in technology (e.g. for more efficient aquaculture and capture) technology to secure control and provide assurance. Meanwhile climate change may create more unstable situations e.g. generating increased uncertainty in supply and change in raw materials either advancing or impeding the use of new technologies.

---

<sup>22</sup> World Economic Forum Future of jobs report in Schwab (2017), Frey et al (2013)

<sup>23</sup> Brynjolfsson and McAfee (2012,2016), Turner (2018), Dellot et al (2017), Schwab (2017)

# 5

## UK seafood, labour and automation – recent and anticipated developments

This section considers how labour and automation may evolve into the future. An overview of how supply chains could look in future is provided before highlighting examples of how new technology may be, and in some cases already is, deployed in various sectors.

### 5.1 Digital intelligence driven food production and consumption

The 4th industrial revolution has the potential to reinvent the supply chain whilst addressing a number of challenges facing the food industry. The ability to machines connected through the internet to manage production, storage and transportation, manufacture products and adapt to new processes, in response to – and in anticipation of – market and sales, with limited human guidance suggests the potential for intelligent food production and consumption systems. Bader et al (2018) illustrate the ‘system’ role played by new Industry 4.0 digital technologies that support automation and co-ordination on a single platform across an ecosystem of different actors in food delivery. See Figure 5.1.

For some, the digital transformation from a linear supply chain to an ‘autonomous ecosystem of firms’ will follow a maturity pathway. This pathway involves the following stages:

- **‘Computerization and Connectivity’**: connecting isolated technologies in separate organisations.
- **‘Visibility and Transparency’**: real time event information from several points in the supply chain.
- **‘Predictive capability’**: end to end supply chain data used to prepare for future scenarios, through to
- **‘Adaptability and Self-learning’**: shared data driving autonomous response from supply chain operators) <sup>24</sup>.

Although an autonomous ecosystem of firms may be a distant prospect in seafood, disruptive digital technologies may be unlocking meaningful progress towards that point. Initial steps on this maturity pathway are already underway with the uptake of a number of disruptive technologies. According to the FAO (2018), disruptive technologies notable for the seafood industry include:

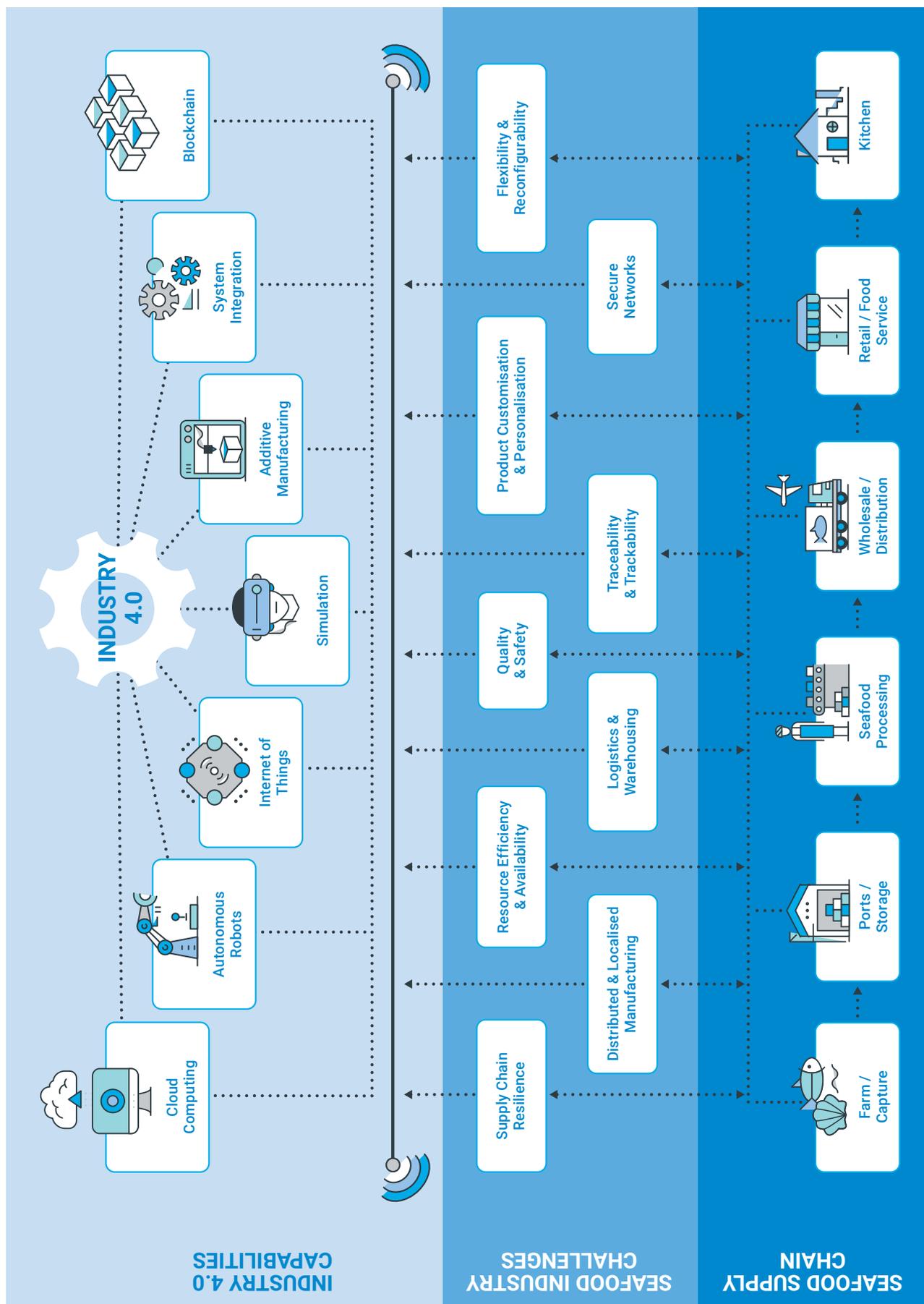
- The proliferation of **sensors** that monitor environmental signals including audio (e.g. voice recognition), visual (e.g. images and videos) and physical (e.g. temperature, pressure and location) signals, provide status reports and receive instructions, could enable new services.
- **Blockchain technology** that avoids storing data on centralized databases or servers in a single organisation, but rather stores information on a network of computers as a distributed ledger, that could improve transparency and traceability.
- **Automatic identification systems (AIS)** that allows vessel identity, position, speed and navigational status to be broadcast at regular intervals, improving safety. Satellite technology can track and video individual vessels in mid ocean, monitoring their fishing activity and helping to reduce Illegal, unreported and unregulated (IUU) fishing.

Other disruptive technologies could contribute further benefits. These benefits include safer fishing (through better weather forecasting), more precise fishing (with support from satellite positioning), and more sustainable fishing (gathering and storing information to improve compliance with regulations and traceability). In addition advanced robotics can support automatic fish filleting, the Internet of Things can support electronic fish tagging, and mobile internet can provide real time market prices for fish.

---

<sup>24</sup> Schuh et al (2017) in Soosay et al (2018)

Figure 5.1: The relationship between Industry 4.0 capabilities and the food supply chain in tackling the challenges facing the food industry (from Bader et al, 2018)



The digital transformation pathway can also be illustrated in terms of seafood job roles. Table 5.2 shows the portfolio of seafood job roles (in table 3.1) and an indicative probability of their automation in the future. This illustrates how those job roles that are focussed on routine (manual or mental) tasks have a higher probability of automation (see dark grey cells). There are also a range of seafood job roles that involve non-routine tasks that could potentially be automated with new digital 'intelligent' technologies. Job roles least likely to be automated are those required to complete non-routine tasks in changeable environments e.g. negotiating relationship roles, creative roles, complex problem solving, and manual tasks in changing situations.

The following sections provide examples of automation already deployed, or having potential for future deployment, in different sectors.

## 5.2 Primary production

Some sectors in the primary production stage have introduced substantial automation. In some instances automation is at such a level that the labour requirement has been reduced to critical roles providing expert oversight and co-ordination.

In wild capture fishing, larger vessels targeting high volume pelagic species have invested heavily in automating catching tasks. Navigating and targeting of these species still requires expert knowledge but this is supported through digital technologies, for example sonar is used to find fish and experiments have been conducted with drone technology. Catching is highly sophisticated with co-ordinating sensors on nets, as well as trialling of laser arrays (rather than wires/ropes), to guide fish into the nets. Being highly species/size selective, on board handling can be automated with very efficient pumps able to guide fish into refrigerated sea water tanks, and able to pump the catch onshore.

In whitefish and shellfish, automation is more limited and the demand is for flexible labour given the higher range of non-routine tasks in these lower volume, more diverse, fisheries. Where automation has been deployed, particularly in larger vessels in whitefish, this has supported navigation, catching, on board handling and landing. Digital technologies such as radar, GPS and video plotters – and in the case of shellfish potters, the use of echo sounders to monitor depth and seabed type – have supported the knowledge of the skipper in navigation and finding target fish species.

Mechanical technologies such as modern net drums and winches, pulse fishing and hydraulic tipping of dredges, have helped automate gear handling and catch. These mixed fisheries can involve additional on board handling tasks such as selectivity of size and species (grading); this can be labour intensive however mechanisation is able to support subsequent movement, washing, weighing and labelling of fish whilst digital technologies facilitate e-log reporting of catch information.

Some larger vessels in shellfish have introduced on board freezing. Landing of catch is also mechanised with the use of nest boxing and cranes. Smaller vessels rely heavily on crew to undertake catching tasks, with some automation solutions from larger vessels adjusted and adopted for specific uses. In some cases smaller vessels leave selectivity tasks to be done onshore where selection is automated using sorting machines.

Table 5.2: Seafood job roles and indicative probability of automation\*

PRIMARY PRODUCTION		PORTS	PROCESSING		OUTLETS	
Fishing	Farming		Primary	Secondary	Retail	Food service
Engineer (marine)	Biologist	Logistics supervisors	Food Engineer	Food Engineer	Website tech team	Fish and chip shop Manager
Skipper	Hatchery / Farm Manager	Market supervisors	Technical manager	Technical manager	Warehouse staff	Chef
Mate	Engineer	Auctioneer	Supervisor / team leader	Supervisor / team leader	Fish buyer	Kitchen operative
Deckhand	Operative	Office Administration	Quality Assurance	Quality Assurance	Warehouse staff	Frier
	Farm technician	Port supervisors	Operative	Smoker	Cashier	Preparation
		Port technician	Filleter	Operative	Independent Fishmonger	Office Administration
		Market technician	Forklift truck driver	Filleter	Supermarket Fishmonger	Waiter / Waitress
		Auction technician		Forklift truck driver	Fishmonger Manager	Front of House
					Delivery driver	Counter Service
			Technologist	IT Manager	New Product Development Manager	Marketing Manager
			Sector Specialist	Management Accountant	Public Relations Officer	Chief Executive Officer
			Seafood Buyer	Customer insight Executive	Sales Manager	HR Manager
					Packaging Technology	Logistics

Indicative probability based on Seafish analysis of Frey et al, 2013:

■ High probability of job role automation

■ Medium probability of job role automation

■ Low probability of job role automation

In the last 15-20 years, aquaculture technologies have advanced significantly, helping facilities expand and support high volume production. In farmed salmon, large operations are highly automated with human labour required for oversight and monitoring purposes. At the hatchery stage, automated systems are guided by algorithms rather than expertise/skill, but expert staff are monitoring these systems. CCTV, auto feeder, and auto life system monitoring technologies are used at the on-growing stage. Salmon are harvested live into wellboats and delivered to processing site via pier by fish pump system. Automatic systems handle stunning / killing / bleeding of fish with staff monitoring for fish that aren't suitable. Post slaughter, there is minimal human handling the fish. However, many low volume aquaculture producers remain labour intensive, maintaining infrastructure, attending to cultivated species, and manual harvesting.

### 5.2.1. Scope and opportunity for future automation

There are further automation opportunities in wild capture fishing, particularly in digital technologies. These are usefully reviewed in the recent report by Espersen (Figure 5.2), which explored new automation opportunities in navigation, catching and on board handling:

1. **Internet of the sea:** *the need to have eyes on, and in, the sea to help us better identify locations, species and movements of fish before fishermen gear in the water.*
2. **Selection of target species:** *using different wavelengths and intensities of light to improve selection.*
3. **Autonomous catching vehicles:** *smaller catching devices powered by multiple torpedo shaped autonomous underwater vehicles (AUVs) in front of the fishing vessel. The AUV's can be programmed to always hover.*
4. **Virtual nets:** *deploying laser beams in place of solid trawl doors to create 'virtual nets' at the front of smaller fish catching devices.*

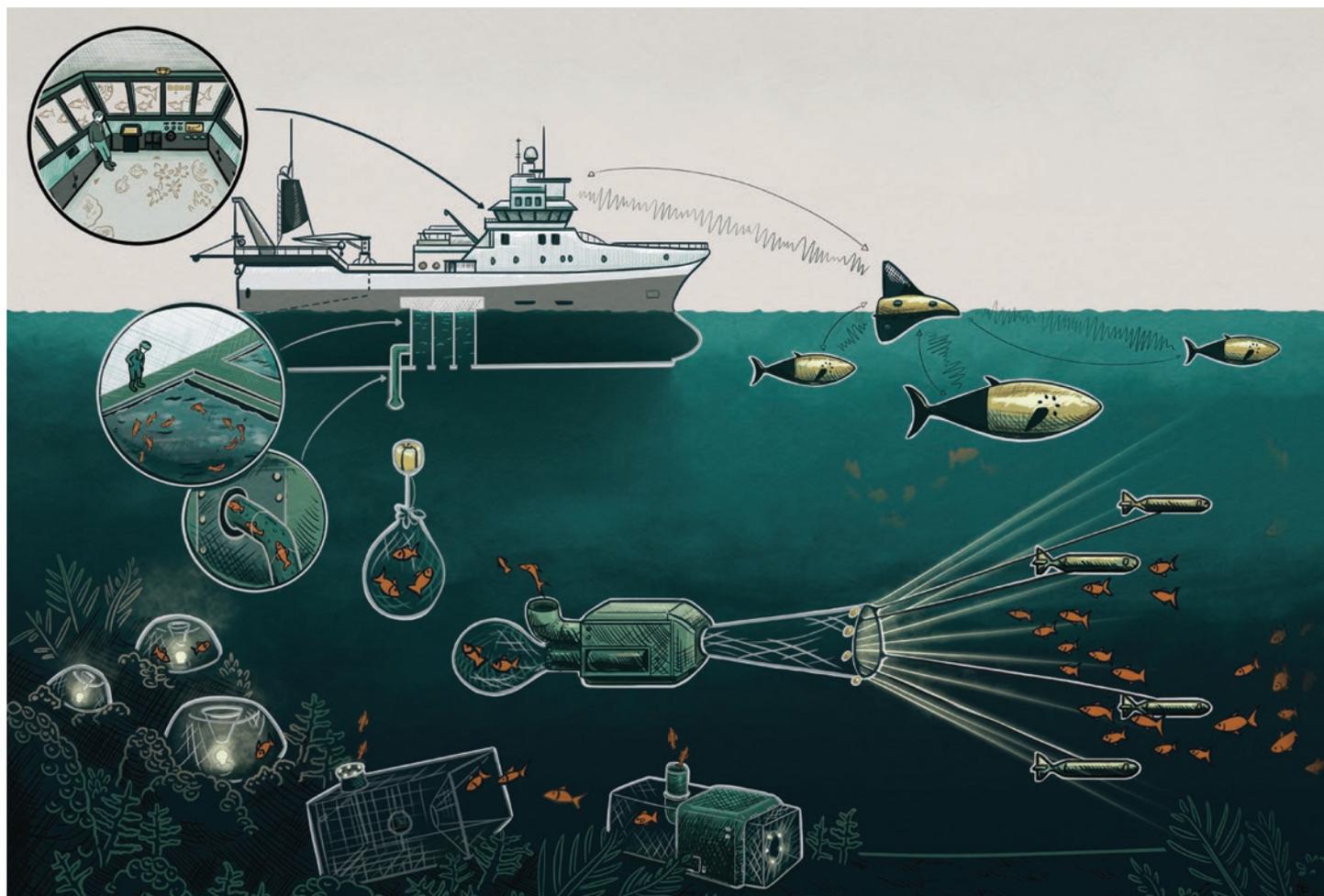
5. **Live fish capture and storing:** *enable fishermen to capture the fish alive in order to make the onboard loading and processing and more controlled and gradual process.*
6. **Fish attractive devices and traps:** *concentrate large numbers of fish in smaller geographic areas to ease the process of catch – either by deploying passive traps, or through smaller catching devices (see above). LED lights, selected for use with particular species, can be applied to attract or repel organisms from a particular area.*
7. **Interactive control room in the wheel house:** *redesign of the skippers' wheel-house on-board the fishing vessel into a high-tech data driven control room.*
8. **Improved processing at sea/live fish:** *includes the storage devices described above, as well as pumps essentially 'hoovering' fish from the sea into the boat for processing or for further live storage in large pools onboard boats (like those developed for off shore salmon farming).*

In aquaculture, there are opportunities to use marine robotics and other technologies to improve primary production. Operational efficiencies and environmental performance could be improved in the near term within current facilities. Longer term, with expanding aquaculture and growing pressure to locate aquatic farms further offshore in more exposed waters, technology could support more radical changes. See for example, closed containment systems to support post-smolt production and on growth (farming in closed tanks) and offshore farming cages<sup>25</sup>.

Marine robotics can enhance observations and other tasks in the underwater environment to support (particularly offshore) aquaculture. Drawing on advances in other sectors, potential lies in Remotely Operated Vehicles (ROVs) to manage subsea infrastructure, and Autonomous Underwater Vehicles (AUVs) to support understanding of the undersea environment e.g. seafloor mapping and imaging. Meanwhile low cost airborne robotics (drones) can support aerial monitoring and inspection.

<sup>25</sup> Marine Harvest (2017)

Figure 5.3: Net positive – Disruptive Seafood Harvesting workshop (Espersen, 2016)



Artificial intelligence is also pushing the boundaries in automating non-routine tasks in aquaculture.

Areas currently being explored <sup>26</sup> include:

- Analysis of fish farming video using software-based logical networks. This can determine: fish size; fish numbers; detect disease, overfeeding and break-ins.
- Transferring facial recognition/artificial intelligence/machine learning techniques used in agricultural production (for cattle feed management) for potential application in salmon aquaculture (better feed management, reducing waste, feed, eutrophication).

The automation opportunities would align with the potential changing job roles in primary production as shown in table 5.1. However, opportunities would be more likely in high volume single species operations (in salmon, pelagic capture, and potentially in whitefish capture). Other operators in low volume production may be expected to remain relatively labour intensive.

### 5.3 Processing

Some parts of the manufactured foods and beverages sector have introduced automation and in-line control systems to a level that means processing is almost labour-free. Within animal protein manufacturing, considerable levels of automation can be achieved where the focus is on a specific animal and are a standard shape and size e.g. chicken.

<sup>26</sup> For example, Innovation Day, North Atlantic Seafood Forum 2019

Nevertheless *“the uptake of industrial robots in food processing has been slow”* (Bader et al, 2018). According to Mitchell (2019) *“the uptake of robotics in meat and poultry processing is 4-6 years ahead of fish processing. Successes have been in routine areas e.g. decanting, pick-and-place, deboning, repacking, end-of-line palletising but are now increasingly in non-routine areas. In poultry, chicken leg deboning has been a particularly successful area for robotic technology given the limited variation in this task (assembly-line systems typically debone 100 pieces per minute). In beef butchery, which has greater variation, and traditionally relied on human touch to assess and make cuts, software and programming creates a 3D model of the carcass that is then used to guide the robotic technology to make the required cuts, then sort and pack individual cuts.”*

In seafood manufacturing, larger seafood processors have already invested and deployed significant levels of automation and robotics in those parts of their operations where this has been feasible. This is largely in high volume manufacturing where the scale and length of production run facilitates automation e.g. frozen sector.

Digital technology is improving performance, allowing automation to move beyond simple, mechanical tasks so that new systems are more flexible and adaptive than mechanical systems. However, even with these advances, automation is still limited in application to processes involving repetitive tasks e.g. fish filleting, trimming, portion cutting, slicing, pack filling, outer case packing and pallet assembly.

For the Seafood Industry Alliance (2017), frontiers in seafood processing technologies include automation in: fish filleting, fish trimming, fish portion cutting, fillet slicing, particulate or fluid dispensing, and ‘pick and pack’ carton handling. The recent development of sensor based technology has enabled more flexible and responsive automation systems, for example fillet trimming, cutting and slicing technologies can ‘see’ the fish and can adjust cutting patterns to

maximise yield or alter portion size/weight. With the ongoing increase in computing power and software capabilities, these technologies continue to evolve.

More complex and short-interval manufacturing lines in fresh and chilled seafood are less suited to task automation. Technology solutions remain less dexterous than human labour (which is ultimately flexible); this can present significant, and potentially insurmountable, barriers to automation – at least with the current technologies available. For smaller companies, longer term potential may lie in collaborative robots (cobots) working alongside humans, particularly as costs fall over time. Cobots can be taught to undertake new tasks and so may be better suited to changeable tasks; including: fetching and carrying of items, final inspection, delivery of ingredients, etc. These are likely to be smaller, safer, slower, and will carry lighter loads than larger robots that are part of an integrated system with dedicated areas that are gated or fenced off<sup>27</sup>.

### **5.3.1. Scope and opportunity for future automation**

The current availability and deployment of automation and robotics in seafood processing (table 5.4) provide an indication of opportunities technology might offer in future:

- In the near term, areas of potential opportunity lie in the uptake of available automation by smaller companies where this is suited to processing of low volumes in short runs.
- In the longer term, improvements and wider uptake of technology might reduce the cost of automation to the equivalent of labour, whilst the development of next generation technologies might support automation in areas not currently possible.

The automation opportunities would align with the potential changing job roles in processing as shown in table 5.1. However, opportunities appear very limited in some areas (e.g. secondary processing) where, even with the deployment of available technologies and next generation solutions, manufacturing is expected to remain a relatively labour intensive industry.

---

<sup>27</sup> Mason (2018)

Table 5.4: Deployment of automation/robotics systems in UK secondary processing, 2018<sup>28</sup>

	AVAILABILITY OF AUTOMATION		
	Available and equal to / better than manual labour cost	Available but more expensive than manual labour	Not currently possible
<b>Defrosting</b>	<ul style="list-style-type: none"> <li>• Process available</li> </ul>		<ul style="list-style-type: none"> <li>• Loading &amp; unloading</li> </ul>
<b>Raw Material Movements</b>		<ul style="list-style-type: none"> <li>• Boxes &amp; palletainer handling &amp; icing</li> </ul>	
<b>Heading / gutting whole fish</b>	<ul style="list-style-type: none"> <li>• Farmed salmon &amp; trout</li> <li>• Round &amp; flat fish of similar size/morphology &amp; processing of high volumes in long runs</li> </ul>	<ul style="list-style-type: none"> <li>• Small scale processing of low volumes in short runs</li> </ul>	<ul style="list-style-type: none"> <li>• Mixed species fish</li> </ul>
<b>Filleting</b>	<ul style="list-style-type: none"> <li>• Good quality fish</li> <li>• Same species /size graded fish in lines processing of high volumes in long runs</li> <li>• Small scale processing of low volumes in short runs</li> </ul>	<ul style="list-style-type: none"> <li>• Lower quality fish</li> </ul>	<ul style="list-style-type: none"> <li>• Outsize fish</li> <li>• Wide size grade fish</li> <li>• Mixed species fish</li> <li>• Artisanal cuts</li> </ul>
<b>De-shelling crustacean</b>	<ul style="list-style-type: none"> <li>• Nephrops for formed formats</li> </ul>	<ul style="list-style-type: none"> <li>• Nephrops for whole tail format</li> </ul>	<ul style="list-style-type: none"> <li>• Crab &amp; lobster</li> </ul>
<b>Trimming</b>	<ul style="list-style-type: none"> <li>• Skinless whitefish &amp; salmon</li> </ul>		<ul style="list-style-type: none"> <li>• Skin on whitefish</li> </ul>
<b>Portioning</b>	<ul style="list-style-type: none"> <li>• All filleted fish of similar size/morphology</li> <li>• Block format products</li> </ul>		<ul style="list-style-type: none"> <li>• Mixed species fish</li> </ul>
<b>Product assembly</b>	<ul style="list-style-type: none"> <li>• Simple multi-component products such as fish in sauce</li> </ul>		<ul style="list-style-type: none"> <li>• Complex product formats such as dressed crab, kebab skewers</li> </ul>
<b>Grading</b>	<ul style="list-style-type: none"> <li>• All round &amp; flat fish</li> <li>• Particulate products such as prawns or scampi</li> </ul>		<ul style="list-style-type: none"> <li>• Large crustacean species</li> </ul>
<b>Placing into retail packs</b>	<ul style="list-style-type: none"> <li>• Bulk packing whole salmon</li> <li>• Fixed weight fillet portions in processing of high volumes in long runs</li> <li>• Depositing particulate products such as prawns, scampi etc.</li> <li>• Depositing fluids such as sauces or marinades</li> <li>• Depositing toppings such as mashed potato or sprinkles such as grated cheese</li> <li>• Economy quality smoked salmon</li> </ul>	<ul style="list-style-type: none"> <li>• Fixed Weight coated &amp; salmon for small scale processing of low volumes in short runs</li> </ul>	<ul style="list-style-type: none"> <li>• Variable weight white fish/whole fish</li> <li>• High quality smoked salmon</li> </ul>
<b>Labelling &amp; coding</b>	<ul style="list-style-type: none"> <li>• Placing packs into sleeves</li> <li>• Date code labelling</li> </ul>	<ul style="list-style-type: none"> <li>• Available but inflexible for frequently changing process lines/small operators</li> </ul>	
<b>Placing into customer cases</b>	<ul style="list-style-type: none"> <li>• Available for lines with consistent product formats/ in processing of high volumes in long runs</li> </ul>	<ul style="list-style-type: none"> <li>• Available but inflexible for frequently changing process lines</li> </ul>	
<b>Palletising / Picking</b>	<ul style="list-style-type: none"> <li>• Available for lines with consistent product formats/ in processing of high volumes in long runs</li> </ul>	<ul style="list-style-type: none"> <li>• Available but inflexible for frequently changing process lines</li> </ul>	
<b>Storage &amp; distribution</b>		<ul style="list-style-type: none"> <li>• Available but expensive due to the flexible pallet movements required</li> </ul>	

<sup>28</sup> Technology and automation in the value-added seafood processing sector, Seafood Industry Alliance (2017)

#### 5.4 Other sectors – logistics, retail and food service

Further automation in the seafood supply chain will be supported by the deployment of new technologies in other non-seafood specific sectors. Related sectors – such as logistics, retail and food service – have a broader set of automation drivers and opportunities which could then accelerate deployment in seafood.

For the RSA (Dellot et al, 2017) the logistics sector – the moving, storing, and organisation of goods across the supply chain – is expected to see the uptake of new technologies in a number of areas. These include:

- **Warehouse robots** that use light and radar to navigate and move pallets.
- **Supply chain management** where shipping companies use artificial intelligence to optimise cargo routes based on live and historic data on weather, congestion etc.
- **Anticipatory logistics** that is primed according to predictive demand for products.
- **Self-driving vehicles** that can autonomously fulfil goods delivery.

Many of these advances may have more potential in rural areas, and be challenging in urban areas, whilst humans will still be required 'for the last mile' delivery to the customer (the non-routine task).

The retail sector is expected to see substantial changes arising from automation. McKinsey (2017) expect digital technologies to transform retail in several ways, resulting in smaller outlets, less inventory, and lower payroll:

- Current online and offline aspects of retail will evolve and merge into a single shopping experience.
- Shelf restocking will be automatised with support from continuous inventory tracking and automated storeroom.
- Current self-checkout kiosks will be phased out in favour of automatic payout via mobile phones and follow-on delivery.
- Robots will be used for cleaning and shelf restocking, autonomous vehicles for delivery to store and to consumer.
- Data analytics will support retailers and suppliers to customise and target promotions.

For the RSA (Dellot et al, 2017), new digital technologies could support some outlets to offer customers a highly automated, low cost, retail experience, whilst other outlets could focus on human experience. Notable advances are expected in:

- **Automated inventory management:** with artificial intelligence to monitor inventory and predict fluctuations in demand.
- **Chatbot retail assistants:** using artificial intelligence interfaces, on websites and physical store locations, to naturally converse with consumers and enrich the consumer experience.
- **Enhanced search engines:** allowing customers to submit visuals of a product to an image based search engine that can then match related products.
- **Automated e-commerce design:** using artificial intelligence to rapidly test, secure feedback and refine website content.

Whilst impacts could be severe for current job roles, they could also end up playing a supporting role where task delivery concludes with a human touch.

Food service, where human experience is a central feature, the potential for transformation appears less clear. For Citi-GPS (2016) technology is driving food service sector changes in three areas; **digital ordering, loyalty** and **labour**. Changes in digital ordering can already be seen in:

- Quick Service Restaurant (QSR) outlets capitalising on the use of smartphones, using mobile apps to drive convenient ordering, particularly for millennials. Customers can choose an outlet, browse, select and customise food items, view the estimated timeframe for order being ready, and pre-pay.
- Casual dining outlets using tablet based ordering systems on table-tops so customers can see menu items, play games, view news, order food, pay the bill, and providing feedback.

These changes provide numerous immediate benefits but longer term these self-service technologies could save food service outlets securing scarce labour.

BRITA Professional (2019) surveyed 750 hospitality professionals for their views on the world of food, drink and hospitality towards 2044, and found that eating out will see:

- Hospitality businesses, with 'back of house' capabilities, providing 24/7 food and multisensory experience 'front of house'.
- Restaurants expected to:
  - provide innovative food, but also entertain and stimulate the senses
  - be flexible spaces that can deliver menus tailored to different experiences, supported by technology, lighting, and sound.

To support this, future kitchens will be '*streamlined spaces with adaptive technology that can customise food to the varying requirements of sophisticated consumers and creative chefs*'. Automation will include:

- Food preparation technology, for example devices that can support weighing, washing and chopping.
- Artificial intelligence to analyse food servings for: weight and portion size; temperature; and detecting foreign objects.

Other opportunities include product innovation eliminating single use plastics, smart cleaning, and methods to achieve zero waste.

# 6

## UK seafood, labour and automation – impacts and response to longer term developments



The level of automation in UK seafood shows clear differences across supply chains, with high volume chains much more automated than low volume chains. High volume chains with continuity of supply have a higher share of standard, routine tasks making them more amenable to automation. These chains include domestic pelagic and salmon, but also include international sourced whitefish, pelagic, shellfish and salmon (particularly high volume frozen). Low volume chains, with inherent variability and a high share of non-routine tasks, tend to be labour intensive. These chains include domestic shellfish and whitefish, and international sourced whitefish, pelagic, shellfish and salmon (particularly low volume fresh).

Different labour/automation choices are associated with contrasting performance in industry productivity (measures of return over cost):

- A number of large (whitefish and pelagic) vessels with sophisticated automation are highly productive.
- A number of mid-sized processors are highly productive, however a number of large sized companies have lower productivity. The weaker productivity of larger companies may be a consequence of automating high volumes at lower yields, serving price conscious markets. It may also reflect the limitations of traditional automation as task requirements are non-routine in fresh and chilled lines and increasingly so e.g. in secondary processing.

The current labour/automation profile across industry is to be expected, given the balance of drivers across the supply chain in recent years:

- The nature of seafood tasks are routine and non-routine, with the balance dependent on the species being handled and sophistication of final product:
  - Whitefish, mixed fishery, fluctuating supplies, variation in species, size and quality.
  - Pelagic, targeted fisheries, relatively standard primary products.
  - Shellfish, mixed fishery, fluctuating supplies, variation in species, size and quality.
  - Salmon, targeted production, relatively standard primary products.
- The availability and cost of labour has been supported by migrant labour:
  - UK membership of the EU has provided access to relatively low cost labour from Eastern European countries and elsewhere in the bloc.

- The availability and cost of technology has supported mechanical automation:
  - With historical advances focussed on mechanisation, this has directed automation towards supporting standard, routine tasks.
- Investment conditions for automation in seafood are mixed due to available volume and nature of supply:
  - Domestic seafood supply chains, with the exception of high volume pelagic and salmon, are complex and changeable in nature. Salmon and pelagic supplies, providing high volumes of relatively stable supplies and standardised products, are more concentrated sectors, strengthening investment conditions.
  - Whitefish, and shellfish supplies, providing lower volumes of fluctuating supplies, a diverse range of products, and more fragmented sectors, weakening investment conditions.

Longer term drivers suggest a number of changes over the next 10 years that could change the labour/automation profile across industry:

- The availability and cost of labour is likely to be more challenging:
  - In the near term, preparations for UK departure from the EU are already impeding access to relatively low cost labour from that source. Longer term an ageing population and shrinking workforce will mean increasingly tight and competitive labour markets.
  - New technology may automate a range of current jobs, providing the opportunity for new roles; for example around managing and negotiating relationships in the supply chain, and complex problem solving.

- The availability and cost of technology is likely to improve:
    - Automation through new digital technologies has the potential to support non-routine tasks, supporting not just efficient but also flexible production.
    - With new technologies increasingly supporting non-routine tasks, there may be new opportunities in:
      - > High volume chains; unlocking value that could not be delivered previously i.e. new technologies improving the automation of existing tasks, or supporting new tasks that could not be achieved manually or mentally. This includes precision-fishing in the catching sector and a shift towards mass customisation for large volume processors.
      - > Low volume chains; supporting or undertaking tasks only labour could have delivered previously. This could include supportive automation as, for example cobots (collaborative robots), become a more cost effective solution for small operators.
      - > Longer term, digital technologies – sensors, blockchain, AIS, etc – may help deliver new added value services and enable new organisational arrangements such that *'supply chains of the future should be viewed as an autonomous ecosystem of firms rather than traditional linear structures'* (Soosay et al 2018).
  - In seafood, investment conditions may improve due to scale and nature of volume of supply:
    - The UK departure from the EU could mean potentially greater volumes of domestic seafood supply, particularly whitefish. This could provide higher volumes of more stable supplies, potentially consolidating a fragmented sector and strengthening investment conditions.
  - Changes in the availability and cost of labour and automation suggest there is scope for technology application, and improvements in productivity, in low volume sectors. More specifically, there may be opportunities:
    - To improve productivity in mid-sized vessels through technology transfer/new build especially in whitefish with greater share of fish in the UK EEZ.
    - For exploring further automation in the catching sector (whitefish and shellfish), in primary processing (whitefish and shellfish), and in secondary processing (whitefish, pelagic, shellfish).
- Realising the benefits of automation would require long term thinking from industry, certainty from government, support for smaller operators and uptake/collaboration with universities. Specific support actions could include:
- Providing financial support for research and development, easing smaller company participation through sensible criteria (e.g. accepting in-kind contributions at full financial value). There may be an opportunity to establish a new funding competition that could i) incentivise new thinking and development opportunities for automation and robotics, and ii) act as a vehicle to drive next generation applications.
  - Canvassing industry for research and development project opportunities and provide cost/benefit analyses to incentivise engagement. This could involve a study of the uptake of existing automation and robotic solutions amongst smaller companies to help identify roll-out opportunities (cost permitting) of known technologies.
  - Identifying and engaging with research partners and technology providers for collaborative projects in research and development.
  - For Seafish, building on this initial work, engaging industry to further these support actions and explore areas of potential opportunity in low volume sectors (whitefish, pelagic, and shellfish and secondary processing).

# **Bibliography and Appendices**

## Bibliography

- Aberdeenshire Council (2018) Labour market report 2017. Available at <https://www.aberdeenshire.gov.uk/media/22985/labour-market-2017-aberdeenshire.pdf>
- All-Party Parliamentary Manufacturing Group (2015) *Making Good: A study of culture and competitiveness in UK manufacturing*. Policy Connect. [www.policyconnect.org.uk/apmg](http://www.policyconnect.org.uk/apmg)
- Bader, F. and Rahimifard, S. (2018) *Challenges for Industrial Robot Applications in Food Manufacturing*. pp. 1–8. doi: 10.1145/3284557.3284723.
- BRITA Professional (2019) *Hospitality in 2044: can you predict the future?* Life is Better Filtered – Catering School of Expertise toolkit. [https://issuu.com/britaprofessional/docs/190903-brita-toolkit-final-single\\_page\\_version](https://issuu.com/britaprofessional/docs/190903-brita-toolkit-final-single_page_version)
- Brynjolfsson, E. and McAfee, A. (2012) *Race Against the Machine: How the Digital Revolution is Accelerating Innovation, Driving Productivity, and Irreversibly Transforming Employment and the Economy*.
- Brynjolfsson, E. and McAfee, A. (2016) *The Second Machine Age – Work, Progress, and Prosperity in a Time of Brilliant Technologies*.
- Dellot, B and Stephens, F.W. (2017) *The Age of Automation: Artificial intelligence, robotics and the future of low-skilled work*. Royal Society for the encouragement of Arts, Manufactures and Commerce.
- Encyclopaedia Britannica (<https://www.britannica.com/technology/automation>)
- Espersen (2016) *Disruptive Seafood Harvesting Workshop: To create and build support for innovative selective harvest design concepts*. Espersen, July 2016.
- FAO (2018) State of World Fisheries and Aquaculture. United Nations Food and Agriculture Organisation.
- Frey, C.B. and Osborne, M. (2013) *The Future of Employment: How Susceptible Are Jobs to Computerisation?* Oxford Martin School, Programme on the Impacts of Future Technology, University of Oxford.
- Frey, C.B. and Osborne, M. and Citi-GPS (2015) *Technology at Work: The Future of Innovation and Employment*. Oxford Martin School, Programme on the Impacts of Future Technology, University of Oxford.
- Frey, C.B. and Osborne, M., and Citi-GPS (2016) *Technology at work v2.0: The Future Is Not What It Used to Be*. Oxford Martin School, Programme on the Impacts of Future Technology, University of Oxford.
- Gartner (2019) Gartner hype cycle. <https://www.gartner.com/en/research/methodologies/gartner-hype-cycle>
- ICF Global Consulting (2018) Getting ahead of the global workforce crisis. The Spark blog (<https://www.icf.com/blog/human-capital/global-workforce-shortage-solutions>)
- Marine Harvest (2017) *Exploring new technology platforms*. North Atlantic Seafood Forum, Seafood Innovation Day, Bergen. March 2017.
- Mason, A. (2018) Could the UK miss out on the Robot revolution? The Grocer. 11 August 2018.
- McKinsey (2013) *Disruptive technologies: Advances that will transform life, business, and the global economy*. McKinsey Global Institute.

- McKinsey (2017) *A future that works – automation employment and productivity*. McKinsey Global Institute.
- McKinsey (2017) *Artificial Intelligence: The next digital frontier?* McKinsey Global Institute.
- McKinsey (2018) *Solving the United Kingdom's Productivity puzzle in a digital age*. McKinsey Global Institute.
- Migration Advisory Committee (2018) *EEA migration in the UK: Final report*.
- Mitchell, M. (2019) *Robotics technology: fish processing*. Presentation by LeanTeamGB at the Scottish Seafood Summit, 2019.
- Marine Management Organisation (2017) *UK Sea Fisheries Statistics*.
- Nedelkoska, L. and G. Quintini (2018) *Automation, skills use and training*, OECD Social, Employment and Migration Working Papers, No. 202, OECD Publishing, Paris. <http://dx.doi.org/10.1787/2e2f4eea-en>
- Office for National Statistics (2018) *Regional Labour market bulletin*. (<https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/bulletins/regionallabourmarket/november2018>)
- Office for National Statistics (2019) *The probability of automation in England: 2011 and 2017*.
- Schuh, G., Anderl, R., Gausemeir, J., Hompel, M. T., and Wahlster, W. (2017). *Industrie 4.0 maturity index: Managing the digital transformation of companies*. Acatech Study, Munich: Herbert Utz Verlag.
- Schwab, K. (2017) *The Fourth Industrial Revolution*. World Economic Forum.
- Seafish (2018) *Fleet survey report 2018*. Sea Fish Industry Authority.
- Seafish (2018) *Processing sector labour reports*. Sea Fish Industry Authority. (<https://www.seafish.org/article/2018-seafood-processing-sector-labour-report>)
- Seafish (2018) *Processing sector census 2018*. Sea Fish Industry Authority.
- Seafish (2014) *Processing sector financial survey 2014*. Sea Fish Industry Authority.
- Seafish (2016) *Processing sector report 2016*. Sea Fish Industry Authority.
- Seafood Industry Alliance (2017) *Technology and automation in the value-added seafood processing sector*. SIA response to the Food Chain Directorate survey, July 2017.
- Soosay, C and Kannusamy, R. (2018) *Scope for Industry 4.0 in agri-food supply chains*. Proceedings of the Hamburg International Conference on Logistics – 25.
- Turner, A (2018) *Capitalism in the age of robots: work, income and wealth in the 21st-century*. Lecture at School of Advanced International Studies, Johns Hopkins University Washington DC April 10th 2018.
- Vidarsson, J. (2019) *Automation: Lessons from Iceland*. Presentation by Matis at the Scottish Seafood Summit, 2019.

## Appendix 1 – Consultees and other contributors

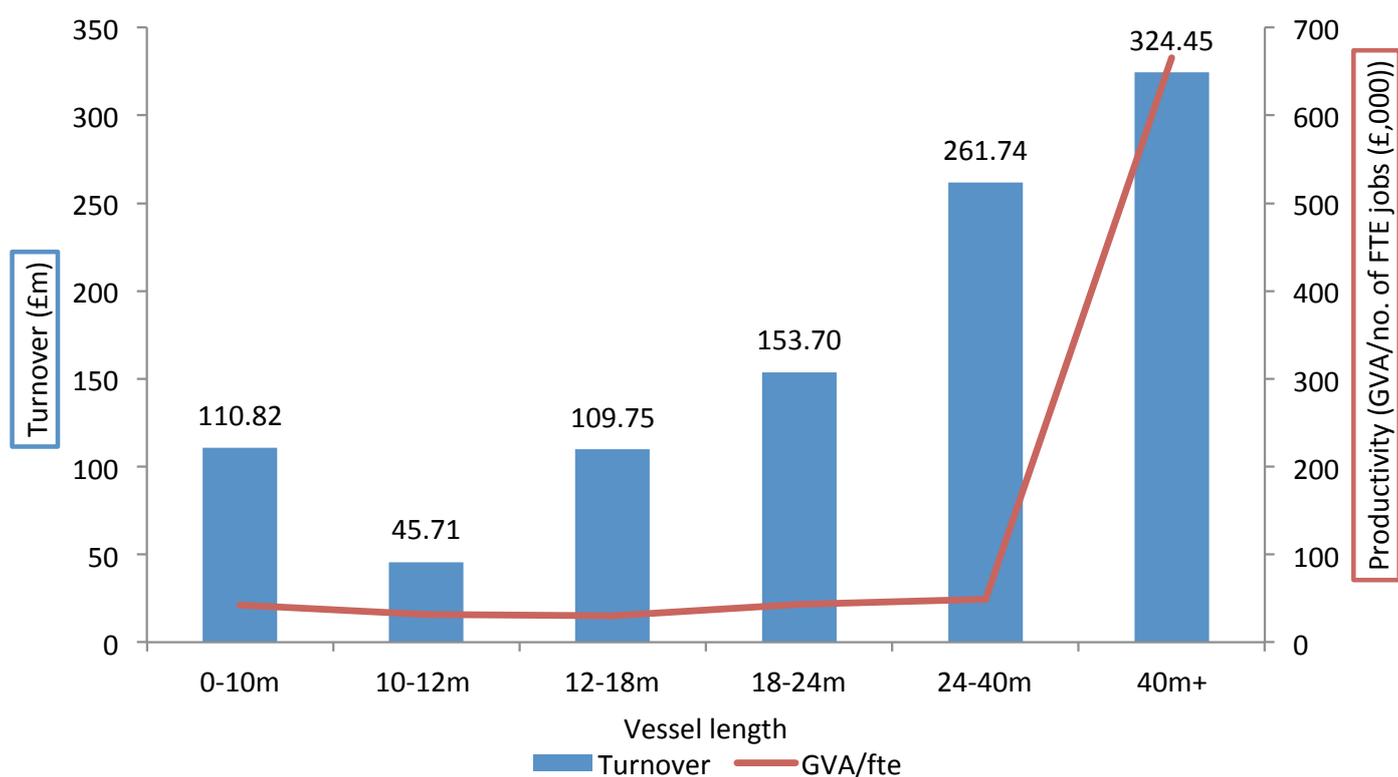
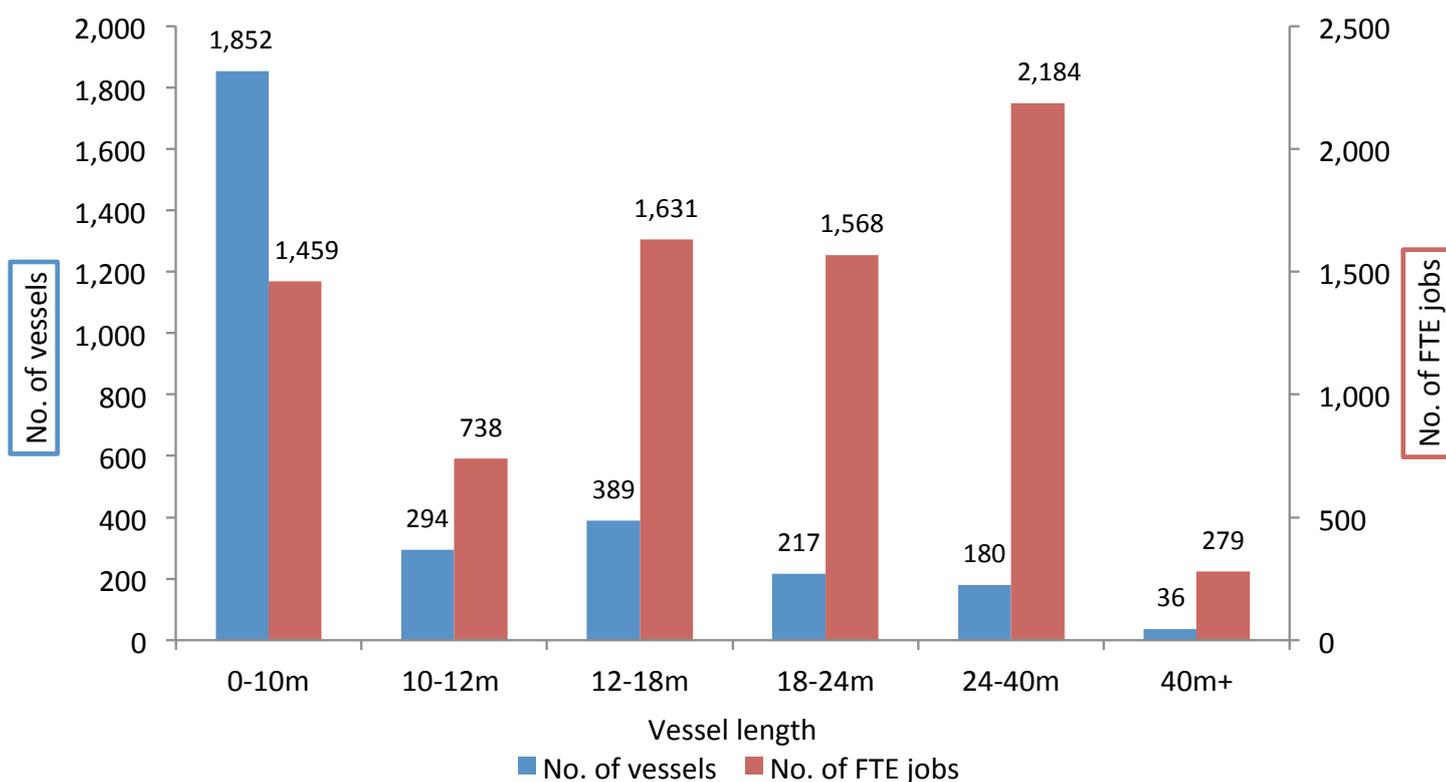
1. Michaela Archer, Seafish
2. Craig Burton, Seafish
3. Lee Cocker, Seafish
4. Andy Gray, Seafish
5. Marcus Jacklin, Seafish
6. Mike Montgomerie, Seafish
7. Richard Wardell, Seafish
8. Gavin Hatton, Seafish
9. Gus Caslake, Seafish

## Appendix 2 – Sector structure employment and productivity

Source: Seafish Processing Sector Census 2018, Seafish Processing Sector Financial Survey 2014, Seafish Fleet survey 2018

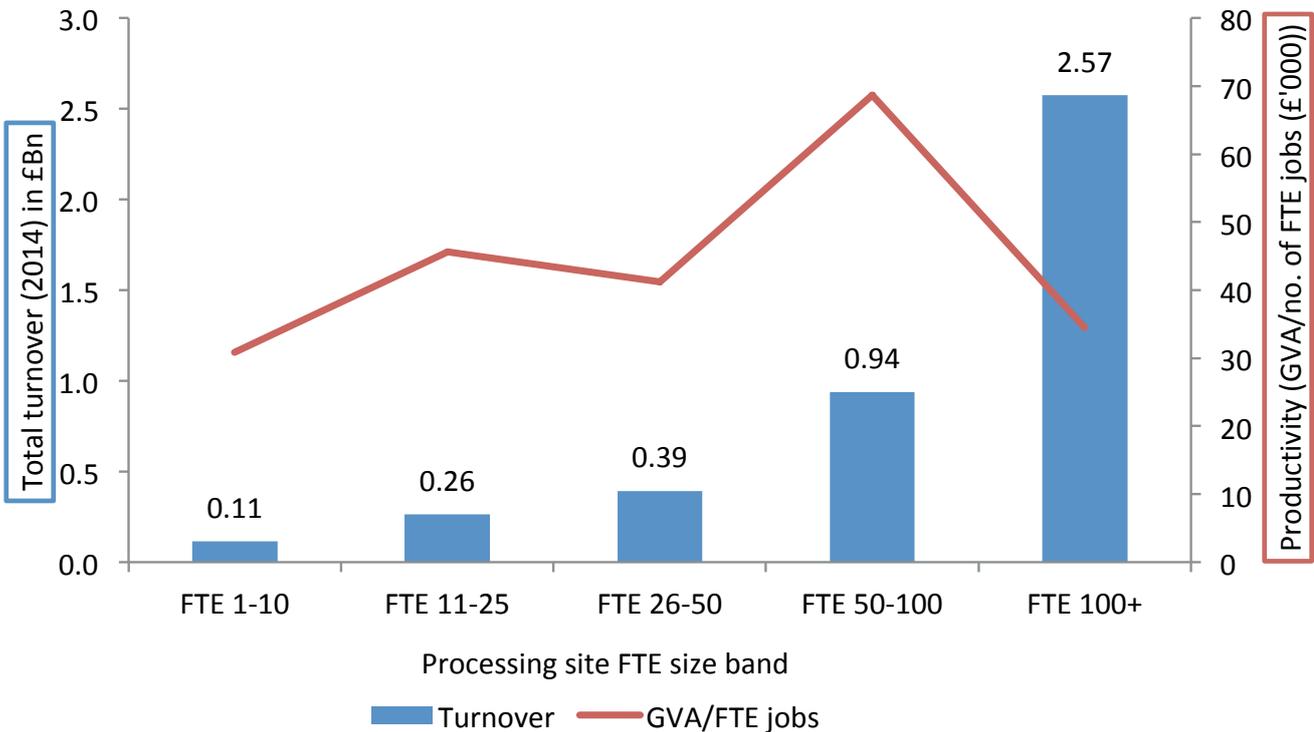
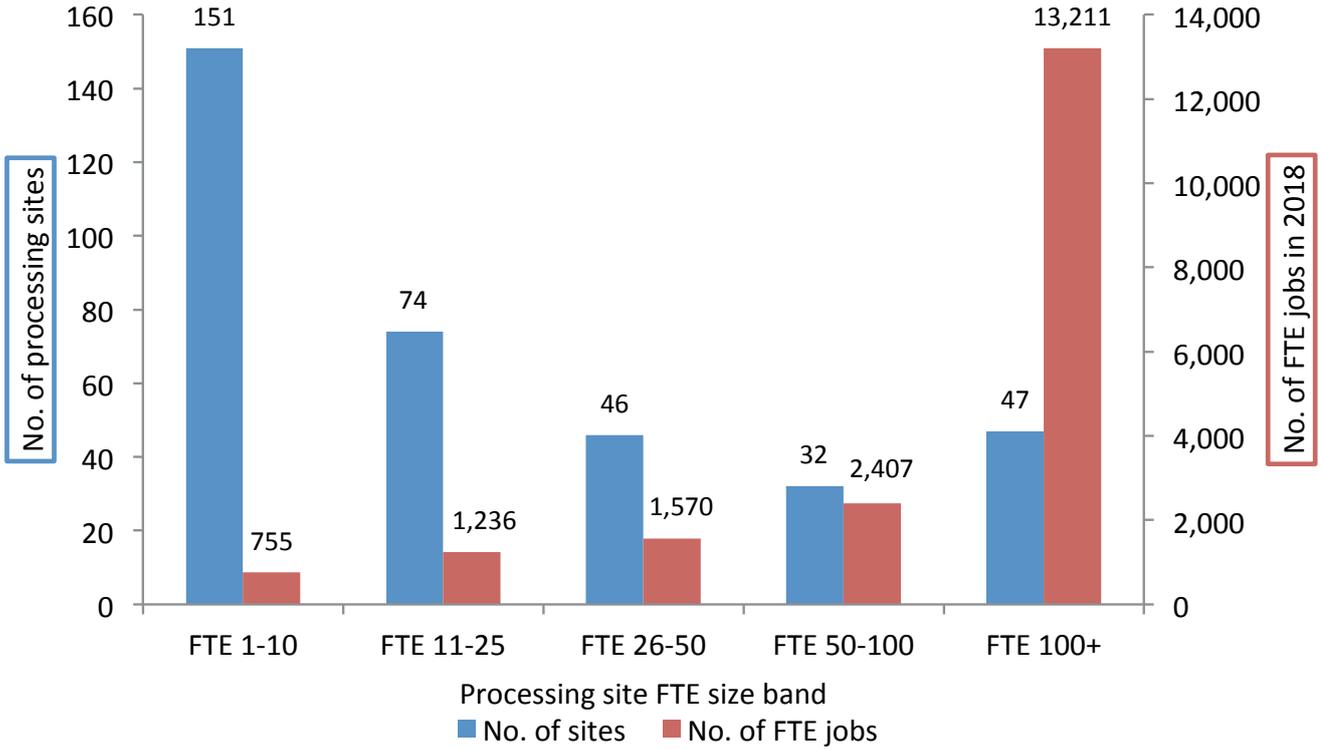
### UK catching sector (preliminary data for 2018)

Level 1: All vessels



**UK processing sector (preliminary data for 2018)**

Level 1: All processing sites





**Seafish**

18 Logie Mill  
Logie Green Road  
Edinburgh  
EH7 4HS

[www.seafish.org](http://www.seafish.org)  
[seafish@seafish.co.uk](mailto:seafish@seafish.co.uk)  
0131 524 8697

© Seafish March 2020

The Seafish logo features the word "seafish" in a white, lowercase, sans-serif font. Above the letters "a", "i", and "h" are three stylized white fish icons, each with a curved body and a pointed tail, arranged horizontally.

**seafish**