Maine Aquaculture Workforce Development Strategy

Evidence Report

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MAY 2020

Report Produced by

Gulf of Maine Research Institute
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In Partnership with

The Maine Aquaculture Association

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Contents

1. Introduction: towards a workforce strategy

The purpose of the Strategy is to create a roadmap for meeting the skills and training needs of the aquaculture workforce in Maine as the sector grows and develops.

Objective: to support the development of a structured, ambitious education and training strategy for Maine aquaculture.

Maine's industry structure is unique, as is its market position and potential and this must be reflected in the strategy, anticipating economic opportunities and constraints in the supply chain, and looking ahead to future operational models and challenges. The opportunity to consider the workforce's knowledge and skills requirement at such an early stage in the state's aquaculture development process is particularly noteworthy.

Much of the international experience in relation to aquaculture skills has been gained with hindsight and through retrospective development, which unfortunately often entails proactive providers designing programs to meet industry's current needs opportunistically, making it difficult for the national provision to remain current.

By appropriately scoping out these issues at an early stage and mapping educational needs to each phase of anticipated sectoral growth scenarios, the sector will be in a much stronger position going forward. This creates an opportunity which the team consider to be particularly exciting. Beyond the workforce itself, a broader STEM capability and, crucially, a state-wide understanding of the sector's opportunities is considered.

Global context: This process has been informed by experience of Scottish aquaculture education, with its exemplary industry-led National Qualifications (NQs) development process, and other leading European education and training systems.

1.1. Acknowledgements

The development of the strategy and evidence report have been a team effort and would not have been possible without a wide-ranging team. This includes:

- Implementation Team: the Scottish Team which combined industry and education specialists; Educate Maine, who as part of the core team were invaluable in understanding the Maine and US education framework and the huge diversity of educators.
- Gulf of Maine Research Institute (GMRI): led the extensive project management, visits, communication across the team and connecting with a wide range of stakeholders and industry contacts, provided secondary information, co-developed the industry interview guide and LPA survey; set up and supported the Steering Committee in providing input and oversight of the work for accuracy and tone; reviewed and coordinated amendments on draft documents; and last but not least, administered the majority of the interviews and survey.
- Educate Maine: provided leadership and management support; in delivery, co-developing industry topic guides and providing review for accuracy and tone, Educate Maine brought crucial and extensive knowledge of the education system, its principles, structure, funding, and integration. They also introduced the team to key education and training providers.
- Maine Aquaculture Association (MAA): provided leadership, document review and guidance, insights from extensive knowledge of the sector, and were involved in conducting interviews during the survey process.

  FocusMaine: Thanks go to FocusMaine for funding and broad strategic guidance across the course of the study, and review of evidence to ensure it is as useful as possible for implementation.

However, above all, acknowledgements and thanks are given to all the educators giving critical review and conceptual input through the Aquaculture Workforce Development Steering Committee ('the Steering Committee'), and the extensive commitment, interest, insight and generosity of industry respondents.

2. Methodology

2.1. Introduction

The existing supply of education and training relevant to aquaculture in the state of Maine has been correlated to the industry demand for skills, education and training for all occupational levels from operative to owner/manager. This has established the gaps in provision and barriers to access for both learners and industry, to inform the priorities within the Maine Aquaculture Workforce Development Strategy (AWDS) for the educators to respond to.

Every effort has been taken to ensure that on both industry and educator sides, consultation is as collaborative, comprehensive and inclusive as possible. Given the diversity of organizations and activities covered, understandably some potentially relevant stakeholders may have been missed. Knowledge gaps are to be expected and have been factored into the analysis (caveats and weighting of evidence as appropriate). See appendix for list of all of consultations - including Steering Committee Membership, one on one meetings with education and training providers, survey respondents, and interviewed businesses.

2.1.1. Demand

An analysis of the industry demand for skills, education, training and qualifications was completed on a sector specific basis. An analysis of job descriptions provides a more detailed insight into the knowledge and skills requirements of the main occupations in each aquaculture sector.

This has been correlated to the supply analysis for each education sector and the outcome was presented to the AWDS Steering Committee in October 2019.

This paper includes analysis of the key skills that aquaculture companies require for particular roles and occupations. It is based on the qualitative and some quantitative research (interviews and surveys) undertaken with companies and organizations and is analysed for finfish, shellfish, mixed and organizations described as covering various part of the aquaculture sector in Maine.

The interview / survey process was set out to ensure sufficient contextual detail as much as a quantitative assessment – this is in line with good social science practice whereby content is respected and not always reduced to aggregated numbers which can lose much of the value of findings. Given that the purpose of the work is to gain an understanding of the skills needs in order to develop a strength approach to skills investment and development, the information is sufficient to confidently use as one strand of evidence on which to base the strategy along with complementary evidence (industry statistics, previous studies). This is especially the case when consultation is necessarily of a sample of the sector's organizations, albeit a large one.

Many of the same skills were listed for different roles and in different part of the sector which demonstrates consistency in what is required by employers. It likely reflects the cross-cutting nature of some of the roles and that in smaller organizations, there may be less division between the tasks undertaken by people in different roles.

2.1.2. Supply

An analysis of the Maine Educator Surveys has been completed to establish the opinion of individual educators regarding the current and future education and training needs of the aquaculture sector in Maine. A PESTEL

(Political Economic Social Technological Environmental Legal) analysis was derived from the returns and the high-level findings were presented to the AWDS Steering Committee in April 2019 to stimulate discussion regarding both the opportunities and constraints. The PESTEL analysis cannot be shared to preserve confidentiality.

A sector specific analysis of current supply of relevant education and training was completed by August 16th 2019, based on 31 Educator survey returns. This included an assessment of the receptiveness of representative institutions from 5 sectors (University, Community College, High School, Career and Technical Education, Adult Education and Maine Department of Labor) to providing aquaculture education and training that they do not currently offer, once a viable demand was proven. The associated pre-requisites for the institutions in each sector have also been analysed. In addition, the opinion of education sector leaders has been gathered, through survey returns and one to one interviews, to evaluate state and federal policy frameworks and each sector leader's appetite for collaborative development in support of the AWDS.

The education sector leaders' will to collaborate was very evident. However, they are realistic and stressed that there must be evidence of a viable and sustainable demand to enable them to support any new curriculum development initiatives. Most education practitioners surveyed expressed the same view within their personal statements during interviews, and / or survey returns. It was also apparent from the interviews in April 2019 that there is high local level autonomy and curriculum development decisions are made by each institution's Board of Management (BOM). The sector leaders can (and will once a viable demand is proven) incentivise and support institutions in their curriculum offer, but ultimately not dictate and it is for institutions to decide if / where they have opportunities to develop.

There were some interim findings from the Educator returns presented to and discussed with the AWDS steering committee in April 2019.

The work was implemented in phases reflecting an agreed workplan.

- Phase 1: Inception phase and scoping
- Phase 2: Industry survey
- Phase 3: Curriculum assessment (completed concurrently with industry survey)
- Phase 4: Training strategy development

2.1.3. Inception phase

The inception week took place in January 2019 to meet the Steering Committee of education and training representatives and industry to ensure the relevant understanding of the workforce development context.

The core members of the team conducted initial interviews with some of the lead representatives of the industry and education and training sector implementing institutions in Maine to assess the current status of the sector, establishing some of the key questions that need to be asked within further survey work, and to get an indication of the industry's opinion regarding the implications of future growth to Maine's aquaculture education and training needs (see appendix for list of meetings).

Stakeholder analysis identified key stakeholders who can provide effective engagement for strategy development. Stakeholders comprised primarily the Steering Committee relating to education and training needs. Industry representatives were consulted during scoping and then extensively through the survey process to identify their needs (see appendix for list of meetings and Educator Survey respondents).

Desk research and baseline sector to-date: this included a baseline assessment of current needs, including existing workforce and upcoming skills requirements.

2.1.4. Survey phase

The survey phase then sought to establish the views and information required from industry and educators. The survey incorporated learning from the scoping phase and the team's knowledge of the sector, including the development of qualitative surveys for industry and Education and Training (E&T) providers designed to explore aquaculture E&T demand and supply. The design was reviewed by the Steering Committee.

The interviews spanned different types and sizes of aquaculture companies, and in aggregating responses it is important to consider size, sector, business life stage. (See appendix for list of companies consulted.)

Separately, LPA holders – mostly pre-commercial business owners – were surveyed using SurveyMonkey. (The LPAs are an interesting group of industry representatives who are usually pre-commercial but still require education and training and are a basis for future industry growth).

There was scope for capturing both quantitative data through the survey topic guide, though small numbers of industry actors in sub-sectors make some quantification disclosive and / or statistically limited.

The topic guide for commercial businesses and associated industry organizations covered the following:

- Workforce demographics;
- Types of positions, skills needs by position, salary, and seasonality;
- Positions with high turnover rates;
- Hard to fill positions;
- Skills gaps;
- Experience with graduates of existing education / training programs;
- Existing recruitment strategies;
- In-house training practices;
- Company growth trajectory (looking ahead to workforce needs in 3 and 10 years' time), and
- Positions needed to achieve company growth

The educator survey included:

- content directed to understanding knowledge gained informally and through uncertificated courses;
- on-the-job experience;
- academic courses;
- industry structure; growth and opportunities;
- risks and barriers to anticipate and mitigate

The survey process comprised:

- *Survey delivery*. GMRI/MAA conducted face-to-face interviews, with scope for remote telephone conversations and follow-up written submissions from consultees where required.
- *Analysis of data*. The consultation team (from GMRI / MAA) recorded the data in written form and sent to the Scottish Team for analysis.
- *Reporting*. An initial findings report was sent to GMRI / MAA for sharing with the Steering Committee, and then a presentation was given on behalf of consultants at the meeting on 14th August 2019. The evidence and analysis was then included in a full report as part of the strategy development process.

The sampling rates vary considerably for each sector and this has been considered during the analysis. For example, two Community Colleges from a total of seven provided two surveys and representatives from both were also interviewed by the Scottish Team, using a bespoke question set, during visits in January and April 2019. Selecting institutions to take the Educator's Survey, participate on the Steering Committee, and meet with one-on-one were key decision points for this project, and were carefully considered and discussed by GMRI, Educate Maine, and MAA and agreed to by consensus. Institutions were prioritized for being most likely to have an interest

in education and training for aquaculture and subjects related to the marine environment, fisheries and the wider coastal zone economy; and proximity to aquaculture businesses. This represent a relatively high sampling rate and provides a reliable data set. In addition, a meeting was held with the Community College sector leaders and was informative regarding the policy frameworks and the general attitude towards the development of a new curriculum and collaboration.

The University sector sampling rates are also relatively high and have included various departments and teams involved in different aspects of aquaculture related education and training. This includes relevant comprehensive Bachelor's and Post Graduate Degrees and much more specific and targeted initiatives, such as outreach.

Conversely, the sampling rates for the High Schools and Adult Education in Maine were low in comparison as a practical necessity, and the team selected schools with aquaculture programming. This included some innovative 'grant dependent' initiatives with relevance to current and future aquaculture provision within these two sectors.

The leader of the CTE sector was also interviewed to provide a policy overview. In addition, the leaders of Adult Education and the Maine Department of Labor Apprenticeship Program, were both interviewed to provide their unique perspectives.

2.1.5. Phase 3: Curriculum assessment

- *Review of current curriculum in Maine*. The current Maine aquaculture curriculum was reviewed, including qualifications and delivery modes – this was supported by Educate Maine as an advisor.
- *Mapping mature aquaculture industry education and training framework*. Mapping drew specifically from Scottish experience but included wider knowledge from team members. The content covers the strengths and weaknesses of alternative aquaculture curriculum development and delivery approaches, as well as information on the content of relevant programs and qualifications.
- *Fact finding on the aquaculture curriculum development potential and institutions in Maine*. Martyn Haines of PLI visited Maine during this phase to meet with relevant institutions and work closely with the education providers to understand their current activities and interests for the future.

2.1.6. Phase 4: Training strategy development

- *Analysis of all project data.* The team assessed all available data and has prepared an evidence report and portfolio.

Following the preparation of an evidence report, findings should lead to clear and realisable recommendations with associated timelines, and ballpark cost ranges to implement. This covers future needs with different high and low growth scenarios as well as timebound projections where meaningful.

This evidence report compiles the relevant data for strategy development and is accompanied by a portfolio of excel files with interview survey content. However, note that these files contain disclosive / attributable commercial information and should not be circulated beyond the participating researchers without permission from industry interviewees.

2.2. Data limitations

The survey work gives a rich contextual base on which to understand the approach of industry representatives – however, the format is largely qualitative content and therefore care must be taken in aggregating and using for quantitative analysis. For example, often respondents have referred to key points or priorities elsewhere in the interview rather than in response to a question targeting that thematic area.

The interviews have sections that are forward looking to anticipate growth and upcoming needs, but the sample includes current actors and those entering the sector with a degree of uncertainty about how their growth will progress, and what emerging needs they can reasonably anticipate. Therefore, the workforce strategy must be reactive and avoid taking the interview results as a deterministic statement of requirements.

3. Characteristics of the aquaculture sector in Maine

3.1. Summary

- The Maine aquaculture sector is growing: some smaller sectors are growing rapidly, including sea vegetables (includes seaweed).
- New entrants reflect different capacity and training requirements as the sector grows, and in some places, matures and rationalises.
- Large changes are taking place in all sectors – an influx of LPA license holders, planning of new RAS operations underway – but it is uncertain how much or how fast this will translate into workforce growth.
- Current commercial finfish production is geographically and operationally quite separate Downeast
- Full time, part time and seasonal roles are all important for different reasons and will have separate training needs.
- There are significant external factors (housing, cost of healthcare, attitudes to and understanding of aquaculture) that will influence workforce development.

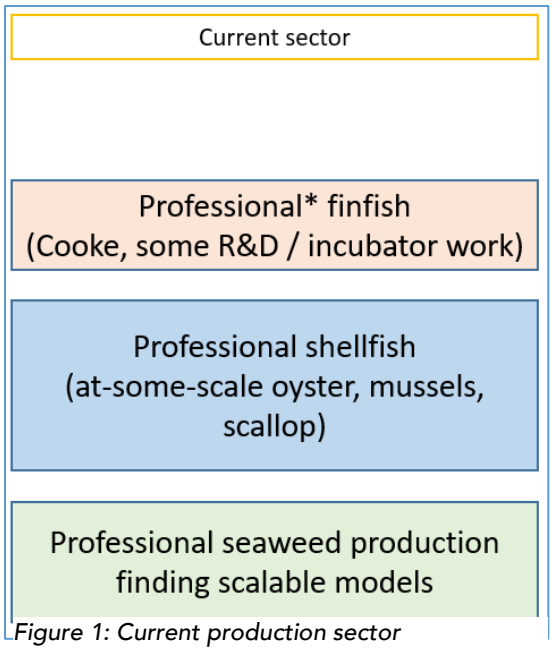


Figure 1: Current production sector

The Maine aquaculture sector comprises differentiated sub-sectors, mostly but not solely divided by species under production.

The vast majority of the finfish production by volume and value (not stated as it is commercially disclosive) is from Cooke Aquaculture, producing salmon, based in Washington County. Since it is part of a multinational company, it can transfer learning and capacity from elsewhere and implement this in Maine. This includes learning and opportunities in workforce development.

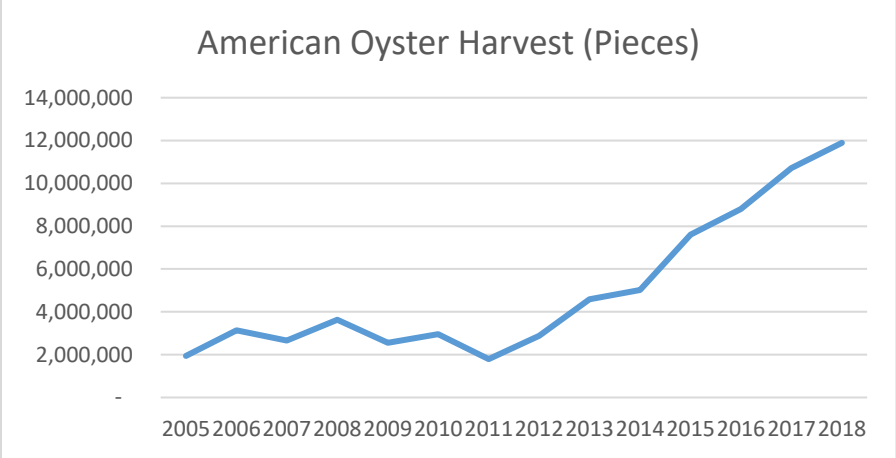
The shellfish sector largely comprises oyster, mussels and to a lesser extent scallop production, though the ratios of these different species may change over time.

The current sector includes primary processing by the producers themselves, but not (usually) secondary processing and downstream hospitality and sales dependent on production – this is important to consider if Maine aquaculture products are promoted on provenance and quality that differentiates them, or integrates them with other Maine branding (i.e. the strategic dependency of downstream jobs may increase over time). Inputs, technical services and contractors (e.g. boat and marine goods suppliers, plumbers, electricians, engineers, construction) may be employed to a greater or lesser extent directly by the companies themselves (discussed further in sections 3.4.2).

3.2. Growth of sector

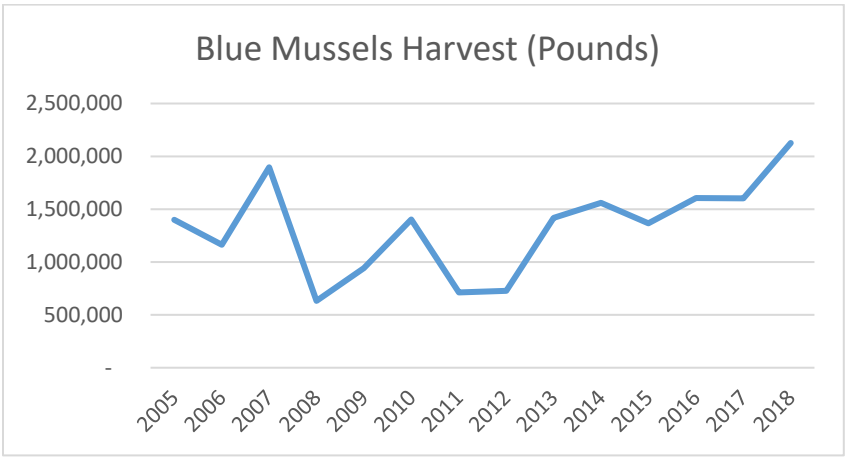
The growth of the sector is significant by volume, though this is not proportionately linked to numbers of jobs and physical scale, both of which tend to be proportionately less than volume growth.

3.2.1. Oyster production, Maine (DMR data)



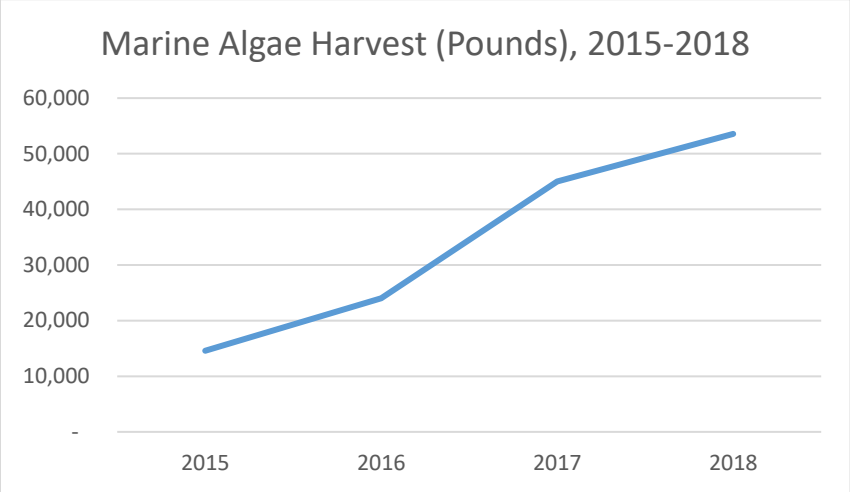
Oysters production for Maine (above) is the largest shellfish sub-sector by employment. Although it is one of the most established in terms of species, it has nevertheless managed to grow substantially in recent years (+56% over previous 3 years, +228% growth over previous 10 years). Production is still predominantly from the Damariscotta River area (approx. two-thirds of total).

3.2.2. Mussel production, Maine (DMR data)



Mussel production has grown significantly (+56% over previous 3 years, +236% over previous 10 years)

3.2.3. Seaweed production, Maine (DMR data)



From a small base, seaweed / sea vegetables production has grown by 267% in 3 years and looks to experience further significant growth in the next decade. It has potential to follow the growth paths of existing aquaculture but also to draw on lobster businesses as a platform for scaling production.

3.2.4. Other species

Data for scallops and other species are not available via the DMR website.

Since there has only been one large finfish producer in Maine to date (Cooke Aquaculture), production figures are not given for the sector since they would be disclosive. This may change with new entrants into the finfish sector.

3.3. Emerging sector and new entrants

In addition to the current sector of professional finfish, shellfish and marine algae ('seaweed', though marine algae may include micro-algae and other sea vegetables), there are new entrants to each. Planned investment in Recirculating Aquaculture Systems (RAS) has the potential to transform the finfish sector and will influence workforce demand for existing firms and education / training providers. This land-based production will have many elements similar to existing RAS research and hatchery facilities in Maine, but at a larger scale.

Seaweed / sea vegetables / marine algae has experienced strong growth over the past 3 years (10-year data from DMR is not available).

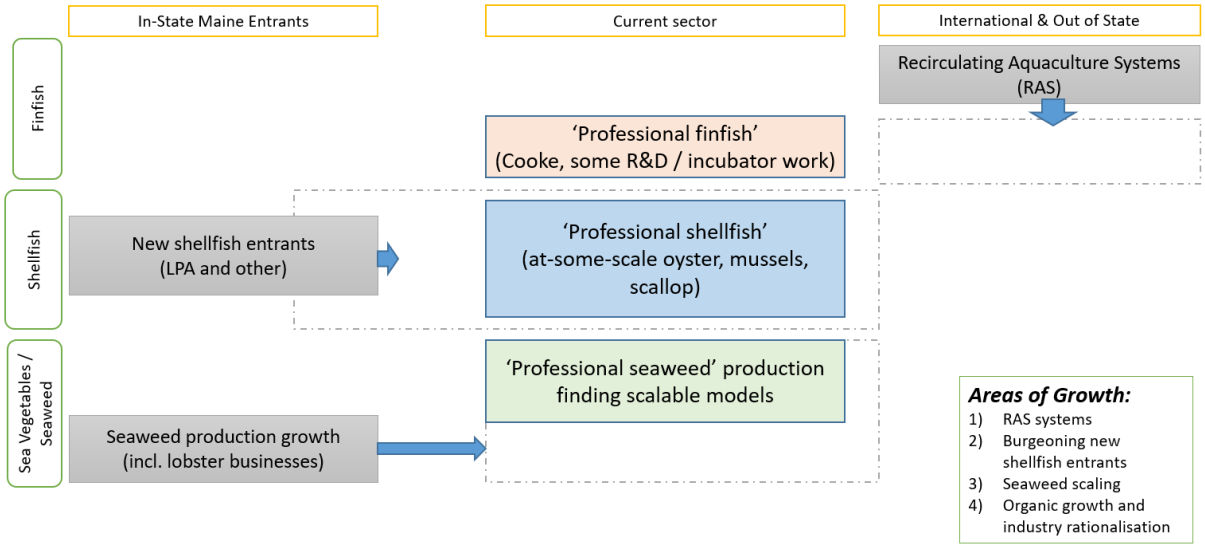


Figure 2: Development of the Maine aquaculture sector

3.3.1. Nascent production: LPA characteristics

The LPA cohort is largely comprised of entrants into the shellfish and sea vegetable sectors. However, those who submitted a survey return may not be representative of the overall group. The LPA respondents (n=28) tend to be pre-commercial (though some LPA are for existing producers seeking to expand). The development of LPAs, and the extent to which they can transition to full licences and commercial ventures, is an important consideration as an 'on-ramp' to greater employment and industry demand for an educated and trained workforce.

- One third are woman
- Just over 20% were full time, other 80% either combining the activity with other work (around 25-30% were fishermen or boat-related activity)
- 15% were interested in hiring staff but can't due to revenue constraints

3.4. Current workforce by sub-sector (identified by survey)

Total Survey returns	301	% of total
Of which oysters	127	25%
Of which mussels	42	8%
Of which seaweed / veg / algae	52	10%
Of which scallops	5	1%
Of which other shellfish	11	2%
Of which R&D / services	47	9%
Of which RAS	17	3%
Plus Cooke	200	40%
TOTAL	501	100%

Table 1: Current workforce surveyed by sub-sector[1]

The interview consultation confirmed 301 staff across different species and services, with an additional workforce from Cooke estimated at 200. This comprises nearly 88% of the 2017 employment figure (Maine Aquaculture Economic Report 2017) though it is expected to be a smaller proportion of the employment in 2019, based on returns and interviews is estimated at 622. These include full and part time jobs (in line with the 2017 economic report). While in some sectors like mussels it is possible to interview most of the sector and have confidence in the percentage of those interviewed, in others like oysters the number interviewed will be a proportion of the total subsector employment.

3.4.1. Full time vs part time

The ratios of full time to part time employment are:

Employment type	TOTAL
Full time, all year	63%
Full time, seasonal	10%
Part time, all year	12%
Part time, seasonal	15%

Table 2: Type of employment across sector

While for some purposes (such as economic valuation) it is important to consider full time equivalent employment, in the case of workforce development it is relevant to deal with total headcount, i.e. a part time or seasonal employee may still require the same (or more) training for specific tasks. A seasonal employee may re-enter the workforce for consecutive or non-consecutive seasons.

3.4.2. Other types of employment

Additional 'hidden' employment is found in the seaweed sector where at least one firm is contracting lobstermen to grow seaweed to supply into the seaweed processing sector. Though the number of lobstermen is currently less

[1] Table references are either above or below table according to legibility

than 20, the management by spouses was cited as a driver of entry into the sector, and suggests additional activities undertaken by those people to manage the seaweed venture. This cohort is likely to increase as the sea vegetables / seaweed sector grows (this is not the uniform production model for the sector, others have direct or other contractual arrangements).

Supply chain actors (technicians, construction, equipment suppliers) are included in the broader sector, which adds a further 88% of jobs to the total. It is expected that as the industry matures and automation increases, the jobs will tend to be increasingly externalised off-site. This may be to external companies, but not always – in Scotland, for example, there is a move by large players such as Marine Harvest (now MOWI) to bring in-house (but still off-site) a number of activities including feed supply and downstream processing. The greater relative growth of external activities vs on-site production is reflected in the stronger multiplier effect cited over the past 10 years (see 2017 Economic Report[2]). Nevertheless, on-site production will still increase as volumes grow.

[2] https://umaine.edu/aquaculture/economic-impact-report/

3.5. Current workforce by occupation

	Director	Management	Scientific / research	Skilled technician / operative	Intermediate technician / operative	Unskilled technician / operative	Maintenance / engineering	Support/ admin	TOTAL
Total survey returns									
Of which oysters	10	25	1	8	8	60	13	2	127
Of which mussels	5	9	0	0	0	26	2	0	42
Of which seaweed / veg / algae	4	10	2	0	0	29	1	6	52
Of which scallops	2	1	0	1	0	0	0	1	5
Of which other shellfish	2	2	1	0	0	5	0	1	11
Of which R&D / services	5	5	18	4	0	7	2	6	47
Of which RAS	10	3	0	0	0	0	1	3	17
TOTAL	38	55	22	13	8	127	19	19	301
Total Survey	*13%*	*18%*	*7%*	*4%*	*3%*	*42%*	*6%*	*6%*	*100% (NB: split figures are rounded)*

Table 3: Current workforce by occupation by sub-sector

- 42% of roles are classed as unskilled (NB: skills still in fact required, at least over time: see list of skills in chapter 4)
- 13% are directors, and 18% of roles are at management level (total of 31% at senior / leadership level)
- 7% are classed as scientific / research focused
- 6% are classed as support / administrative roles

3.6. Growth scenarios and drivers

Growth scenarios are based on stated industry growth plans from:

- interviews and surveys of current employment – this is a fairly large segment of the total but not comprehensive, and the largest employer is based on an estimate which may be lower than real employment (i.e. it is a conservative estimate)
- general industry development trends based on previous studies
- known industry growth trends such as rationalization and efficiency gains, i.e. that more output can be gained with less overhead and staff over time.

It also takes into account the risk that what is hoped to happen in the sector may not transpire as planned – businesses may be optimistic in growth plans and (more often) on timelines.

Finally, consultation explored whether previous growth rates are a reliable indicator of future growth. Strong recent growth is likely to continue to some extent, but is expected to face some constraints on the allocation of new sites (both large and small scale).

The ratios will also change with a change in areas of growth: RAS may be more labor-intensive and more expensive than current marine grow-out techniques (it will be more capital intensive and this will change the employment mix), and expansion may be in more labor-intensive sub-sectors or stages in the value chain.

Table 4: Growth scenarios to 2030

Sub-sector	Assumptions (Low Scenarios)	Assumptions (High Scenarios)	Likely Growth	Current Employment	Employment by 2022	Low	Medium	High	Employment by 2030	Low	Medium	High	Primary occupation growth
Oysters	Market development doesn't keep pace with growth in production. Social acceptability of oyster farms (occupying marine space) becomes an increasing constraint.	Existing businesses have large scope for operational efficiency gains on each site, and as a sector overall where contract farming and management is possible. Acceptability and incremental growth prevails, with LPAs converting to full-scale operations.	Medium-High High current and expected volume growth (+56% over previous 3 years, +228% growth over previous 10 years); less-than-proportionate labor growth. Growth expected in next 3 to 5 years as new LPAs and interest convert into jobs growth.	250	350	300	350	400	450	400	450	500	General aquaculture farmers and managers
Scallops	Scallop companies unable to scale from current very low capacity; scaling remains limited through technical constraints.	Strong demand continues pushing increased price to cover costs; other companies enter scallop supply. Technical constraints to scaling overcome.	Medium-High	5	15	10	15	20	25	20	25	50	General aquaculture farmers and managers
Mussels	Social acceptability of oyster farms (occupying marine space) becomes an increasing constraint	Existing businesses grow significantly through new sites and operational efficiency / husbandry techniques.	Medium High current and expected volume growth (+56% over previous 3 years, +236% over previous 10 years); less-than-proportionate labor growth. Possibly greater challenge to scale than oyster farming.	50	75	60	75	100	150	100	150	200	Aquaculture farmers, processing workers
Finfish	Cooke becomes limited in setting up new sites, and must manage growout capacity through increased smolt capacity.	Global demand for salmon and other finfish grows and continues to increase price.	Medium, but with uncertainty.	250	350	250	350	400	400	300	400	500	Likely to be weighted towards Recirc systems (technicians) and supply chain.

Sub-sector	Assumptions (Low Scenarios)	Assumptions (High Scenarios)	Likely Growth	Current Employment	Employment by 2022	Low	Medium	High	Employment by 2030	Low	Medium	High	Primary occupation growth
	RAS faces operational challenges including getting technicians and suppliers / very high costs of production.	RAS is a success and goes to scale over 10 years.	Growth plans dependent somewhat on social acceptability of marine grow-out which is changing. Expect mitigation of this through freshwater smolt production. Uncertainty around RAS until it is implemented.										
Sea Vegetables / Seaweed	Problem or challenge regarding one current contracting model with outgrowers (used by one processor), facing currently unforeseen issues. Use of marine space for seaweed becomes socially less acceptable as scale grows. Price constrains growth in an unforeseen way	Increased demand for seaweed is exponential in the US, and currently undersupplied. With 5,000 lobstermen there is a very large pool of potential out-growers with whom to go to scale, after factoring in spatial questions. Model is scalable.	High Planned growth of 1,000-2,500% over 10 years. Previous 3 year growth is +267% with reason to expect higher scale-up in 'lift-off' phase to 2022, then on to 2030. Growth of employment depends on classification of lobstermen growers, and accuracy of beliefs about economies of scale not requiring many more employees. Expected to grow volume higher than proportionate to growers. Low growth in employment, high growth in processing and sales.	50 17	60 34	50 27	60 34	75 51	75 75	50 50	75 75	100 100	Processing / direct employees and out-growers (split in number)
TOTAL				622	884	697	884	1,046	1,175	920	1,175	1,450	

3.6.1. Full workforce requirement

Table 5: Workforce requirements to 2030

			2022			2030		
	By 2022	By 2030	Low	Medium	High	Low	Medium	High
Total Employment across aquaculture production	884	1,175	697	**884**	1,046	920	**1,175**	1,450
Total Employment across aquaculture value chain	1,669	2,218	1,316	**1,669**	1,975	1,737	**2,218**	2,738

Aquaculture production includes direct employment across producing companies and some selected relevant organisations e.g. those undertaking trial production.

It is expected that the total aquaculture workforce in Maine:

- *2022:* Is likely to comprise around 880 employees in direct employment through production, including initial processing and selected relevant organisations; and over 1,600 across the supply chain
- *2030:* Could exceed 1,000 over the next ten years, and over 2,000 in the total production, supply chain and downstream markets. This may be higher depending on the depth of strategic linkages, in particular with research and downstream processing and provenance initiatives.

3.6.2. Commentary on industry growth

The sector's growth will depend on potentially transformational projects like RAS and successfully navigating barriers around site availability and acceptability, which will require positive public awareness of the sector.

However, it will also depend on more organic growth in current operational models that can gain scale in the shellfish and sea vegetables sectors, driven by, *inter alia*:

- *Seed supply:* the availability of seed through commercial providers such as Mook Sea Farms and Ocean Approved
- *Contract farming and contract management:* intermediary service provider companies such as Ocean Approved and Glidden Point Oysters who envisage providing services across a number of smaller producers.
- *Attitudes to aquaculture in the marine space:* this is potentially the most significant driver of the aquaculture sector, because it will influence how many LPA sites can be converted to full commercial sites, and how far existing firms can expand. It will also likely drive the extent to which additional finfish volume is achieved through land-based activity (RAS or extending the duration of the freshwater smolt production phase generally).

3.6.3. Growth in demand for skills and training

Current industry

In 2017 the aquaculture sector comprised 571 direct employees, and a total of 1,078 including supply chain and multiplier effects.[3]

Of this, some 200-250 jobs are concentrated in one company, Cooke Aquaculture, in Washington County. Cooke's operations split into three broad categories:

1) Freshwater operations (hatchery and smolts)
2) Grow-out (marine fish farms)
3) Processing

Shellfish employees are estimated at over 300 (likely to be higher in 2019, though unconfirmed), and under 50 in sea vegetables / seaweed.

Direct and indirect jobs

The Maine aquaculture sector is changing in seaweed and the outsourcing model above will change who is directly employed by the main companies. Further, contract processing labor in some areas may become the norm rather than direct employees.

Future growth of the industry

The growth of the sector going forward will include two important new cohorts of operators:

1) A growing number of part-time fishers and LPA operators
2) Increasing technical and supply chain actors not directly involved in traditional marine husbandry, especially if implementation of RAS finfish production takes off. These will to some extent emulate the freshwater operations currently in Cooke and some other research unit but will require a different set of skills to most marine-based production.

[3] UMaine 2017 report - https://umaine.edu/aquaculture/economic-impact-report/

These trends will cause some definitional changes to how the workforce is identified and described but will also inform the implementation of skills and training channels.

3.6.4. Finfish employment growth

Possibly joining Cooke in large scale finfish production are two Recirculation Aquaculture System (RAS) entrants: Whole Oceans and Nordic Aquafarms. Their on-shore operations would be more similar in character to the employment requirements of the on-shore operations in Cooke, with more of a focus on tank / hydraulic systems. This will likely change the types of skills required across finfish production and might require more in external suppliers / maintenance than the current marine production system.

Currently, labor supply is bolstered by Cooke's in-house training which aligns with their Canadian training materials, and their emerging partnership with Washington County Community College. This supports the need for technical and husbandry requirements.

3.6.5. Shellfish employment growth

There was a consistent aspiration among interviewees that while they sought to grow their operations, they believed that employment would have a less-than-proportional increase, i.e. there will be significant economies of scale and experience. Looking beyond the responses, there may be some owner / entrepreneur optimism in this view, but there are clear and reasonable ways in which economies of scale could be achieved, given the current growth phase will include less efficient start-ups. This is admitted by business owners, so it is fair to attribute scale gains to an admission of early-stage challenges rather than over-exuberance.

Based on the 2017 Aquaculture Economic Report:

Shellfish employment	Percentage of total employment
Full time, all year round	43.4%
Full time, seasonal	14.5%
Part time, all year round	16.7%
Full time, Seasonal	25.4%

Table 6: Shellfish employment by type

The entrant cohort in LPAs are important to consider in growth expectations.

LPAs as future demand

The LPA experimental license holders are predominantly part time operators, some of whom are keen to progress to full time business operations. There has been a surge over 600 LPAs recently following a more streamlined process to acquire a license (up to 4 licenses per respondent was the norm), and it is still to be determined whether this increase has been due to a backlog of interested parties who have found the process more accessible (likely), or whether it is the start of a sustained increase. It should be noted that some LPA holders are also existing businesses or related to existing businesses. There is also likely some self-selection in the returns since those with more intent, knowledge or capacity may be more willing to complete the questionnaire.

Assuming that 500 LPAs may help create a 'new normal' in terms of capacity, they could be a source of growth in two ways:

1) They may form a base of small production that could increase productivity on existing LPA sites, possibly through collaborative / aggregation systems.
2) A proportion of these new LPAs should convert into full sites over time.

Just over half of LPA respondents described themselves as 'revenue-generating but not yet profitable', and around 10% describing themselves as profitable.

Noting again that the survey responses are unlikely to be fully representative of the LPA cohort: around two-thirds described their aim to run the business as a full-time job, or part-time combined with something else.

Around two-thirds sought to buy key infrastructure or expand business functions in the medium term.

One-third of LPA respondents have staff – many are seasonal but the numbers varied between 2 and 15 (averaging 3-5). It is important to note that the larger employers in the LPA cohort are identifiable as current / existing sector employers and therefore their current workforce figures should not be considered additional to the general survey; but it is possible that there are additional employees and or owners requiring training / upskilling in the low hundreds in the LPA segment.

Some feedback in the main interviews of established commercial aquaculture companies was a concern that the boom in LPAs may have an adverse effect on social acceptability of aquaculture sites. This is in contrast to an incrementalist approach in Scotland now being adopted. There are advantages and disadvantages to each approach – maintaining an image of familiarity, rather than 'creeping' site development may be preferable.

3.6.6. Wider industry and social factors

Competition within and from outside the sector

Competition for labor from non-aquaculture sectors (including recruiting of current workforce), for example other seasonal rural sectors including agriculture and tourism, was perceived to be a risk to recruitment and retention, and in future the demand for experienced aquaculture employees may pose a 'flight risk' in the short run to incumbent operators.

- 52% state it is negatively impacting now
- growing to 55% by 2030

Constraints on supply chain skills

Interviews cite the need for technical skills. Those that are large developments (RAS) may find suppliers more limited than expected and was reflected in their interviews (which understandably take a can-do approach). This belief is supported by views from Cooke in Machias. This may be mitigated by the RAS firms locating closer to relatively larger populations.

Employment costs (esp. healthcare)

A significant majority of interviewees cited healthcare as a strong factor influencing hiring decisions.

Demographics

A wider issue for the economy is that young people leave more remote and rural areas and don't return due to an interplay of economic and social reasons.

- *Housing:* Affordable housing was consistently cited as a potential constraint in attracting workers into aquaculture, especially in areas such as the Damariscotta River region where second homes are in demand.

Related to this, in scoping interviews it was suggested there might be fewer young people in such areas, in turn providing fewer recreational and social opportunities. However:

- *Overall optimism remains:* there is generally a positive sense amongst employers that more young people are interested in working in the sector – as a lifestyle businesses of their own or working in conservation, science and the environment.
- *Age:* Some employers report issues of an ageing workforce – but:
    - Young people seem to be becoming more interested in a career in the marine economy
    - Figures suggest a strong proportion of young workers
- *Representation and employment of women:* Out of those giving gender disaggregated data in the survey, nearly 78% of firms stated employment was either evenly split or majority female, while just over 22% were majority male.

  Women are well represented in the sector, with presence in meetings and interviews representing firms (some are co-owned with spouses, so cited owner does not always reflect leadership and benefit, i.e. a man may be the cited owner but it is a husband and wife leadership team). Across employment, from data gathered there tended to be a gender split between farm teams (tended towards male) and processing team (tended towards female). In new sub-sectors such as algae / seaweed, processing is believed to favor female employment, and where lobstermen are growing seaweed under contract, it is reported that women (as business administrators and business managers landside) have tended to initiate this diversification from fishing. This could achieve high numbers for employment if the model is replicated over time and care should be taken to include such landside jobs as they can be overlooked.
- *Diversity:* Perceived lack of racial diversity – but possibly reflects the population of rural Maine. Positive feedback about non-USA nationals working in the sector, often in processing. Early interviews suggested that immigrant workers were providing flexible processing skills and capacity, often switching as contract labor between businesses which helped manage seasonal peaks in demand.
- *Out-of-state:* 69% of employers have staff who have been trained out-of-state (LPA survey also cites out-of-state training at Roger Williams program in Rhode Island)
- *Inclusivity:* 31% have successfully recruited and trained people who are re-entering the workforce including people facing disadvantages e.g. homelessness and previous offender. Jobs generally accessible for different education levels, though attitude to work is cited as key driver.
- *Management skills are a gap:* Lack of training to develop management skills consistent across small, medium and large firms.

3.6.7. Recruitment and retention

Succession

Short-term succession planning is an issue for around a third of businesses:

- 40% believe it is having at least some impact
- A greater proportion report it is a likely issue by 2029
- Applies to small companies who depend on family members' appetite to enter the sector
- Larger firms also face different succession challenges, hiring good management and leaders
- 33% report that the flow of new entrants is inadequate to meet their needs – 67% say it's not currently an issue
- 43% report that it will be an issue in the future

Key message: Recruitment and retention is superficially 'under control', but in fact interviews and scoring suggest they are an issue.

Recruitment

Recruiting to keep pace with growth:

- 65% report it is currently impacting on ability to grow
- 81% say it will have an impact by 2029
- 90% report issues in recruiting people with the right technical skills now or in the future:
    - 41% say it is critical now and it will worsen
    - 55% say it will be a critical issue in the future
- A sense amongst some that technicians are quite straightforward to recruit e.g. monitoring water quality, feeding

Retention

Currently employee retention is an issue for 35% of companies.

- Time lag between losing a staff member and replacing can be difficult – particularly at operative level – in a time dependent industry
- Challenging positions to recruit for: diverse range, no consensus or pattern

Key message: general work-readiness and attitude are important.

- *Work readiness / attitude:* Lack of employability and work readiness is also an issue in recruitment – a need for staff with soft transferable skills. Soft skills and problem solving are valued highly
- *Manual nature of some roles:* A third of employers report a significant challenge in recruiting people who can cope with the manual labor and demands of the role – expected to be an on-going issue

Future retention: 43% report it will be an issue in the future.

- *Automation:* an increased use of automation and digital technology may change roles and retention needs
- *Pool of seasonal / temporary labor:* Employers report recruiting from fishing industry and seasonal recruitment of school and college students
- *Recruitment methods:*
    - Recruitment is often by word of mouth and through existing networks
    - Social media is used as a route to raise awareness about opportunities

3.6.8. Key challenges to recruitment and retention

Table 7: Key challenges to recruitment and retention

Issue	Cause
Lack of affordable housing	Economic geography of sector
Relatively high cost of living	Economic geography of sector
Travel and transport links and costs	Economic geography of sector
Seasonal working – skilled staff want year-round job and income security	Sectoral characteristics: Many all-year-round jobs, seasonal working needs to align with other activities.
Pay levels, terms and conditions are increasingly under competitive pressure	Sectoral characteristics: Healthcare commitments becoming serious barrier to hiring

Lack of clear and well communicated career progression opportunities	Sectoral characteristics: Small firms = career depends on company growth. Large firms = integration
Workers often leave to start their own businesses due to lack of progression	Sectoral development stage (shellfish)

3.6.9. Future trends

- *Changing technology:* Increased need for digital technology skills e.g. data handling, use of drones, environmental sensors
- *Recirculating Aquaculture Systems (RAS):* Development of RAS will require new skills and ways of working – it will be a step-change in the industry
- *Climate and biological change:* Increasing need for science and research e.g. impact of climate change, fish/shellfish health
- *Leadership and management:* Industry likely to become more consolidated so leadership and management capacity and capability will be increasingly important
- *Maturity of the supply chain:* Shipping and logistics will need to develop in response to sector growth

3.6.10. Summary of Maine industry and wider factors

- *There is a workforce skills constraint:* Sector has potential to grow but education and training are a constraint to enhanced productivity and growth. They are also a big commitment for industry at present.
- *Sectoral growth:* the sector is likely to grow and thrive – labor demand will grow, potentially significantly, though at a lower proportional rate in comparison to volume. Risks are identified.
- *Higher education graduates:* There seems a belief that quality and supply of HE graduates is good in relevant areas such as marine science, though perhaps still need practical and hands-on skills (as with other groups), and business management skills.
- *Vocational and trades skills:* There is an Aquaculture Vocational Education and training vacuum in the state of Maine. Formal, flexible pathways towards gaining credentials in Aquaculture need to be created through collaboration between CC, CTE, apprenticeship and most importantly, industry representatives.
- *In-house:* Current strategy of in-house training in large salmon will not translate into rest of the sector, so educators have a clear cross-cutting role to meet short-course gaps and 'grounding' of employees in basic competencies.
- *Business skills:* Business management (and marketing) are large parts of the job and these should be firmly embedded in the education and skills packages available.
- *Occupations:* Standardisation of roles in shellfish could help benchmarking and training – this can tie in with tailored education solutions.
- *Perception of sector:* Wider understanding of aquaculture across Maine would help maintain social license – the trend back to 'farm-to-table' careers could naturally deliver this.
- *Gender:* Representation of women in the sector seems high, and likely to increase.
- *Transferability:* Lack of coherence in terms of how roles and skills translate from one employer to another which could hinder career progression for the individual and mean that employers are training and retraining as staff move around the sector.
- *Leadership:* Need to respond to structural changes in the industry including leadership skills for larger and more complex enterprises.
- *Technology:* Also changes in technology and production methods – important that education and skills providers keep up to date with changes in industry and align provision.
- *Emerging opportunities:* Major opportunities in seaweed – but global competition so how to capitalise on this asset.

4. Skills demand

4.1. Summary

Qualifications

- Companies frequently undertake in-house training to develop the technical skills that best align with their needs.
- Hands-on, practical training delivered on-site and externally, is highly valued.
- However, in-house training is not co-ordinated across the sector which leads to inconsistency and duplication of training as people move jobs.
- Small companies are limited in HR / training structure, while Cooke is using formal training with global company resources and collaboration with Washington County Community College.
- Community Colleges are viewed as providing important opportunities for skills development and learning and there is a perception by industry that they are under-valued.
- Training and learning are not always well aligned with industry need which is a key driver for work-based learning within companies.
- High school graduates with transferable employability skills and people with trades can be provided with aquaculture skills and knowledge by employers. It is the soft skills and the trades that are the key starting point.

Skills

- Transferable skills such as communication, problem-solving and team working are highly valued and deemed important by industry.
- Boat, seamanship and navigation are key skills required across the sector and in a wide range of roles.
- Staff across a number of roles are expected to be able to operate and maintain vehicles and equipment including pallet trucks and pneumatic tools.
- Technical and trade skills are valued by aquaculture businesses, e.g. plumbing, electrical, fabrication
- HACCP Basic was widely reported as being in demand.
- Digital literacy and more specific IT skills are important and likely to become increasingly so as the sector develops.
- Employers are looking for their staff to have skills and knowledge of health, safety, regulation and compliance.
- Unsurprisingly, key skills include seed handling, grow out techniques and production processes.
- Fish/shellfish health, welfare and disease management are critical areas and staff are expected to have skills, albeit to various levels depending on their role.

4.2. Introduction

This chapter examines the demand for skills in the aquaculture sector in Maine drawing on the qualitative research with industry and LPAs. It assesses the skills that are required by different types of roles, the challenges faced by industry in ensuring an adequate and sustainable workforce and the skills development needs reported during the research.

The analysis of industry demand is derived from a two-stage process;

- Assessing consultee's attitude towards qualifications.

- Analysing the skills needs reported in the qualitative and quantitative content from interviews undertaken by GMRI and MAA staff

4.3. Qualifications

In general, all sectors of industry see value in a wide range of qualifications, reflecting the variety of occupations and occupational levels. Respondents had a good awareness of the qualifications available within most of the main education sectors. The six categories below were the most often cited by 36 industry consultees, reflecting the employer's awareness and focus on different education and skills levels.

Table 8: Qualifications cited by industry respondents (n=36)

On-site training	Community College	Apprentice	Internship	Bachelor's Degree	High School Dip	Vocational training (short)
10 (28%)	16 (44%)	10 (28%)	9 (25%)	16 (44%)	10 (28%)	10 (28%)

Industry are very aware of the potential value of Community College provision, and it was cited 16 times by 36 respondents equal to the number of Bachelor's Degree citings. (Added to this figure is Cooke Aquaculture's recent partnering with Washington County Community College, which emerged later in consultation – this is in line with their approach to training in Canada.) Considering the relative visibility and prevalence of the University sector and the void with Community College provision, this is a strong endorsement. Some industry consultees appear to see Community College as an undervalued 'Cinderella sector', but its value is captured by the following comment:

"*Technical grads can really help you to get off the ground*".

This is consistent with Scottish policy whereby a new marine training center is planned to address technical skills across the wider marine sector, with aquaculture stakeholders being among the most actively engaged.

Whilst qualifications are recognised as being very valuable, industry consultees also emphasised the importance of 'hands on' practical training, both through externally delivered short courses and on-site training that is more specific to the companies' procedures. This sentiment was evident in all sectors, shellfish, sea vegetables and finfish (including RAS) and did not vary according to the sector, level of technology deployed or size of business.

In terms of training and staff development, there is strong culture of independence, particularly amongst shellfish producers. The consultees reported that they expect to have to train people themselves and are used to doing so. In their view, internal training allows them to closely align the training to their own operating procedures, and training can be provided flexibly, 'on the job' which is beneficial to the business and the trainee. However, some acknowledged that this can be resource intensive and puts additional pressure on existing staff, particularly if staff are seasonal and / or turnover quickly meaning there is an on-going need to train new people as they join the workforce. These employers would value increased assistance from external educators and trainers, but it would need to be closely aligned with their specific needs. This could form the basis of apprenticeship work and a 'Training the Trainers' approach within companies. It would also have to 'dove-tail' with any future company bespoke 'on-site training', essential to ensuring compliance with their own procedures.

Although there is a persistent belief in the benefits of learning 'on the job', aquaculture specific knowledge and skills were regularly cited as important and relevant by all sectors. Despite the comments made by finfish respondents indicating a preference for learning aquaculture in the company, they have invested time in establishing a comprehensive program with a Community College in Canada. This implies that they see more value in formal aquaculture education with a high-level technical emphasis, than was apparent from finfish representatives during interviews.

All sectors placed a high value on the trade skills (plumbing, electrical, fabrication and engineering) and would welcome more High School graduates with these skills. They are confident that they could teach them fish husbandry to sit alongside their trade skills. Some businesses recognised that high quality Degree graduates, well versed in marine science with the associated laboratory skills, would also benefit from trades skills, particularly in a small business with a less specialised workforce.

The shellfish sector generally saw high value in a marine science education as it provided an awareness of the dynamic nature of the marine environment. The biology and culture techniques of farmed shellfish species was also highly valued by many.

Cooke Aquaculture respondents believed that fish husbandry knowledge and skills could be taught on the job. However, an aquaculture Certificate program is under consideration with the Washington County Community College, partially informed by the program provided by a college in Canada.

4.3.1. Qualifications: Finfish

The table below sets out the feedback about qualifications and sources from finfish businesses. It shows their attitudes and views on four different types of training and education[4]. It illustrates the importance currently placed on on-site, on-the-job training. On-site training is highly valued as a means for ensuring employee compliance with elaborate site specific Standard Operating Procedures (SOPs) associated with 'high tech' aquaculture, including live feed production, in some facilities. 'Hands-on experience' through internships and apprenticeships is highly valued. However, it is less clear whether the qualification that an Apprenticeship leads to is valued over and above a less formal internship. Higher level qualifications are valued, including certificated 2-year programs (Associate Degrees) from Community College and 4-year Bachelor's Degrees, probably reflecting the 'high tech' nature of RAS.

Vocational short course received a mixed review, with one respondent complaining that professors never asked about the content of short courses needed by the company, whilst others praised the fish disease short courses available from Auburn and the 2/3 day course on RAS from Pentair.

The feedback from the finfish respondents regarding the value placed on qualifications as opposed to informal on-site training, appears ambiguous. Whilst giving the impression that the most important aquaculture skills "*are not trainable*", they go on to demonstrate that they do see value in Community College programs, having adopted this approach in Canada. The degree to which these programs are 'bespoke' and reflect their own SOPs, may have some bearing on how this can be translated into program content for new finfish entrants and in turn others in the sector.

[4] The nature of the responses does not allow for a quantitative analysis.

Table 9: Qualifications: Finfish (n=4)

Qualifications cited	Comments
On-site training	*Commitment to innovation important….* *Inspection observation skills, attention to detail, people who can understand what they are looking at and can ID problem before it becomes an issue. Not a trainable skill.* *Fish processing operatives - Inspection (make sure flesh is right color, no pin bones, no bruising etc…)* *Life skills, employees understand that it can be a career, can do attitude*
Community College	*Suitable for supervisory roles….* *Community College is great and undervalued.* *HS & CC degree tells me you want to learn. Plumbing and electrical great, we can teach them to grow fish.* *Cooke Canada use 12-week CC program on fish production*
High School Diploma	Cited, but no comments provided
Vocational training (Short)	*…changing nature of technology would be very useful.*

4.3.2. Qualifications: Finfish (RAS)

The table below sets out the feedback about qualifications and sources from finfish (RAS) businesses. On-site training is highly valued, to ensure employee compliance with elaborate site specific SOPs associated with 'high tech' aquaculture, including live feed production, in some facilities.

A high value is placed on 'hands on experience' that internships and apprenticeships can help to provide. However, whether the qualification that an Apprenticeship leads to is valued over and above a less formal internship, is less clear. Higher level qualifications are valued, including certificated 2-year programs (Associate Degrees) from Community College and 4-year Bachelor's Degrees, probably reflecting the 'high tech' nature of RAS.

Vocational short course received a mixed review, with one respondent complaining that professors never asked about the content of short courses needed by the company, whilst others praised the fish disease short courses available from Auburn and the 2/3 day course on RAS from Pentair and the importance of Community Colleges. It supports the finding that there is a sense that the Community College offer is undervalued.

Table 10: Qualifications Finfish (RAS), n=4

Qualifications cited	Comments
On-site training (2)	*…a lot of in-house training because their facility will have its own SOPs and site-specific things employees will need to be taught.* *Hands on experience—something as simple as someone who has fed fish for a full growth cycle. Actual work experience and farm experience can carry as much weight as any of the higher-level degrees.* *…need to train everyone in live-feeds.*
Community College (3)	*…establish certification programs, not just a hodgepodge of courses. Need not be a full Aquaculture major. Could be a 2-year program. But, 2 years technical skill hands on and then another 2 years at university and get an Aquaculture Degree. Also, could help create a pipeline of "managers" or people specializing in certain aspects beyond those 4 years.*
Apprenticeship (1)	*…apprenticeships or internships can help students to get operation and business experience*
Internship (3)	No comment
Bachelor's Degrees (3)	*Science degrees* *Four-year degree most valuable*
Vocational training (Short) (4)	*Hands on training programs* *…specific training (Note: Respondent claimed that University professors don't ever come in to ask about how they can help meet the needs of the businesses for their workers.)* *Short course on fish disease by Auburn. (Pentair was also good but may be phasing out).* *Courses are often accessed through other states, e.g. VIMS Virginia institute marine science or freshwater institute courses in recirculating aquaculture or 2/3-day course through Pentair.*
Certificated Aquaculture program (Any) (1)	No Comment

4.3.3. Qualifications: Oysters

The table below gives an overview of the feedback about qualifications and sources provided by oyster producers during the consultations. Respondents in this sector covered businesses of varying scale and organizational complexity meaning that a wide range of qualifications are relevant to the sector collectively. Community College, Apprenticeships, internships, Bachelor's Degrees and High School Diplomas are all seen as valuable by oyster producers, but it was stressed that they must be organised within a well devised pipeline to encourage access and progression, with well-defined employment opportunities at each step off point.

As with finfish, the table below illustrates the prevalence and value of internal, hands-on training and skills development amongst oyster producers. However, as with all on-site training, it is perhaps worth considering if this is so prevalent as a result of a lack of alternative, fit–for-purpose training, a lack of awareness of external training on the part of employers, or if available training is not easily accessible for example due to cost, the need to back-fill the position while an employee is off-site (and associated costs), and travel implications. The comment about the potential impact of Community Colleges if it could be more specifically focused on aquaculture suggest that the training may not currently be well aligned to industry need.

Interestingly, several respondents reported that Bachelor's Degree graduates from a liberal arts background are valuable because they are perceived to be more independent with a greater learning aptitude and better innate skills. Engineering graduates are also considered highly valued which correlates with the importance placed on skills to design and implement new gear.

Vocational training does not get cited frequently by oyster producers possibly because respondents expect to train their employees in-house. However, Maine Aquaculture Innovation Center (MAIC) 2-week course on shellfish biology and husbandry was reported as a strength and could have an important role to play going forward, bearing in mind the high number of citing's received for shellfish/oyster biology and husbandry.

Table 11: Qualifications: Oyster n=14

Qualifications cited	Comments
On-site training (3)	*Hands-on training is key no matter what.* *…we are self-taught people and can learn on our own.* *…a lot of the information in courses/qualifications isn't really that relevant to the day to day operations.* *…have a hatchery manual to train crew; developing a river manual. These are proprietary but used as a training tool.*
Community College (7)	*Community College and technical grads are the people who really get you off the ground. Need more Community College and technical skill type people.* *…could have significant impact but needs to be more focused on aquaculture specific programming.* *…good for middle level employees*
Apprenticeship (7)	*…but based on several different farms*
Internships (5)	*…had some very impressive High School internships in the past*
Bachelor's Degree (7)	*4-year college degree* *Diverse liberal arts background preferred* *…have had the best experience with private school kids (liberal arts, because they are more independent and have more skills. Elite liberal arts schools attract people with a higher degree of learning aptitude.)* *Level of expertise needed will be higher in the future as technology gets more sophisticated* *…valuable in the longer term* *…someone with an engineering degree to build and develop equipment* *…needed for minority of staff*
High School Diploma (6)	*Exposure to aquaculture in high school, college, is great and it builds awareness as well, but not all that necessary for building a workforce.* *…include personal finance, business finance, and business skills at the high school level to help prepare graduates for working in a business earlier on.* *CTE ideal*
Vocational training (Short) (2)	*Chris Davis 2-week course on shellfish biology and husbandry was fantastic, but only offered once.*

4.3.4. Qualification: Mussels

The table below provides feedback about qualifications from consultees in the mussels sector and illustrates the value placed on on-site training. However, most respondents also see value in High School Diplomas as a

minimum requirement, if designed to include a rotational work experience and skills training in knot tying and HACCP.

Short vocational courses across a diverse range of topics were also cited, including; trade skills (welding, electrical and fibre-glassing), boat handling, food safety and shellfish biology and operations.

Community College is valued as an affordable education that could include aquaculture technical skills as well as engineering, trade skills and machine maintenance. Bachelor's Degrees are perceived to be relevant to the back-office, as opposed to farm operations - production, processing and maintenance.

Table 12: Qualifications: Mussels

Qualifications cited	Comments
On-site training (2)	*All training done in house*
Community College (2)	*2-year course - technical skill and machine maintenance* *…Southern Maine Community College 2-year model makes the most sense because its affordable, career focused, and the students who attend know what they want to do. Could condense 2 years into a specific program with useful skills.*
Apprenticeship (1)	No comments
Mentorships (1)	*Mentorship in the aquaculture cohort could be very helpful to bring people into the community in the right ways and connect to the right people.*
Bachelor's Degrees (2)	*…needed for office jobs*
High School Diploma (3)	*Right now, they have a student from the local school who was struggling in a traditional school setting. He was interested in working in the marine trades, so the school allowed him to work with them and learn about marine trades as part of his education.* *…should set up a program for juniors in High-School through early years college that introduces kids to the industry and rotates them (gives them exposure) at several farms. Could train them in short-term skills quickly (knot tying, equipment, HAACP).* *…minimum requirement, but both staff have degrees*
Captains Licence	*…desirable but not essential*
Vocational training (Short) (3)	*…wiring, welding fibre-glassing* *…technical practical skills, boat handling, HAACP plan understanding and food safety, basic biology as it relates to farm operations, production and safety.*

4.3.5. Qualifications: Scallops

One scallop producer noted the importance of skills and experience over knowledge and qualifications and overall no one type of qualification was identified as being of importance above the others. They see no need for qualifications and believe in on-site training only and learning on the job. However, an interesting comment was made regarding apprenticeships being seen by one employer "*as an extended job interview*", going on to make a reference to the need for employers to be attractive to applicants, recognising the need to compete to recruit and retain the best staff. This reflection and attitude is very positive and could help other aquaculture employers, especially in de-populated counties where good potential recruits can select from a range of employment options.

Table 13: Qualifications: Scallops

Qualifications cited	Comments
None (1)	*…looking for skills, experience and knowledge over qualifications*
Community College (1)	No comment
Apprenticeship (1)	*…serves as an extended job interview for companies, and because the apprentices aren't necessarily going to stay with the business, it forces the business to have better management practices to keep people.*
Bachelor's Degrees (2)	*…for top positions overseeing food safety* *Business degree needed for Chief Finance Officer*
Master's Degree (1)	*…for top positions overseeing food safety*
Industry exchange (1)	No Comment

4.3.6. Business leaders and LPA License-holders

As well as considering the skills of their workforce, the research consultation explored the skills and training needs of business leaders themselves. Where business leaders have moved from more operational roles into management, they have to shift and develop their skills set and that can be challenging. In Scotland, recognising the importance of business skills, Stirling's Institute of Aquaculture has sought to embed business operational management into coursework. In the research business leaders provided very clear insight in to the business and technical skills and training they require and these are summarised below.

- Over 50% cited business training, including
  - Sales and marketing
  - Financial management
  - Business plans
  - Data management (specifically relating to new RAS finfish venture)
  - Operational efficiency
  - General operational management, e.g. HR, defining roles
- 50% cited aquaculture and husbandry, including:
  - Aquatic systems / hatcheries
  - Marine biology ('basic')
  - Biotoxins
  - Growing and husbandry techniques
- Some referred more broadly to technical requirements, including
  - Rigging techniques
  - Engineering (diesel engines, hydraulics)
  - Designing and building equipment
  - Boat-handling

The survey of Limited Purpose Aquaculture (LPA) license holders identified the following aquaculture training:

- One-third of LPA respondents have participated in the Aquaculture in Shared Waters program
- Around one-quarter cited the Islands Institute Aquaculture Business Development program
- DMR mandatory training for LPA holders
- Roger Williams Applied Shellfish courses (Rhode Island)

Other training:

- LPAs require IT and sales and marketing training
- LPAs reported less need of technical and husbandry skills which is perhaps a reflection of their state of development as a pre-commercial business where there is less risk involved in trial and error

The findings show that shellfish, sea vegetable, finfish and RAS business owners recognise the importance of a wide range of business skills. Their views on these skills reflect the challenges they had faced during their personal journey in the aquaculture sector. The range of specific skills cited included; personnel management, the development of organizational structures and standard operating procedures, financial management (budgeting, book-keeping and accounting) marketing (including brand development) and entrepreneurship (including raising capital). Interestingly, the importance of these skills, whilst mentioned in the LPA survey returns, were not emphasised to the same degree, with many LPA holders believing they were well placed to deal with the business management aspects based on their previous careers and life experience. One shellfish farmer believed that business skills could be usefully included within the High School curriculum to make young people with appropriate trade skills more business aware.

4.4. Skills Needs

Qualifications and skills are two different, although inter-related aspects of ensuring an adequate and sustainable workforce. The following sections report on the findings of the skills reported for the range of roles in the aquaculture sector. Given the numbers of respondents and the similarities in the skills reported, the analysis is presented separately for finfish, shellfish, mixed producers, seaweed and algae, and 'various' which covers research organizations with commercial or semi-commercial capacity. The findings for producers who rely on RAS are also separated out to reflect specific skills required in this emerging area.

The responses were provided qualitatively and so it would not be credible to analyse and present data quantitatively. The findings give good insight into the types of skills required which is very valuable for shaping the workforce strategy. Communication skills, problem-solving and regulation and compliance are threads running throughout the findings. Broadly, shellfish farmers report a need for employees who have the skills to design and make equipment to suit their specific site dynamics and likewise, the finfish sector emphasised the importance of practical innovation. The need for a positive attitude, and transferable employability skills was emphasised and many employers reported these as being the priority, and that they would provide more technical and operational aquaculture training based on the specific needs of the business and its processes.

The increasing use of data, automation and technology means that digital literacy is increasingly important across the majority of roles in aquaculture, clearly demonstrated by the evidence gathered through the consultations.

Boat and water operations is very important to the shellfish and sea vegetable sector so that staff, at a range of levels and in different roles can navigate, operate and maintain boats and tie knots. The lack of these skills is a major impediment at every level of a small to medium sized businesses in this sector. These skills do not appear to be so essential in the finfish sector, particularly RAS reflecting the different operational models.

Another thread running through the findings is the need for Hazard Analysis and Critical Control Points (HACCP) training at basic level, across roles and sectors. HACCP is a systemic production system approach to controlling hazards in food production and will apply to comparable seafood and other food processing in Maine (indeed, some processing takes place in industrial zones around Portland where contract labor with processing qualifications are available).

4.4.1. Skills needs: Finfish

The table below sets out the key tasks and skills reported for each role by the two finfish companies that responded. It shows that Directors require to be skilled in strategic development and decision making. Communication is a key skill for Directors and Managers, and it is likely that this is outward facing communication, as well as communicating with the team.

Table 14: Finfish Skills Needs by Role (n=4)

Role	Total number in the workforce	Key tasks and skills required
Director	10[5]	
		Setting and driving strategy
		Prioritization and delegation
		Communication
		Conflict resolution and problem solving
Management	3	
		Project management
		Operations management
		Communication including writing and public speaking
		Interpersonal skills
		Prioritization and delegation
		Conflict resolution and problem solving
		Compliance and regulation
		Financial management
		Accessing finance/grant writing
		Understanding of science including fish health
		Quality assurance
		Health and safety
		HACCP Basics
Scientific / research	0	N/A
Skilled technician / operative	0	N/A
Intermediate technician / operative	0	N/A
Unskilled technician / operative	0	N/A
Maintenance / engineering	1	
		Interpersonal skills
		Communication
		Conflict resolution
		Health and safety
		Knowledge of regulation and protocols
		Record keeping
		Machine and vehicle operation and maintenance

[5] Skills likely to reflect a range of different types of Director roles given 10 Directors over 2 companies

Role	Total number in the workforce	Key tasks and skills required
		Digital literacy
Support / administration	3	
		Payroll
		Administration skills
		Call handling and communication

The table below provides the analysis of skills requirements reported by producers who depend on RAS technology. Four RAS companies were consulted, two representing 'pre-operation' large scale salmon farming companies, one eel farmer about to scale up and one ornamental producer specialising in clown fish. The data set is limited due to the very early stage of development of the 'pre-operation' salmon companies, and the specialist nature of the other RAS based businesses.

Aquaculture technical skills, RAS system design and engineering and business management skills were the most frequently cited. Business management skills development for graduates is seen as important to help them 'transition' from scientific research-based thinking to business thinking. One respondent cited entrepreneurship, including the importance of understanding personality types of investors and the process for accessing capital.

As an example of a possible approach, in Scotland National Occupational Standards for RAS have been developed within the last ten years. This could provide a useful reference when defining RAS technical competences at the operative and supervisory level to inform curriculum development.

The table is based on parallel team analysis, more of which is found in the appendices.

Table 15: Skills Needs Finfish (RAS) n=4

Skills and knowledge requirements cited	Owner / Manager	Operative	Details derived from survey responses
Transferable core skills			
Communication	Yes (1)	Yes (1)	Communicating 'science' to the public
Employability		Yes (1)	Work etiquette within different environments and cultures
ICT	Yes (1)	Yes (1)	Data science – (continuous monitoring systems, frequent discharge sampling) Internet technology skills, web design, internet servers (to help real time monitoring of fish stocks and staff recruitment)
Technical (non-aquaculture specific skills)			
Construction / trade skills		Yes (1)	Plumbing and electrical
Aquaculture related skills			

Skills and knowledge requirements cited	Owner / Manager	Operative	Details derived from survey responses
Aquaculture technical	Yes (2)	Yes (2)	RAS, aquaculture engineering and system design.
Live Feed culture	Yes (1)		*No details provided*
Biosecurity	Yes (1)	Yes (2)	Biosecurity, and quality control are (more important than experience working with fish)
Business Management Skills			
Business Management	Yes (4)	Yes (1)	Business operations and KPIs Leadership and networking Business courses to differentiate working in research from business for graduates. Business financial management -costs of production, sales, etc.
Budgeting	Yes (1)		
Entrepreneurship	Yes (1)		Accessing capital and business financing. Understanding nuances, personality types of investors, fit with investors.

4.4.2. Skills needs: Mixed finfish / shellfish

This group includes companies and organizations who are service providers to the industry and not aimed purely at production (e.g. CCAR) – nevertheless they provide aquaculture production services and are therefore relevant for the workforce analysis as would a hatchery within or external to a producer company. The table below sets out the tasks and skills reported by the two companies in the sample who span finfish and shellfish production. Along with the transferable skill such as communication and problem solving, the companies focused on the need for science and research skills, including disease management. As part of the communication piece, written skills, particularly preparing funding applications, was considered important.

Table 16: Mixed finfish/shellfish Skills and Tasks (n= 2)

Role	Total number in the workforce	Key tasks and skills required
Director	1	
		Science
		Maths
		Finance and accounting
		Written skills and grant applications
		Communication
		Problem solving
		Regulation and compliance

Role	Total number in the workforce	Key tasks and skills required
Management	0	
		Communication
Scientific / research	12	
		Lab and research skills
		Communication
		Regulation, protocols and compliance
		Disease management
		Digital literacy
Skilled technician / operative	0	N/A
Intermediate technician / operative	0	N/A
Unskilled technician / operative	4	
		None recorded
Maintenance / engineering	1	
		Communication
		Lab and research skills
Support / administration	1	
		Communication
		Team working
		Problem solving

4.4.3. Skills needs: Shellfish

The table below sets out the skills and tasks required by role, as reported by companies in the shellfish sector. It shows the wide and diverse range of skills across all operational roles. Further detail by species is provided in the appendix.

As the table shows, the 21 shellfish companies participating in the consultations reported a wide range of strategic and operational skills to ensure that staff can undertake their tasks effectively. It shows that shellfish companies require directors and managers to have a full range of business skills and that practical skills such as boat handling are important across the roles. In the oyster sector, owner managers place a particularly high value on business skills, likely to be as a result of the challenges they faced when setting up their business.

Pallet truck handling was deemed to be important across the sector as was handling seed stock, grow-out techniques and handling equipment, including pneumatic tools.

At the managerial and operative level, great emphasis is placed on employability and a general determination and hardiness to ensure resilience when working in the coastal zone, which each respondent describes in their own way. The most highly cited operative 'hard skills' are boat operations and oyster biology and culture. Trade skills were cited by three oyster respondents at the operative level, however interestingly, the aquaculture technical skills get cited five times at managerial level with a useful detailed reference made to the value placed on site specific gear design and construction. This higher-level skill correlates to references made to engineering

qualifications at a higher level. Trade skills and a general 'handiness' is useful, but their value is probably amplified if teamed up with higher level engineering and design skills within the same company. This may be indicative of how the larger and more progressive businesses that are pioneering new production methods will evolve in the future, increasing the emphasis placed on high level engineering skills.

The skills requirements reported by mussel producers are very similar to the oyster sector and emphasises the high value placed on mechanical engineering by the sector. The importance of marketing is emphasised and may have more urgency, due to the challenge of accessing and distributing to USA markets, bearing in mind that mussels are less well-known than the long-established Maine oysters.

One respondent specialises solely in scallops only and they consider employability skills to be key, making no other reference to skills needs.

Table 17: Skills Needs Shellfish (n=21)

Role	Total number in the workforce	Key tasks and skills required
Director	18-19	
		Financial management and accounting
		Strategic planning
		Writing grant applications
		Business processes and management
		Regulation and protocols
		HR/Personnel
		Communication
		Problem solving
		Seamanship/boat handling/navigation
		Operating equipment
		Health and safety
		Digital literacy
		Science background
		HACCP Basics
Management	37	
		Leadership
		Project management
		Operations planning and management
		Marketing
		Interpersonal skills
		Communication
		Conflict resolution and problem solving
		Sales and business development
		HR/Personnel management/team building

Role	Total number in the workforce	Key tasks and skills required
		Training
		Understanding of aquaculture/ocean science and biology
		Monitoring and reporting/record keeping
		Health and safety
		HACCP Basics
		Boat handling
		Digital literacy
Scientific / research	1	
		Marine biology
		Lab and research skills
		Safety
		Digital literacy
		Understanding of husbandry to identify R&D focus
Skilled technician / operative	21	
		Boat skills
		Diving
		Mechanical (pumps, boats)
		Safety
		Pallet truck operation
		Communication
Intermediate technician / operative	12	
		Communication
		Conflict resolution and problem solving
		Safety
		Boat skills
		Vehicle, machinery and boat maintenance
		Knot tying
		Operating machinery (pneumatic tools)
		Regulations and protocols
		Handling seed stock
		Record keeping
		HACCP Basics
		Digital literacy
		Time / temperature controls, thermometer calibrations
		Lab and research skills

Role	Total number in the workforce	Key tasks and skills required
		Understanding and applying company protocols
		Disease management
		Pallet truck operation
Unskilled technician / operative	83-89	
		Communication
		Health and safety
		Regulation and protocols
		Team working
		Equipment and vehicle -handling, repair and maintenance
		Knot tying
		Time keeping
		Operational techniques e.g. grow-out technology, temperature calibration, disease management
		HACCP Basics
Maintenance / engineering	15	
		Boat skills/seamanship/navigation
		Organizational skills
		Communication
		Health and safety
		Equipment and vehicle operation and maintenance
		Knowledge of the production process
		Knot tying
		Natural science knowledge
		Communication and writing skills
		Digital literacy
		Record keeping
		Operational problem solving
Support / administration	9	
		General admin skills
		Organization and office management
		Bookkeeping and financial management and software
		Record keeping
		Communication
		Problem solving
		IT/Digital literacy
		HACCP Basics

4.4.4. Skills needs: Various

The key tasks and skills needs of organizations participating in the research classed as 'various' are provided in the table below. these three organizations cover research organizations and an industry body. Many of the skills that are common across other parts of the sector are also important within these organizations although not surprisingly, there was a greater focus on scientific and research-type skills. Some specific IT skills were also cited, probably reflecting the need for IT to record, manage and analyse research data.

Table 18: Skills Needs: Various (n= 3)

Role	Total number in the workforce	Key tasks and skills required
Director	4	
		Communication, including public speaking
		Strategic development
		Financial planning and management
		Critical thinking
		Conflict resolution
		Raising finance
		Lab and research skills
		HR / Personnel
		Safety
		Production techniques
		Regulation and protocols
		HACCP Basics
		Sanitary requirements
		Disease management
		Record keeping
		Digital literacy
		Time / temperature calibration
Manager	5	
		Delegation
		Communication
		Lab and research skills, including testing
		IT, including Access and SQL
		Logistics
		Conflict resolution and problem solving
		Safety
		Record keeping
		Vehicle, boat and equipment operation and maintenance

Role	Total number in the workforce	Key tasks and skills required
		Shellfish biology, handling seed stock and grow out techniques
		Regulations and protocols
		Disease management
		HACCP Basics
Scientific / research	6	
		Analytical skills and critical thinking
		Testing and running assays
		Molecular biology or genetics
		Communication
		Lab and research skills
		Fish health
Skilled technician / operative	4	
		Vet certification to diagnose disease
		Aquatic animal health / disease management
		Regulatory knowledge (national and international)
		Critical thinking
		Vaccine manufacture
		Communication
		Problem solving
		Safety
		Lab and research skills
		Boat, vehicle and equipment handling and maintenance (pneumatic tools)
		Grow out techniques and seed stock handling
		Knot tying
		Navigation
		Record keeping
		Regulation and protocols
		Digital literacy
Intermediate technician / operative	0	N/A
Unskilled technician / operative	3	
		Communication and interpersonal skills
		Interest in science
		Safety
		Handling seed stock

Role	Total number in the workforce	Key tasks and skills required
		Record keeping
		Problem solving
Maintenance / engineering	1	
		Communication
		Safety
		Problem solving
		Vehicle boat and equipment handling and maintenance (pneumatic tools)
		Record keeping
Support / administration	5	
		Understands federal legislative issues
		General accountancy and bookkeeping
		Financial software packages
		Sales and customer service
		Communication
		Problem solving
		Vehicle boat and equipment handling and maintenance (pneumatic tools)
		HACCP Basics
		Safety
		Lab and research skills
		Sanitary requirements
		Regulation and protocols
		Export processes and paperwork
		Handling seed stock, grow out techniques and fish husbandry
		Shellfish biology
		Digital literacy
		Record keeping

4.4.5. Skills needs: Seaweed and algae

As with other parts of the aquaculture sector, companies involved in seaweed and algae production[6] report a need for a raft of business skills covering areas such as personnel and HR, marketing, organizational development, collaboration and networking, accounts and records and financial modeling. They also require transferable employability and work readiness skills, particularly amongst school leavers. In terms of Information and Communications Technology (ICT), specific mention was made of cloud-based ERP software and spreadsheet

[6] One of the respondents is a business that sources pre-dried wild product as opposed to producing or harvesting themselves

applications. Other frequently cited skills linked operational tasks are food-safety and boat operations. One respondent mentioned the need to have staff who are qualified to drive trucks for product distribution. Another discussed that training and education on seaweed culture as they started out would have been very useful. Based on what they have now learnt, they have written a book, may be a useful learning resource for people in or looking to move into the sector.[7]

Table 19: Skills Needs Seaweed and Algae (n=4)

Role	Total number in the workforce	Key tasks and skills required
Director	4	
		Communication
		Conflict resolution and problem solving
		Safety
		Sanitary requirements
		Digital literacy and IT
		Scientific skills
		Boat handling
		Engineering for systems
		Operations managements
		Marketing
		Product development
Management	10	
		Communication and writing
		Training (on the job)
		Leadership
		Conflict resolution and problem solving
		Safety
		Vehicle, boat and equipment operation and maintenance (pneumatic tools)
		Digital literacy and IT
		Scientific skills
		Grow out and handling seed stock
		Lab and research skills
		HACCP Basics
		Regulation and protocols
		Sanitary requirements

[7] Ocean Approved [now Atlantic Sea Farms], 2013. *Kelp Farming Manual.* https://static1.squarespace.com/static/52f23e95e4b0a96c7b53ad7c/t/52f78b0de4b0374e6a0a4da8/1391954701750/OceanApproved_KelpManualLowRez.pdf [accessed December 2019]

Role	Total number in the workforce	Key tasks and skills required
		Disease management
		Health and safety
		Record keeping and data entry
		Pallet truck operation
Scientific / research	2	
		Writing skills
		Grant funding
		Regulation and compliance
		Test methods
		Record keeping
Skilled technician / operative	0	N/A
Intermediate technician / operative	0	N/A
Unskilled technician / operative	28-29	
		Reading and writing
		Data tracking
		Record keeping
		Quality control
		Digital literacy
		Food safety
Maintenance / engineering	1	
		Communication
		Vehicle, boat and equipment operation and maintenance (pneumatic tools)
		Pallet truck operation
		Conflict resolution
		Navigation
		Record keeping
		Regulation and protocols
		Knot tying
		Digital literacy
		Safety
		Time / temperature controls and thermometer calibration
Support / administration	6	
		IT and office systems including financial packages
		Bookkeeping and accountancy
		Regulatory awareness

Role	Total number in the workforce	Key tasks and skills required
		Problem solving
		Communication
		Disease management
		HACCP Basics
		Lab and research skills

4.5. Summary of aquaculture sector skills needs

The final table below summarises the skills by role for aquaculture in Maine. It is analysed qualitatively to give a flavour of the key hard and soft skills required across the sector by role type. In considering the findings, it is important to recognise that the skills required in some types of aquaculture activity e.g. lab skills, may not be required across all types of organizations. The detail by sector is in the tables above.

The majority of employers across all sub-sectors report that they need staff to have a range of softer, transferable skills to respond to the current and future needs of the sector. This includes team working, communication, problem solving and generally, having a positive attitude to their work. Underpinning all of this, we know that there is a need for workers who can adapt to the changes within the sector and develop new skills and knowledge to respond to changes to ways of working, processes and equipment as the sector continues to evolve. Employers specifically value all-round and highly transferable skills around regulation and compliance, digital literacy, health and safety and record keeping.

Being able to write grant applications and understand how to access finance is an important skill for Directors and Managers and can be difficult to develop without guidance.

Not surprisingly, boat skills, along with vehicle and equipment operation and maintenance are in demand across the sector. There is a strong sense that people in different roles across aquaculture in Maine have to be able to undertake a wide range of tasks and that tasks within roles are not always strictly delineated. For example, a Manager who must display leadership and strategic thinking, may very likely be expected to have boat and navigation skills.

With a move away from manual processes, particularly in finfish, to mechanised and automated systems, the demand for digital technologies skills and digital literacy is likely to increase. Even in shellfish, many functions require digital skills and literacy, and this is reflected in the findings. It is likely that across the aquaculture sector that the demand for technical and digital enabling skills will increase given the global trend in technological development and intensification of production required to remain competitive. This may mean that the more manual / operative roles become redefined.

Currently, shellfish tends to be lower tech than finfish in terms of production processes. Arguably its primary skills need is '(hu)man-power' for lower skilled jobs in shellfish production. This is frequently seasonal so there is not necessarily a demand for year-round staffing which can make it harder to attract people and also, means training new staff. Looking internationally, there has been consolidation in shellfish production which has led to some companies looking at how technology can be developed and applied to production and starting to deploy this. It will be important for shellfish producers in Maine to keep abreast of these changes and not lose competitive advantage – and clearly this has an implication for future skills needs.

Maintenance of fish health and disease control is vital for the industry reflected in the demand for staff to have disease management and fish health knowledge and skills. Some of this will be very specialist, relating to fish health, biology and husbandry and in other roles, it's sufficient to have a sound knowledge. Depending on how the policy focus develops, the need for research and management of fish and shellfish health and welfare is likely to see an increase in demand for this expertise.

4.6. Skills and roles

Table 20: Summary of skills needs across the aquaculture sector

Role	Number in aquaculture sample	Role description: summary, examples, variation by firm scale or department where applicable	Hard skills / Knowledge	Soft skills
Directors (13%)	37	• Oversight and continuity of business • Understanding all aspects of the business • Financial well being • Strategic direction Smaller companies require all-round engagement by director. Larger firms will have directors focused on departmental functions. Management, research, budget, scheduling, administrative tasks, strategic direction, occasional on the water, delivery, sales, HR 'Wear many hats.' Company vision and direction, financial sustainability, sales, business development. (O*NET equivalent - https://www.onetonline.org/link/summary/11-9013.03)	Financial planning and management Business management Marketing Regulation and compliance HACCP Basics Seamanship/boat handling/navigation Operating equipment Health and safety Science, including fish health Lab and research skills Accessing finance and grant writing	Strategy thinking and delivery Communication, written and oral Conflict resolution and problem solving Leadership Work ethic
Management (18%)	55	*General:* Small business – handling day-to-day operations. Larger finfish operations are more specific in management functions, including significant separation of departments (e.g. hatchery separate from farm operations and processing) Awareness of risks and demands – particularly around quality, health and safety, fish health *COO:* Oversees operations, some strategy, sales, business development ***Farm Manager:*** Manages water crew, guides and consults land based crew, training aspects, land-based and water based maintenance (the go-to	HACCP Basics ICT Financial management Operations planning and management Project management including monitoring and reporting Quality assurance Health and safety Understanding of aquaculture, ocean science and biology Handling seed stock and grow out techniques	Leadership Prioritization and delegation Conflict resolution and problem solving Work ethic

Role	Number in aquaculture sample	Role description: summary, examples, variation by firm scale or department where applicable	Hard skills / Knowledge	Soft skills
		person to fix something that breaks); can work on business development aspects of company, innovation ***Processing Manager:*** Oversees land-based operation and crew; manage processing crew; data entry and synthesis of harvest and business metrics; following HAACP and food safety regulations; training; troubleshooting machines; tracking simple inventory (tags, bags); personnel safety (O*NET equivalent - https://www.onetonline.org/link/summary/11-9013.03)	Regulation and protocols Vehicle, boat and equipment operation and maintenance Understanding of science, including fish health Sales and business development HR/Personnel Logistics Accessing finance and grant writing Work Ethic	
Scientific / research (7%)	21	Laboratory work, regular testing, molecular / genetic requirements, e.g.: *Molecular biologist:* Molecular lab, PCR, develop new assays, run assays. *Veterinarian:* Act as vet for clients (practitioner) and make decisions for how to treat an animal based on testing results. Also regulatory affairs/compliance, USDA inspections. Service suppliers may be operating specialised function separated from production companies, i.e. specific testing (O*NET does not offer one clear equivalent, but an example role is: https://www.onetonline.org/link/summary/19-4021.00)	Lab and research skills Regulation, protocols, compliance Disease management/fish health Molecular biology Genetics Testing and running assays Digital literacy and record keeping Completing grant applications Work Ethic	Analytical skills and critical thinking Communication Writing Follow internal protocols Work ethic
Skilled technician / operative (4%)	25	Day-to-day functions and tasks in hatcheries, farms and processing. Some operations-specific functions, e.g. day-to-day farm operations (farm checks, water-testing, diving, knot tying) will differ from processors (shucking or filleting, equipment tests)	Boat, vehicle and equipment handling and maintenance Diving Navigation Mechanical pumps/tools Pallet truck operation	Communication Problem solving/critical thinking Conflict resolution Work ethic

Role	Number in aquaculture sample	Role description: summary, examples, variation by firm scale or department where applicable	Hard skills / Knowledge	Soft skills
		(For farm and processing operatives see 'Intermediate' below.) *Fish health coordinator:* Know what type of testing is necessary and how to comply (e.g., sample size) generating reports, billing/invoicing. *Vaccine Specialist:* All aspects of vaccine manufacturing. Growing, QAQC; process engineering; use vaccine-specific software (O*NET equivalent: https://www.onetonline.org/link/summary/45-1011.06)	Health and safety Regulation and protocols Grow out techniques and seed stock handling Knot tying Lab and research skills Vaccine manufacture Record keeping Digital literacy Work Ethic	
Intermediate technician / operative (3%)	12	As above, implementing day-to-day tasks *Farm Crew:* Growout, seeding, harvest, husbandry, maintenance of structures & vessels, gear installs; everyday, on-the-water farm operations *Processing Crew:* Setup and cleaning, run onshore processing, odd jobs when shutdown for red tide, inspect product	Boat skills Vehicle, machinery and boat maintenance Knot tying Regulation and protocols Time/temperature controls, thermometer calibration Lab and research skills HACCP Basic Pallet truck operation Understanding and applying company protocols Handling seed stock Fish health/disease management Digital literacy Record keeping Work ethic	Communication Problem solving / critical thinking Conflict resolution Work ethic
Unskilled technician / operative*	125	As above, implementing day-to-day tasks. *Farm and processing operatives:* fulfilling more basic functions of farm and processing crew. Often	Helping under supervision with activities listed for "Skilled (and Intermediate) technician / operative" above.	Communication Time keeping Team working

Role	Number in aquaculture sample	Role description: summary, examples, variation by firm scale or department where applicable	Hard skills / Knowledge	Soft skills
(42%)		processing operatives work as a student summer job. *Non-technical lab technician:* Cleaning, filling tubes, labelling, organization	*Note that despite 'unskilled' definition being used, in fact they were expected to quickly obtain skills e.g. shucking, food safety, water safety.	Problem solving Work ethic
Maintenance / engineering (6%)	19	Maintaining and repairing a range of machinery and production functions: - Hydraulics - Pneumatics - Engines (boats, factory power) - Electrics - Plumbing - Construction Potentially significant differences in demand between sub-sectors, though all shared these characteristics for job role to some extent. (O*NET equivalents, inter alia: https://www.onetonline.org/link/summary/49-9071.00 https://www.onetonline.org/link/summary/49-9043.00 https://www.onetonline.org/link/summary/49-2094.00)	Boat skills Seamanship and navigation Vehicle, machinery and boat maintenance (pneumatic tools) Health and safety Knot tying Natural science Production processes Time/temperature controls, thermometer calibration Digital literacy Record keeping Work ethic	Communication Safety Problem solving and conflict resolution Organization Work ethic
Support / administration (6%)	19	Various job roles: Sales and record keeping Book-keeping and accountancy Human Resources Information Technology Specific tasks relating to financials. Accounts payable and accounts receivable, handles all the expenses; invoicing; purchases; keeps compliant for USDA audits.	Various depending on role, but include: Office management IT Bookkeeping and accountancy HACCP Basic Disease management Call handling Regulatory awareness	Problem solving Communication Regulatory awareness Teamwork Work ethic

Role	Number in aquaculture sample	Role description: summary, examples, variation by firm scale or department where applicable	Hard skills / Knowledge	Soft skills
		Specialisation of roles much stronger in larger firms. Smaller firms (especially shellfish) noted HR and IT as an area not easily covered by managers and directors (or through basic hiring). (O*NET equivalents – various, search by role)	Digital awareness Record keeping Work ethic	

Interview returns confirmed the scoping findings, that the degree of aquaculture-specific education and training required varied according to size and of firm which influenced specialisation. It is estimated that, currently, the vast majority of the total workforce require some level of aquaculture production knowledge (fish husbandry, monitoring, etc). Additionally, a larger proportion in the LPA entrant cohort will require such skills, with the proportion normalising to the industry averages as those entrants become established and hire auxiliary staff (e.g. bookkeepers, additional processors) who are not directly involved in farm work.

Of the 'unskilled operatives', interviews demonstrate that while the entrant is not expected to have skills when starting work, the roles do in fact require some skills and training to be required, be it food standards, disease management, basic boat handling, monitoring, basic husbandry and warehouse training. This suggests that aquaculture-specific training requirements already exceed 500 people under the current industry, rising to approximately 800-1,000 in 2030. However, workforce development will require a broad range of skills (not least trade skills and food handling) that should be considered on an equal basis as on-farm requirements.

4.7. Salaries

The salary ranges for different roles are set out below:

Role type	Salary
Director	$ 73,333
Management	$ 51,226
Scientific / research	$ 60,163
Skilled technician / operative	$ 34,106
Intermediate technician	$ 33,203
Unskilled technician / operative	$ 31,664
Maintenance / engineering	$ 50,006
Support / administrative	$ 44,109

Table 21: Average salaries across aquaculture sector respondents

NB: Salaries by sub-sector include disclosive information where one or two companies submitted information, and therefore sub-sector analysis should be undertaken with data protection addressed.

It is expected that these values are lower than expected, at least for the upper ranges, for the following considerations:

1. The largest mature company did not submit a return – from knowledge of other large finfish aquaculture, the salaries are likely to be higher in such firms.
2. There is likely to be a selection bias for voluntary information on salaries, whereby those paying higher salaries for senior staff may be less inclined to disclose this.
3. Only 19 of the 32 companies gave us salary information, mostly shellfish organizations. This means Seaweed numbers are based on 1 organization and Various based on 2. No salary information for Finfish or Mixed Finfish/Shellfish organizations was given.
4. Because the salary options were banded to increase respondents comfort level in providing salary data, the median value in the band was taken for each answer, i.e. where a company has said $40,000-$60,000 for a particular role, $50,000 has been used in the analysis.
5. Companies had the option to either select annual or hourly rates. For the hourly rates, the analysis uses the middle figure (e.g. from $15-$18 is represented by $16.50). We don't have enough info re: full time / part time from all respondents to accurately break this down.

It is proposed that regular annual industry returns or periodic surveying of salaries would be a preferable way to establish transparent salary bands – this was not emphasised heavily in this study so as not to deter companies from giving other occupational information.

4.8. Benchmarking with O*NET

Industry respondents demonstrated that there is a variety of classifications of staff according to company scale, and there are differing requirements for a small-scale aquaculture owner-manager compared to Director / Manager level in larger firms.

The O*NET system has classified aquacultural workers as follows:

- Aquaculture Managers (code 11-9013.03)
- First Line Supervisors of Aquacultural Workers (code 45-1011.00)
- Aquacultural Workers (code 45-2093.00)

These coded occupations reflect both the hard and soft skill requirements for workers, and the occupational role they would perform. The benchmarking suggests that in the case of managers and first line supervisors, a Bachelor's degree is desirable – this does not fully reflect the degree of emphasis in surveys, where business were less concerned about a degree (see below) and were more focused on soft skills of trainability, work ethic, problem solving, and 'handiness'. Hands-on experience was also valued. Employers recognised that a Community College degree or similar would be beneficial, and an access to education and training that would assist in general handiness / problem solving, particularly around trade skills.

The O*NET classifications also provide income and earnings data that was less clear from survey returns, where banding of salaries and hourly pay was less specific.

The O*NET content covering skills and roles by occupation appears generally valid for educators and industry to use – particularly for small companies who may require guidance in setting out job descriptions and anticipating training and knowledge gaps at different levels (this was raised in consultation as a Human Resource need for owner-managers, who have team members undertaking 'all-rounder' positions that are often hard to define.)

4.8.1. Example: O*NET requirements for first line aquacultural workers (source: www.onetonline.org)

Updated 2019

Details Report for:

45-1011.06 - First-Line Supervisors of Aquacultural Workers

Directly supervise and coordinate activities of aquacultural workers.

Sample of reported job titles: Brood Hatchery Manager, Fish Culture Supervisor, Fish Farm Manager, Fish Hatchery Manager, Fisheries Manager, Fisheries Technician Supervisor, Hatchery Manager, Marine Site Manager, Wildlife Manager, Wildlife Technician Supervisor

View report: Summary | Details | Custom

Tasks | Technology Skills | Tools Used | Knowledge | Skills | Abilities | Work Activities | Detailed Work Activities | Work Context | Job Zone | Education | Credentials | Interests | Work Styles | Work Values | Related Occupations | Wages & Employment | Job Openings | Additional Information

Tasks Save Table (XLS/CSV)

10 of 16 displayed (16 important)

Importance	Category	Task
87	Core	Record the numbers and types of fish or shellfish reared, harvested, released, sold, and shipped.
83	Core	Direct and monitor worker activities, such as treatment and rearing of fingerlings, maintenance of equipment, and harvesting of fish or shellfish.
82	Core	Observe fish and beds or ponds to detect diseases, monitor fish growth, determine quality of fish, or determine completeness of harvesting.
81	Core	Plan work schedules according to personnel and equipment availability, tidal levels, feeding schedules, or transfer and harvest needs.
80	Core	Train workers in spawning, rearing, cultivating, and harvesting methods, and in the use of equipment.
78	Core	Confer with managers to determine times and places of seed planting, and cultivating, feeding, or harvesting of fish or shellfish.
78	Core	Assign to workers duties such as fertilizing and incubating spawn, feeding and transferring fish, and planting, cultivating, and harvesting shellfish beds.
74	Core	Engage in the same fishery work as workers supervised.
73	Core	Prepare or direct the preparation of fish food, and specify medications to be added to food and water to treat fish for diseases.
72	Core	Maintain workers' time records.

Knowledge (O*NET list)

- Biology: Knowledge of plant and animal organisms, their tissues, cells, functions, interdependencies, and interactions with each other and the environment. Administration and Management: Knowledge of business and management principles involved in strategic planning, resource allocation, human resources modeling, leadership technique, production methods, and coordination of people and resources.

- Production and Processing: Knowledge of raw materials, production processes, quality control, costs, and other techniques for maximizing the effective manufacture and distribution of goods.
- Clerical: Knowledge of administrative and clerical procedures and systems such as word processing, managing files and records, stenography and transcription, designing forms, and other office procedures and terminology.
- Customer and Personal Service: Knowledge of principles and processes for providing customer and personal services. This includes customer needs assessment, meeting quality standards for services, and evaluation of customer satisfaction.

Skills (O*NET list)

- Management of Personnel Resources: Motivating, developing, and directing people as they work, identifying the best people for the job.
- Judgment and Decision Making: Considering the relative costs and benefits of potential actions to choose the most appropriate one.
- Time Management: Managing one's own time and the time of others.
- Active Listening: Giving full attention to what other people are saying, taking time to understand the points being made, asking questions as appropriate, and not interrupting at inappropriate times.
- Critical Thinking: Using logic and reasoning to identify the strengths and weaknesses of alternative solutions, conclusions or approaches to problems.

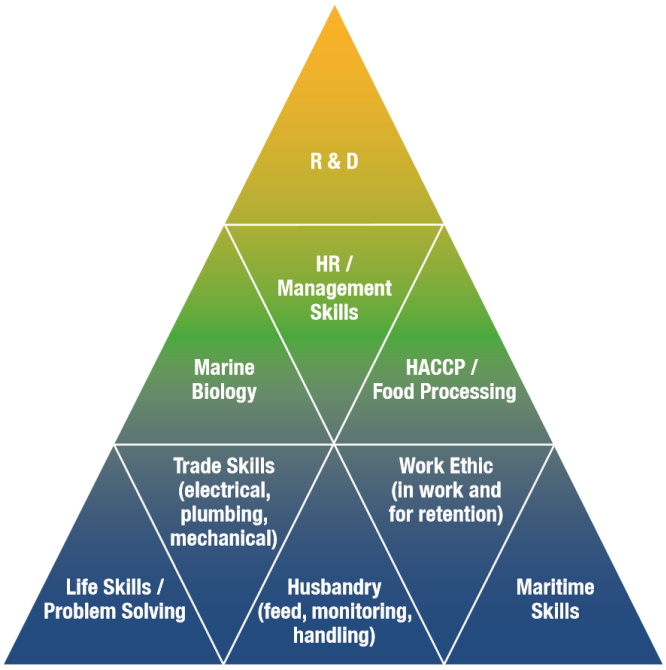
The O*NET system reflects the specific activities and details on what constitutes work-readiness, formalising many of the skills and education needed for the aquaculture workforce. In comparison to the interviews, O*NET:

- cites slightly higher degrees as suitable for the job
- it is relatively narrow in the occupations classified
- perhaps does not reflect the degree of IT and automation that may be introduced, in terms of remote monitoring and sensor equipment, robotics, etc.

In practice, there will be a wider array of roles that span these, and many of the roles may be serviced by the supply chain rather than take place on the farm. This is relevant for inland Maine job opportunities too, whereby servicing of semi-marine skills (plumbing, hydraulics, electrical, construction) will be required from across the State.

In general, O*NET is useful in benchmarking against other sectors but is not sufficient to fully identify requirements for workforce training (see Supply section).

4.9. Industry prioritization



The industry responses prioritize a pre-requisite or core (base of pyramid, in dark blue) set of skills involving work ethic, life skills, and trade skills. Marine-specific areas of fish husbandry and boat handling may not be necessary for the incomer immediately, but they do need to be acquired quickly. R&D / laboratory testing work, and more generic marine biology, is seen as useful but not fundamentally undersupplied – therefore, while maximising the industry's economic benefit will and should include high income roles, industry tended to see the priority for workforce development as building on a strong core sector capacity – the blue base tier.

4.10. Meeting aquaculture workforce demand

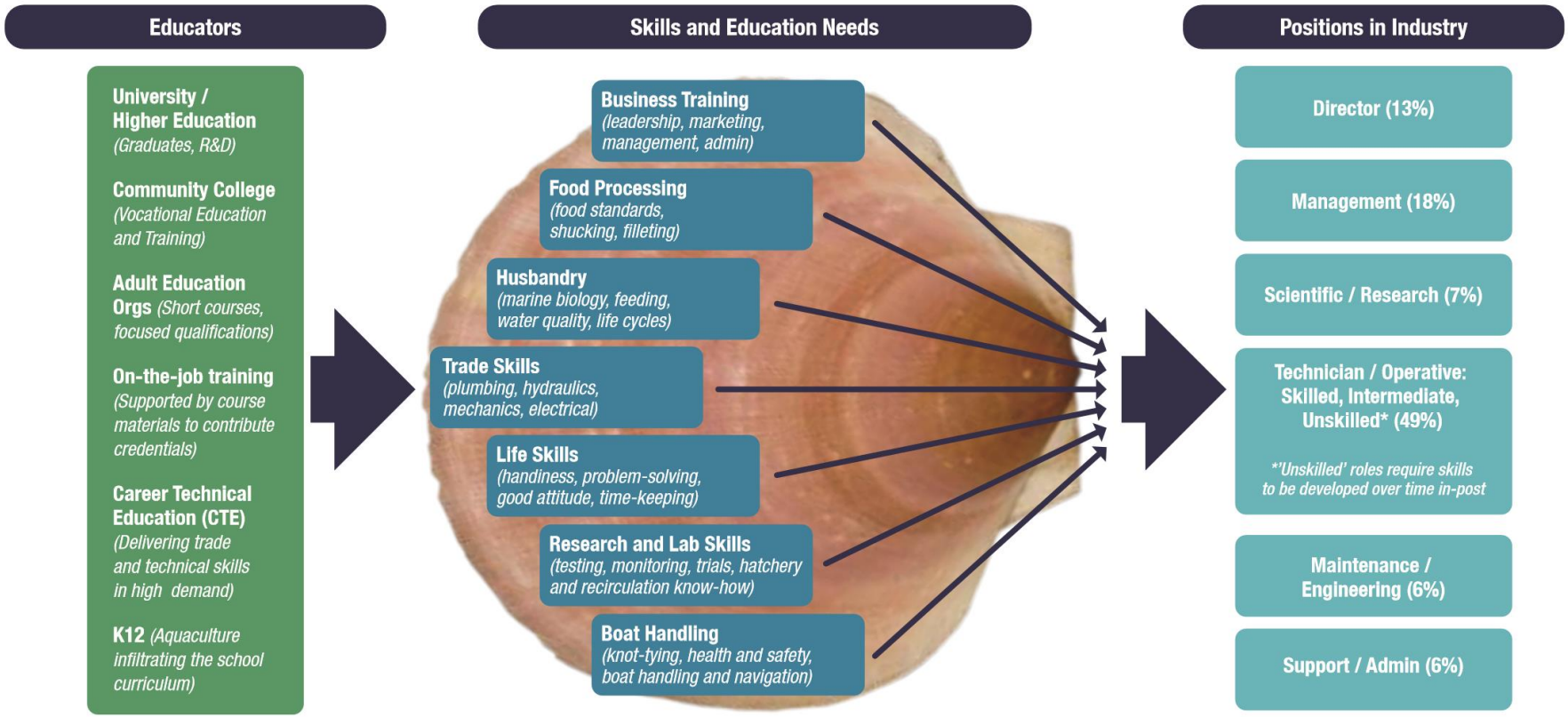


Figure 4: Meeting Aquaculture Workforce Demand (NB: percentage figures are rounded)

The diagram above outlines the high-level aquaculture workforce demand, showing: *Educators* offering means for acquiring skills and education to the aquaculture sector, including on-the-job training; *skills and education needs* required in different proportions across the sector across *positions in the industry*. The spread of skills across different roles is set out in table 20. Often the skills mix for a manager or director will contain overlapping elements with operatives, and the degree to which a function is undertaken in-house by an operative or externally by a contractor (e.g. engineering tasks) will depend on the skills and 'handiness' available in the team.

The skills and education needs for the industry are likely to change as the sector grows, with an increase in the scientific and research jobs in proportion to farm jobs. Where those higher education research skills are required, there was reported to be less shortage of skills, which is encouraging for the development of research, testing and hi-tech sub-sectors.

Educators and industry representatives alike took the view that aquaculture growth would continue to provide hundreds of farm and operative jobs in remote rural areas, which should help de-risk those areas where the long term sustainability of fishing may be under threat. These jobs would require a mix of the skills and education needs cited above, again with a focus on the core skills including maritime and trade skills.

While there is expected to be an increase in owner / directors in the short run with the increase in LPAs, over time this is likely to give way to employed management as the sector rationalises and attracts external investment.

5. Current skills provision (supply)

5.1. Summary of supply

- Very strong Higher Education and Community College provision in Marine Sciences and associated academic staff, facilities and resources
- One Aquaculture Undergraduate program at the University of New England
- No Community College provision for aquaculture currently, although receptiveness is strong in short term
- No apprenticeship for Aquaculture exists, but if standards are developed with industry involvement this could provide formal skills development on well-equipped farms
- A high level of receptiveness from the High School sector including CTE in getting involved in Aquaculture provision for grades 9-12
- Some highly valued programs that do not lead to credentials are being delivered by the Adult Education sector (bespoke to aquaculture)
- One magnet school, the Maine Ocean School, is in the early stages of considering aquaculture inclusion in its 'Ocean themed' offer
- Some aquaculture distance learning resources exist, but interest in their further development and deployment is patchy
- Sector leaders from Community College, CTE and Maine Department of Labor (apprenticeship) are all keen to collaborate, but need to see evidence of demand to commit

5.2. Supply analysis

The term 'Educators' has been used throughout to denote providers within the entire education and training pipeline for Maine, from K12 to post graduate University Degree. The following analysis of the education and training supply has been derived from two main sources:

a) Responses to the Educator surveys co-developed by the Consulting Team, GMRI, and Educate Maine and collected through SurveyMonkey, of which there were 32 respondents in total (plus one submitted by an out-of-state comparator, plus one complementary submission from within Maine)
b) One to one interview with educator stakeholders held by GMRI and the Scottish consultancy team.

SurveyMonkey was used capture and transfer the interview responses within (a) above for analysis by the Scottish team.

Table 22: Summary of educator survey returns

Education Sector respondents	Number of surveys returned
Community Colleges	2
Universities	13
High Schools	4
Adult Education	7
High School and Adult Education	2
Sector leaders and partnerships	4

The survey information returned by the educators has been analysed and complemented by additional interviews in some cases, prior to the completion of the demand surveys by the industry.

The purpose of this analysis was:

(a) *To establish Maine educators' opinion of state priorities for the development of aquaculture education and training*

State level priorities were derived from responses to questions that clearly differentiated state needs from institutional vested interests. The opportunities and constraints facing aquaculture education and training development within Maine were identified and used to inform a collective 'PESTEL' analysis which was presented to the Maine AWDS Steering Committee in April 2019 and discussed.

(b) *To establish the current supply of education and training and future supply aspirations*

The curriculum being delivered by each institution surveyed was identified, alongside their interest in for the delivery of new provision in the short or longer term. This was to establish the appetite within each sector for aquaculture related curriculum development. It also helped to identify strategically important institutions.

(c) *To determine the pre-requisites for the delivery of new curriculum in the future*

The relative importance of a range of pre-requisites for new curriculum delivery was established, providing an indication of each institution's resource needs, and the needs of each sector.

Through the deployment of Excel workbooks key aspects were evaluated quantitatively. Each institution is identifiable according to their survey return number, allowing a traceability back from the aggregated data to each and any individual full return, if required.

The current provision, appetite for new curriculum and the pre-requisites to development has been evaluated for each sector, derived from the three-stage analysis above and is described in turn below.

5.3. Pathways to aquaculture positions

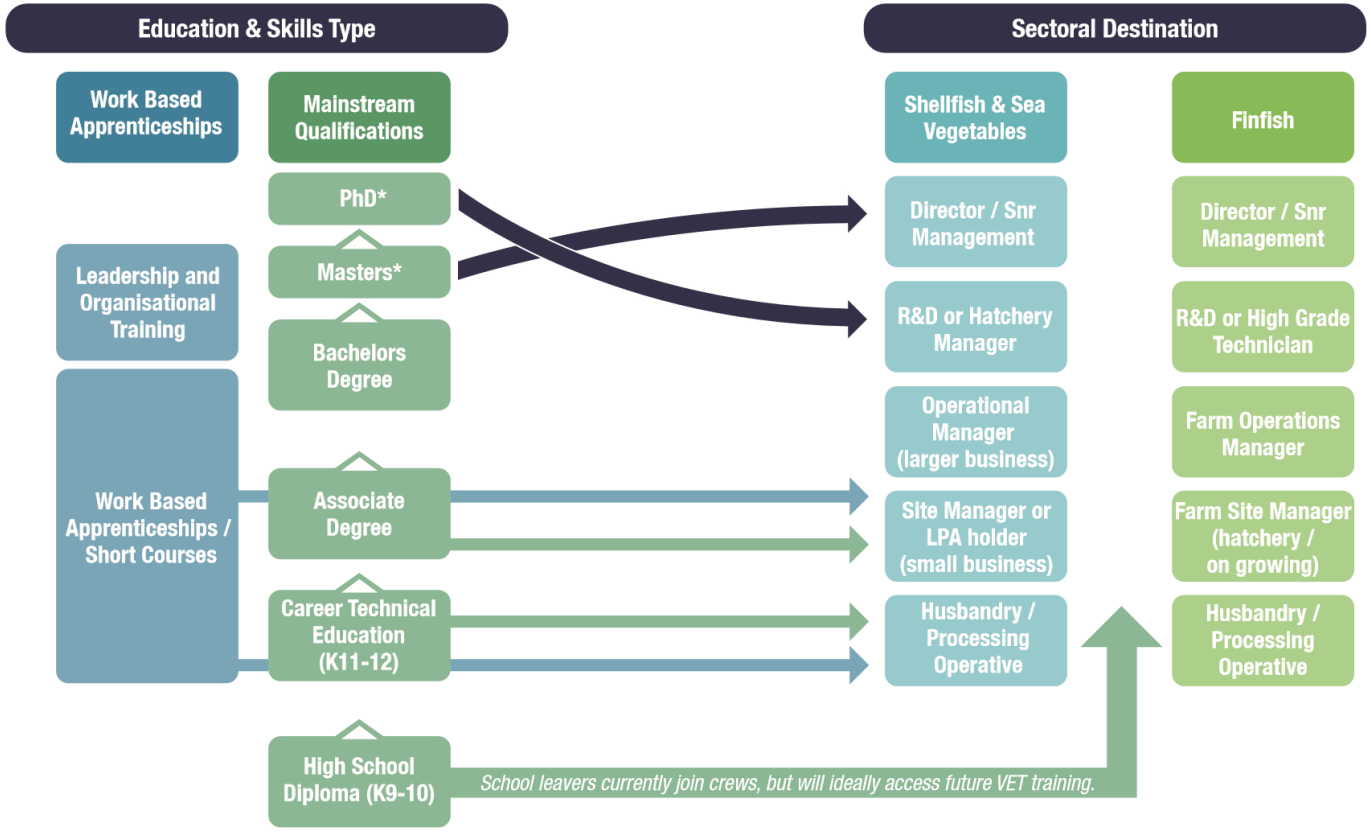


Figure 5: Pathways & Destinations

Figure 5 shows the general skills and education requirements typical (but not obligatory) for different aquaculture roles. The following sections will describe the educator pathways available for the sector. Note in some cases, companies work across a mix of species and sub-sectors (e.g. Kennebec River Biosciences and Center for Co-operative Aquaculture Research), covered here largely by the finfish pathway.

***Masters degrees seen as common education requirement for senior management.**
PhD often required for research-related roles, though many technician roles could work with Associate Degree / BSc level.

5.4. Community College sector

5.4.1. System level perspective

During a meeting in April 2017, the sector leaders provided an insight to the Maine Community College system. They are governed by one Board of Trustees responsible for seven Community Colleges (CCs) and nine campuses across the state. Some general policy guidance was offered, before considering the specific challenge of developing a CC aquaculture education.

In terms of geography, there is potential for marine-focused colleges to deliver aquaculture-specific training, but more widely every college (including inland ones) could include aquaculture demand for technical and trade skills in their scoping for demand within the state.

Typically, they prefer to support program development based on recognised 'credentials' and noted that in some sectors the need for 'licensed practitioners' often provides the development stimulus and an initial framework to work from. Credentials were defined as qualifications underpinned by standards that have been devised by industry (at company level or by a collective) that are recognised and endorsed by that sector. The point was made that tuition is relatively low cost and learners are eligible for means tested subsidy. Arguably, this makes Community College programs more accessible than University education across a wider socio-economic group which may offer the aquaculture industry some advantages when it comes to the recruitment of suitable entrants. A high percentage of CC students reside locally, some in remote areas where aquaculture is prevalent. Therefore, this type of learner already has housing and spouses with jobs and may be better placed to join the aquaculture workforce on qualifying as they do not face those common barriers.

Effective industry representation is seen as essential within the development process, with all sectors of the Maine aquaculture sector (finfish, shellfish and sea vegetables) involved to inform the development of standards to underpin credentials and the curriculum. In addition, the link to specific occupations within the aquaculture sector must be clear for any new proposed programs, with robust evidence of employer demand which is sustainable and growing to provide the leaders enough confidence to invest in resources and provide political support during any new program 'start up' phase.

Programs can be initiated with the intention of attracting recruits from across the coastal zone and state (including inland trade skills supply and similar), which can help to achieve program viability, if prospective learners are thinly and widely spread. The Community College system offers design flexibility and the opportunity to articulate and/or integrate with other qualifications, particularly apprenticeships and blended learning delivery models are said to be commonplace. Whilst the CC curriculum is generally modularised, there is a lot of flexibility, as modules are not standardised regarding their time allocations. Learner progression via the 'two plus two model' is a well-established norm, whereby a two-year CC Associate Degree provides a progression pathway to two years of Degree level completion at a University.

With evidence from industry of a well-defined and viable demand, the sector leaders support could be mobilised for specific programs by a nominated lead CC centre. The linkage to occupations and standards devised by industry would also need to be explicit and inform any proposed new set of aquaculture credentials to underpin such a program. However, it was made clear that any support provided to an individual CC institution would obligate them to cooperate with and support other Maine Community Colleges with an interest in offering aquaculture education and training and considered strategically important. The lead college would be expected to support the development of the staff and curriculum at other selected CCs, effectively compelling collaboration.

It is worth noting that the leaders of Department of Labor Apprenticeships Programs and the Career and Technical Education sector were both receptive to collaboration with the CC system. They are also keen to develop new, flexible Vocational Education and Training (VET) pathways for aquaculture, once a viable demand was proven. This receptiveness towards collaborative with other sectors, particularly the Department of Labor and Career and Technical Education, was reciprocated by the CC system leaders as a necessary part of building a robust education and training pipeline.

5.4.2. Current supply and future aspirations

The Southern Maine CC and Washington County CC in the north both submitted survey returns for the CC sector, and both were interviewed. However, the survey was also sent to Bellingham College in Washington State, as they have a mature aquaculture curriculum, and they completed a return for comparative purposes. Bellingham are well advanced with the development of their aquaculture curriculum and could be a useful 'out of state' collaborative partner for the sector leaders and any interested Maine CCs to collaborate with.

Table 23: Community College sector supply analysis

Note C = Current supply RST = Receptive Short Term; RLT = Receptive Long term

Which of the following does your organization offer currently and what are you receptive to offering in the future, if proven viable?	Survey 1	Survey 42	TOTALS Current
Full time, on campus associate degree in aquaculture	RST	RST	1
Full time, on campus associate degree programs including marine science subjects	C	RST	1
Distance or blended learning programs in aquaculture	RLT	RST	-
Short courses - technical skills training in subjects relating to aquaculture	RST	RST	-
Short courses - technical skills training in subjects relating to the maritime economy	RLT	RST	-
Basic skills development (e.g. literacy and numeracy)	C	C	2
Work based apprenticeship programs in aquaculture	RST	RST	-
Work based apprenticeship programs in other maritime sectors	RLT	RLT	-
Vocational courses (modules) relevant to aquaculture	RLT	RST	-
Vocational courses (modules) relevant to maritime engineering	RLT	RST	
Vocational courses (modules) in business management skills	C	C	2
Vocational Courses (modules) in entrepreneurship and business start up		C	1
Credit bearing experiential learning or internship opportunities in Aquaculture	RST	RST	-

Incumbent worker training through Maine Quality Centres or related programs for aquaculture or maritime economy workers	RLT	RST	-
Professional development offerings (workshops, courses, etc) in aquaculture-related subjects for K-12 teachers	RST	RST	-

Currently, there are no CC Aquaculture Associate Degrees in Aquaculture offered in Maine. However, Southern Maine CC does offer a highly regarded Associate Degree in Marine Science and has a dedicated indoor facility holding a range of fish stocks for educational purposes. They also offer basic skills (literacy and numeracy) and vocational courses in business management skills. The survey respondent was receptive to offering an Associate Degree in Aquaculture in the short term, including a credit bearing internship. The development of short courses (technical skills training) in aquaculture subjects and a work-based Apprenticeship is also of interest in the short term.

Washington County CC surveyed in the north is in the process of conducting a needs analysis for 'Commercial Fisheries and Marine Technology' including aquaculture, and they have engaged with Cooke Aquaculture to establish their needs and other companies to some degree. Although they have no aquaculture provision currently, they do offer some modules of interest to Cooke within their 'outdoor' education program, including; marine science, nautical studies and outboard engines, to build on. Their intention to offer a 1-year certificate in aquaculture as a strand within a multi-disciplined program, to serve the needs of the wider maritime economy including commercial fisheries, is under ongoing environmental exploration. They are also receptive to offering a full Associate Degree in Aquaculture in the short term, as well as; technical skills training relating to aquaculture and the maritime economy, vocational courses in maritime engineering, an Associate Degree that includes maritime science subjects and distance or blended learning in aquaculture.

In common with Southern Maine CC, they currently offer basic skills (literacy and numeracy) and modules in business management, but also offer entrepreneurship and business start-up modules.

Their programs are modularised and designed to meet the needs of industry. However, as the duration of a module is not prescribed by state policy, there is a lot of design flexibility, with a three-credit module representing 45 hours of learning and assessment activity, and one to two credit modules possible. Seasonal workloads are considered when timetabling with November – April often treated as a window of opportunity when the coastal zone is relatively quiet, and workloads have reduced. Classes are also offered on Fridays and Saturdays to increase accessibility to those in employment.

They are very receptive to apprenticeships in the short term and see great potential in their integration as they would rely heavily on access to industry facilities for much of the practical skills training and experiential learning.

The contextualisation of the delivery of generic subjects to reflect the specific vocational interests of learners is believed to be key and could be applied to aquaculture in the future. This is consistent with the ethos of the local highly regarded 'Eastern Maine Skippers' program, endeavouring to increase school retention by improving the relevance of Secondary School education to the young people from the county's fishing families.

5.5. Prerequisites

The pre-requisites to curriculum delivery are indicative of the preparedness of individual providers to meet their short-term aspirations.

Table 24: Pre-requisites to curriculum delivery for Maine Community Colleges

Note 3 = Very important; 2= Important 0 = Unimportant

Pre-requisites at institutional level for providing aquaculture E&T (Q6)	Survey 1	Survey 2	TOTALS
Evidence of a viable demand from students and / or employers	3	3	6
Improved linkage and partnership with the aquaculture industry	2	3	5
An aquaculture industry skills-needs analysis	2	3	5
Technical (aquaculture) development for existing staff	2	2	4
Appointment of teaching staff with an appropriate technical background	2	3	5
Investment in facilities for aquaculture practical training	2	2	4
Access to commercial aquaculture farms as training facilities	3	3	6
Investment in aquaculture curriculum development	2	2	4
Investment in aquaculture distance learning resources and delivery systems	0	3	3
Partnerships with other education and training providers	2	3	5
Effective promotion of aquaculture career opportunities in Maine	3	3	6

Both Southern Maine and Washington County CC believe that evidence of a viable demand from learners and industry and the effective promotion of aquaculture career opportunities in Maine are very important, demonstrating a realistic outlook. Resources to deliver an aquaculture curriculum, including access to industry facilities for education and training purposes, are also seen as very important, reflecting a mutual interest in Apprenticeships and less formal internships, which require cooperative commercial farms. It is possible that access to farms would also be essential to the delivery of some modules within any future Associate Degrees and Certificates in Aquaculture, on the assumption that any future investment in CC training facilities is unlikely to fully serve all aspects of aquaculture.

Washington County CC believe that the appointment of staff with an appropriate technical background is very important, along with partnerships with other educators and investment in distance learning resources. This implies they recognise that their capacity for the development and delivery of an aquaculture curriculum from within their current staffing compliment is a constraint, and they would need to appoint someone with the necessary aquaculture technical background. The importance they place on partnerships with other educators may have many facets. As a part of their investigation into the local demand for education and training relating to commercial fisheries and maritime technology, they are discussing articulation with local high schools to determine pre-requisites to CC program entry as well as credentials that can be carried from High School and recognised within the CC system. The need to carefully transition 'non-traditional' family trained High School learners into their programs is being discussed with the local High Schools and the Eastern Maine Skippers program leaders. The schools' curriculum offer varies considerably, and some do not offer a formal curriculum. In addition, there may be a greater need to work with other educators to develop progression pathways to the CC, to help establish a viable and sustainable recruitment base. Broad awareness will help the social license required for aquaculture expansion, and to crowd in trade skills from service providers coming out of CC.

The two CC's views on the importance of distance learning are diametrically opposed, with the Southern Maine CC having no interest in distance learning in the short or longer term and Washington County CC placing high

importance on it in the short term. This may reflect differences in geography, demography and the nature of their respective learners. The learners are more thinly spread across an expansive rural coastal zone in the north, necessitating delivery modes that can reduce the amount of travel to college from home and/or the workplace to attend a course, to widen access. Distance learning offered through collaboration with other educators, may also provide access to a wider pool of aquaculture teaching specialists who could help to develop and deliver the curriculum, supported by remote tutoring methodologies and technology.

The Washington County CC in the north has links with the Downeast Institute providing potential access to a well-resourced and well stocked facility and academic staff for education and training in shellfish biology and culture. The Downeast Institute are receptive to providing access to the other providers and their other learners and teachers. Washington County CC also have halls of residence, allowing aquaculture learners to be recruited from across the state to attend all, or specific components of an aquaculture program.

The CC sector leaders have an ongoing involvement in discussions and the research into the viability and design of a program embracing the commercial fisheries and maritime technology sectors. However, although there have been several meetings with Cooke aquaculture within this process, communication with any Maine RAS company has not commenced at this stage.

Both CCs see the investment in the aquaculture curriculum and practical training facilities as important. Southern Maine CC has a strong reputation for its Associate Degree program in Marine Science and is well equipped with labs and equipment to support delivery. It also has a covered facility and some small demonstration scale recirculation systems and enough space where additional RAS systems could be further developed in support of an aquaculture curriculum, building on their Marine Science strengths and working in cooperation with industry. They have the Maine shoreline a 10-minute drive from the college and a pier that could support boat operations and provide access to commercial fish farms in the vicinity.

Southern Maine CC has an experienced member of staff who is a highly qualified marine scientist with practical aquaculture experience in shellfish and finfish and enthusiasm for the establishment of an aquaculture curriculum at the college.

5.6. High school

The High School system is composed of mainstream High Schools, Magnet Schools and schools dedicated to Career and Technical Education (CTE).

5.6.1. System level perspective

Maine has over 200 school districts throughout the state, each with a discrete elementary, middle, and high schools governed by a Board of Directors. Districts can be made up of students from one town or multiple towns and there are 461 public elementary / middle schools (grades K-8) and 116 public high schools (grades 9-12). In addition, Maine has 101 independent elementary/middle schools and 79 independent high schools and 9 charter schools (two of which are online charter schools).

The state requires High Schools to comply with minimum education standards and students must earn high school diplomas in grades 9-12. However, there is some flexibility to adopt a curriculum that better suits a locality and its community. Each school district can impose additional requirements for students to earn diplomas beyond the minimum outlined by State statute. Currently, Maine school districts can decide whether to have a credit-based diploma system, which is more academically based, or a proficiency-based diploma system, which can be more vocational in nature.

There are examples of more radical reformation of the curriculum to address social problems associated with unacceptably high drop-out rates in some regions. Initiatives have been launched to try and make the curriculum more relevant to the community and economy young people know and have grown up in, and there is no

insistence on the delivery of Diplomas or Credentials by some schools. Each school has a 'high degree of autonomy' to operate as determined by its Board of Directors who are drawn from the local community, to ensure a suitable and relevant curriculum offer and service. The ability of High Schools to customise their curriculum is most clearly exemplified by the Eastern Skippers and Rural Schools initiative (see 3.2.2).

Magnet Schools

Maine has two magnet high schools, including the Maine School of Science and Mathematics (MSSM) and the Maine Ocean School and both schools receive public funding.

Magnet schools have admission processes and they do not need to serve all public students. MSSM mostly serves high achieving students and the Maine Ocean School serves students from a wide range of ability levels. The magnet schools have a career focus, much like CTE schools and both schools have residential options.

Career Technical Education (CTE)

There are 27 Career Technical Education (CTE) centres in Maine. The CTE system is devised so as students from sending high schools apply for specific career programs at CTE centers. As they receive High School students, these learners can also be considered eligible for an Apprenticeship pathway that could start with CTE and designed to be 'credit bearing'.

The system is flexible, and some schools may send learners for a half day or day, to offer an addition to their main curriculum, as opposed to an entirely alternative vocational curriculum. Typically, when CTE provision is longer duration, learners are preparing for an occupation and targeting a 'credential' devised, recognised and respected by industry. This leads to programs aligned to industry standards, which can provide a pathway to Apprenticeship. There are some good examples to examine, as exemplified by agriculture programs in the north of Maine.

Close ties and articulation with the Community College sector are the norm, to facilitate progression and state-wide articulation agreements exist for other sectors and could be formed for aquaculture. For example, it is quite common for learners to be completing their 'High School Standards' whilst also on a CTE program, so as their numeracy and literacy meets a minimum standard. The CTE sector believes that it is good practice for an industry to define the basic skills needed and applied within the standards for their sector. It is worth noting that Adult Education are receptive to involvement in basic skills delivery (See 5.4)

Currently, Maine Centres offer courses to support High School students career pathways based on applied learning directly relevant to the Maine workforce, specific trades and vocations. CTE traditionally applies to Juniors and Seniors (17/18 years) but increased Middle school activity (9-10 - 15/16 years) is about to be piloted and 'introductory' programs, driven by local survey needs and an Advisory Committee could be in scope.

The majority of CTE Centres offer courses for students in grades 11 and 12 and serve students from a range of High Schools. Each public Maine High School has a nominated CTE Centre partner, allowing all Maine students to access these 'vocational' courses, depending on the availability of places. Some CTE Centres are co-located with traditional High Schools while others are located centrally. Students are often bused to these centres for part or all the school day for specialised programs.

The location of the CTE Centres in Maine is available from: http://mainecte.org/find/

CTE Centre Programs are currently organized in 10 career clusters and employability skills:

- Agriculture & Natural Resources
- Architecture, Construction & Manufacturing
- Arts, Audio/Video Technology & Communications
- Business Management, Administration, Finance, Marketing, Sales & Service
- CTE Employability Skills
- Education & Public Services
- Health & Human Services
- Hospitality & Tourism

- Public Safety & Security
- Science, Technology, Engineering and Mathematics (STEM) & Information Technology
- Transportation

An overview of these clusters is available from: https://www.maine.gov/doe/learning/cte/clusters

The above CTE structure is currently under review and towards the end of 2020 there may be 16 National Career Clusters introduced.

5.6.2. Current supply and future aspirations

Educator survey returns were provided by six High Schools, four of which are mainstream High Schools, one a Magnet School and another a CTE provider. The CTE provider and one of the mainstream High Schools also provide Adult Education.

This represents a very small percentage of Maine's High Schools, and therefore the semi-quantitative analysis below cannot be assumed to be representative of the High School sector within the state of Maine. However, a combination of survey feedback and interviews held have provided the basis for some conclusions to be drawn, based on the assumption that the small sample is broadly indictive of the state, as opposed to atypical.

There were additional returns from the Maine Education Department CTE Director, and Rural Aspirations, a program that runs across several schools in the north of the region. These have been segregated from the High School returns, for the purpose of analysis.

Table 25: High School sector (relevant selected schools) supply analysis

Which of the following does your organization offer currently and what are you receptive to offering in the future, if proven viable?	Totals current supply	Totals receptive short term
A 9-12 career pathway in aquaculture or marine science related subjects	1	3
Courses in aquaculture or marine science related subjects	3	2
Distance or blended learning courses in aquaculture or marine related subjects	0	5
A career and technical education pathway in aquaculture or marine science related subjects	0	4
Units in particular courses relating to aquaculture or marine related subjects	4	1
Career development programming related to aquaculture or marine science related subjects	2	3
Job shadowing, internships, or other work-based experiences in aquaculture or related subjects	4	1

High Schools were selected by relevance, i.e. focusing on those with relevant aquaculture programming or likely interest. Mindful of the low sample size and considering information provided during one to one interview, several observations can be made. There is only one High School (a Magnet School) providing aquaculture or marine science pathways at 9-12, although two others were receptive to doing so in the short term. Three respondents are providing courses in aquaculture or marine science subjects, and five were receptive to providing distance/blended learning courses in aquaculture or marine science related subjects in the short term. Four were receptive to providing CTE programs in the short term and bearing in mind only one of the respondents

represented CTE, this implies that there may be a strong appetite from mainstream High Schools to offer CTE. This could be interpreted as a benefit or a hindrance, depending on local needs and the availability of an alternative supply. The relative influence of state education development policy and decision makers on school Boards will also have a bearing in each locality (see Chapter 7).

Job shadowing or work experience in aquaculture or related subjects was already being provided by four of the six respondents and two were providing aquaculture career development programming with three more receptive in the short term.

Representatives from the Maine Ocean School established in 2017, a Magnet School with an ocean theme and residences, designed to attract High School age learners from across the state, were interviewed. Currently there are 11 students in their program ranging in age from 15 to 18 years (9-12). They are state funded but not state governed and their finance model is complex, and they feel at a disadvantage, due to the way funding is currently administered. The school budget is aligned with the Charter of Schools requiring them to report to the Committee of State Legislature under the Education and Cultural Affairs Committee, composed of a 17-member Board.

The Magnet School has a clear ocean focus and creates Career Professional Development (CPD) for High School teachers as an important part of its remit. The summer CPD provide an income stream, allowing them to develop their role as a supporter to other Maine high schools.

Four pathways to ocean related careers exist, but aquaculture is not amongst them currently. The school must maintain broadly based vocational pathways and all four sectors are visited by learners. Educating people to think entrepreneurially, is an important theme, as opposed to education for setting up business (entrepreneurship).

They could undertake internships but a direct input to Apprenticeship delivery is less likely. Learning resources are used to support the delivery of 'student centred learning' and a marine science lab is being planned. The CTE sector is seen as a natural partner and they can access their provision. They are aware that the best of CTE have 'Signature Programs' which link to certification and they plan to partner and not compete with CTE in the future.

Bespoke education initiatives

There are Maine education initiatives influencing the development of the High School curriculum in selected regions of coastal zone, exemplified by the Eastern Maine Skippers (EMS) program and the Rural Aspirations (RA) project in the north east of the region, which are particularly relevant. The EMS program aims to find ways to keep teenage learners engaged within High School education for longer by increasing its relevance. Many are attracted into the fishing industry on a 'students' license' and following a very profitable summer holiday fishing when in their mid-teens, see little point in school. This phenomenon has been having negative consequences socially and at community level. The EMS program has engaged students in aquaculture as potential solutions to problems in their communities by inspiring them to develop new opportunities for their future.

The RA team believe that the students they work with know that aquaculture is happening, but probably don't understand the career tracks and active ongoing initiatives could be harnessed to form the core capacity to raising aquaculture career awareness. The schools they work with are looking for place-based, project-based opportunities and some are looking to develop entrepreneurial and innovation pathways for students.

The RA team engage with schools and/or communities wanting to retain young people and not send them away for 9-12 education. Their experience with marine, fishing and aquaculture curriculum is with small, rural, coastal, cash-strapped high schools and districts. Student numbers are small, teaching staff limited and hard to recruit and maintain. They note that any new curriculum would need be able to be flexible and scaled for each district/school and customised for teachers and individual students, with support available.

The insights provided by these Maine education initiatives have implications to the future role of magnet schools and CTE and the nature of their partnership the rest of the High School sector, which may need to vary regionally (see Chapter 7).

5.6.3. Prerequisites

Table 26: Pre-requisites to curriculum delivery for Maine High Schools

Note: 2 = Very important; 1= Important 0 = Unimportant

Pre-requisites at institutional level for providing aquaculture E&T (Q6)	Totals (High Schools)
Evidence of a viable demand from students and/or employers	9
Improved linkage and partnership with the aquaculture industry	10
An aquaculture industry skills-needs analysis	8
Technical (aquaculture) development for existing staff	4
Appointment of teaching staff with an appropriate technical background	9
Investment in facilities for aquaculture practical training	7
Access to commercial aquaculture farms as training facilities	7
Investment in aquaculture curriculum development	6
Investment in aquaculture distance learning resources and delivery systems	4
Partnerships with other education and training providers	7
Effective promotion of aquaculture career opportunities in Maine	11

The evidence of a viable demand and effective promotion of aquaculture career opportunities were rated as very important, alongside the appointment of teaching staff with an appropriate technical background and improved linkages with industry. The investment in an aquaculture curriculum, teaching facilities, improved access to commercial facilities and partnerships with other educators were rated as important. Interestingly, considering the high proportion of respondents expressing a short-term interest in distance/blended learning, the importance of an investment in the development of distance learning resources and delivery systems was not as great as might be expected. This may imply that respondents believe such resources are already available. Whilst this could be true for the Maine Ocean School interviewed, as they are already delivering 'resource-based learning' to the 9-12 category, for the majority it is more likely to indicate that their focus is on the short-term priorities above, before distance learning can be considered.

Beyond giving opportunity to individuals in the workforce, it is apparent that high schools in their broader role of setting out choices and awareness of different careers can play a role in informing the younger generation in Maine about aquaculture. This, as much as any other intervention, may be important in establishing conducive conditions for the sector where impacts and contributions are understood, and workers entering the industry do so in an informed environment.

5.7. Apprenticeship

There is no Apprenticeship for aquaculture currently in the state of Maine. This restricted survey returns and discussions to the Department of Labor leaders responsible for the Apprenticeship system.

5.7.1. System level perspective

In Maine, an Apprenticeship requires 2,000 hours structured and supervised training, which can include 'on the job' naturally occurring skills development opportunities and informal training mapped to specific Learning Outcomes underpinned by industry occupational standards. Typically, O*NET, a generic and industry specific tool, is used to assist the definition of nationally recognised competences and credentials. However, this information may be insufficient, necessitating the establishment of a process for this purpose (see Chapter 7).

Apprenticeships commonly articulate with Associate Degrees and 'Pre-Apprenticeships' can be designed and developed to articulate with CTE, which provides the opportunity to place an Apprenticeship at the heart of Maine's Aquaculture Vocational Education and Training pathway. The mandatory 144 hours component of 'classroom' activity is very flexible in terms of the delivery mode and can include employer and college led education and training, as well as distance learning.

Demonstrable skill gains must lead to an increase in earnings in recognition of Apprenticeship completion. A wage schedule linkage to the Apprenticeship is mandatory within Maine and therefore the Apprenticeship assessment process must be robust. This is often handled by the Community College system within the state. Consequently, it is commonplace for a Community College to take on the role of sponsor, via business partners, with sector associations providing the administration for the Apprenticeship to make the process manageable and accountable.

Grants pay for the classroom-based component issued via US Department of Labor and additional workforce funding can be added and braided with this funding source.

Validation takes 4 months to meet state and Federal Standards for approval of the skills needs for an occupation and it is possible for internships to evolve into Apprenticeships.

5.7.2. Current supply and future aspirations

As there is no current provision related to aquaculture, there are no providers to consult. However, the sector leaders made it clear during interview that they are aware of the important role that could be played by an Aquaculture Apprenticeship

5.7.3. Prerequisites

There have been no providers asked to comment on their readiness to deliver Apprenticeships. However, providers from both the Community College and High School sectors have stressed the importance of strengthening linkages to industry. Arguably this is the most significant pre-requisite for entering Apprenticeship delivery, as employers and their facilities are central to the development of the learners' practical competences and the provision of robust assessment evidence that can contribute towards their achievement of credentials within an Apprenticeship program. This is explored further in Chapter 7.

5.8. Adult education

The Maine Adult Education sector represents a 'broad church', including; mainstream providers of generic coreskills relating to employability and bespoke aquaculture training initiatives.

5.8.1. System level perspective

Currently there are 70 Adult Education (Adult Ed) programs funded by local dollars approved by each school district The Adult Ed department must deal with the management of delivery and compliance and forms the interface between industry and Adult Education services.

They can help to match funds to employer needs and priorities and commonly work with and support course delivery within the CC system and Maine Department of Labor Apprenticeships. Adult Ed is often provided on campus to a cohort formed of learners from a wide range of courses, in order to help the learners to cope with CC courses that they are enrolled on but may not have the necessary core skill pre-requisites to cope. It is common for people to go back to CC who need help to avoid the stigma associated with Adult Ed. It also sets them on a defined vocational pathway. Adult Ed support is sometimes provided in CC technical subject classes.

They can support provision of core/transferable skills on CTE programs in local schools and are very receptive to an involvement with credit bearing course within CTE (11-12) that are funded by the state.

Currently they have a 'soft skills for work' program; '7 standards work ready' which can be contextualised to any sector. Language courses are run for non-English immigrants, some of whom have high credentials and a lot of experience in their sectors. This is exemplified by the New Maine resource centre in Portland offering English courses to professionals.

Teachers CPD is offered, to help build capacity in the teaching profession for the better and more effective delivery of core skills. There are Adult Ed clusters and hubs to be aware of in the state, and 'braided funding' is seen as key to offering better services across a wider demographic.

5.8.2. Current supply and future aspirations

There were ten survey respondents from a diverse pool of providers categorised as Adult Ed including a number on 'non-profits' and as such this is a diverse sample. Although indicative, it cannot be assumed that the sample represents the state of Maine.

Of these five are 'aquaculture bespoke' Adult Ed providing a range of programs for industry and prospective new entrants and five are mainstream providers with a current focus on basic skills, with three of these also providing High School education.

Table 27: Adult Education sector supply analysis

Which of the following does your organization offer currently and what are you receptive to offering in the future, if proven viable?	Totals current	Total receptive short term
Short courses - technical skills training in subjects relating to aquaculture	5	3
Short courses - technical skills training in subjects relating to the maritime economy	2	4
Distance or blended learning courses in aquaculture or marine related subjects	2	5
Basic skills development (e.g. literacy and numeracy)	5	1
Vocational courses (modules) relevant to aquaculture	2	5
Vocational courses (modules) relevant to maritime engineering	2	3
Vocational courses (modules) in business management skill	3	3
Vocational courses (modules) in entrepreneurship and business start up	5	2
Professional development offerings (workshops, courses, etc) in aquaculture-related subjects for K-12 teachers	2	2

Five of the ten respondents are already providing short courses (technical skills training) in aquaculture and a further three are receptive to doing so in the short term. Five are providing basic skills development and a similar number providing vocational courses in entrepreneurship and business start-up. Two are providing distance or blended learning in aquaculture or marine related subjects and a further five are interested in doing so in the short term. Two provide vocational modules in aquaculture with another five are interested in doing so in the short term.

The overall impression is of a sector engaged in the delivery of relevant curriculum and applying delivery modes that are in demand from industry and of interest to other providers, namely, practical short courses and distance learning, respectively.

Aquaculture bespoke Adult Ed

The apparent high level of aquaculture provision within this category is largely due to the inclusion of five organizations established to provide training to the aquaculture sector. Whilst forming a valuable role within aquaculture training and business start-up in the short term, some are private sector initiatives with a philanthropical motive. Therefore, the sustainability of their services cannot be assumed and may become an issue.

The range of services provided by this sample is summarised below

- Courses for prospective, new and existing shell-fish farmers on shellfish biology and culture and has a well-developed learning resource.
- Support in enterprise selection and business planning, combined with periods of practical experience and an opportunity to network with existing aquaculture businesses to establish contacts and price information.
- Basic skills with an oyster farming course (knowledge and skills based) combined with a two-week internship
- Training in aquaculture techniques for soft and hard clams for shellfish harvesters and oyster farmers
- Aquaculture distance learning resources used to support course delivery

5.8.3. Prerequisites

Table 28: Pre-requisites to curriculum delivery for Adult Education

Note: 2 = Very important; 1= Important 0 = Unimportant

Pre-requisites at institutional level for providing aquaculture E&T (Q6)	Totals
Evidence of a viable demand from students and / or employers	19
Improved linkage and partnership with the aquaculture industry	16
An aquaculture industry skills-needs analysis	16
Technical (aquaculture) development for existing staff	9
Appointment of teaching staff with an appropriate technical background	9
Investment in facilities for aquaculture practical training	8
Access to commercial aquaculture farms as training facilities	13
Investment in aquaculture curriculum development	12
Investment in aquaculture distance learning resources and delivery systems	12
Partnerships with other education and training providers	12
Effective promotion of aquaculture career opportunities in Maine	14

In common with other education sectors, evidence of viable demand form students followed by improved industry partnerships, an aquaculture-skills needs analysis and aquaculture career promotion are the most important pre-requisites.

Access to commercial farms, investment in the aquaculture curriculum and distance learning resources and partnerships with other training providers are also seen as important. As a result of the large proportion of aquaculture bespoke providers and training initiatives represented, the technical development of existing staff and staff appointment are not seen as important, relative to the other educations sectors responses.

5.9. University

5.9.1. System level perspective

The state of Maine has twenty-eight accredited, degree-granting institutions of higher learning. The state's land-grant university and only research university is the University of Maine in Orono. It is the flagship of the University of Maine System, which also has branch campuses in Augusta, Portland / Gorham / Lewiston, Farmington, Fort Kent, Machias, and Presque Isle.

The state's three oldest institutions of higher education are Bowdoin College (founded in 1794), Colby College (1813), and Bates College (1855). The three colleges collectively form the Colby-Bates-Bowdoin Consortium and are ranked among the best colleges in the United States; often placing in the top 10 percent of all liberal arts colleges.

In terms of their governance, Universities are relatively independent and typically faculty play a role in strategic decision-making and shaping institutional priorities. Commonly college bylaws and guidelines for promotion and

tenure, determine how the college's schools and programs can achieve their goals and individual faculty members can develop their own careers.

The University of New England, a private, coeducational university based in Biddeford is the only provider of a Bachelor's Degree in Aquaculture. Marine Science is offered by several Universities, including the Universities of New England and Maine, some liberal arts colleges and the Maine Maritime Academy, whose primary focus is providing graduates for the maritime industry.

The state priorities are often more significant to University investment decision making than global ambitions and / or recruitment of out of state students as there is no direct link between departmental growth and recruitment.

Growth in Marine Science Undergraduate recruitment is learner demand driven currently, fuelled by the environmental concerns of youth. A recent SEANET grant of approximately $20 million resulted in investments in aquaculture infrastructure and staff but did not lead to a growth in specialist aquaculture teaching capacity.

5.9.2. Current supply and future aspirations

There were thirteen respondents to the Educator Survey in total, six of which were schools or departments of the University of Maine and included the School of Marine Sciences, School of Business, Down East Institute and several departments with specific roles, including the Aquaculture Research Institute and Cooperative Extension, reflecting the University of Maine's status and prominence as the states only land grant and research University. In addition, there were returns from four other Universities, one of which was a Liberal Arts School and one a provider of Human Ecology Degrees.

Visits were undertaken and interviews held with the University of New England, University of Maine School of Marine Sciences, Aquaculture Research Institute and School of Business, Down East Institute and the Maine Maritime Academy. Unity College was consulted by phone.

In terms of the Marine Sciences and Aquaculture higher education provision, the combination of extensive interviews and survey returns provides a comprehensive, reliable and representative sample. Therefore the data analysis can be assumed to be representative of Higher Education provision and capacity within Maine.

Table 29: University sector supply analysis

Which of the following does your organization offer currently and what are you receptive to offering in the future, if proven viable?	Totals current	Total receptive short term
Post graduate degrees in Aquaculture	4	0
Undergraduate degrees in Aquaculture	1	2
Undergraduate and/or Post graduate degrees in Marine Sciences	9	-
Courses that teach high level technical skills related to aquaculture and the maritime economy (e.g. lab skills, marine science, computer modeling, engineering	9	1
Courses that teach hands-on skills related to aquaculture and the maritime economy (e.g. boat skills, knot tying, navigation, diving)	6	-
Courses in aquaculture	6	3
Courses in marine science	10	1
Courses relating to maritime engineering	1	4

Which of the following does your organization offer currently and what are you receptive to offering in the future, if proven viable?	Totals current	Total receptive short term
Courses in entrepreneurship and business development	8	1
Distance or blended learning programs in aquaculture	3	3
Degrees that include experiential learning or internship requirements in aquaculture or the maritime economy	6	3
Professional development offerings (workshops, courses, etc) in aquaculture-related subjects for K-12 teachers	6	

Within the survey sample, there was one provider of Undergraduate Degrees and four providers of Post-Graduate Degrees in the field of aquaculture, as opposed to nine providers of undergraduate and/or post graduate degrees in the Marine Sciences. There are nine providers of courses that teach high level technical skills related to aquaculture and the maritime economy and six teaching hands-on skills related to aquaculture and the maritime economy (e.g. boat skills, knot tying, navigation and diving).

Courses in entrepreneurship and business management are delivered by eight respondents and three provide some form of distance / blended learning in aquaculture with an additional three receptive to doing so in the short term. There are six providers offering internship / experiential learning with three more receptive in the short term. Professional development is offered to K12 teachers by six of the respondents.

In summary, the Higher Education sector supply appears healthy, although there is a much stronger emphasis on Marine Sciences as opposed to aquaculture at this relatively early stage of the industries development, partly to meet student aspirations and interests and partly due to the relatively small number of graduate level opportunities that the industry is able to offer currently.

The interviews held provided more detailed insights:

Currently, placement rates are high for Marine Science Majors and the many of the University of Maine Marine Science school graduates take the opportunity to travel beyond the confines of New England and go overseas to Australia and UK, to join inspirational environmental projects. Some do go into aquaculture out of state where there are more opportunities. Notwithstanding the general preference for environmental careers, the school sees aquaculture as a great recruiting tool, as working outdoors and the business aspects appeal to more practically minded applicants not seeking laboratory-based science careers. The school had an interest in an aquaculture with business minor combination 5-6 years ago, which could have merit today. It was suggested that it may be possible to promote business minors to 5-6 of their Marine Science undergraduates a year, who could then potentially join the start-up LPAs group. Most of their aquaculture research effort has been applied to solve local issues and the school believe that strong links have been developed with the aquaculture industry.

At the University of New England an Aquaculture Major is available that subsumes an Aquarist course, with water recycling technology providing a common technological bridge between the management of aquaria systems for ornamental fish, commercial finfish hatcheries and pre-operational large-scale RAS (Recycling Aquaculture Systems) on-growing Atlantic Salmon. This package is growing fast in popularity and the program is presented as a global provision with 40 students currently undertaking the Major. A Marine Science with Law Major is also growing in popularity due to the increasing role of the regulators, and the school has just started a Masters-Degree with global appeal in 'Ocean Food Production' which is attracting many applications. There are 15 PhD research students in the school.

They recognise that there are lots of Grads who want to stay in Maine, and to encourage this, the school believes the entire supply chain needs to be in scope for employment, including processing and distribution. They make their students aware that jobs at a higher technical level are scarce and Grads must be prepared to start as operatives.

The University of Maine has a Business School placing 300 internships every summer, mostly within the large sectors, including the financial services, such as banks, and undergraduates may not be so well attuned to food production. However, the Dean believed that talks by guest speakers from the food producing sectors, including aquaculture, would be effective in raising awareness of their entrepreneurship potential. The school has a Professional Development Center and 'Business to Community' projects are undertaken by Undergrads and Postgrads.

The other possibilities discussed were:

- Offering business minors for Marine Science students.
- The development of bespoke contextualised business development courses to assist future entrepreneur industry entrants.
- The development of aquaculture 'project -based service learning' which normally incurs a cost to the business. This could tackle a sector level supply chain/marketing issue, as opposed to an individual business level challenge, potentially.
- Project based learning by Under-Graduates through their business club scheme, on a fish farm (at no cost).

5.9.3. Prerequisites

Table 30: Pre-requisites to curriculum delivery for Maine Universities

Note: 2 = Very important; 1= Important 0 = Unimportant

Pre-requisites at institutional level for providing aquaculture E&T (Q6)	Totals
Evidence of a viable demand from students and / or employers	22
Improved linkage and partnership with the aquaculture industry	22
An aquaculture industry skills-needs analysis	15
Technical (aquaculture) development for existing staff	10
Appointment of teaching staff with an appropriate technical background	17
Investment in facilities for aquaculture practical training	14
Access to commercial aquaculture farms as training facilities	16
Investment in aquaculture curriculum development	22
Investment in aquaculture distance learning resources and delivery systems	7
Partnerships with other education and training providers	16
Effective promotion of aquaculture career opportunities in Maine	20

Based on the analysis of survey returns, the University sector believes that most important pre-requisites are evidence of student demand, improved partnerships and linkage with industry, investment in the aquaculture curriculum and effective aquaculture careers promotion.

Partnerships with other educators, appointment of teaching staff with an appropriate technical background, access to commercial farms and investment in facilities are also seen as important. The investment in aquaculture distance learning resources and delivery systems is seen as relatively unimportant.

Interviews with University representatives revealed further insights regarding the resource requirements and pre-requisites for aquaculture curriculum development for the sector and concerns were expressed that aquaculture

faculty staff constraints could lead to a loss of momentum, post SEANET. Conversely, they do recognise that the University infrastructure and fish holding facilities in Maine are now well developed.

The main issue appears to be staffing the development and delivery of an experience-led and high-quality curriculum. One University alleges that latterly the aquaculture curriculum has suffered due to the loss of faculty staff and one or two new Professors in Aquaculture are needed to allow courses to be offered. To bolster their programs, they are open to aquaculture businesses approaching them to discuss paying for internships and are very open to partnership. In the absence of any opportunity to appointment staff with a commercial aquaculture background, this is a worthwhile short-term measure, using internships to strengthen the aquaculture emphasis within the curriculum.

Community College links are good and there is a genuine political will and support for collaboration between the CC sector and University. However, there have been some failures at institutional level to finalise new 'two plus two' pathways, allegedly. One respondent claimed that there is a reluctance for some CC students to leave their communities which can inhibit their academic progression. Many CC students are employed while enrolled, and it may take them 10 years to complete a Degree on a part time basis, which is a 'hard sell', especially to the economically disadvantaged. However, in principle the respondent believed that CC partnerships were a good idea and should be pursued and could lead to a better utilisation of the state's Higher Education facilities and improved aquaculture content within the CC and Higher Education curriculum.

Competition for undergraduates in Marine Science and related fields by two of the leading Universities was a fact of life where institutions must compete for fees. One recognised that students in professional science majors could benefit from collaborative partnerships that allowed access to an expanded or more specialised Degree program.

5.9.4. Prioritization of Higher Education Institutions

Higher Education institutions recognise how they can support industry in research and development, with PhD and Masters-level laboratory and technician staff, and the supply of marine biology graduates who have a range of transferable marine knowledge. They also recognise the value of management skills, husbandry and in equipping graduates with hands-on maritime skills to supplement their academic knowledge.

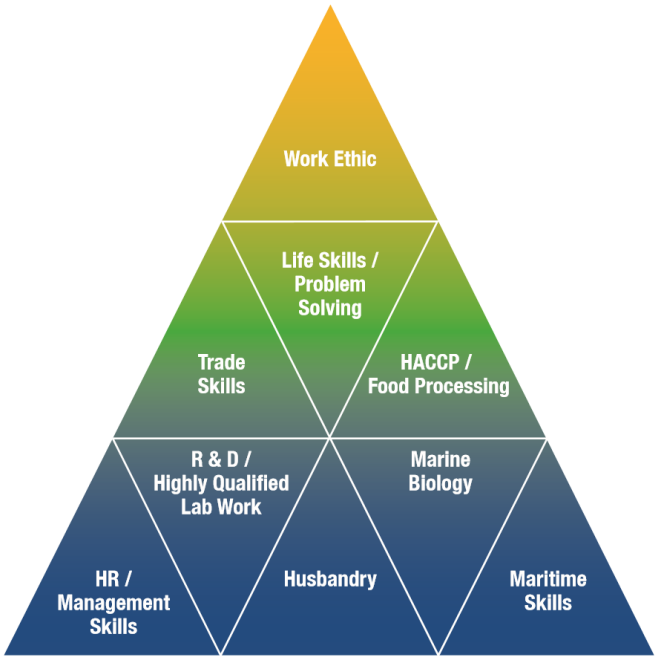


Figure 6: Education and Skills pyramid as seen by HE

However, areas such as work ethic and trade skills are more assumed as a given elsewhere in skills provision, when they are seen as core requirements by industry (section 4.9). Often university graduates will be attracted by other sectors, meaning the university priorities do not always filter through to industry's base needs which are, *inter alia*, maritime skills in semi-skilled operative roles, life skills, working knowledge of marine biology, trade skills, certifications for machinery, food handling, etc. More positively, many of the core areas universities prioritise – such as research and skilled marine biology graduates – the industry now considers supplied, while those running university aquaculture courses are increasingly keen to furnish their graduates with VET-style, hands-on capabilities. There can be strong synergies, then, between the universities' current offer and a wider VET platform.

Regarding the ambition for Aquaculture Higher Education in Maine to compete within international markets, one respondent alleged that any growth in student numbers from international recruitment could not be clearly incentivised. All income is centrally held and administered and income generation from increased student recruitment and research dollars did not directly correlate to the school's staffing budget. University leaders setting the institutions priorities for investment had many competing demands for resources to respond to. Although the respondent felt that their school was well enough supported to replace marine science staff who retired, it could not currently invest in aquaculture specialists through the creation of new posts.

The University of New England has converted some of its multi-purpose Marine Science facilities for holding 'macro and mega-fauna' into fish holding facilities to provide Undergrads the opportunity to set up and run recirculation systems. There are some internships on commercial farms as well as research facilities and a close contact is maintained with the Maine aquaculture industry.

6. Supply and demand gap analysis

6.1. Summary

Demand

- There is a demand for Aquaculture Vocational Education and Training that could be met by a new VET pipeline led by the CC sector working with CTE and Department of Labor (Apprenticeship Program)
- Industry representatives need to get involved with 'standards development' for each sector, working from the information provided in this report
- (Demand for) Bachelor of Science Degree in Aquaculture seen as medium level significance short term and of increasing importance longer term
- Importance of aquaculture careers marketing in schools and extension to inform and positively influence learners, their parents and the public, regarding aquaculture
- Strong support for industry skills need analysis and aquaculture careers promotion from most providers
- Strong support for the development of Associate Degree, CTE, Apprenticeship and technical short courses is evident

Supply

- Access to farms for formal training that leads to credentials is essential element of forming a new Aquaculture VET pipeline for Maine and cooperative farms are essential to future success
- New Educator consortia are needed from the outset to develop VET credentials and ultimately resources that can be shared between consortia members
- Interest shown by the Adult Education sector in increasing their involvement in aquaculture curriculum delivery
- Staff with aquaculture experience appear scarce at all levels of the education system and recruitment is needed starting with CC and CTE as a priority
- Strong interest from Southern Maine Community College in the development of aquaculture provision, referring to some suitable resources to deploy
- No potential CC centre suitable for aquaculture education mid coast, necessitating a close partnership between CC, CTE and the Universities to provide Vocational Education and Training
- The complex state and federal funding environment make it difficult for coastal High Schools to make applications for aquaculture curriculum development support
- Very good insights regarding the challenges and opportunities provided by respondents, informed

6.2. Industry view on solutions to workforce constraints (demand)

- Generally, there is a needs focus on in-house / on-farm training and technical skills requirements (Technical Education)
    - There is a pre-formed idea about continuing this training in-house, but that shouldn't be assumed as optimal (and indeed Scotland is trying to get away from this where skilled staff are trained then poached – moving towards an integrated training program)
    - Apprenticeship / internship / in-house upskilling to be considered (in relation to providers at Community College level and outreach / extension services)
    - Other skills – accounting, transport, etc, mentioned but not prominent except management capability

- Industry deems flow of young workers as sufficient … for now
    - At marine biology college level
    - But … housing, repetitive work, population trends, are relevant

- Macro factors (beyond industry) are relevant though there may be limited leverage
    - *Housing* is a major risk / barrier
    - *Medical cover* is prominent in almost every survey return
    - *Attitudes to aquaculture* are quite mixed – seen as desirable to work in, but equally there are strong attitudes to social license to operate in shared space, and sustainability
- Growth & Industry Structure – jobs deemed unlikely to grow as fast as volume, leading to a discount rate on jobs vs growth … *however:*
    - This may be an over-optimistic view from smaller firms (though Whole Oceans are similar) that they can do more with the same staff
    - Social license may only continue with small-scale companies that have limited scale efficiencies (though models using contract management systems for owners may be accepted)
    - RAS systems to grow volume will be more capital intensive but impact on jobs may be unknown until full operationalisation and scale-up.

6.2.1. Potential levers to address gaps

From industry feedback in interviews, below is a summary of potential solutions put to industry around workforce constraints. Some areas were perceived as having higher risk, priority or potential but may not be directly addressed through education and skills.

	Potential for future (out of 4)	Summary of views	Potential for change? Red – Amber – Green
In--house training	2.58	Significant reliance on in-house / hands-on training, but creeping realisation this is resource–intensive.	Strong potential – recognise strong benefits of in-house training / hands-on learning but general appetite to reduce burden.
Technological change	2.38	RAS relying on step-change, others very pragmatic about what's needed.	Recognised as important but not particularly lacking – and rate of change in demand is uncertain. Technical suppliers may require attention.
Academic provision in Maine	1.97	Generally positive about academic capabilities available, not convinced it is under-supplied.	Considered to be meeting demands and needs, and supply of skilled graduates is positive.
College courses and CTE	1.80	Enthusiastic about certifying / validating know-how and skills, especially trades skills (around pumps, electricians, engineering)	Potential to grow trade skills and broad aquaculture know-how (especially certified) is welcome. (Scoring didn't reflect degree of nuance of qualitative findings.)
Short–courses	2.17	Enthusiastic about potential to update skills and address specific needs e.g. HACCP. Can give a good grounding, expand work pool, hands-on experience.	Potential to address large numbers of people and tailor to specific skills gaps
Pay & Conditions	2.66	Recognised as important to retain and develop staff. Healthcare repeatedly cited as a challenge.	Very important but will depend on company capability and macro factors (healthcare policies) relatively outside of the sector's control.
Perception of aquaculture	2.58	Very mixed – industry perceives two competing ideologies at play, 1) hardening of attitudes against aquaculture (negative), and 2) 'return to the land' provenance and global sustainability (positive)	Possibly a strong education issue to maintain social license, but not a workforce development one. Educators have important role.
Other	–	Cultural isolation in remote areas was a further driver to deter young people to move into aquaculture. There is inherent risk in new, growing sector.	May be outside of immediate control of the sector, other than awareness-raising in K- 12 arenas.

Table 31: Industry view of constraints and solutions

6.3. Bridging the supply-demand gap

Some of the main challenges and opportunities, evaluated through a confidential PESTEL analysis (though high-level findings were presented to the AWDS Committee in April 2019), are reiterated below, to provide the context to the aquaculture education training supply and demand gap analysis and ultimately Maine Aquaculture Workforce Development Strategy.

The population of the coastal community of Maine is thinly spread, and many aquaculture operations are based in inaccessible coastal locations. Traveling from the south to the north east, this geographic and demographic reality becomes more accentuated, and broad band connectivity is increasingly patchy in the more remote areas, limiting the potential application of online learning solutions for some communities.

The corporate finish sector is currently located in the north east ('Downeast'), with some ambitious pre-operational RAS Atlantic Salmon farming companies appearing south / mid region. Conversely, the 'atomised' shellfish and emerging sea vegetable sector is widely spread across the state and dominated by small businesses. Due to the encouragement of new entrants (LPAs) and evidence of recent growth and the scaling up of some businesses, the shellfish and sea vegetable sectors are of most relevance to lobster fisherman considering

diversifying in response to declining catches – this is perceived as a risk further south in the State but all are aware of the emerging challenge. However, in finfish aquaculture too, fishermen are gaining opportunities e.g. in the marine growout areas of the sector.

Maine education is generally well served from K12 to post graduate level and the states' marine sciences degrees are nationally and internationally renowned. Many Marine Science Grads go overseas to seek environmental or aquaculture related employment. Very few are being retained within Maine currently as the opportunities are limited, however, a range of measures that could be taken to retain and deploy more home-grown Graduates within Maine (see Chapter 7).

Despite a recognition by industry of the growing importance of Under Grads over time, it is clear from the demand analysis that the entire aquaculture industry recognises the current vacuum in Aquaculture VET as a major issue. The strategic priority to develop a formal Aquaculture Vocational Education and Training was corroborated by the educator surveys held earlier in the year. Many of the educators recognised that a more robust and sustainable partnership between the educators (private / public sector) and industry is required to overcome the current status quo. This will help align the education sector with the industry's prioritization of education and skills (as set out in the pyramid schematic in section 4.9. To achieve this, state and federal funded initiatives could be much more selective and focused, though this will require collaborative effort for each institution to fully realise the potential of such an approach.

The skills and roles analysis (in section 4) differentiates the skills and knowledge requirements according to role, with (as can be expected) more emphasis on the business side for entrepreneurs. However, the main finding was one of strong overlap and synergy: much of the content around basic husbandry and maritime skills which is applicable to the broad worker base is currently only available in quite limited numbers for entrepreneurs taking the Shared Waters program and similar. These elements could be efficiently incorporated into the core of the workforce development strategy by adapting them for use by the workforce at large, though the teaching platform may vary according to cohort (through CC / CTE, adult education or structured apprenticeships). Equally, the workforce development core activities should strengthen access for entrepreneurs and incoming graduates to get affordable and accessible business and management training, both through CC courses and through universities collaborating with the core program.

6.3.1. Educators

Mindful of the above, the priority target audiences for the education sector for formal aquaculture education delivery (leading to credentials in most cases) are:

a) Youth - 14-18-year olds (High School 9-12)
b) High School leavers - 18 years plus, undertaking tertiary education
c) Employees in the industry needs to address knowledge and skills gaps and/or gain credentials to progress within their careers
d) New and prospective entrants (entrepreneurs) requiring selected knowledge and skills to address their personal needs and gaps

However, despite some very successful initiatives to date supporting the development of new-entrants' knowledge and skills, a limited formal aquaculture curriculum is available. The current offer is not underpinned by industry standards and credentials, as required to build a well-recognised and credible aquaculture skills pipeline for Maine and this should be addresses as the top priority.

Once available, the aquaculture skills pipeline can be promoted as part of a future state-wide aquaculture promotional drive, providing prospective aquaculture learners a clear and positive message about the environmental and societal benefits of aquaculture and the affordable career pathways available within Maine's public sector education system that they can access. The importance of the aquaculture education development role of outreach programs in developing teachers so as they can introduce aquaculture and marine science to enrich the school curriculum for all ages and education stages is fully acknowledged as a vital part of any future aquaculture career promotion strategy.

As the industry is small and therefore the demand for education and training is starting from a low base, the educators will need to find ways to aggregate demand through the creation of a modularised curriculum and resources that can be 'repurposed' to serve the needs of as many target audiences above as possible, to ensure program viability during an initial start-up phase. An alternative way to aggregate demand is to develop a more broadly-based curriculum that includes aquaculture, alongside 'proximate industries' such as commercial fisheries as they share a need for many common skills and knowledge, including; boat operations, marine science. maritime technologies and the construction and engineering trades. This concept is under serious consideration by Washington County CC (see Chapter 5).

More specifically, the gaps between supply and demand and the associated resource issues to address are presented below in order of their urgency:

1) Aquaculture teaching staff

The supply analysis reveals a general dearth of staff within all education sectors with the necessary combination of aquaculture technical knowledge and teaching experience. Despite the recent $20 Million SEANET investment in the University sector for aquaculture capacity building, higher education survey respondents also reported that aquaculture curriculum development was constrained by staffing.

As the development of standards and credentials requires significant teaching staff input and leadership, this constraint should be addressed before embarking on priority 2 below, with appointments made by the Community College Sector to support the development of a program in collaboration with the CTE and Apprenticeships sectors and industry (see Chapter 7).

In addition, the secondment of staff from the Adult Education 'aquaculture bespoke initiatives' who do have training experience and a commercial aquaculture background to join the collaborative development effort may become mission critical (see Chapter 7) in the short term. Any new appointees from industry made by educational establishments are likely to have no education and training experience and will need support – they may be able to 'train the trainers' within the education sector.

The lack of staff with aquaculture experience may be an issue with short term implementation of the intended role of the CTE sector, although staffing capacity issues has not been investigated with those CTE providers considering introducing aquaculture within their curriculum.

The recruitment of industry advocates for the AWDS with a strong commercial background on a part time basis, may offer an alternative way to build aquaculture experience within the Maine collaborative teaching team in the early stages.

2) Aquaculture standards, credentials and qualifications

There is a generic description of standards provided by O*NET, but this is inadequate as a 'framework of standards' to inform aquaculture credentials.

The AWDS work undertaken has provided some insight to skills needs and the education and training demand from industry, based on an analysis of the demand survey returns. This has been bolstered to some degree by an analysis of the limited number of job descriptions provided by employers and through comparison to O*NET data.

Although useful information, it is not sufficiently detailed to constitute 'industry approved standards' and subsequently credentials. Therefore, the formation of a committee with industry representation led by the appropriate education sectors is a high priority. They would be charged with the responsibility of formulating a comprehensive definition of 'specific standards' for each of the main aquaculture sectors; finfish (including RAS), shellfish and sea vegetables, building on the work undertaken by the Scottish team to date. Refer to Chapter 7 for details.

3) Aquaculture vocational education and training (VET) pathway

Once standards have been developed representatives of the following education sectors on the committee should develop the credentials and qualifications that each can offer, leading to a recognised aquaculture pathway and

agreed pre-requisites for learner progression and credentials that can be 'carried' to the next phase for recognition. For example, CTE providers could offer 16-18-year olds trade skills leading to credentials that can be transferred and recognised within the Community College and Apprenticeship system. This precedent has already been established in other sectors and such an approach would maximise the future Aquaculture credentials gained during compulsory schooling (9-12), reducing the future cost of tertiary education and therefore widening access for the economically disadvantaged and drawing more practically minded and well-motivated recruits through the system who eventually become employed as operatives and site managers

For further details on the process and specific roles see breakdown in Chapter 5:

- CTE courses and credentials
- Modularised CC Certificate and Associate Degree
- Apprenticeship practical competences and underpinning knowledge

4) Industry links

Whilst most educators surveyed have some contacts within industry, for many it appears limited and most see the strengthening of links as an important pre-requisite. Mindful of the vital role industry need to play in the development of aquaculture standards and Apprenticeship delivery (see Chapter 5) the nature of the relationship between industry and the educators needs to evolve.

For a competence based modular aquaculture VET system to evolve in the future, the Industry will need to be much more actively involved with education and the pioneers will require some development. This will ensure that they uphold the industry standards when providing evidence of competence that contribute towards credentials and that their facilities are used to their full potential within the delivery of aquaculture credentials at various stages of the VET pipeline, including the Apprenticeship.

5) Aquaculture Distance Learning resources and delivery systems

Although industry has not expressed any interest in distance learning and many educators have other priorities, some do recognise the vital role it must play in order to widen access to aquaculture Vocational Education and Training (VET) to overcome the severe geographic and demographic challenges referred to in the introduction to Chapter 6.

Well-designed up to date learning resources, developed to support the delivery of the underpinning knowledge within the VET pipeline at various stages, offer a range of advantages. Demand can be aggregated in effect, as such resources can support delivery to all target audiences referred to above, once academically levelled and linked to credentials.

In addition, a distance or blended learning approach that reduces face to face delivery is an effective way of delivering standalone modules to new and proposed entrants on a more flexible pick and mix basis, as required, once the resource has been developed. Whether or not those undertaking such modular courses undertake assessment to gain credentials can be left to their choice according to personal needs and motivation. The collaborative development of distance learning resources in discussed in Chapter 7.

7. Proposed roles for educators

7.1. Summary

- An Aquaculture Associate Degree program should be developed led by one CC with an experienced staff member leading collaboration with CTE, Maine Department of Labor (Apprenticeship) and industry representatives
- Aquaculture provision by CTE should be developed, building on the trade skills in high demand at the operative level by industry
- The development of a new Apprenticeship should be led by the CC with active industry involvement as providers of on farm training and through supporting the assessment process
- Relevant High School educators and institutions should accelerate development to perform a pivotal role in teacher CPD, to support infiltration of the High School Curriculum (grades K8) by aquaculture and marine sciences
- The University Sector could support the VET pipeline through the provision of two plus two progression and access to specialist resources and staff across the state
- Contextualised business courses could be provided to more University Graduates (including Marine Science) and industry new entrants leading to credentials
- Aquaculture bespoke Adult Ed providing aquaculture knowledge and skills to new entrants should be mainstreamed and linked up to the formal VET delivery pipeline and resources to safeguard and amplify their legacy

7.2. Introduction

Each one of the education sectors has a role to consider within the below proposal and Chapter 6 pilot provides a gap analysis and sequential priorities that the educators need to address collaboratively in order to over-come Maine's legacy of competitive tendering and fragmented initiatives that do not have the desired impact, and / or are not sustained.

Regional hubs for the south and north or Maine are proposed, with industry representatives for each region working together to ensure the industry are fully represented at all stages of the Aquaculture VET capacity building process described.

The proposed role of each sector is described below:

7.2.1. Community College

The Community College system should have a central role within the leadership, development and delivery of Aquaculture Vocational Education and Training (VET) pathways within the state of Maine to address the current void and evident demand from industry.

The Southern Maine and Washington County CCs interviewed are well positioned to provide 'regional hubs' in the south and north east of the state for the establishment of Aquaculture programs in collaboration with the Department of Labor (Apprenticeship) and High School CTE sectors. However, a creative approach to partnership working will be required mid coast, as there is no suitable CC facility and the CTE and University sectors will need to be more heavily relied on in this key aquaculture region. Once robust pathways are agreed, the recruitment of High School graduates (including CTE) and their progression to CC, Apprenticeship and ultimately aquaculture employment can be facilitated with reference to employment opportunities (occupations) and credentials available to learners at each stage.

Each CC in the south and north east offers different strengths, in terms of geographic location, facilities, existing curriculum, staff and its proximity to and links with industry. Both are open to developing partnerships with other educators and the Washington County CC is ideally placed in the north to take the lead regarding finfish, building on its Cooke Aquaculture connections and could provide education and training relating to the shellfish sector by accessing the Downeast Institute and local industry facilities. However, they need to recruit an aquaculture specialist before real progress can be made.

Mindful of the current CC aquaculture staffing constraint, it is recommended that the aquaculture curriculum development process is led by the experienced member of staff at the Southern Maine CC to develop a Magnet Program. Alternatively, a new appointment from industry could be made by CTE and CC in partnership. If based mid coast, this person could be dedicated to building the alliances needed between educators and industry needed for VET delivery in the mid-coast region as well as the south and north east.

A new Aquaculture Skills Foresight Forum (ASFF) should be constituted, with representatives from industry (finfish, shellfish and sea vegetables), the CC system, Maine Department of Labor and High School CTE. Within the ASFF, the industry should be integral to the development of comprehensive standards (knowledge and skills required by each occupation) as described more fully under Apprenticeship Section (see Chapter 5). Once the standards are approved, a CC led Aquaculture Curriculum Development Group (ACDG) would be constituted to develop specific subject areas/modules, as required. The recruitment of selected aquaculture academics and teachers could follow to ensure that new credentials were designed with reference to the industry standards.

Bearing in mind their strong interest in distance learning, the Washington County CC could lead the development of resources to support the widening of access to overcome geographic and other barriers. The formation of a discrete collaborative development group - Maine Aquaculture Vocational Education Resources Consortium (MAVERC), is recommended, composed of selected institutions with existing aquaculture learning resources that could be re-purposed and / or aquaculture experts. It should also be noted that some companies have training manuals in subjects such as shellfish hatchery, river operations and seaweed culture that could also be useful, if they were willing to join MAVERC as industry members. Existing resources could be pooled and further developed to respond to industry demand, with the output available to MAVERC members. The resources could be designed to support the delivery of underpinning knowledge and attainment of aquaculture credentials at a range of academic levels within the pathway with the intellectual property rights under shared ownership by MAVERC members. Full use should be made of digital learning technologies and infrastructure by MAVERC, including Virtual Learning Environments (VLEs), but making alternative paper-based resources available to support those communities with inadequate Broadband access.

7.2.2. High school

There is a need for the mainstream high schools, the Magnet School and CTE providers to agree their respective roles which may need to vary in the two geographic regions (Southern and North East Maine) identified for pilot.

Mainstream High Schools
Currently, it is possible for the mainstream High Schools to offer a curriculum based on the state 'Proficiency Standards', that may prepare, or partially prepare, young people (11-12) for a specific vocational pathway. However, typically High Schools are not as well equipped as to deliver industry credentials as the CTE centers established for this purpose. It is proposed than an Aquaculture CTE centre is established in each region by selecting a suitable CTE provider already offering the trade skills that aquaculture employers seek, for further development of a 'Signature Program' (see below).

Where a suitable CTE centre exists, or has been nominated to serve a defined region, it is advisable to ensure that High Schools in that catchment do not offer comparable provision, through policy or negotiation. If permitted, this is likely to have the effect of spreading the demand too thinly and could make the provision of an aquaculture to the 9-12 group, unviable for all providers.

However, in some regions of the state, due to the influence of some long established education initiatives and in the absence of a suitable and accessible CTE provider, it may be advantageous for a well-placed High School to provide this role for their own learners, and others within a reasonable travel distance / time.

High Schools will have a role in the broadening the understanding of aquaculture as a sector. This could range from giving a wider understanding to students of the industry's need for technical skills (hydraulics, plumbing, electrical) to a 'social license' function where the population in Maine understands the sector and what impacts and potential it has.

7.2.3. CTE

Currently, aquaculture exists within CTE as one of nine Units within 'Agricultural Production', which sits under General Agriculture within the Agriculture and Natural Resources cluster. Consequently, the subject has very low visibility and is portrayed as an alternative land-based agricultural enterprise, as opposed to being associated with the marine and freshwater environment. It is recommended that the Agriculture and Natural Resources cluster title is revised and replaced with 'Food Production and Natural Resources'. This would allow aquaculture and fisheries to be presented under a new section within a revised cluster, with Aquatic Environment (marine and freshwater) and Commercial Fisheries. Alternatively, a new sector could be produced called Aquatic Environmental Management and Technologies. This would major on the marine environment and could accommodate and promote those CTE subjects important to the coastal zone economy, but currently in danger of falling 'under the radar'.

An entire CTE center based aquaculture curriculum could be offered and include a credit bearing structured internship, targeting the juniors / seniors stage. The most successful examples from other industry sectors provide access to CTE 'Signature' Programs that are well resourced, staffed and have a good reputation, enabling them to maintain a viable volume of learners by drawing recruits from across the state. Such an initiative would be of particular importance mid-coast, in the absence of a suitable CC facility.

When 'standards' are developed, it is a local decision whether to share them, as some funding comes from other (non-central CTE) sources. Therefore, it would be wise for suitable CTE centers selected and deemed suitable for aquaculture Vocational Education to establish a collaborative grouping at the outset, prior to the standards development phase.

Generally, competition does not arise between CTE centers, however, there are times when High Schools will 'mimic' provision to protect their school enrolment figures and funding. For example, welding has sometimes been offered. High schools are rarely equipped to offer the credentials industry need, however, and CTE can differentiate, especially when a successful 'Signature Program' is created. However, it can be hard to recruit teachers and consequently CTE is flexible and will recruit from industry and fast track develop recruits to become teachers.

Interestingly, according to survey returns, the Education Department responsible for CTE were interested in courses, CTE and distance / blended learning in aquaculture and marine science in the longer term, whereas the CTE provider responding to the survey indicated a short-term interest. Further conversations are required to determine whether the Education Department are reluctant to support CTE developments in the short term, if a viable demand were proven in selected regions and to explore how a working relationship between the development of CTE and Magnet Schools can best be fostered.

The trade skills and engineering deemed of high importance by employers is already available at a lot of CTE centers and popular. Existing credentials could be incorporated within the Aquaculture VET pipeline and recognised by the CC and Apprenticeship system.

7.2.4. Magnet schools

The Maine Ocean School could develop capacity to become influential within the development of the High School aquaculture curriculum and school teaching staff in an 'enabler' role. However, as their current 'capacity' regarding aquaculture was described as 'minimal' during interview, they would need to invest in staff development, and/or appoint staff with a suitable aquaculture technical background. Encouragingly, the Maine Ocean School leaders are aiming to be 'robust' within three years and may apply for a lease (LPA) for aquaculture education and training purposes. Current state policy encourages them to employ non-teachers and develop their teaching skills, allowing someone with an aquaculture technical background and experience to be recruited. Collaboration with Adult Ed (bespoke aquaculture providers with technically qualified staff) and CTE and effective promotion of their services to High School will be essential for the achievement of their mission, within which aquaculture is to be included. Several organizations within Maine could also fill the 'enabler' role by helping K-12 teachers incorporate aquaculture themed content that fulfils mandated education standards into their classrooms.

7.2.5. Apprenticeship

The Apprenticeship can play a central role within the development of an Aquaculture VET pipeline but relies on access to commercial farm facilities for practical skills training and the assessment of credentials. This form of formalised work-based learning ensures learners can access to the latest equipment and technology, keeping the VET program technically up to date. On the proviso that industry join representatives from CC, CTE and the labor Department, credible 'sector specific' standards could be developed to inform the credentials educators design and embed within the Apprenticeship.

This necessitates the constitution of an Aquaculture Skills Foresight Forum (ASFF) to ensure that all sector specific skills for finfish (including RAS), shellfish and sea vegetables are adequately represented for aquaculture in Maine, ultimately leading to well understood and respected credentials. The initial work of this group should refer to the analysis of skills needs, and the information derived from job descriptions provided. However, the final definitions need to be sufficiently comprehensive and granulised to inform occupational standards that can accommodate the technology and methods applied in each sector as they evolve.

It is proposed that a selected Community College lead the process, with the aim of becoming the sponsor, working with aquaculture business partners and assisted by a newly constituted organization to take responsibility for the administration for an Aquaculture Apprenticeship program.

With the support of the appropriate sector leaders an administrative group should be constituted to provide administrative support for Apprenticeship Program delivery and quality assurance. Mindful of the vital role employers undertake within Apprenticeship training and assessment, including the recording of reliable assessment evidence, farms will need to be recruited and incentivised to take part in a formal Apprenticeship pilot phase. Employers will need to be targeted across Maine's Southern, mid-coast and Downeast regions proposed for piloting the apprenticeship, with a representative from each region for each aquaculture sector on the ASFF developing the occupational standards.

During the pilot phase, the CC leading the Apprenticeship delivery will need to take responsibility for quality assuring all aspects of delivery and assessment. It is advisable that they provide development programs for employers involved in the pilot in order to ensure they understand the standards for their sector and apply them consistently as 'Witness Testimony Providers' when assessing practical competence on farm. The CC should provide a technically competent trainer who is qualified as a work-based assessor and can lead and coordinate Apprenticeship delivery across the state. They should be supported by an effective on-line 'e portfolio' system and assessors based at each partner CCs working as a team under their coordination.

In summary, whilst being governed and regulated by the Department of Labor, the new Aquaculture Apprenticeship will need a long-term commitment and co-ownership by the CC partners and industry, committing them to uphold the standards developed and approved by the ASFF.

7.2.6. Adult education

The role of this diverse sector can be considered firstly from the perspective of basic skills development and secondly from the perspective of the bespoke providers of technical training for the aquaculture sector.

The Adult Ed department were interviewed and appear confident that they could deploy specialist Adult Ed staff in several ways, including the deployment of basic skills development within CTE and CC classes by specialists, working in partnership with the subject specialist teacher to contextualise delivery to suit the basic skills requirements of the program. This role may be particularly valuable within CTE in the future, depending on the academic profile of learners attracted to the aquaculture and associated trade skills. Support can be requested on a needs basis as the demand is dependent on learner profiles, which could vary annually. They may also have a role to play in wider more generic employability skills, as weaknesses in some recruits has been raised as an issue by many employers. In addition, if the aquaculture sector were to recruit from the ethnic communities in the future which is occasionally incentivised by the state, the mobilisation of Adult Ed could be instrumental in overcoming the learners' inevitable communication barriers through their English language development. Finally, Adult Ed staff can help to develop subject specialist teachers to incorporate basic skills within their teaching more effectively, thereby helping 'capacity building' across the state, where needed.

7.2.7. Bespoke aquaculture training providers

The bespoke aquaculture training providers perform a vital role currently and are at the heart of the states' support for start-up producers (LPAs) as well as operatives and managers within existing businesses. The service they provide is recognised and valued by many employers, as evidenced by the demand survey. Therefore, the continuation and extension of this provision across the coastal zone is important, which may be challenging for some private sector initiatives, depending how they are currently being funded.

The mainstreaming of this provision through public/private sector partnerships is recommended for two reasons:

- They employ trainers with an aquaculture technical background who could be deployed more widely within a capacity building role to help strengthen public sector education (CC, CTE and Apprenticeship) service within newly formed partnerships.

- Two providers have existing distance learning resources which could be further developed in partnership with others (Chapter 6) and used to support the gaining of knowledge-based credentials in the future, aligned to occupational standards (Chapter 5).

7.2.8. University

The University sector in Maine have attracted thousands of higher education applicants from out of state and overseas for their Marine Science provision. How to use this advantage to establish and position themselves as providers of Aquaculture Higher Education nationally and internationally, leading to further growth of their already buoyant marine science schools is addressed below. However, it must be recognised that based on feedback from respondents, the current academic staff capacity in aquaculture is likely to constrain such ambitions in the short term if it remains unaddressed.

The main thrust of the proposed AWDS is towards the development of an Aquaculture VET pipeline which articulates with higher education through the 'two plus two' model. It will require the cooperation of Universities to provide CC learners clear guidance differentiating the career pathways available from each Degree that CC providers ultimately articulate with.

Currently, only the University of New England provides an Aquaculture Major, but there may be other progression options including business studies and marine science that could be of interest to some CC learners. There are a

wide range of relevant laboratory and practical skills provided by many higher education providers, which may not be fully recognised by industry judging by some of their feedback. The Universities may benefit from closer engagement with industry to explain their program content and counter what may be a limited appreciation of the curriculum's scope and transferable skills gained.

There are other roles for the University sector to consider:

Retention of Undergrads within Maine Aquaculture

Employers have suggested that an increase in practical engineering skills and general handiness alongside business skills and acumen (including people management and communication), would provide more useful industry entrants who could fast-track to positions of responsibility within their businesses.

The University of Maine business and a marine science schools appear receptive to considering the incorporation of business studies within a marine science major to encourage more graduates to take up LPAs as a step in the right direction. Business development support and advice is currently offered by some bespoke aquaculture Adult Education initiatives, but one school is exploring how business studies could be modularised, packaged and promoted for delivery to new entrants who were seeking credentials as well as advice and support.

Distance and / or Blended Learning

There are several Universities who are deploying distance or blended learning, who may have instructional design expertise and be willing and able to join MAVERC, the collaborative development team proposed, to develop a shared Distance Learning resource bank.

Aquaculture facilities

The University sector has a wealth of aquaculture research facilities across the state and associated academic expertise with technician support. If made more widely accessible, these facilities could provide an education and training resource for other learners from CTE, Community College and work-based learners undertaking short courses to benefit from. Courses in RAS technology and systems maintenance, live feeds culture, shellfish hatchery and teacher CPD could be provided and integrated within their operations, helping to improve the viability of some of the more specialist and remote facilities.

Postgraduate research

The finfish sector has referred to technological innovation as being essential feature of their work and both Cooke and the pre-operational RAS salmon producers are anticipated to offer a range of applied PhD and Post Doc. Research opportunities that would provide career paths to high grade specialist technical roles within a large finfish producing company.

7.3. Potential for national and international workforce development

The State of Maine has a developed and rapidly growing aquaculture sector. It has strengths in:

- Established oyster production
- Growth in seaweed production
- Salmon production at scale in the US, drawing on international ownership linkages
- Potential for ground-breaking RAS production of salmon

Industry respondents noted the degree of research and production jobs planned (Cooke, RAS entrants) that are distinct from normal marine outgrowing.

Maine's position in having research capability and an established aquaculture sector suggests potential for becoming a national centre for aquaculture education and training, though much of the focus of job creation

remained on how to attract local Maine youth, including those from areas further inland where job creation remains a challenge. In the same vein, 'out of state' students are subject to substantially higher fees than for students from Maine, which is not unique to this sector but may work against attracting those without financial means.

From an industry perspective, there were some references to programs outside the state that were valued, for example the Roger Williams Applied Shellfish courses in Rhode Island.

7.3.1. National

At the national level, universities in Maine are potentially competing with aquaculture education and training provided by universities in other states. Given the geographic scale and environmental diversity of the USA there is considerable diversity in provision, with most institutes focusing on aquaculture species and systems relevant to their own state. A particular consideration may however be the institutions supported by the U.S. Department of Agriculture National Institute of Food and Agriculture as Regional Aquaculture Centres. These specifically encourage cooperative and collaborative research and extension education programs in aquaculture that have regional or national application. They are also specifically required to support other publicly funded research and extension programs. They are particularly well placed to link vocational and academic activities, although few appear to have substantive aquaculture programs at Bachelor's or Master's levels.

Table 32: Regional aquaculture sectors

Regional Aquaculture Center	University	Web link
Northeastern Regional Aquaculture Center (NRAC)	University of Maryland / University of Massachusetts	https://agnr.umd.edu/research/research-and-education-centers-locations/northeastern-regional-aquaculture-center & https://www.northeasternrac.org/
North Central Regional Aquaculture Center (NCRAC)	Iowa State University	https://www.ncrac.org/ Publications at: https://lib.dr.iastate.edu/ncrac/
Western Regional Aquaculture Center (WRAC)	University of Washington	https://depts.washington.edu/wracuw/ Publications at: https://depts.washington.edu/wracuw/publications/research_publications.html
Southern Regional Aquaculture Center (SRAC)	Mississippi State University	http://www.srac.msstate.edu/ Publications at: http://www.srac.msstate.edu/publications.html
Center for Tropical and Subtropical Aquaculture (CTSA)	University of Hawaii and Oceanic Institute of Hawaii Pacific University	http://www.ctsa.org Publications at: http://www.ctsa.org/index.php/publications/ctsa_publications1

The Regional Aquaculture Centres have played an important role in supporting government extension services and have produced a wide range of guides and training resources in aquaculture.

At an international level, the US universities most engaged with aquaculture development has been Auburn University, (particularly pond culture including tilapia and shrimp - two of the most important aquaculture sectors worldwide) and the University of Oregon (which also has expertise in fish health). These two now cooperate together with North Carolina State University, Purdue University, the University of Connecticut, University of Michigan and University of California Davis under the umbrella "AquaFish Innovation Lab" https://aquafishcrsp.oregonstate.edu which has many programs funded through USAID including around 350 short courses in many international locations. Auburn University offers a Bachelor's degree in Fisheries Science and a Masters in Aquaculture, which has attracted students from many countries.

From a technology perspective, the USA has been highly engaged with the development of recirculated aquaculture systems. Virginia Tech hosted a biannual conference on recirculated aquaculture systems between 1994 and 2014, which is now continued commercially as RASTech (https://www.ras-tec.com) on an annual basis. Linked with this were active research programs at Cornel University and more recently the Conservation Freshwater Institute (https://www.conservationfund.org/our-work/freshwater-institute) which has large-scale RAS research facilities and close collaborative links with NOFIMA in Norway. Internationally well-known scientists working in the area can also be found at the University of California Davis and University of Maryland. The USA has contributed to the development of hatchery technologies for tropical marine species particularly through the University of Miami (https://aquaculture.rsmas.miami.edu) which also runs hands-on short courses for national and international students. Also significant are contributions to shrimp farming technology and aquaculture for more arid areas through the University of Arizona, Texas A&M University and University of Texas Austin.

Universities in Maine will need to consider how they can differentiate their course(s) from aquaculture courses offered by institutions in other states if they wish to attract students from out of state. This is particularly the case if fees are substantially higher for out of state students. Aspects to consider include the quality and profile of the research staff, the focus of the courses with respect to subsequent employment, and linkages that exist with industry and government research agencies. A key attraction would be an expanding industry with career opportunities for course graduates. The establishment of Nordic Aquafarms may be one such opportunity although a realistic view would need to be taken on the number of graduates such facilities might employ and the extent to which the industry will grow in this region.

Table 33: Indicative list of US HE providers of aquaculture courses

Area	Institution	URL
West Coast	Bellingham Technical College	https://www.btc.edu
	Washington University, School of Aquatic and Fisheries Science	https://fish.uw.edu
	Oregon State University	https://oregonstate.edu https://seagrant.oregonstate.edu/outreach-and-engagement/aquaculture
	Carlson College of Veterinary Medicine, Oregon State University	https://vetmed.oregonstate.edu/
	University of California Davis, Center for Aquatic Biology and Aquaculture	https://caba.ucdavis.edu
Central	University of Wisconsin (26 campuses)	https://www.wisconsin.edu
	University of Idaho	www.uidaho.edu/aquaculture
	Purdue University, College of Agriculture	https://ag.purdue.edu/Pages/default.aspx
	Forestry and Natural Resources, Aquatic Sciences	https://ag.purdue.edu/fnr/Pages/resfisheriesaquatic.aspx
South	Auburn University, School of Fisheries, Aquaculture and Aquatic Sciences	https://sfaas.auburn.edu

	Texas A&M University	https://fisheries.tamu.edu
	University of Texas Austin, Marine Science Institute	https://utmsi.utexas.edu
	University of Arizona, College of Agriculture and Life Sciences, Animal & Comparative Biomedical Sciences	https://acbs.cals.arizona.edu (mainly pathology, shrimp disease expertise) – https://acbs.cals.arizona.edu/aqua College of Science, School of Earth and Environmental Sciences, Department of Soil, Water and Environmental Science (tilapia expertise) https://environmentalscience.cals.arizona.edu
East Coast	Cornell University	https://www.cornell.edu
	University of Massachusetts, Boston	https://www.umb.edu/
	University of Rhode Island, College of the Environment and Life Sciences	Fisheries, Animal and Veterinary Sciences – Aquaculture program https://web.uri.edu/favs/aquaculture-program/
	University of Miami, Rosentiel School of Marine and Atmospheric Science	Aquaculture program https://aquaculture.rsmas.miami.edu
	(University of Maine)	
	(University of New England)	
	Cross-cutting	see Maine Aquaculture Innovation Center – https://www.maineaquaculture.org/aquaculture-research/

Universities in Maine will also need to consider potential competition (or opportunities for collaboration) with centres in Canada, especially on the East Coast. These include Memorial University of Newfoundland which has a graduate program on aquaculture and the Atlantic Veterinary College, University of Prince Edward Island which specialises in fish health. Guelph University – Ontario Agricultural College has also been active with an MSc aquaculture program in the past.

7.3.2. International

There are examples such as the Institute of Aquaculture at Stirling University (Scotland, UK) which have both provided skilled graduates for their national aquaculture sector, but also internationalised and exported students across the globe, including Africa and Asia.

There is potential for universities in Maine to attract international students. The USA has a good reputation for higher education and as an English-speaking country will be attractive to a wide variety of students. US college fees are generally high by international standards, but for Universities in Maine these may not be so different to alternatives in UK or Australia. In general there are few undergraduate courses in aquaculture. Particularly in Europe, that level of industry specialisation tends to take place at Masters level.

Given the projections for global aquaculture growth, there should be a clear case for US institutions to develop similar capacity, and Maine may be sufficiently diverse in its production, with active aquaculture educators, to be a good candidate. However, to deliver this would require a significant increase in capacity of educators, while the concern that education runs too far ahead of industry demand being cited in interviews. This may be best judged by institutions who wish to internationalise through their own strategies.

Comparative analysis at the International level could include the following institutions for instance:

Country	Institution	URL
United Kingdom	University of Stirling, Institute of Aquaculture	http://www.aqua.stir.ac.uk
	University of Plymouth	https://www.plymouth.ac.uk/courses/postgraduate/msc-sustainable-aquaculture-systems
	Scottish Association for Marine Science	http://www.emm-aces.org
Belgium	Ghent University	http://www.aqua.ugent.be
Netherlands	Wageningen University	https://www.wur.nl/en/Research-Results/Chair-groups/Animal-Sciences/Aquaculture-and-Fisheries.htm

Norway	Norwegian University of Life Sciences	https://www.nmbu.no/en/studies/study-options/master/master-of-science-in-aquaculture
	Nord University	https://www.nord.no/en/about/faculties-and-centres/faculty-of-biosciences-and-aquaculture
	Norwegian University of Science and Technology (NTNU)	https://www.ntnu.edu/studies/msocean/aquaculture
Germany	Humboldt University of Berlin	https://www.agrar.hu-berlin.de/en/lehre-en/studgang-en/mfs
Australia	James Cook University	https://www.jcu.edu.au/college-of-science-and-engineering/academic-groups/marine-biology-and-aquaculture
	Flinders University	https://www.flinders.edu.au/study/courses/postgraduate-aquaculture

Table 34: International comparators for aquaculture education

Whilst it is possible to run a research-based Masters program with a limited range of staff expertise, a full taught program generally requires a broad range of expertise. Visiting lecturers can be used to help fill gaps in provision, but typically a postgraduate course in aquaculture would include most of the following elements in the curriculum:

- *Biology and function of cultured aquatic animals and plants*
  - Physiology
  - Energetics
  - Reproduction
  - Environmental requirements
- *Aquaculture species and production systems*
  - General principles – intensity of culture / monoculture and polyculture
  - Land based and water-based holding systems
  - Maintaining environmental conditions – RAS and other treatment systems
  - Production planning
  - System engineering
- *Aquatic animal reproduction*
  - Broodstock management / control of maturation
  - Breeding and reproduction systems
  - Larval development and rearing
  - Genetics & selective breeding
- *Aquatic animal nutrition*
  - Nutritional requirements and physiology
  - Feed ingredients and formulations
  - Feed manufacture
  - Feed management
- *Aquatic animal health management*
  - Diseases of aquatic animals (bacteria, viruses)
  - Parasites and fungal disease
  - Behaviour and welfare
  - Health management strategies
  - Treatments, therapeutants and toxicology
  - Immunology and vaccines
  - Diagnostic techniques
- *Aquaculture in the environment*
  - Environmental impacts of aquaculture
  - Aquaculture and fisheries interactions & biodiversity
  - Environmental systems and modeling
  - Approaches to environmental management
  - Governance, site selection and regulation

    - Impacts of environment on aquaculture – resilience
- *Business of aquaculture*
    - Value chains, markets, trade and economics
    - Post-harvest / quality control / HACCP
    - Business structures, finance and investment
    - Risk assessment and management
    - Business organization, and management
    - Standards and certification
- *Aquaculture development*
    - Aquaculture and communities
    - Social acceptance and governance structures
    - Education, training and extension approaches

8. Aquaculture workforce development strategy

Aim of the strategy

The aim is to develop 'a structured, ambitious Workforce Development Strategy for Maine aquaculture.' Furthermore, the strategy should ensure a skilled and adaptable workforce to drive the sustainable development of aquaculture in Maine, through applying education, learning and skills development which is;

- aligned with current industry demand and can respond to changing needs over time,
- accessible by the current workforce and potential recruits, regardless of their location, and
- underpinned by standards and credentials that have been developed collaboratively by industry and the appropriate education sectors

Principles

The strategy should:

- Be flexible and responsive to the changing requirements of the aquaculture sector in Maine, ensuring there is an adequate supply of the right skills in the right places.
- Align with and draw on other relevant state-wide strategies addressing education, infrastructure, talent attraction and retention.
- Build on the state's education and training supply and legacy, to maximise leverage on existing resources, build synergies and gain efficiencies through targeted curriculum development.
- Incentivise collaboration between key education sectors and with industry.
- Ensure transparency of aquaculture skills and qualifications across the sector through the availability of well understood credentials underpinned by industry standards.
- Apply all relevant education and training delivery mechanisms, including the application of learning technologies (ICT) and formal on farm training and assessment.
- Culminate in a well understood education and training pipeline that help to promote aquaculture careers across the state and safeguard the sectors social license.

Consultation findings

Based on the analysis of the educator supply and industry demand surveys, there are real strengths upon which a Maine Aquaculture Workforce Development Strategy (AWDS) can be based. The post-secondary education sector is well placed, with highly regarded marine science provision at Associate Degree (CC), Bachelor's and Post Graduate levels and one recently established Bachelor's Degree in Aquaculture offered by the University of New England. In addition, some 'uncertificated' development programs have been offered through the 'Shared Waters'

program and the Island Institute, to assist new aquaculture entrants to address husbandry and business start-up perspectives, respectively. Both initiatives have been highly valued by industry, despite some challenges with the availability of places (it is in-demand and offered at limited times). There is existing provision within CTE that once harnessed can provide the trade skills industry consider to be most valuable to employment at the husbandry operative level.

Figure 7: Towards a structured, ambitious Workforce Development Strategy for Maine aquaculture

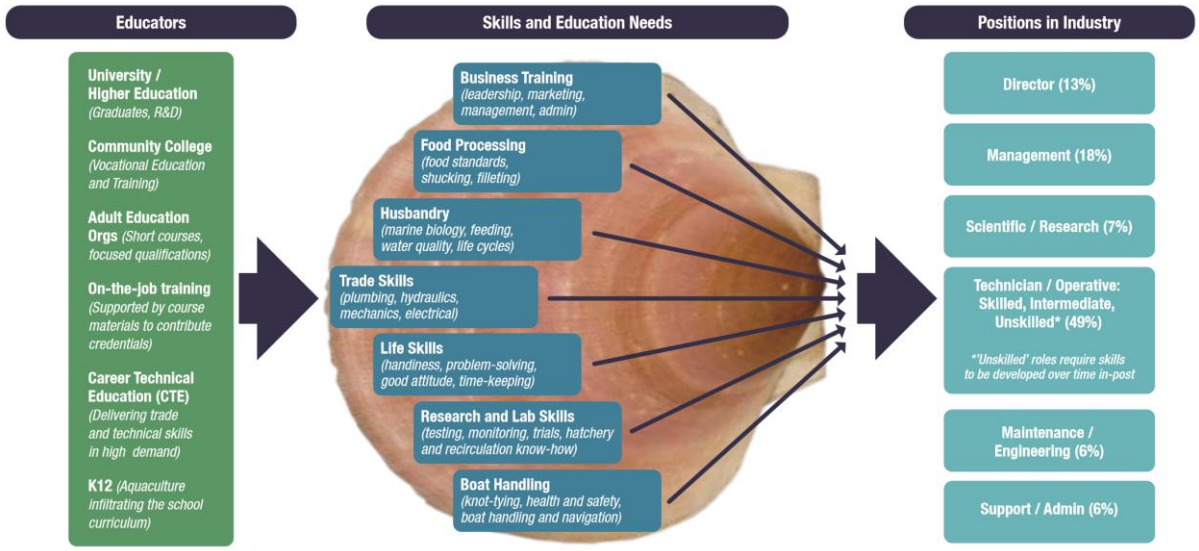


Figure 7 outlines the high-level aquaculture workforce requirements (NB: percentage figures are rounded). Educators (and employers) must offer the required skills development opportunities and education to the aquaculture sector, including through (supported) on-the-job training. Often the skills mix for a manager or director will contain elements that overlap with operatives, particularly in smaller companies, and the degree to which a function is undertaken in-house or outsourced (e.g. engineering tasks) will depend on the skills and 'handiness' available in the team. While many education and training components are partially available, they are often not functionally available to meet current or future workforce needs.

Changing sector needs: The skills and education needs for the industry are likely to change as the sector grows, and education sector leaders should consider where the skills development and education are needed and inadequately supplied, and direct funding accordingly.

Impact: Educators and industry representatives alike took the view that aquaculture growth would continue to provide hundreds of farm and operative jobs in remote rural areas, which should compensate those areas where the long-term sustainability of fishing is under threat. These jobs would require the mix of skills development and education cited above, with a focus on core skills, including maritime and trade skills.

While there is expected to be an increase in owner / directors in the short run with the increase in LPAs, over time this is likely to give way to employed management as the sector rationalises and attracts external investment.

An integrated workforce development strategy

Significant gaps in Vocational Education and Training (VET) provision need to be addressed, starting from the development of occupational standards with industry input for each of the main aquaculture sectors as a pre-requisite. Thereafter the providers driving the development of a new Aquaculture VET pipeline can build new

qualifications, collaborate to develop resources and ultimately offer accessible programs to the key target audiences, young new entrants from the secondary school sector and business start-ups.

The constitution of a well governed, representative committee structure, that is and can ensure a collaborative approach towards AWDS implementation, including bidding for state and federal funds to support implementation and the leadership of the Aquaculture VET pipeline development will be mission critical. Ongoing initiatives and where possible, recently secured funding streams and resources, will need to be factored into the collaborative development process in order to manage stakeholder expectations and continue building on the strong spirit of cooperation established during the AWDS development phase under the leadership of GMRI. This includes Shared Waters continuation linked to the Mid Coast School of Technology development, two key initiatives that are integral to the Aquaculture VET pipeline development process described.

The strategic recommendations are grouped into five key areas:

1. Aquaculture VET Pipeline
2. Partnerships and funding
3. Representation within standards development
4. Geography and VET accessibility
5. Aquaculture VET marketing and sustainability

8.1. Aquaculture VET pipeline

The main scope of the AWDS education is vocational, with close attention paid to programs that lead to jobs. Many of the objectives of the AWDS can be delivered primarily through meeting the VET gaps through Community Colleges and Career and Technical Education across Maine, with the following lead hubs:

Region	Proposed Vocational Hub
Southern Maine	Southern Maine Community College
Mid-Coast	Mid-Coast School of Technology (This is CTE rather than a CC – the modalities of this are considered in section 8.4)
Downeast	Washington County Community College

Table 35: Vocational Hub Institutions for the AWDS

A discussion of the geographic and organizational rationale for these recommendations is set out in section 8.4.

High Schools have a vital role to play, through a plethora of initiatives to raise awareness of aquaculture by infiltrating the curriculum and contextualising STEM. The delivery of core skills by High Schools is valued by employers from a range of sectors, including aquaculture. However, the impact of local High School initiatives is currently limited, due to the significant gap regarding 'formal' Aquaculture Vocational Education and Training (VET). This must be addressed as the top priority within the AWDS.

A formal Aquaculture VET pipeline is required that is; readily accessible, has defined pre-requisites for each point of entry and clear points of exit for each level of occupation, to ensure learners leave with credentials employers recognise and respect. Once a robust VET pathway has been defined for aquaculture, it should feature prominently in a state-wide Aquaculture Careers Marketing Strategy and local aquaculture education promotional initiatives (see 8.5).

The development of the Aquaculture VET pipeline will require a well-coordinated effort by the CTE and CC sectors under the leadership of an appointee that represents CTE and CC sector interests equally. They will need to be fully conversant with formal VET processes and have Maine aquaculture knowledge and experience in order to lead and manage a well-orchestrated VET development phase. They must also work with HE providers in support of negotiations regarding facility access for VET and progression to HE, as well as the Department of

Labor to ensure a compliant Apprenticeship program, is integrated within the VET pipeline effectively. In the following recommendations, a clear description and vision is given so that stakeholders can develop the required implementation models with tangible direction and activities.

8.1.1. CTE aquaculture signature program

A CTE Aquaculture Signature Program is required in several regions (see section 8.4) and should provide pre-requisites for entry to a new Associate Degree within the CC system to form the central trunk of the Aquaculture VET pipeline. Well-located CTE centres offering the trade skills the industry requires at husbandry operative level, including plumbing, electrics, hydraulics and light engineering, should be selected in each region (see 8.4) for 'development fast tracking' as CTE Aquaculture Signature Program providers. Their selection will be influenced by the distribution of fish farms within the state and with the aim of maximising accessibility to all aquaculture learners seeking husbandry qualifications. On CTE completion, an 18-year-old graduate will be equipped with sufficient trade skills, boat handling skills and aquaculture knowledge to enter the industry as a husbandry operative, allowing them to immediately comply with their employers' safety and operating procedures as productive members of the workforce.

CTE qualifications will be recognised by CC centres as credits towards the completion of an Associate Degree, allowing the CC stage of the VET journey to be shortened. The new CTE Aquaculture Signature Program should be designed in collaboration with CC representatives to ensure transferable credits are offered at the CTE stage of the pipeline. Suitably located CTE providers short listed by sector leaders in each of the three regions (see 8.4) should complete an approval process to ensure their facilities and academic staff are adequate for the delivery of specified CTE components, including those eligible for Associate Degree recognition. It is recommended that CC representatives are included within the approval process for those CTE components that provide transferable credits.

Although unusual, it is permissible for a well-resourced CTE centre to offer an entire Associate Degree program. In order to ensure adequate VET access within strategically important regions, this approach has been recommended for the Mid coast region, as a CC facility suitable for development as an aquaculture education provider is lacking (see section 8.4).

8.1.2. Apprenticeship

The inclusion of a well-integrated Apprenticeship program within the Aquaculture VET pipeline is an essential element of the AWDS. This will encourage access to reputable commercial farms for VET delivery and the assessment of credentials. Most CTE graduates that qualify at husbandry operative level, will be advised to gain at least two years-experience before considering progression to a CC Associate Degree. Bearing in mind the diversity of aquaculture and the high investment required to provide adequate training facilities in a CTE and/or CC setting, practical competence is best developed and proven within a well-equipped commercial workplace.

Practical experience gained during the CTE stage and subsequently whilst in employment should be 'credit bearing' by design and contribute to Apprenticeship completion. This will increase the overall quality of the VET pipeline and provide credits based on practical competence that can be recognised within a CC Associate Degree at a later stage, for those that progress.

The recruitment of commercial farms willing and capable of supporting skills instruction and the formal assessment of practical competence is important to AWDS implementation, and the industry have a key role to play (See section 8.3.1).

8.1.3. CC associate degree

It is proposed that the South of Maine and Washington County Community Colleges collaborate to develop a new Associate Degree that provide Aquaculture VET at site manager level. They would become CC hubs for the south and north east (Downeast) of Maine, respectively and work collaboratively with the Mid Coast School of Technology to develop and support the delivery Associate Degree level credits, thereby building capacity at the Associate Degree level within the mid coast region (see 8.4).

By design, the proposed CTE Aquaculture Signature Program would provide access to the new CC Associate Degree, thereby preparing learners for progression from husbandry operative to farm site manager level. However, this stage of development will be most effective if undertaken following a period of husbandry employment to gain experience and potentially credits.

HE articulation will be negotiated and formalised with selected Universities in Maine that have aquaculture, marine biology or maritime undergraduate programs, to allow progression from CC Associate-Degree, to Bachelor's Degree and for some, post graduate degree level. Those learners progressing from the new VET pipeline will be prepared for managerial and higher-level specialist technical and R&D related employment.

Due to the promising but still emergent aquaculture industry growth predictions and relatively low level of demand from aquaculture VET at Associate Degree level in the short to medium term, it is recommended that the needs of proximate sectors (such as fisheries) with common knowledge and skills requirements are accommodated. By factoring them in to VET design, the viability of Aquaculture VET will be improved through the shared delivery of common curriculum components. Unitisation of the curriculum and thoughtful timetabling of any facility-based face to face delivery will further improve the resource efficiency of delivery and therefore medium to long term viability, assisted by flexible delivery modes (see below).The market research (environmental analysis) ongoing by Washington College in the north east could be expanded state-wide, in order to establish the precise needs of proximate sectors, prior to the development of new Associate Degree level qualifications within the Aquaculture VET pipeline.

8.1.4. VET delivery modes and facilities

Distance learning, including online learning, where suitable broadband connectivity to the internet is available, should be deployed to improve VET accessibility and viability. Learners thinly scattered across a vast landscape will be served as a cohort and their knowledge and understanding of specialist aquaculture subjects developed, supported by remote tutoring. Face to face conventional delivery should not eliminated, but reduced and complimented, by adding distance learning, on farm skills development and short courses. This 'blended learning' approach is the most flexible, efficient and effective way to deliver VET to dispersed learners with differing needs, provided the Program is well designed, unitised and well tutored.

8.1.5. Practical facilities for VET

Despite lacking nominated VET centres, some regions do have a wealth of very well-equipped aquaculture R&D facilities, most of which are owned and operated by the University sector. Although established to support HE research in many cases, through negotiation VET providers could gain access to specialist facilities and university staff who could input to VET Programs. These possibilities should be fully investigated and factored into Associate Degree design thinking once confirmed.

Next steps

- CTE and CC sector leader's appointment a lead coordinator of the Aquaculture VET pipeline development
- Sector leaders select lead CTE and CC centres to form the core of the Aquaculture VET pipeline.
- Extend the investigation into proximate sectors being undertaken by the Washington County CC to include coverage of the entire state to inform Associate Degree design
- Establish the availability of facilities that could be accessed by providers within CC and/or CTE VET delivery.

8.1.6. Core VET capability and linkages across the education sector

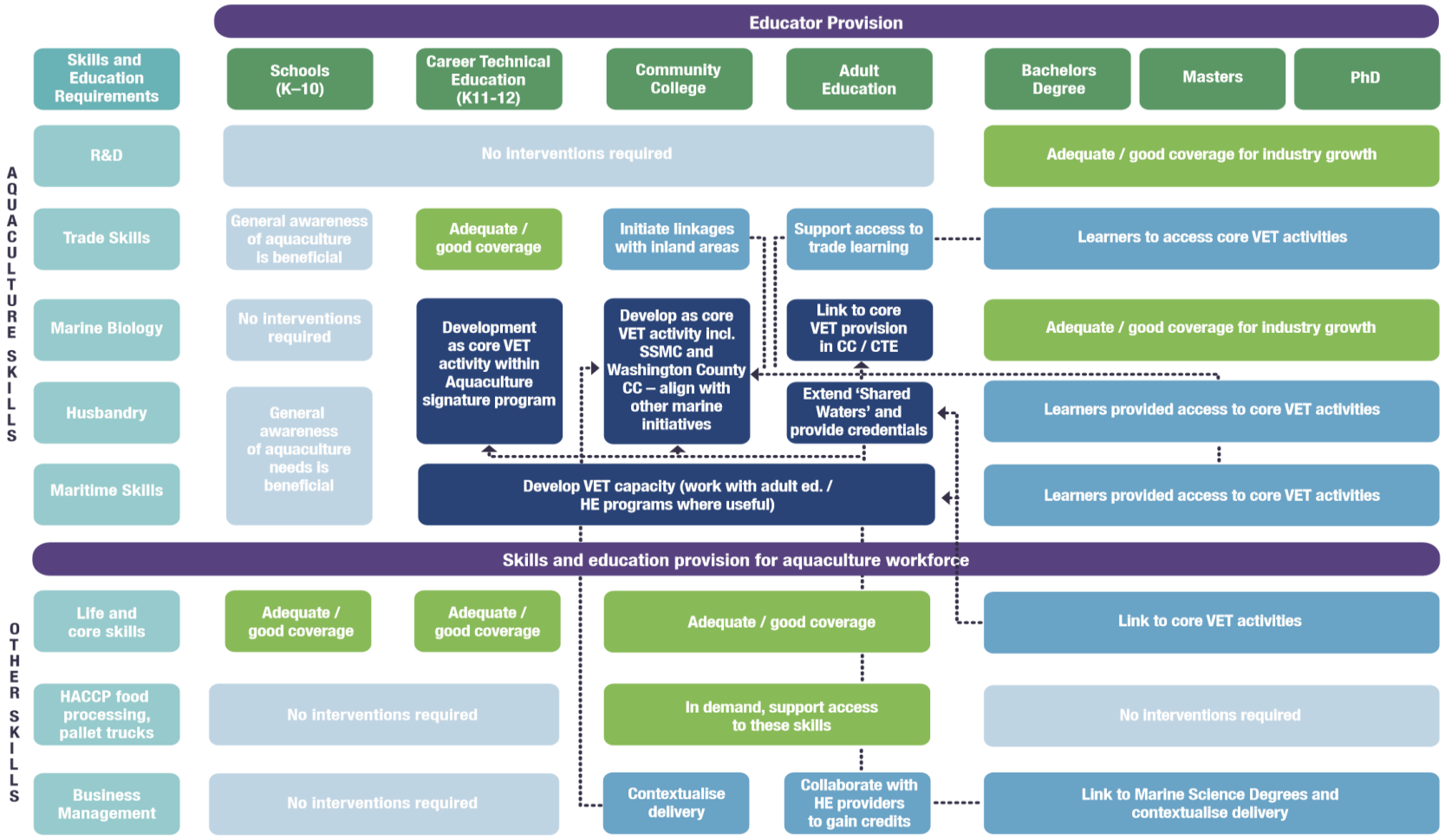
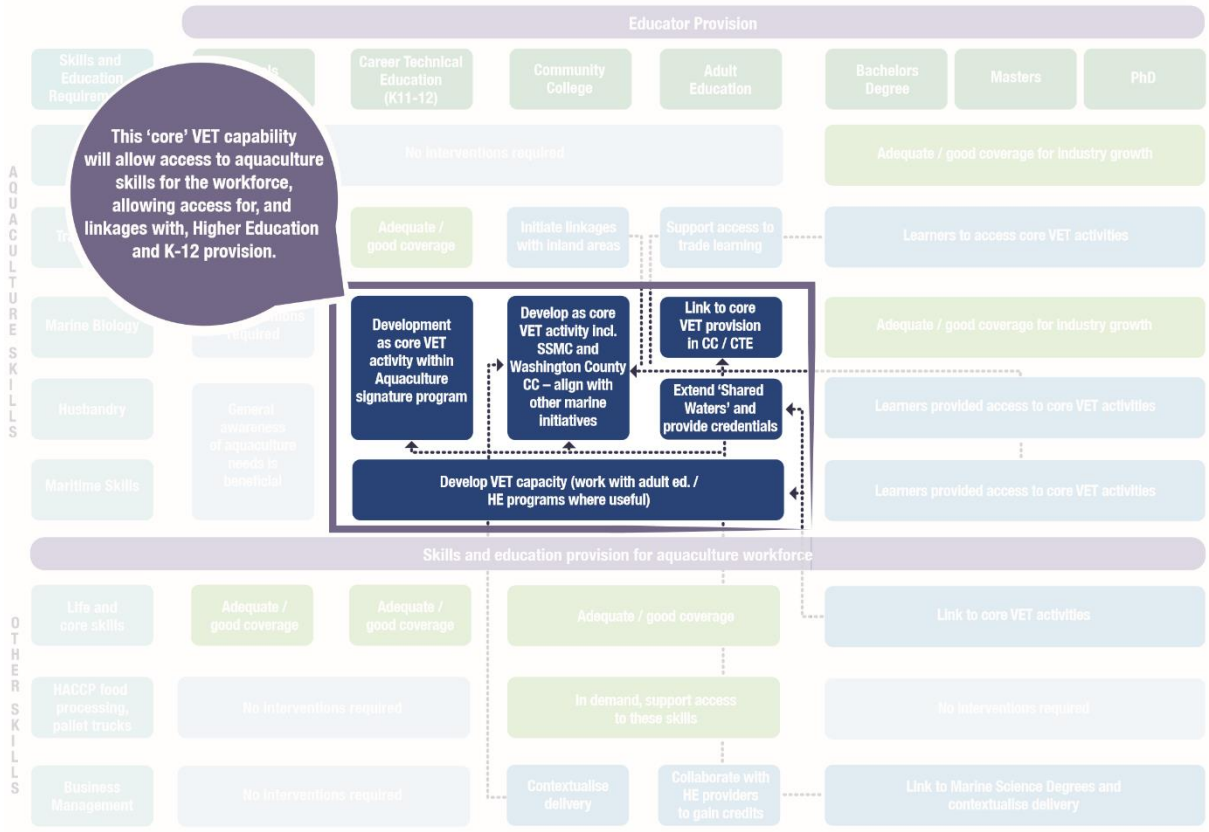


Figure 8: Core VET capability and linkages across the education sector

Key:

- Green boxes indicate where provision is adequate or good
- Light blue boxes indicate where action or linkages need to be developed or improved
- Bright blue boxes indicate where core VET capacity should be developed to anchor workforce development activities.

Figure 9: Core VET capacity for accessible skills and education needs



The figures above demonstrate how a core of VET capacity will enable the sector to grow with the requisite skills:

- Current provision at HE level, including supply of marine biology skills and research capability, is considered as sufficient and may continue, but there are other areas such as the integration of business management (supplying into the VET core) and hands-on practical training (gaining from the VET core) where universities can forge new linkages.

As set out in the main report, there are many paths into aquaculture, and it is accessible for unskilled entrants and high-level researchers. However, both cohorts are in fact expected to have or quickly gain aquaculture skills that can be gained through the VET system. On the basis of financial and geographic access, this model would allow skills and training for the full range of industry workers from 'unskilled' entrants through to supplementing PhD candidates with core trade and maritime skills.

8.2. Partnerships and funding

Whilst not unique to Maine, the secondary and tertiary education funding regimes are complex. The prevailing culture of competitive bidding by relatively autonomous educational institutions to support many of the local initiatives, is ad-hoc, unpredictable and largely sits out with state level controls. Due to the variable scale of different institutions, the system can favor the larger and better staffed organizations, over the smaller, however worthy their educational cause may be. The AWDS Steering Committee must establish a strategically driven collective effort for the implementation of the AWDS, building on the 'spirit of cooperation' generated through the comprehensive stakeholder consultation led by GMRI during the AWDS development phase. An effective AWDS should provide:

- leadership/organization to coordinate implementation;
- development of recognized industry occupational standards;
- program development founded in recognized industry skills need and demand;
- development of sustainable apprenticeship program.

A coherent AWDS with the backing of stakeholders will undoubtably assist future bids to support aquaculture VET development. When planning new provision, the funding opportunities to support development and delivery phases need to be 'braided' in order to maximise available support and resources. However, cooperation within sectors, such as CTE and CC and across sectors will need to be 'ramped up', alongside the development of a more effective and proactive partnership with industry.

Sector leaders must establish collaborative groups within this new constitution below, clarifying their roles, authority, protocols and responsibilities for representation and communication. This should be led by an AWDS Steering Committee, as Chaired by GMRI during this analysis, to ensure continuity from the AWDS development phase. The AWDS Steering Committee responsible should wherever possible coordinate bids for state and federal funds, and marshal their deployment, led by AWDS strategic priorities and next steps.

The holder of the proposed new post, 'Aquaculture VET pipeline coordinator' shared by the CTE and CC sectors is the natural chair of the ASFF and ACDG proposed below and should be answerable to the Steering Committee who could oversee their employment. Collaboration with the Maine Aquaculture Association will be integral to development of the Occupational Standards and organizing the Aquaculture Skills Foresight Forum.

Table 36: Proposed new AWDS representative bodies and their roles

Name of committee	Role	Membership
AWDS Steering Committee	Governance of AWDS implementation and collective bidding	Led by: MAA, GMRI, Educate Maine, Aquaculture VET pipeline coordinator, CTE sector leader, CC leader Similar makeup to the Aquaculture WD Steering Committee convened for this project.
Aquaculture Skills Foresight Forum (ASFF)	To develop aquaculture occupational standards for finfish, shellfish and sea vegetables	Led by: Aquaculture VET pipeline coordinator & MAA Representatives from industry (finfish, shellfish and sea vegetables), the CC system, Maine Department of Labor and High School CTE
Aquaculture Curriculum Development Group (ACDG)	Constituted to develop new qualification frameworks for CTE and CC followed by specific subject areas/modules, as required.	Led by: Aquaculture VET pipeline coordinator to ensure that all new credentials were designed with reference to the industry standards. CTE and CC institutional leaders, selected aquaculture academics and teachers recruited to serve the groups needs
Maine Aquaculture Vocational Education Resources Consortium (MAVERC)	Collaborative development of shared distance learning resources	Led by: Chair elected by CTE and CC Composed of selected institutions with existing aquaculture learning resources that could be re-purposed and/or aquaculture experts

Next steps

- Develop the constitution for the AWDS Steering Committee and recruit members
- Develop the constitutions for the ASFF, ACDG and MAVERC committees, prior to recruitment of members

8.3. Representation within standards development

The creation of the Aquaculture VET pipeline central to implementation of the AWDS, depends on partnership between industry and VET provider representatives, formalised within the new committee structure above. Therefore, high quality and committed representatives and advocates from industry and the VET sector need to be identified, engaged and recruited at the outset.

8.3.1. Industry representation within occupational standards development

The involvement of the industry within the development of standards to inform credentials is essential. Effective aquaculture VET supply must be 'demand led', which necessitates development of 'sector specific standards. However, the 'standards development' process should be coordinated by the leader of the VET pipeline development – there could be an additional role here for a coordinator, so long as the role is supporting and stimulating industry input. They must ensure that industry needs regarding the future skills and 'knowledge and understanding' of staff at a range of occupational levels, are fully expressed and the output documented in terms meaningful to industry and unambiguous to VET providers, allowing them to derive credentials and qualifications for each occupational level within each industry sector.

The sectors to be represented within the standards development process are:

- Finfish
- Shellfish
- Sea vegetables
- Technology supply and support services (all aquaculture sectors)

Concurrently, respected individual owners and managers of farms from each sector will be engaged, lobbied and recruited to support the VET pipeline creation and subsequently, the learners' skills development. Through discussion, the level of 'active' support farm owners and managers are willing and able to provide will be evaluated according to the following parameters:

Willing and able to offer –

a) Support and inform the standards development process for their sector
b) Short duration educational visit/tours (2- 4 hours)
c) Supervised periods of work-placement and internship from 1- 2 weeks
d) Longer duration periods of work placement 2 weeks to 3 months
e) Apprenticeship placements/internships with practical skills training
f) Assessment and documentation of learners' practical skills according to a given grading system

This information will be held on a database of employer details for reference during the VET pipeline development and piloting phase. The LPAs will be differentiated within the data set and any LPA volunteers will be vetted, mindful of the large proportion of relatively inexperienced operators that are included within this subset, many of whom will not be well placed to support VET learners without support.

8.3.2. VET provider representation within qualifications development

Representatives of CTE and CC sectors should be appointed by their state leaders to join the ACDG committee. It is advisable that a senior manager from each CTE and CC establishments selected to deliver components of the signature programs during the first phase of delivery are included. They would represent their sector during the standards development process and design of credentials and qualifications subsequently.

Proposed Next steps

- Formation of the ASFF committee composed of industry and VET provider representatives, with a remit for standards development, the quality assurance of VET provision and skills fore-sighting to ensure provision remains technically current
- Review of the Maine aquaculture industry by sector to determine how well represented each sector is at state level
- Engagement with individual members of industry respected for their advocacy and/or with a strong vested interest in workforce development to gauge the level of support according to the above evaluation criteria.
- Recruitment of farms willing to offer apprenticeship and/or internships and provide formal instruction and the assessment of skills (as specified by the Maine Aquaculture Standards above).
- Formation of the ACDG and MAVERC committees in succession, ensuring adequate representation by stakeholders from industry and education.

8.4. Geography and VET accessibility

Maine's geography, and the distribution of farms and learners are important considerations in proposing delivery modes for skills development, education and training at all levels. The strategy must take account of the needs of learners, their travel options and range and the access to fish-farms and VET facilities required.

In recognition of the geographical challenges, the AWDS necessitates that the two Community Colleges, SMCC and WCCC work closely with the Mid Coast School of Technology, not only leading the VET pipeline development in each of their respective regions, but collaborating to ensure the completion of state-wide provision at the husbandry (CTE) and site manager (CC) levels. Those providing bespoke aquaculture provision in the adult education sector and the universities all have important specific roles to play within the VET pipeline, as exemplified by the legacy and diversity of opportunity within the Mid- Coast region.

8.4.1. Physical facilities vs virtual platforms

The strategy recognises the need for trade, technical and business skills integrated with the core marine science curriculum. Many of these can be built on and around the CTE and Community College system, integrating unitised programs with the apprenticeship system to ensure flexibility and access to high quality on farm training and assessment. Unitisation and flexible delivery modes (including online learning) will allow any graduates and incoming cohorts such as lobstermen to address their skills gaps on a specific personal-needs basis.

The CTE and CC systems span the state, and provide a basis for the development of an aquaculture VET pipeline within three regionally discrete loci:

- Southern Maine, which has a well-regarded Marine Science programs (good capacity and potential demand from Universities into CTE and CC activities), basic marine facilities, and trade, technical and business module.
- Mid-Coast, where much of the aquaculture industry operates but has a more diverse ecosystem of providers fish holding facilities and commercial farms. It does not have a strong CC presence but is establishing CTE capacity.
- Downeast, a geographically distinct region already considering VET implementation platforms ahead of the rest of the state.

Distance learning, while not currently prominent or seen as a high priority by many educators, should play a vital role and will be essential for many learners. As acknowledged by the Washington County Community College, a totally 'campus' based delivery model would be misplaced, given the need for farm based hands-on skills development in industry, complemented by distance learning and short courses, all of which could be credit bearing.

8.4.2. Downeast

Washington County Community College (WCCC) should provide the VET development lead and hub 'down east', working in close liaison with the Southern Maine CC and the Mid-Coast School of Technology to develop an Associate Degree that can serve the needs of aquaculture and 'proximate sectors'. They will build on their ongoing 'environmental analysis' in the region, finalising the needs of the salmon farming workforce in their area through consultation with Cooke Aquaculture. Subsequently they will lead the state-wide environmental analysis to inform AWDS implementation at the Associate Degree level. The physical infrastructure of the Downeast Institute nearby provides an opportunity to access practical shellfish education and training that complements its main research function within the north of the State. The WCCC could play a central role in developing the delivery of VET for aquaculture, alongside proximate marine sectors in both Washington county and the rest of the state.

8.4.3. Southern Maine

It is proposed that SMCC should act as the lead hub for Southern Maine, building on their respected Marine Science program and basic marine facilities. Southern Maine aquaculture activity is widespread from UNE and processing capacity south of Portland, with extensive production in the Casco Bay area (and islands), e.g. mussel, scallop and oyster farms. This area is broadly within 1-2 hrs of Portland and has the Darling Marine Center as well as Community College, university and CTE capacity, within reasonably close proximity.

The University of New England (UNE) has an outwardly focussed recruitment strategy for its relatively new aquaculture degree program. This is a promising prospect for Maine aquaculture in the medium term. The AWDS can provide some stimulus to UNE and UMaine to further develop their degrees by offering credit bearing periods of commercial work experience and practical skills-based VET Units in aquaculture. This will allow those HE graduates who are not destined to progress to scientific research careers to be 'more work ready' in the eyes of aquaculture employers, and the best will be able to 'fast track' to aquaculture management positions.

A lead CTE provider could be selected for Southern Maine to work closely with the Mid Coast School of Technology to create the network of CTE providers required state-wide to support for husbandry level VET (see 8.4.4 below) This will ensure that grade 10 High School learners in the south of the state can progress to an Aquaculture Signature Program as 'juniors' (grade 11) and gain recognised credentials for entry to employment at the husbandry operative level, progressing to SMCC for Associate Degree completion in some cases subsequently.

8.4.4. Mid-coast

The Mid coast region has a great diversity of aquaculture and educator activity and a wealth of opportunities for productive collaboration between CTE, CC, the Universities and the highly valued bespoke adult education such as the Shared Waters and Island Institute programs. Harnessing this region's legacy will be essential to providing access to the appropriate level of education and training for new entrants and existing operatives in this important region for aquaculture.

Mid-coast Maine also hosts the emerging 'high tech' RAS industry in Bucksport and Belfast, although these facilities are currently pre-operational. Their relative proximity to University of Maine in Orono will allow graduates to be exposed to aquaculture laboratory work demands and RAS systems. The Darling Marine Center,

CTE institutions and the college network are relatively central within Maine and should be able to provide for the workforce development needs of many.

The SMCC has a small campus that includes business courses at Brunswick which could be contextualized to complement the education available in the technical aspects of aquaculture. This may help to retain more university graduates who have previously moved out of state and overseas to pursue marine science careers.

The CTE sector already has a significant footprint and local impact in terms of providing 18-year-old graduates with many of the trade skills aquaculture and other employers in the coastal zone require.

Considering these factors, the Mid-Coast School of Technology is proposed as the CTE hub and lead the development of the region's Aquaculture Signature Program, in liaison with the CC sector and working with other lead CTE providers nominated for development to deliver the Signature Program in the south and north east. As there is no suitable Mid-Coast CC facility for aquaculture, the Mid Coast School of Technology and its staff will be developed to deliver as many credits required for Associate Degree level completion as possible, in effect performing the role of a Community College. Close collaboration with the SMCC and WCCC as well as the development of flexible delivery systems will be essential to make this stage of the VET pipeline accessible to all in the Mid Coast region.

The Mid-coast base line can be summarised as follows:

- *Strong industry presence:* The greatest density of shellfish production and the sectors natural heartland, providing a fertile recruitment ground for the industry advocates needed for ASFF standards development and accessible facilities for formal VET delivery, including apprenticeship.
- *Emerging RAS sector:* The chosen base for some pre-operational companies (emerging RAS finfish). CCAR and the Darling Marine Center facilities exist in this region that demonstrate RAS technology, albeit on a demonstration scale.
- *Shared Waters program:* University of Maine (Darling Center) are a lead partner of the 'Aquaculture in Shared Waters' program which is highly regarded by industry and a legacy and must be safeguarded and built on.
- *Island Institute:* Based in Rockland, business start-up training and experiential learning is offered to aspiring aquaculture entrepreneurs.
- *Mid-Coast School of Technology*: A geographically well placed and highly motivated CTE provider undergoing a facility development phase currently.

This rich legacy of education and training activity and associated facilities are conducive to the Mid-Coast region playing an active and central role within the development of the Aquaculture VET pipeline and future VET delivery by working together constructively. The AWDS will stimulate and incentivise collaboration between the key players, overcoming current competitive tendencies and drivers.

Developing the Mid-Coast Aquaculture VET supply

The pre-requisites to success regarding Aquaculture VET development for this region that will help to marry CTE, CC, apprenticeship and vocational short courses are:

- The development of the Mid Coast School of Technology as a facility that can offer the CTE Signature Program in aquaculture (Grade 9-12) and pathway to Associate Degree completion in partnership with SMCC and WCCC.
- The negotiation of arrangements with Universities, including the Darling Marine Center, to enable access to their facilities to support specialist aspects of VET delivery.

- Collaboration by VET providers (CTE and CC) with the highly regarded informal VET initiatives (Shared Waters and Island Institute program for entrepreneurs) to develop shared distance learning resources within MAVERC.
- Collaboration between CTE providers with a proven track record in the delivery of trades and engineering skills relevant to industry, led by the Mid Coast School of Technology as the regional hub. This will create a widely accessible CTE network for learners interested in entering aquaculture at the husbandry operative level.

8.4.5. Inland regions of Maine

Inland Maine is cited as an area where job creation would be desirable. While there is some geographic constraint with most aquaculture remaining coastal (other from RAS), there is much in the supply chain that offers promise for inland Maine, including technical and trade skills. This will be highlighted in marketing the sector's opportunities, stressing the sector's credentials for inclusive growth. It is likely that those inland population hubs that can access the mid-coast players (e.g. proposed RAS in Belfast and Bucksport, processing facilities for mussels and oysters, etc.) will find economic opportunity in the delivery of auxiliary service.

8.4.6. Macroeconomic factors

In addition to direct industry-focused implementation, the sector (through the coordinator and/or industry representatives directly) should lend its voice to addressing wider economic development factors, including:

- *Housing* – cited as a constraint in many areas where tourism and desirable coastal areas have made housing expensive or limited in supply, particularly seasonally.
- *Healthcare* – cited as having significant impacts on the ability to hire staff.
- *Connectivity* – operating in remote areas can pose challenges for operational and social offer for staff
- Global trends – sustained increase in global demand for aquaculture and generally seafood products (there is an emerging threat to supply of fish stocks).
- *Transferability of skills and learning* – aquaculture is well regarded in having (and needing) transferable trade and marine skills, along with fostering a 'can-do' attitude.
- *Digitally enabled workforce* – as demand increases for digital skills, this will also entail a general shift of jobs from direct farm jobs to remote supply chain ones. This should be tracked to ensure the right companies remain in the conversation as the industry develops.

There are further advantages to the VET platform in being able to meet education and skills needs more affordably and in remote regions intrinsic to the aquaculture sector.

8.5. Aquaculture VET marketing and sustainability

Whilst recognising that Aquaculture VET development should and will be informed by industry needs, in order to secure the continuity of supply it is equally important that learner demand for Aquaculture VET is assessed, developed, harnessed and shared in a way that ensures viability for providers. The growth in provision should be aligned to the growth in learner demand in response to industry growth, and the stimulus provided by the proposed Aquaculture Careers Marketing Strategy. Consequently, VET learner demand should be shared between providers in way that increases the quality and accessibility of the provision, whilst avoiding unhelpful competition between providers, spreading demand so thinly that it threatens viability for all.

There are several important aspects to industry demand that VET providers need to understand and periodically evaluate, namely, the

- skills and knowledge needed by each occupation,
- numbers of staff needed at each occupational level,
- proportion of the workforce that requires recognised credentials and qualifications, and
- geographic location of future jobs.

Whilst information on the knowledge and skills required by the Maine aquaculture workforce have been determined in broad terms from recent surveys, the volume of future demand for learners from industry for each point of entry is difficult to specify. Employers have indicated the skills they would like new entrants to have and/or quickly gain, which is a positive sign. Providers now need to ensure that the credentials and qualifications they gain from the VET pipeline, deliver those skills. Once this is recognised by employers, they will increasingly respect formal VET and preferentially seek 'qualified' new entrants, and demand from learners will grow.

Anecdotal evidence from the High School system indicates that Maine youth have a positive and growing interest in aquaculture, although attitudes to finfish culture are more variable. However, the volume of learner demand for Aquaculture VET specifically, has not been evaluated and is subject to a range of influences that AWDS stakeholders are aware of. It is essential that the strategy is responsive to and helps inform rapidly changing public awareness of aquaculture and food production more generally.

The main determinants will be:

- The pervasiveness of aquaculture within the High School curriculum
- The attitudes of High School teachers towards aquaculture and the effectiveness of aquaculture related teacher development
- The image of aquaculture portrayed by mainstream and social media locally, within Maine and the USA
- The attitudes and enthusiasm of the learners main 'career choice influencers' towards aquaculture, including parents, guardians and career advisers
- The attitudes of incoming entrepreneurs towards aquaculture as a business start-up and life-style opportunity
- The attitude of the fishing community, particularly lobsterman, towards aquaculture as a business diversification opportunity and/or necessity
- The effectiveness of the Aquaculture Careers Marketing Campaign

Both the industry and learner demand described above will be very influenced by the delivery modes available within the VET pipeline as this will impact on learners' accessibility and employers' perceptions regarding VET suitability. In addition, the quality of the new provision, the reputation of providers and the credibility of the credentials and qualifications delivered, are all dynamic parameters that will shape the 'ebb and flow' of demand over time and require constant management.

Learner demand will be strongly influenced by evidence of career success as a result of VET courses undertaken and the credentials and qualifications gained. Therefore, if industry continue to rely heavily on informal uncertificated training, delivered on farm by owners and managers themselves, the demand for formal VET will diminish and new provision will 'wither on the vine.'

By upgrading most of the on farm informal training, to join the formal VET pipeline, latent demand for VET will become part of the formal VET supply fundable by the public sector. This in turn will help providers to commit to the investment required in facilities, industry partnerships and the design, development and growth of a sustainable VET supply.

The efforts of the multitude of individuals and organizations currently presenting and promoting the industry to a range of audiences needs to be better coordinated, resourced and supported by those agencies that are 'enablers' within the AWDS as opposed to VET providers. The VET providers will support the marketing effort, with a focus on their sector and the provision available from their organization within their catchment for recruitment.

Both educators and industry representatives have important roles within marketing.

8.5.1. Industry representative's role

First and foremost, the industry will project a positive image of an environmentally friendly well-regulated sector that is developing harmoniously regarding the interests of other water users, thereby safeguarding its social licence to operate. In addition, assisted by the educators, the benefits of aquaculture will be defined and presented on a sector specific basis, to get the Maine industry consistently 'on message'. Continued development of the K-12 curriculum by aquaculture-related topics should be undertaken by organizations playing an 'enabling role' within the state.

Once the key messages have been formulated and presented within well designed and illustrated formats, the education institutes and agencies supporting the coordinated Aquaculture Careers Marketing Strategy, can distribute information within their catchments and networks. This will be paralleled by a social media campaign to relate the same messages with career awareness raising as the central aim.

Proposed Next steps

- Plan the Aquaculture VET marketing effort with reference to the VET pipeline development plan and timing

8.6. Other AWDS strategic considerations

Whilst the establishment of the Aquaculture VET pipeline forms the core of AWDS implementation, there are other considerations within the AWDS to acknowledge that sits out with the formalised process described in section 2. These are outlined below and can be addressed by individual institutions and / or through informal collaboration.

8.6.1. The role of HE within the AWDS

While the focus of the AWDS is in addressing the VET gap, there are numerous roles that HE should continue to deliver, and can contribute to the development of the sector, including (but not exclusively) through linking with the VET core.

Bachelor's Degree-level vocational enrichment
At Bachelor's Degree level, both the University of New England (UNE) and University of Maine (UoM) are taking a national and international view of aquaculture education. Marine Science graduates from the State are well regarded, and as a destination Maine has a lot to offer when marketing its education. However, some places such as Orono or Portland will be more attractive for long term degrees while it may be a 'harder sell' to attract incoming students to the more remote areas beyond short term courses or internships. The UNE is actively developing its course and it is understood that the VET initiatives outlined above may give a strong platform for UNE to crowd-in technical, trade and other skills to its course, and help them to provide a route to increased access to industry facilities, internships and apprenticeship models through the improved linkage to industry representatives proposed.

Postgraduate level alignment
At post graduate level there are opportunities to more closely align academic research activities with aquaculture industry priorities. This has been highlighted as an important opportunity by Cooke Aquaculture who are looking for scientists in the future who can solve aquaculture problems and lead innovative developments of techniques and technology. The emerging RAS sector will provide more opportunities for post-graduate research that support the pioneering companies as they get established and develop their human resource base

Business skills addition
The discussions that have started between the UMaine Business School and the School of Marine Sciences to explore the potential to bolt on business skills to encourage marine science graduates to enter aquaculture and better prepare them for fast tracking to managerial positions as well as encouraging some to considering a business start-up. This is a valuable career alternative for those graduates who are not destined to pursue laboratory-based research roles in the future but are more practically orientated.

In addition, talks should be held with the Island Institute to explore the potential for collaboration to further develop of the program for industry start up entrepreneurs, and the potential interest in accreditation through the UoM to allow learners to accumulate credits as evidence of their business competence.

Outreach alignment within the Aquaculture Careers Marketing Strategy
The invaluable outreach work undertaken by the University sector needs to continue and align with the Aquaculture Careers Marketing Strategy. Increased public awareness of aquaculture and its benefits to the state will lead to more parents and guardians encouraging young people to enter aquaculture careers and will also safeguard the industry's social licence.

8.7. Collaboration with out of state organizations

During the AWDS research there have been several potentially valuable opportunities for collaboration out of state to recognise and explore.

Washington State Community College (CC) advice
The Washington State CC were invited to submit an educators' survey return which revealed that they had an established Associate Degree in aquaculture and were well placed to advise Maine regarding this level of provision. It is unlikely that there would ever be aby fears of competition and the establishment of a relationship encouraging them to act in an informal advisory role, may be helpful.

Canadian Community Colleges
Cooke Aquaculture in Canada have received bespoke VET from Canadian college providers to serve their company needs. With consent, some examination of the Canadian curriculum by WCCC in collaboration with Cooke Maine, may provide access to resources, and/or useful advice regarding the VET requirement for finfish if a relationship with the Canadian colleges could be forged.

High School aquaculture exchange
The specialist secondary school BRASTEC in Bridgeport Connecticut and the nearby Sands School have interesting models for providing 'aquaculture themed science to High Schools in their region. They have a very well-equipped RAS facilities as well as industry and community partnerships. A relationship that encouraged staff exchange and possibly study weeks my learners may be worthwhile exploring.

Higher education partnerships
The University competitor analysis which reveals the leading providers out of state within the United States and internationally is worth consideration from an alternative angle. Every competitor is a potential collaborator, and if Maine HE specialised within RAS and gained wider recognition in this field, this may be of interest to other HE providers with alternative specialisms seeking exchanges or collaborative post-graduate research degrees. The UNE alignment of aquatics technology within its new Bachelor's aquaculture program, is a step in this direction.

8.8. Summary of proposed next steps

THEME	ACTIONS
Aquaculture VET Pipeline	CTE and CC sector leader's appointment a lead coordinator of the Aquaculture VET pipeline development.
	Sector leaders select lead CTE and CC centres to form the core of the Aquaculture VET pipeline.
	Extend the investigation into proximate sectors being undertaken by the Washington County CC to include coverage of the entire state to inform Associate Degree design
	Establish the availability of facilities that could be accessed by providers within CC and/or CTE VET delivery.
	AWDS steering committee appointment a lead coordinator of the Aquaculture VET pipeline development.
Partnerships and funding	Develop the constitution for the AWDS Steering Committee and recruit members.
	Develop the constitutions for the relevant development committees, prior to recruitment of members.
Representation within standards development	Formation of the a committee composed of industry and VET provider representatives, with a remit for standards development, the quality assurance of VET provision and skills fore-sighting to ensure provision remains technically current.
	Review of the Maine aquaculture industry by sector to determine how well represented each sector is at state level.
	Engagement with individual members of industry respected for their advocacy and/or with a strong vested interest in workforce development to gauge the level of support according to the above evaluation.
	Recruitment of farms willing to offer apprenticeship and/or internships and provide formal instruction and the assessment of skills (as specified by the Maine Aquaculture Standards above).
	Formation of the curriculum and resources committees in succession, ensuring adequate representation by stakeholders from industry and education.
Geography and VET accessibility	Constitute the Mid Coast School of Technology as the lead CTE centre for the development of CTE Signature Program in Aquaculture.
	Enrol the leaders of Shared Waters and the Island Institute as members of the learning resources committee in order to build on their existing programs.
	Negotiate access to University facilities and staff who can contribute towards Aquaculture VET delivery.
	Formalise a mid-coast partnership of CTE centres offering trade skills who can contribute to CTE delivery of an Aquaculture Signature Program, led by the Mid Coast School of Technology.
	Develop the Ocean Magnet School CTE program for High School teachers to assist aquaculture curriculum delivery within the secondary education sector.
	Enrol representatives of CTE and CC from Southern and Eastern Maine to join the VET pipeline development committees and process.
Aquaculture VET marketing and sustainability	Plan the Aquaculture VET marketing effort with reference to the VET pipeline development plan and timing.

Table 37: Summary of proposed next steps

9. Appendix

9.1. List of consultees

Table 38: Respondents of Educator's Survey (33 total including 32 valid Maine responses and 1 external comparator)

Institution	Respondent
Algae Foundation; USM	Ike Levine
Bellingham Technical College (Washington State)	Sara Smith
Bigelow Labs	Nichole Price
Casco Bay High School	Derek Pierce
College of the Atlantic	Dr. Chris Petersen
Downeast Institute	Brian Beal
Eastern Maine Skippers Program	Tom Duym
Gulf of Maine Research Institute	Katie Flavin
Hurricane Island Foundation	Jenn Page
Island Institute	Yvonne Thomas
Islesboro Central School	John Van Dis
K-12 and Vocational Edu expert	Tom Keller
Maine CTE Programs	Dwight A. Littlefield
Maine Department of Education - Adult Education	Gail Senese
Maine Department of Labor Apprenticeship Program	Eileen Miazga
Maine Maritime Academy	Bill Brennan
Maine Ocean School	John D'Anieri
Maine Sea Grant	Gayle Zydlewski
Manomet	Ethel Wilkinson
ME EPSCoR at University of Maine	Laurie Bragg
Mid Coast School of Technology	Beth Fisher
Pemaquid Oyster Co. Maine Aquaculture Innovation Center	Chris Davis
Rural Aspirations	Val Peacock
Southern Maine Community College (SMCC)	Brian Tarbox
The Education Exchange (Rhode Island)	Cam Ennis
Unity College	Erika Hutchinson
University of Maine - Aquaculture Research Institute	Deborah Bouchard
University of Maine - Maine Business School	Niclas Erhardt
University of Maine - School of Marine Sciences	Wge Ellis
University of Maine Cooperative Extension/4-H	Laura Wilson

University of New England (UNE)	Barry Costa-Pierce
University of Southern Maine	Richard Bilodeau
Washington County Community College	Nicole Sawyer

Table 39: Members of the Aquaculture Workforce Development Steering Committee

Institution	Representative
Bigelow Laboratories for Ocean Sciences	Nichole Price
Casco Bay High School	Derek Pierce
Downeast Institute University of Maine Machias	Brian Beal
Eastern Maine Skippers Program	Tom Duym
Educate Maine	Jason Judd
FocusMaine	Kim Hamilton
Gulf of Maine Research Institute (GMRI)	Katie Flavin
Hurricane Island Foundation	Jenn Page
Island Institute	Yvonne Thomas
Islesboro Central School	John Van Dis
K-12 and Vocational Edu expert	Tom Keller
Maine 4-H	Lisa Phelps
Maine Aquaculture Association	Sebastian Belle
Maine Department of Education - Adult Education	Gail Senese
Maine Dept of Labor Apprenticeship Programs	Joan Dolan
Maine EPSCoR	Laurie Bragg
Maine Maritime Academy	Bill Brennan
Maine Ocean School	Kylie Bragdon/ John D'Anieri
Maine Sea Grant	Gayle Zydlewski
Maine State Chamber of Commerce	Megan Sanborn
Mid Coast School of Technology	Beth Fisher
Pemaquid Oyster Co. Maine Aquaculture Innovation Center	Chris Davis
Southern Maine Community College	Brian Tarbox
Unity College	Erika Latty
University of Maine - Aquaculture Research Institute	Deborah Bouchard
University of Maine - Maine Business School	Niclas Erhardt
University of Maine - School of Marine Sciences	Wge Ellis
University of New England	Barry Costa-Pierce
Washington County Community College	Nichole Sawyer

Table 40: Commercial Aquaculture Businesses Interviewed

Company	Interviewee
Acadia Aqua Farms	Theo and Fiona de Koning
American Unagi	Sarah Radamaker
Aquaculture Research Institute	Deb Bouchard
Bar Harbor Oyster Company	Joanna Walls and Jesse Fog
Captian B Oysters	Jeff Putnam
Center for Cooperative Aquaculture Research	Steve Eddy
Chebeague Island Oysters	Robert Earnest
Cooke Aquaculture	Andrew Lively, Duran Cercone, Greg Lambert, Gatchel Griffin
Flying Point Oyster Company	Valy Steverlynck
Glidden Point Oyster Farm	Ryan McPherson
Island Creek Oysters	Meggie O'Neal
Isleboro Marine Enterprises	Shey Conover
John's River Shellfish	David Cheney
Kennebec River Biosciences	Bill Kelleher
Maine Coast Sea Vegetables	Shep Erhart
Mere Point Oyster Company	Dan Devereaux/Doug Niven
Mook Sea Farms	Bill Mook
Nonesuch Oyster Company	Abigail Carroll
Nordic Aquafarms	Marianne Naess
North Haven Oyster Company	Adam Campbell
Norumbega Oysters	Eric Peters
Ocean Approved	Paul Dobbins
Ocean Approved	Briana Warner
Oceans Balance	Tollef Olsen
Peaks Island Shellfish	Mark Green
Pemaquid Oyster Company	Christopher Davis
Penobscot Bay Scallop Company	Marsden Brewer
Pine Point Oyster Company	Nate Perry
Sea and Reef Aquaculture	Soren Hansen
Spinney Creek	Lori Howell
Trundy Point/Calendar Island Mussels	Peter J. Stocks
USDA National Cold Water Marine Aquaculture Center	Brian Peterson
Whole Oceans	Jen Fortier
Wild Ocean Aquaculture/Bangs Island Mussels	Matthew Moretti

Table 41: List of institutions met with outside of Steering Committee Meetings (in person or on conference call)

Education/Training Institution	Representatives
Maine Community College System	David Daigler & Janet Sorter
University of New England	Barry Costa Pierce, Adam St. Gelais, & Zach Miller-Hope
Island Institute	Peter Piconi
Maine Department of Labor Apprenticeship Program	Joan Dolan & Eileen Miazga
Maine CTE Program	Dwight Littlefield
Maine Ocean School	John D'Anieri & Gayle Zydlewski
University of Maine Business School	Nic Erhart
Maine Department of Education Adult Education	Gail Sense & Megan Dichter
Eastern Maine Skippers Program/Rural Aspirations Project	Korah Soll, Val Peacock & Tom Duym
Southern Maine Community College	Brian Tarbox & Carol White
Maine Sea Grant	Dana Morse
University of Maine School of Marine Sciences	Damian Brady
Downeast Institute	Brian Beal & Dianne Tilton
Center for Cooperative Aquaculture Research	Steve Eddy
Maine Maritime Academy	David Gardener
University of Maine Aquaculture Research Institute	Debbie Bouchard
University of Maine 4-H Cooperative Extension	Lisa Phelps

Table 42: List of Aquaculture Companies met with Outside of Interview Process

Aquaculture Business	Representatives
Chebeague Island Oyster Co.	Bob Earnest
Ocean's Balance	Tollef Olson
Sustainable Seafood Sales	Sean Bergen
Nonesuch Oysters	Abigail Carroll
Pemaquid Oysters & Maine Aquaculture Innovation Center	Chris Davis
Calendar Island Mussels	Peter Stocks
Bangs Island Mussels	Matt Moretti
Ocean Approved	Briana Warner
Glidden Point Oyster Farm	Ryan McPherson
Mook Sea Farms	Bill Mook, Jeff Auger, Andy Stevenson
Acadia Aquafarms	Fiona and Alex de Koning
Cooke Aquaculture	Andrew Lively, Greg Lambert, Duran Cercone & Frank Lank
A.C. Inc	Wendell Bradford
American Unagi	Sarah Rademaker
Whole Oceans	Jenn Fortier

9.2. Education Supply Summaries

9.2.1. Post-Secondary Aquaculture Education Supply Summary

Sector and number of survey returns		Adult Ed		Community College		University	
		Available	Receptive	Available	Receptive	Available	Receptive
Aquaculture provision	Technical skills training short courses relating to aquaculture	5	3 (2)	x	2	x	x
	Aquaculture relevant vocational courses (modules)	2	5 (2)	x	1 (1)	6	3
	Distance or blended learning programs in Aquaculture	x	x	x	1 (1)	3	3 (3)
	Undergraduate Bachelor or Associate Degrees in Aquaculture	x	x	x	2	1	2 (5)
	Post graduate degrees in Aquaculture	x	x	x	x	4	0 (2)
	Work based Apprenticeship programs in aquaculture	x	x	x	2	x	x
Marine Science provision	Marine Science Associate, Bachelors, and post graduate Degrees	x	x	1	1	9	0 (1)
	Courses in marine science	x	x	x	x	10	1
	Distance or blended learning courses in aquaculture or marine related subjects	2	5 (2)	x	x	x	x
Maritime Engineering	Short courses - technical skills training relating to maritime economy	2	4 (3)	x	1 (1)	x	x
	Vocational courses (modules) relevant to maritime engineering	2	3 (2)		1 (1)	1	4 (1)
	Work based Apprenticeship	x	x	0	0 (2)	x	x

Sector and number of survey returns		Adult Ed		Community College		University	
	programs in other maritime sectors						
Business E'preneurship	Courses (modules) in entrepreneurship and business start up	5	2 (1)	1	x	8	1
Business Management	Vocational courses (modules) in business management skills	3	3 (2)	2	x	x (see note*)	x
Basic Skills	Basic skills development (e.g. literacy and numeracy)	5	1 (1)	2	x	x	x
Teacher development	Professional development offerings (workshops, courses, etc) in aquaculture-related subjects for K-12 teachers	2	2 (2)	x	2	x	x
Internships	Degrees that include experiential learning or internship requirements in aquaculture or the maritime economy	x	x	x	2	6	3 (1)
Incumbent worker training	Incumbent worker training through Maine Quality Centers or related programs for aquaculture or maritime economy workers	x	x	0	1 (1)	x	x
High level scientific skills	Skills related to aquaculture/maritime economy (e.g. lab skills, marine science, computer modeling, engineering	x	x	x	x	9	1 (1)
Maritime practical skills	Skills related to aquaculture/maritime economy (e.g. boat skills, knot tying, navigation, diving)	x	x	x	x	6	0 (1)

*Educator surveys recorded the availability of aquaculture related courses. In some cases there may be provision of subjects that is not explicitly embedded in aquaculture education, but may be linked through strategy implementation (e.g. business management in universities).

9.2.2. Secondary (High) Schools Aquaculture Education Supply Summary

Sector and number of survey returns	High School	
Provision summary	Available	Receptive
A 9-12 career pathway in aquaculture or marine science related subjects	1	3 (3)
Courses in aquaculture or marine science related subjects	3	2 (2)
Distance or blended learning courses in aquaculture or marine related subjects	x	5 (3)
A career and technical education pathway in aquaculture or marine science related subjects	4	1 (1)
Units in particular courses relating to aquaculture or marine related subjects	4	1 (1)
Career development programming related to aquaculture or marine science related subjects	2	3 (2)
Job shadowing, internships, or other work-based experiences in aquaculture or related subjects	4	1 (3)

High schools contributing to the educator survey were selected according to aquaculture-related interest and are therefore not representative of provision across the state.

9.3. Survey materials

For copies of the industry, LPA and Educators survey materials, please contact Chris Vonderweidt, Gulf of Maine Research Institute Aquaculture Program Manager, at cvonderweidt@gmri.org.