Shellfish Centre

Shellfish Production in Wales

Opportunities, Constraints and Research Needs

Report of a workshop held at
Marine Centre Wales, Bangor University

4th December 2018

PRIFYSGOL BANGOR UNIVERSITY

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Executive summary

Bivalve shellfish farming is one of the most efficient and sustainable forms of food production; it is a low impact activity that generates positive environmental benefits and can be compatible with most conservation designations. There is potential to significantly increase farmed shellfish production in Wales in terms of both volume and value, but growth has stalled over recent years – indeed there is a risk of contraction. This is despite government strategic aims to develop the sector and industry ambitions for investment and growth.

The Shellfish Centre, based at Bangor University, is an ERDF-funded research & innovation initiative supporting development of shellfish production in Wales through research and innovation partnerships with industry. The opening Shellfish Centre workshop brought together 37 participants representative of shellfish producers, government and regulators, academic researchers and other stakeholders (supply chain, consultancy, ports, hospitality, public health). Participants posted over 200 individual comments identifying opportunities, constraints and research needs for shellfish production across Wales. These were aggregated into 45 issues, which were ranked for importance in individual scoring by each participant.

There were positive views on the potential opportunities to develop shellfish production, in an enabling regulatory environment with streamlined consenting of new production areas and integrated working between industry, government, regulators and researchers. Conversely, the highest ranked constraints were the time taken to gain consent for new production areas and perceived ineffectiveness of policy and legislation as currently implemented. The highest ranked research topic was also concerned with the need to speed up the consenting process. Not unrelated to the difficulties in consenting new sites, opening up new production areas, including offshore, was identified as both an opportunity and a research need,

The limitations imposed by wild seed supply were highly ranked as a constraint on growth and as a research need. In part, this related to dissatisfaction with the slow speed of approval of applications for permission to harvest wild seed resources. This topic also related to the variability in wild seed supply, with some production areas having no seed to replenish beds.

Concerns about water quality were ranked highly as a constraint on the sector, especially by industry. This was reflected in the ranking of the need for research in the areas of catchment modelling and water quality. In contrast, improvements to coastal water quality were identified as contributing to increasing the range of areas suitable for aquaculture.

Diversification of shellfish species and products was highly ranked as an both an opportunity and a research need. Apart from diversification of farmed production of shellfish, the potential for increasing fishing of wild capture bivalve shellfish, such as razor and surf clams, was identified as both an opportunity and research need. Similarly, there was interest expressed in development of other low-impact aquaculture species, specifically seaweeds.

Limited UK consumer interest in shellfish and difficulties in accessing markets were identified as constraints, while improved marketing was identified as an opportunity. This is consistent with the identified need for better communication of the health and environmental benefits of shellfish, as well as their potential contribution to health and well-being of consumers.

Why focus on shellfish?

Bivalve shellfish farming is one of the most efficient and sustainable forms of food production, with very low land and freshwater use and the lowest carbon footprint of all farmed animal production[1].

Globally, 16 million tons of shellfish are produced each year while at the same time generating a range of ecosystem services including water quality regulation, carbon sequestration, coastal protection, habitat creation and support for biodiversity that are worth somewhere between $3-$10 billion in addition to the value of the food produced[2].

Shellfish farms are net removers of nitrogen and phosphorous from the aquatic environment – compared to the 50-100 kg of nitrogen fertilizer added annually to each hectare of agricultural grassland in the UK[3].

These environmental benefits from shellfish production are becoming increasingly recognised internationally, with a range of initiatives in Denmark, Sweden, USA and Australia using mussels and oysters to reduce nutrient loads in coastal waters.

The recent Food from the Oceans Report[4] asked the question

"*How can more food and biomass be obtained from the oceans in a way that does not deprive future generations of their benefits*?"

The conclusion was that

"*The greatest and most feasible potential identified for expansion globally lies in mariculture (i.e. marine aquaculture) - notably of herbivore filter feeders (e.g. molluscs)…..*"

Environmentally-integrated aquaculture

Shellfish farming is a sustainable, low impact activity that has positive environmental benefits and can be compatible with most conservation designations. In fact, the largest and most well-established shellfish production area in Wales has operated for many years within both an SAC and SPA – and was a global first for MSC sustainability accreditation.

Ecosystem services from shellfish

Farmed shellfish have the lowest carbon footprint of all forms of animal protein production

Only ~1Kg of CO2 per Kg of protein produced, which is comparable to plant crop protein

Shellfish can help achieve cleaner seas

A one hectare mussel bed filters up to 30,000 m^3 of seawater per day, removing up to 1 ton of nitrogen per year. Globally cultivated bivalves remove 49,000 tons of nitrogen and 6,000 tons of phosphorus, an ecosystem service worth a potential $1.2 billion.

[1]Nijdam et al. (2012) Food Policy 37:760–770, [2]*Van der Schatte Olivier et al (2018) Reviews in Aquaculture* doi: 10.1111/raq.12301, [3]Qi et al (2018) Science of the Total Environment 634: 1108-1118, [4]EC Scientific Advice Mechanism, Scientific Opinion No. 3/2017

The opportunity for growth of shellfish production in Wales

Shellfish farming in Wales is one of the main contributors to overall shellfish production across the UK. Mussel cultivation in the Menai Strait is the largest component of Wales' aquaculture sector, producing on average between 5,000–8,000 tonnes of mussels per year. The Welsh mussel sector has strong sustainability credentials, with Menai Strait production accredited by the Marine Stewardship Council. Elsewhere, mussel production in Conwy is a long-standing traditional fishery, while development of farming of mussels on ropes in Swansea docks and recent trials of offshore mussel production on longlines in North Wales are examples of new approaches to developing the sector. Oyster farming is less well developed, at least in terms of overall production, with farms established in the Menai Strait and Milford Haven.

Current value of shellfish production

Recent reports have estimated farm gate value for the Welsh shellfish production at £15.1M (SEAFISH 2016, SR694 Aquaculture in England Wales & Northern Ireland), though consultation with industry during the development of the Shellfish Centre indicates current farm gate value closer to £8M, due to recent low production output and low wholesale prices in the European markets. Applying multipliers (SEAFISH 2016, SR694) the overall economic value of current shellfish production in Wales is *circa* £12.5M.

Potential for growth in the short term

There is significant potential to increase Welsh shellfish production, as an efficient low impact form of food production. However, growth in shellfish farming in Wales has stalled over recent years – indeed there is a risk of contraction. This is in stark contrast to government strategic aims to develop the sector as well as industry ambitions for investment and growth.

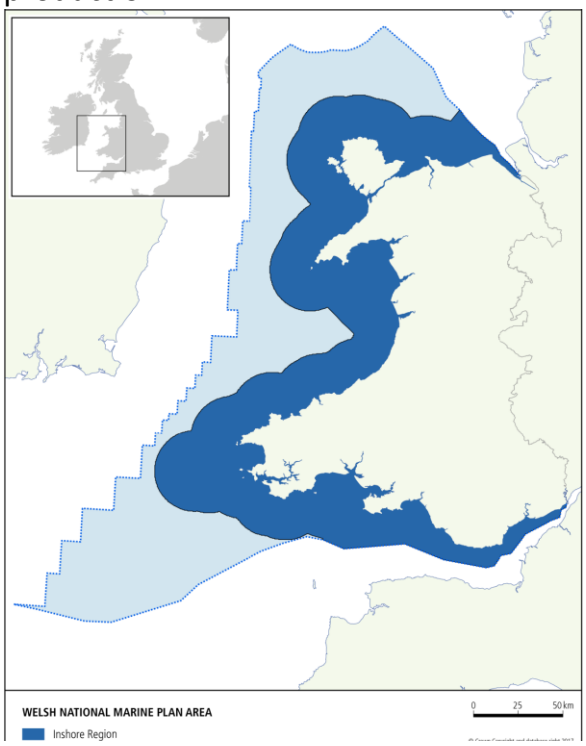
Given appropriate enabling policy to allow opening up of new production areas, doubling of shellfish production volume in Wales is an attainable short-term goal. A recent SEAFISH market analysis provided a review of the UK market for shellfish, which identified year or year growth of 11% in some segments. Furthermore, as access to higher value retail, restaurant and food service markets develops, it is likely that over the longer term most shellfish produced in Wales will have value-added or be intrinsically higher value. Assuming 50% of production is higher value products, doubling of shellfish production would be worth £37.5M.

Ecosystem services can be an integral benefit from expansion of the sector. These benefits accrue whether or not monetised, but development of payment schemes could yield further income in the region of £900 per ton (Van der Schatte Olivier et al 2018). Hence, ecosystem services from doubling of shellfish production could generate a further £14M in value for the sector.

Opportunities for increasing production volume and value include:

- Opening of new intertidal shellfish production areas
- A step change expansion through opening up offshore areas
- Development of production new high value species
- Increasing the proportion of shellfish that is value-added in Wales

Availability of suitable coastal and marine space should not be a limitation on shellfish production in Wales.
The Welsh marine area to 12nm covers 15,000 km^2, with 1,680 miles of coastline**,** Shellfish production can produce up to 3,000 tons per km^2. Opening up less than 0.02% of the Welsh marine area to new shellfish farms could double national production



Sustainable, high quality farmed shellfish from Wales - the wider opportunity

The projections above could be the first steps towards significant longer-term sustainable growth in the sector. Enabling development of sustainable high value shellfish will allow the Welsh industry to access higher value markets at sufficient scale and position to emphasize the identity of Welsh shellfish. Emphasising environmental benefits, with increased understanding of the concept of nature based solutions and ecosystem services, can be central to the development of a distinct 'Wales' brand. This can include how evidence and information are incorporated into the planning, operation and overall sustainability of Welsh shellfish production, supporting not only potential within the UK market and further afield, but also to contribute to the identity of Welsh food production. Increasing consumption within Wales, highlighting the health benefits of consuming bivalve shellfish, can also contribute positively to the longer-term branding of Wales as an attractive seafood tourism destination; a high quality environment producing high quality sustainable seafood

About the Shellfish Centre

The Shellfish Centre is a research & innovation initiative supporting development of shellfish production in Wales. The Centre is part-funded by the EU's West Wales and the Valleys European Regional Development Fund (ERDF) Operational Programme through the Welsh Government with a £2.8M grant (out of £3.9M total funding) that will support the initial three years of operation from 2018-2021. The aim is to establish a high profile, internationally connected, centre for shellfish-related science and innovation that can help secure a sustainable growth of shellfish production in Wales, through research and innovation partnerships with industry. Based in Marine Centre Wales at Bangor University, the Shellfish Centre builds on a history of productive research partnerships with Welsh shellfish producers.

Aims of the Workshop

This was the opening Shellfish Centre workshop and brought together industry stakeholders, representatives of government, agencies and regulators and academic researchers to collectively identify opportunities, constraints and research needs for shellfish production across Wales. It was the first in a series of stakeholder workshops running throughout the project, that will help maintain a focus on the needs of the sector. All research activity undertaken by the Shellfish Centre will be conducted within a series of well-defined collaborative projects with industrial partners and the workshop was also an opportunity to identify and prioritise research needs and to develop new collaborations.

Workshop methods

Participation in the workshop was open, with invitations extended to a range of participants to give coverage of key perspectives on the sector. A total of 37 participants were assigned to one of four sectoral categories:

- Shellfish producers (11 participants)
- Government and regulators (9 participants)
- Research scientists (9 participants)
- Other stakeholders (supply chain, consultancy, ports, hospitality, public health) (8 participants)

The participants were mixed in groups spread across seven tables, to ensure a good level of exchange of perspectives during the workshop. Individual participants submitted "Post-it" note comments in three categories:

- Opportunities for growth
- Constraints on potential growth
- Research needed to support growth

Individual comments were then aggregated into related topics/issues and a summary list of topics presented back to the workshop. A moderated open forum for discussion allowed review and validation of the listings, including individual responses to the topics/issues identified, exchange of opinions and discussion, leading to confirmation or adjustment to the wording of the headings used to group the topics/issues.

Each participant then scored the importance of the identified topics/issues, using a scale from 0-5. The prioritisation scoring was anonymous with individuals only identified by category (ie shellfish industry, government/ regulator, research scientist, other). This was intended to allow comparison of views from the different perspectives.

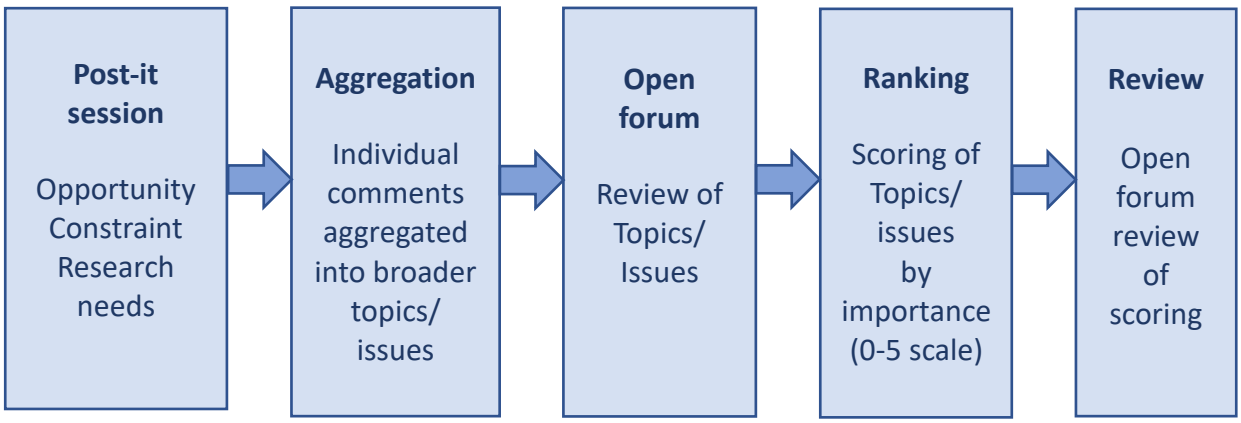


Figure 1. Overview of the process of issue identification and ranking

Outcomes

General overview

The workshop captured the views of a range of stakeholders with differing perspectives on opportunities, constraints and research needs for shellfish production in Wales. There was a high level of engagement throughout the workshop, as indicated by the large number of individual comments posted and the discussions during the open forum sessions. There was broad consistency of opinion between different categories of participant, though the scoring of issues differed in some cases. Nearly all the aggregated topics/issues identified were scored highly (mostly >3 on a scale of 0 -5), which again indicates consistency in views on their importance. There was also some consistency between the opportunities and constraints identified and the related research needs. However, the aggregation and group scoring methodology may undervalue some very focused issues raised by shellfish businesses, which are of high importance in specific locations or which affect specific businesses. For this reason, we have included all the individual comments submitted by all participants in Appendices 1-3. These provide a greater level of detail of the comments underlying the aggregated topics, and provide a useful narrative summary of the views of all the participants.

There were positive views on the potential opportunities to develop shellfish production. The highest ranked were opportunities that could arise in an enabling regulatory environment with streamlined consenting of new production areas and integrated working between industry, government, regulators and researchers. Conversely, the highest ranked constraints on growth reflected industry frustration at the time taken to gain consent for new production areas and perceived ineffectiveness of policy and legislation as currently implemented. Also identified was a need for research that could help speed up the consenting process. Not unrelated to the difficulties in consenting new sites, opening up of new production areas was identified as both an opportunity and a research need, including offshore development and the potential for co-location with renewables.

The most frequently cited opportunities and constraints were related to governance & policy

"*Streamline and review the legal/policy aspects to remove barriers"*

"Improved working with government to ensure policies are cohesive/allow development"

"Lack of vision for reducing time for consents"

"Impossible to get new fisheries orders granted in Wales"

"*Inappropriate regulatory structure unable to deliver adaptive co-management based on peer-reviewed science*"

The limitations imposed by wild seed supply were also consistently highly ranked both as a constraint on growth and as a research need. In part, these were related to the dissatisfaction with the speed of government responses to applications for permission to harvest time-limited wild seed resources. More generally, this topic related to the variability in wild seed supply, especially for mussels, and changes in patterns of recruitment in recent years – with some production areas having no seed to replenish beds. Industry scoring of opportunities and constraints also highlighted the need for hatcheries, for oysters specifically with some interest also expressed in hatchery production of seaweeds.

Consistent supply of shellfish seed was identified as a major constraint

"There is sufficient ground in the Menai East fishery order to sustainably produce 10,000MT of mussels annually. Limiting factor is seed availability"

"Collection of seed mussels not understood and difficult to get permits in Wales"

"What has happened mussel seed settlement in the Conwy since 2010?"

Concerns about water quality were ranking highly as a constraint on the sector, especially by industry. This was reflected in the identification and scoring of needs for research in the areas of catchment modelling and water quality. In contrast, improvements to coastal water quality were also identified as contributing to increasing the range of areas suitable for aquaculture.

Opportunities for growth of the sector were identified around the potential for diversification of shellfish species and products. Research into production methods for new species and techniques was also highly ranked, including suggestions for scallop ranching, rope production of more shellfish species and integrating production of a range of species.

The need for better communication and joined up working was a common theme both in the issues identified through the posted comments and in the general discussions. For example, a better understanding of environmental benefits and ecosystem services from shellfish production was scored highly as a research need, while in both the scoring and in open discussion there was also a clear message that there is need for better communication of these benefits to both government and in marketing. Also identified was a need to maintain communication between industry and research community, including maintain international links to learn from experience and new developments elsewhere in Europe and further afield.

Limited UK consumer interest in shellfish and difficulties in accessing markets were identified as constraints, while improved marketing was identified as an opportunity. This is consistent with the identified need for better communication of the health and environmental benefits of shellfish, as well as their potential contribution to health and well-being of consumers.

Apart from farmed production of shellfish, the potential for increasing fishing of wild capture bivalve shellfish that are currently not exploited in Wales, such as razor and surf clams, was identified both as an opportunity and as a related research need. Similarly, within the comments promoting diversification, there was interest expressed in development of other low-impact aquaculture species, specifically seaweeds.

Summary of comments posted

A total of 203 individual comments were posted during the opening session, and these are evenly divided across the three questions posed. The full list of all comments posted are shown in Appendices 2-4. The individual comments were aggregated in 44 common topics or issues, as listed in Tables 1-3, which also show the number of comments that were related to each topic/issue. The frequency of number of comments included in each topic/issue shows the degree to which responses were concentrated on particular issues within each of the three main questions – (a) Opportunities for Growth (b) Constraints on Growth and (c) Research Needs for the shellfish production sector in Wales.

Opportunities for Growth (Figure 2a), the number of individual responses were evenly spread across the aggregated topics, ranging from 1 – 9 comments per aggregated category, indicating a broad range of views amongst the participants with no specific issues dominating the responses. The three single topics/issues that attracted the most comments (7-9 each) were concerned with the potential benefits of

- Diversification of species and products
- Improved marketing
- Improved communication and integration between industry, government and researchers

Constraints on Growth (Figure 2b), there was a greater spread of frequency of responses, ranging from 1 – 16 comments per aggregated category. There were a range of specific issues that each were derived from only a few (1-3) posted comments. Two issues dominating the responses, with 26 individual comments that focused around:

- Difficulties in dealing with Welsh Government and the long delays in new area approvals and consents
- Dissatisfaction with the current legislative and regulatory framework

Research needs (Figure 2c), the frequencies of comments posted ranging from 1 -13, also with a skewed distribution. Ten of the topics identified were based on relatively few (1-4) comments posted, while a smaller number of topics generated a high number (8-13) comments that were focused around:

- Development of new aquaculture species and techniques
- Better understanding of wild seed resources that underpin shellfish production
- Human health and shellfish diseases

Summary of ranking of topics and issues

The average scores for each of the topics or issues identified in the initial workshop session are shown in Tables 1– 3. Each tables shows scoring separated by participant sector (Industry, Government/Regulator, Research, Other), as well as an overall average.

Opportunities for Growth The two highest ranked opportunities identified by shellfish industry participants and across all the other categories of participant were:

- Shortening of the time required for approval of new aquaculture sites
- Improved communication/working between government, industry, regulators, research

In general, there was agreement on the relative importance of the opportunities between the various categories of participants, with minor differences for some topics. All opportunities identified were considered important across all categories of participant, with overall average scores ranging from 3.1 – 4.9. Other opportunities that industry also scored highly were the development of hatcheries, access to investment, diversification of production and development of new productions areas. Average scores from other (non-industry) participants, were higher for the need for improved marketing, jointly–developed strategic approaches, food security and public health and well-being.

Constraints on growth The shellfish industry participants most strongly identified specific issues, with the three highest ranked constraints identified scoring between 4.8 - 5.0, ie these were universally recognised as very pressing issues by all the industry participants. These were:

- Dealing with Welsh Government/time required for new area approvals.
- Current policy & legislation
- Seed supply

Again, there was a fairly high degree of consistency between the participant categories, with a spread of overall average scores from 1.9 – 4.7. Policy/legislation and Seed Supply were given slightly lower scores by non-industry groups, so that the overall highest ranked constraint across all participants was the difficulty in dealing with Welsh Government and the time taken to consent new production areas.

Research needs There was fairly good agreement between the ranking of research needs by the shellfish industry participants and the other groups. The range of scores (3.1 - 4.8) indicates that all of the research topics identified were considered to be important. The top three research needs were identified as:

- Research to help inform policy/speed up consenting
- Understanding of seed resources
- Environmental benefits and ecosystem services of shellfish production

Table 1. Opportunities for growth in the shellfish production sector in Wales: Ranking of aggregated topics

AGGREGATED TOPIC/ISSUE (number of individual comments posted in brackets)	**Industry**	**Government/ Regulator**	**Research**	**Other**	**Overall**
Shortening time required for approval of new aquaculture sites (6)	5.0	5.0	4.7	5.0	4.9
Communication/joined up working, government, regulators, industry, research, including international (7)	4.8	4.9	4.6	4.5	4.7
Development of hatcheries (2)	4.4	3.8	3.6	4.0	3.9
Investment (public & private) (3)	4.2	3.6	4.7	4.5	4.2
Diversification, new shellfish species, seaweeds, secondary products (9)	4.1	4.0	3.5	3.4	3.7
Development of new production areas (6)	3.9	3.4	3.3	3.6	3.5
Improved marketing, including a Wales brand (8)	3.9	4.6	4.5	4.5	4.4
Jointly-developed strategic approach and protocols (3)	3.9	3.9	4.3	4.1	4.0
Food security (3)	3.8	3.9	4.1	4.0	4.0
Increasing public health and well-being (4)	3.8	4.4	4.3	3.5	4.0
Offshore development, including co-location with renewables (6)	3.6	3.4	4.3	3.1	3.6
Cooperation between producers to improve year-round supply (1)	3.4	3.6	3.8	3.8	3.6
Enhanced fisheries, eg scallops (1)	3.3	2.9	3.5	3.4	3.3
Ecosystem services, quantification, payment (4)	3.1	3.0	2.9	3.4	3.1
Underexploited bivalve fisheries, eg razors clams (2)	3.1	3.3	3.6	3.4	3.3

Table 2. Constraints on growth in the shellfish production sector in Wales: Ranking of aggregated topics

AGGREGATED TOPIC/ISSUE (number of individual comments posted in brackets)	**Industry**	**Government/ Regulator**	**Research**	**Other**	**Overall**
Policy and legislation (10)	5.0	4.3	4.3	4.4	4.5
Seed supply, wild & hatchery (7)	4.9	4.1	4.0	4.0	4.3
Welsh Government / red tape / lead time (16)	4.8	4.7	4.5	5.0	4.7
Water quality / biosecurity (6)	4.5	3.8	4.3	4.5	4.2
Mechanisms for highlighting benefits to govt/UK market (2)	4.1	4.2	4.8	4.8	4.5
Suitable space/ideal conditions/weather (3)	4.0	3.2	3.4	4.1	3.7
Crown Estates / land ownership (3)	3.8	4.1	3.4	4.0	3.8
UK consumer interest /routes to market (5)	3.6	3.7	4.3	4.4	4.0
Marine spatial planning conflicts (6)	3.5	3.1	3.9	3.9	3.6
Certification of aquaculture vessels vs fishing vessels (2)	3.5	2.1	1.8	2.0	2.4
Depuration/processing facilities (1)	3.5	3.5	3.8	3.9	3.6
Offshore /rural logistics (1)	3.1	2.4	2.8	2.6	2.7
Brexit (1)	2.9	3.1	4.4	2.0	3.1
Overly focused on certain species (1)	2.5	2.5	1.8	1.9	1.9

Table 3. Research needs for growth in the shellfish production sector in Wales: Ranking of aggregated topics

AGGREGATED TOPIC/ISSUE (number of individual comments posted in brackets)	**Industry**	**Government/ Regulator**	**Research**	**Other**	**Overall**
How to speed up policy/consenting (6)	4.8	4.7	4.9	5.0	4.8
Understanding seed supply/wild resources (8)	4.7	4.8	4.5	4.4	4.6
Environmental benefits/ecoservices (2)	4.5	4.2	4.6	4.3	4.4
New aquaculture species (13)	4.4	4.3	4.3	4.4	4.3
Offshore production (3)	4.1	3.8	3.8	3.6	3.8
Catchment modelling/ water quality (2)	4.0	4.0	4.0	4.1	4.0
New aquaculture techniques, incl hatcheries (8)	4.0	3.8	4.1	4.1	4.0
Interactions with offshore renewables (1)	3.7	3.3	3.8	3.8	3.6
Invasives (1)	3.7	3.4	4.1	3.1	3.6
Upscaling - research to industry (1)	3.7	4.1	4.3	4.0	4.0
Human and animal diseases (9)	3.5	3.7	4.1	3.6	3.7
New fisheries species (3)	3.4	3.9	3.9	3.6	3.7
Climate change (1)	3.3	3.8	4.4	3.6	3.8
Depuration (4)	3.2	2.3	3.4	3.4	3.1
Coastal modelling (4)	2.9	3.6	4.3	3.5	3.6

Appendix 1. Opportunities for growth of the shellfish production sector in Wales; individual written comments and aggregated issues/topics

INDIVIDUAL COMMENT	AGGREGATED ISSUE/TOPIC
Fast tracking consenting process Sectors with established methodology fast tracked through marine licence/several order Streamline and review the legal/policy aspects to remove barriers Rapid permitting Reduce emphasis on precautionary approach Rapid permitting Provide justification to reduce time to obtain shellfish farming licences	**Shortening time required for approval of new aquaculture sites**
Communication from Welsh Government to developers Improved working with government to ensure policies are cohesive/allow development Link with European colleagues leading many aspects of seafood production Knowledge exchange with other countries - sharing good practice Collaboration across academia/industry sectors Joined up thinking from government and regulators, sell the benefits to government of payment for ecosystem services/water quality improvement, benefits to society/SMNR/Well-being of Future Generations Act/Marine Planning	**Communication /joined up working, government, regulators, industry, research, including international**
New areas Many viable sites in Wales Capitalise on water quality improvements, Identify new areas suitable for aquaculture Is there potential for oyster farming in Conwy? How can we increase seed production in the Conwy area? Onshore recirculation systems?	**Development of new production areas**

Investment - from public & private sector Investment support Commitment to fund equipment for small-scale Conwy mussel farm	**Investment - public & private**
Ecological benefits, additional farm income, eco benefits for nation Bioremediation - public goods provision Nature-based solutions - payment for ecosystem services Achieve best balance of terrestrial-marine ecosystem services - eg nutrients/productivity	**Ecosystem services, quantification, payment**
Grow more species - mussels scallops oysters Diversify species Diversification of products - frozen, cooked/smoked etc Diversification - seaweed cultivation Growth by species diversification - high value species in areas harvested for other bivalves Develop more species for consumption - oysters, razor clams etc Marine algae develop North Wales New species, especially as water temp increases Use different techniques - "eyes wide open"	**Diversification, new shellfish species, seaweeds, secondary products**

Develop brand of North Wales shellfish to be identified valued more easily High quality marketable product Is there a market for more production? Increase UK market for shellfish Increased promotion of sustainability & environmental benefits of shellfish Market opportunities - develop different products? New markets for different species Public engagement, increase understanding/highlight importance	**Improved marketing, including a Wales brand**
Co-existence/ co-location with other sectors Co-location processing facilities Producer driven strategy/policy for mussels/oysters	**Jointly-developed strategic approach and protocols**
Hatcheries? Shellfish/seaweed hatchery co-location	**Development of hatcheries (shellfish & seaweed)**
Increase public health and environmental health Highlight benefits of more sustainable protein as people eat less meat. Shellfish is more ethical protein Well-being of Future Generation Generations Act & Environment Act	**Increasing public health and well-being**
Offshore farming (eg suspended bivalve aquaculture Offshore farming (eg bivalves) Sort out permitting for offshore aquaculture (England took 7 years!) Offshore development Offshore Rope cultivation mussels - incidental production scallops/crab/algae	**Offshore development, including co-location with renewables**
Different fisheries can support each other to maximise space efficiency and ensure output throughout year	**Cooperation between producers to**

Regulate production to ensure all competitors can sustain their business Co-location with seaweeds	**improve year-round supply**
Contribution to future food security Feedstock for aquaculture Safe, year-round production of shellfish	**Food security**
Enhanced fisheries, eg scallops	**Enhanced fisheries, eg scallops**
Razor clam fisheries Sublittoral bivalves in profusion - *Spisula, Ensis*	**Underexploited bivalve fisheres, eg razors clams**

Appendix 2 Constraints on growth of the shellfish production sector in Wales; individual written comments and aggregated issues/topics

INDIVIDUAL COMMENT	AGGREGATED ISSUE/TOPIC
Welsh Government Fisheries Time scale of Welsh Government help Process for application for new areas opaque Impossible to get new fisheries orders granted in Wales Getting permission to use a site Welsh Government want to double production but are not doing anything Lack of vision for reducing time for consents A presumption against sustainable development and use of the marine environment at Welsh Government Welsh Government slow to process Order applications Complex consenting process Unreasonably long consenting process Consenting process Poor communication from Welsh Government on risks in consenting Time for permissions and licensing for experimental work Need for a simplified permitting system - traffic light Several orders cannot be processed until Brexit. Issues with permits, time consuming	**Welsh Government / red tape / lead time**
Current regulatory framework and timescales Legislation Inappropriate regulatory structure unable to deliver adaptive co-management based on peer-reviewed science No local control of Welsh waters, Sea Fisheries Committees not replaced Funding to kick-start new initiatives is lacking	**Policy & legislation**

No encouragement for data sharing Permissions/policy	
Environmental benefits need to be highlighted at ministerial level Highlight benefits to government	**Mechanisms for highlighting benefits to gov't/UK market**
There is sufficient ground in the Menai East fishery order to sustainably produce 10,000MT of mussels annually. Limiting factor is seed availability Wild seed capture Collection of seed mussels not understood and difficult to get permits in Wales Major seed resources in England under control of IFCAs with no Welsh input since joint Sea Fisheries Committees abandoned for political reasons What has happened mussel seed settlement in the Conwy since 2010? Lack of tetraploid-diploid cross triploids (oysters) Scaled-up hatchery production/triploids	**Seed supply, wild/hatcher**
Poor regulation due to poor testing systems Threat of mass mortalities in oysters Water quality - microbial and algal toxins Biosecurity - in both seed and product Water quality and hence shellfish quality Biosecurity - pathogens, invasive non-natives poorly understood in many areas and not properly regulated	**Water quality / biosecurity**
UK consumer interest Limited availability of seafood generally and shellfish specifically Low wider awareness of quality, environmental and health benefits Infrastructure constraints which encourage exports and limit opportunities to develop local market Consistency of supply	**UK consumer interest / infrastructure (routes to market)**

Crown Estates applications constraints and time consuming Land ownership Crown Estate and cost of consents	**Crown Estates / land ownership**
Access to sites Weather and exposure Space with ideal conditions for growth/physical protection	**Suitable space/ ideal conditions/ weather**
Depuration facilities/processing	**Depuration/ processing facilities**
N2K sites, MPAs SSSI consents Designated areas, legislation etc Some MPAs compatible with shellfish production, others not Permits - few "open areas" free of SPA, SAC etc Are there alternatives to Strategic Resource Areas?	**Marine spatial planning conflicts**
Access to EU market post Brexit	**Brexit**
Logistics - knowing how to work offshore	**Offshore/rural logistics**
Onerous vessel licensing constraints Aquaculture vessels treated as fishing vessels in Wales - will not grant molluscan seed harvesting licences	**Certification aquaculture vessels vs fishing vessels**
Limited awareness in Wales of opportunities of high quality seaweed Seaweed not high on agenda, danger of missing out New markets/new species, especially algae Europe is leading in raising awareness of environmental benefits of seaweeds - we are not	**Overly focused on certain species**
Funding/investment Funding for starter projects - culture of algae in Menai Strait and Cardigan Bay Financing of new development	**Funding/ finance*** (*not included in ranking)

Appendix 3: Research needs for growth of the shellfish production sector in Wales; individual written comments and aggregated issues/topics

INDIVIDUAL COMMENT	AGGREGATED ISSUE/TOPIC
Mapping use of space for all uses Research to ensure regulators understand issues. Science no good unless it is used by regulators How to improve licensing/policy to make production growth easier while balancing other uses Link between yield and carrying capacity of the environment Sharing of data/research Understanding gap between growth of salmon sector vs static shellfish sector	**How to Speed up policy/ consenting**
Locating existing wild beds for spat/seed collection Correlating water quality with mussel seed behaviour Larval distribution and settlement Seeding spat collection testing Seed cultivation for bivalves Increasing spat settlement Seed supply Understanding spat settlement - hydrodynamics and environment	**Understanding seed supply/ wild resources**
Increasing public understanding of benefits of shellfish production (CO_2, diet) Develop more holistic awareness of environmental potential	**Environmental benefits/ ecoservices**

Trial new cultivation methods Alternative to bottom culture of mussels Oyster structures for high current areas Optimal conditions for different species Multispecies aquaculture Scallop ranching Investigate scallop ranching/seed Suspended bivalve aquaculture techniques effect on benthic communities Can we develop year-round production and supply of Welsh shellfish Potential for different types of aquaculture to overlap How can shellfish aquaculture work in tandem with other activities Can we get research on Conwy river to explain decline of mussel stocks Bio-products from seaweeds	**New aquaculture products and techniques**
Contaminant transport Catchment to coast modelling – bacteria-viruses	**Catchment modelling/ water quality**
Species-based culture yields and early life cycle cultivation for seaweeds Water quality seaweed utilise to absorb CO2 and de-acidify Co-location with seaweed Mechanisation of harvest/seeding (seaweeds) Marketing linking new species to market opportunities What do consumers want to eat locally and nationally What product formats are consumers looking for Can algae culture replace need for algal harvest	**New aquaculture species e.g. algae**
Upscaling of hatchery production	**Upscaling - research to industry**

Offshore research/development of other shellfish species Offshore Offshore technology	**Offshore production**
Likely changes in productivity with climate change	**Climate change**
Pathogen persistence and infectivity Shellfish hygiene - better understanding of human pathogen sources Shellfish hygiene- diffuse agriculture source impacts Norovirus levels offshore Fix norovirus Disease resistant oysters Shellfish disease trends Linking virus levels and disease Planning ahead for mass mortalities	**Human and animal diseases**
Razor clam fishery potential Develop survey techniques for razor clams - littoral/sublittoral New sublittoral and littoral survey methods for species such as razor clams	**New fisheries species e.g. razor**
What impact do windfarm pylons have on ecosystem functioning	**Interactions with offshore renewables**
Monitoring for invasive species - if moving offshore and using more areas	**Invasive species**
Contaminant transport Practical modelling to identify best farm locations (seaweed) Hydrodynamic modelling Coastal shelf sea modelling Larval behaviour for connectivity modelling Larval dispersal	**Coastal modelling**

Improved modified atmosphere packaging (MAP) Water quality re norovirus - way to remove in timely manner Improved depuration regimes	**Depuration & Processing**