University of Exeter

Policy paper

INVESTING IN THE UK'S BLUE TRANSFORMATION:

An opportunity to deliver world-leading, innovative land-based seafood solutions

From left to right: **King prawn (*Penaeus vannamei*)**, Shutterstock licence; **Rainbow trout (*Oncorhynchus mykiss*)**, iStock licence - Zigmunds Dizgalvis; **Sea lettuce (*Ulva lactuca*)** cultivated in land-based AlgaFlow system, Image by Ocean Greens; **Pacific oyster (*Magallana gigas*)**, Image by Patou Ricard from Pixabay.

Executive summary

The majority of global seafood consumption now comes from seafood farming (aquaculture) which needs to double by 2050 to meet rising demand. The UK has a unique opportunity to help meet this need by adopting and developing innovative land-based seafood production technologies, which can dramatically increase the supply and range of aquatic species farmed in the UK, both for domestic consumption and high-value export markets.

Widespread adoption of land-based seafood production technologies across the UK would create jobs, boost productivity, enhance domestic food security, support exports, drive international technology leadership and provide opportunities to meet sustainability targets.

What is land-based seafood farming?

Land-based seafood farming – known technically as Recirculating Aquaculture Systems (RAS) - are closed, high-control production facilities using continuous water treatment and recycling. They:

- Operate independently of rivers, seas, and weather.
- Use up to 99% less water than traditional methods.
- Enable consistent, high-quality seafood production in any region with appropriate infrastructure.
- Provide strong biosecurity, disease control and high welfare standards.

RAS enables scalable, clean growth of species such as trout, salmon smolt, warm-water prawns, mussels, oysters, seaweed and high-value finfish like yellowtail kingfish.

Boosting the UK economy through adoption of high productivity land-based seafood farming will deliver:

1. **Economic growth:** Existing UK aquaculture production is a £1 billion industry; 93% salmon by value. Recirculating Aquaculture Systems (RAS) can radically modernise and expand the sector, improving productivity and growth for many more seafood species, and boost wider economic benefits.

2. **Job creation:** RAS technology can be set up virtually anywhere - including rural, coastal, brown-field and urban settings; bringing jobs to where they are most needed.

3. **Productivity:** Land used for RAS-based seafood production generates 50 to 400 times more (as well as healthier) protein per hectare (depending on aquatic species) than beef production.[1]

4. **Reduced reliance on imports, increased export opportunity and unlocking new markets:** Growing more seafood domestically reduces import needs and increases the opportunity for export trade.

5. **Skills & training:** RAS provides higher skill opportunities and workforce development.

6. **Circular economy benefits:** Waste streams can generate biogas and soil enhancers as well as high value pharmaceutical products, whilst also supporting renewable energy and sustainable farming.

7. **Meet UK government targets:** Low productivity land can be freed up for delivery of Government commitments on energy, climate and the environment while supporting coastal and rural employment.[2,3]

8. **Export world leading expertise:** UK Universities and industry can be at the forefront of the Blue Transformation and RAS technology, engineering positive solutions to food needs globally.

9. **Boost food security:** RAS aquaculture reduces reliance on imports and improves bio-security. [4,5,6]

10. **Climate Benefits:** Producing seafood in the UK cuts import transport emissions and avoids environmental damage linked to overseas production.

The UK has an opportunity to lead this sector; but we must ACT NOW or risk being overtaken by countries who are investing in this technology such as Denmark and Poland.

We recommend the UK government:

1. Builds international leadership through a UK Centre for Land-Based Seafood Production - a hub for innovation in engineering, technology and production, workforce training, and regulatory streamlining.
2. Diversifies existing support portfolios to help farmers and investors adopt RAS technologies.
3. Aligns research funding and broader incentives to Blue Transformation RAS opportunities.

Why a UK centre for land-based seafood production?

Enabling the transition:

Creating a dedicated centre would help overcome several barriers identified in Seafood 2040[7] by providing:

- **Innovation support:** Funding to drive world-leading translational research from concept to market, including advances in system design, animal welfare, energy efficiency, economic performance, multitrophic systems, alternative crops, and circular waste-recovery solutions.
- **Regulatory coordination:** A single destination for regulators, planners, and producers, enabling more streamlined processes across planning, environmental, land, water, and other regulatory frameworks.
- **Skills and training:** A coordinated skills pipeline, with universities partnering with higher and further education providers to deliver training for workers and businesses at all levels.
- **UK hatchery capacity:** Domestic hatcheries for key species to strengthen biosecurity, reduce reliance on imports, and support the growth and diversification of the aquaculture sector.
- **Business incubation:** Facilities and programmes—such as accelerators—to support new enterprises and help scale innovative aquaculture businesses.
- **A hub for partnership and engagement:** A focal point for industry collaboration, community engagement, marketing, promotion of UK products, and the development of accredited standards.

"This is a transformational opportunity to boost not only productivity and exports, but also the technology and engineering capabilities behind it."

Professor Ian Bateman, OBE, US-NAS, FBA, FEARE. FRSA, FRSB. Co-Director of the Land, Environment, Economics and Policy Institute (LEEP), University of Exeter. Regular advisor to HM DEFRA and Treasury and member of the First Ministers Environmental Council for the Scottish Government.

The global context:

A Blue Transformation: *"The FAO's Blue Transformation Roadmap recognises the importance of aquatic food systems as drivers of employment, economic growth, social development and environmental recovery, which all underpin the SDGs."*[8]

One Health: *"For aquaculture to deliver significantly enhanced volumes of food in a sustainable manner, appropriate account neeeds to be taken of its impacts on environmental integrity, farmed organism health and welfare, and human health."*[9]

Female worker working in fish farm, iStock licence - alvarez.

A land-based seafood sector for the UK:
The opportunity and the impacts

1. **Economic growth:** Salmon farming in sea lochs is already the UKs biggest food export valued at £1 billion, supporting 3,400 jobs. Yet an estimated 80 % of UK seafood demand is met by imports from overseas. Seafood farming on-land can unlock a second, cleaner and greener production stream to meet domestic and expanding export markets for native seafoods (e.g. trout, salmon, mussels) and expand markets for non-native species (e.g. king prawns, yellowtail kingfish, Asian seabass (barramundi) and additionally unlock higher value markets (e.g. RAS-grown allergen-free seaweed). Such high-value products can only be grown in closed-environment RAS.

2. **Job creation:** New skilled work opportunities[8] created within coastal and rural communities, as well as novel urban and brown-field areas, characterised by low agricultural opportunity costs (where both crop & livestock values, and wage rates, are low) - enhancing prospects where they are needed most and where there are few alternative employment options or other subsidies. New domestic hatcheries would risk-proof new sec- tors and create employment, and as they expand would boost smaller existing sectors, such as shell- fish production, and speed up access to high-value markets for novel seafood and other RAS products.

   Maintaining jobs: Fishing Communities - RAS could offer viable additional income/livelihoods for fisher communities and opportunities for younger generations to re-skill. RAS is a safer, more stable livelihood than fisheries, and provide greater long-term certainty compared to the fishing sector. [11,12]

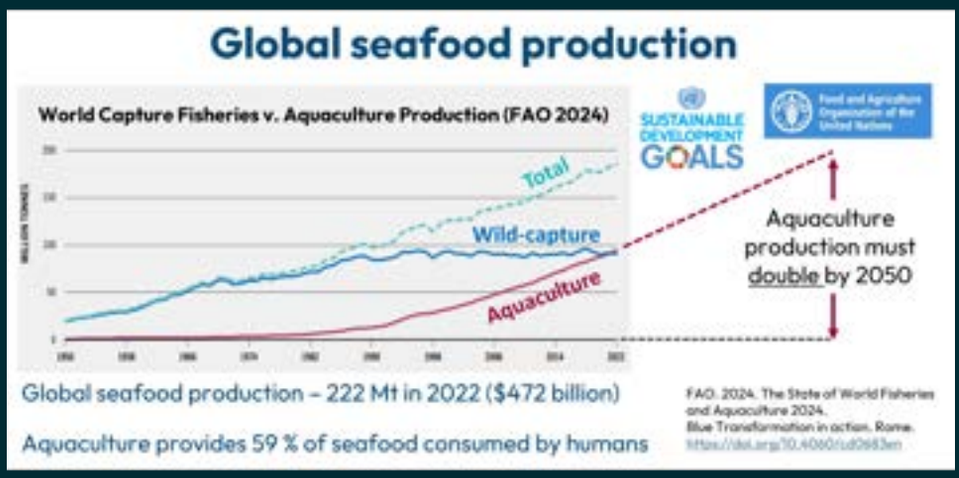
   Trout Farming - RAS would make it more resilient to environmental and legislation change, as well as ensuring the water dis- charged back into our rivers is both greatly reduced in volume, and cleaner than originally abstracted water.

   Opportunities outside of traditional farm settings: Urban, brown field sites, novel sectors, and other cost-effective resource use such as waste heat from data centres and anaerobic digesters. More urban settings are also possible – there are already successful examples - base- ment operations in London growing mushrooms and micro herbs, for example.

3. **Productivity:** RAS production of seafood species can generate over 400 times more protein per hectare than beef, and 45 times more calories per hectare than the average beef, dairy or sheep farm, depending on the species being farmed.[1] Pressure is mounting on our traditional food systems, and we need to find ways to feed a growing population, including a UN expectation to double global aquaculture production by 2050.[13,14] Land-based RAS will be a key part of achieving this sustainably. In the UK alone, population growth (12 million people by 2050), will require 1,230 tonnes of additional protein per day. Indoor RAS allows for a level of control not available to outdoor aquaculture. Conditions can be optimised to achieve the best productivity, whilst also maximising biosecurity against disease and minimising water use and waste outputs.

4. **Reducing reliance on imports, increasing export opportunities and unlocking new markets:** Growing more seafood domestically reduces import needs and increases the opportunity for export trade. RAS hatcheries would risk-proof new sectors, and boost smaller existing sectors, such as mussel and algae production, through technological advancement. Some 'waste' from RAS is also valuable and creates new markets - for the pharmaceutical industry, for example. [15]

5. **Skills & Training:** New jobs would be boosted through training programmes and workforce development. Teaching and training for individuals and business via a bespoke centre to train and maintain the new workforce. UK Universities provide expertise to deliver skills at all levels from short courses in practical skills through to executive education and degree level training, supporting NVQs in partnership with HE and FE providers. The centre would also host events and webinars for wider audiences.



6. **Oportunities for co-location and circularity:** Waste ('manure') from seafood RAS production can be safe to mix with terrestrial farm waste for anaerobic digestion, and create biogas for renewable energy, generating heat, as well as a soil enhancer for crops. Tropical species production in RAS can benefit from being co-located with sources of waste heat, such as anaerobic digestors and data centres. Valuable by-products: RAS farming of prawns produces high quality chitin from their shells. Shed repeatedly as they moult throughout the growing process, chitin can be converted to high value chitosan and sold to the global pharmaceutical industry, creating a new high value market opportunity for the UK. [15]

7. **Meeting existing government targets:**

   Increasing seafood consumption: by 75%, alongside a 10-fold increase in aquaculture production in England by 2040 as set out in the English Aquaculture Strategy[16] - a national centre would boost not only production but also help to market and assure the quality of UK produced seafood. The UK and ICES nations are due to undershoot seafood demands by ~7 million tonnes by 2050[13]. Only 5-25% of consumer demand could be met by current national aquaculture production, highlighting the urgent need for a national policy to fill the gap.

   Fishing and Coastal Growth Fund: Aimed at breathing new life into coastal economies. RAS could play a key role in providing such jobs (see point 2).[2]

   Increasing tree canopy and woodland cover: Ambitious legally binding targets to increase this from 14.5% to 16.5% of total land area in England by 2050 – equating to about 240,000 hectares.[2] Land-use efficiency of UK RAS could, if paired with planting incentives, allow farmers to contribute more towards national targets and make gains for renewable energy.

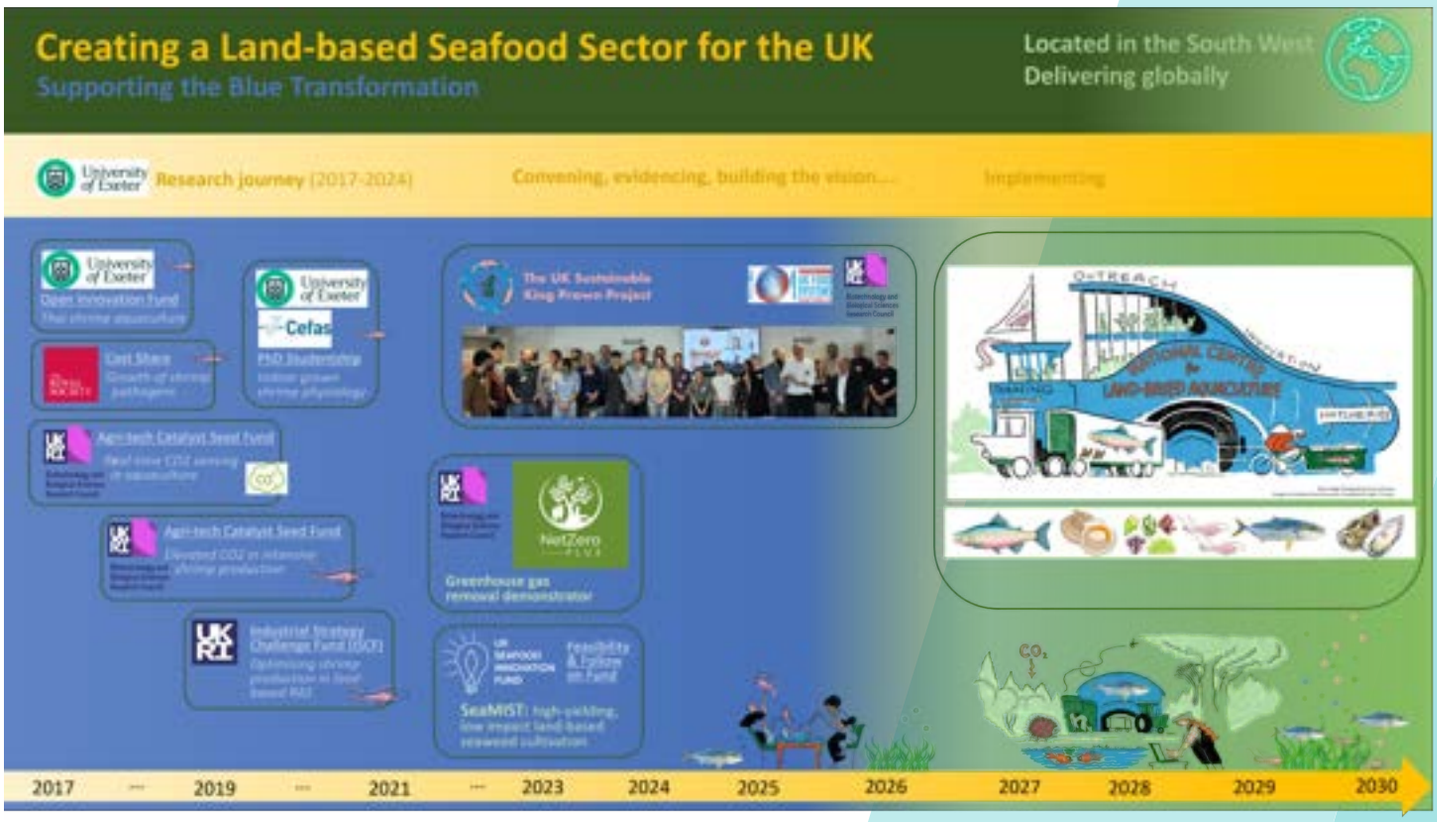
8. **Export world leading expertise:** UK universities are at the forefront of this technology, engineering innovations to support food solutions globally. This work must be supported now to maintain a competitive advantage with other countries investing now such as Denmark and Poland.

9. **Boost food security:** RAS would enable large production capacity that can be re-routed domestically should existing import supply chains suffer disruption. RAS systems greatly improve biosecurity; inputs and outputs to the system are closely monitored and controlled at all stages. RAS would boost renewable energy usage, production and efficiency. Reducing the amount of water required to produce food, whilst reducing contamination risk. The recently published Nature Security Assessment also highlights the importance of domestic food security and the immediacy of the need to shore up domestic production.[4]

10. **Drive climate action:** RAS can offer a climate friendly option to retailers, using waste heat, incorporating circular feeds, and providing global leadership, innovation and expertise. Growing seafood via RAS in the UK would reduce CO2 emissions from imports and help to protect important global ecosystems such as mangroves. Historically, growing warm water prawns overseas has been associated with extensive damage to vital mangrove f orests, which absorb and trap more CO2 per hectare than any other of Earth's ecosystems. We note that there are recent efforts to reinstate such habitats, yet further action is vital.[17,18]

The South West is ideally placed to pioneer growth of this future facing industry:

A confluence of existing expertise and partners exists in the South West and analysis shows a real potential for new starters and diversification opportunity in the region. Through UKRI we have worked together with partners to develop the capability and technology so far. We want to build on the impetus already generated and deliver on the innovation this has helped to create. A prospectus outlining the detail of what is needed over the next five years will support this paper.



There is strong momentum and significant success regionally to establish transformative innovation in agri, marine and circular food systems sectors, on which to build to help pioneer this approach. There are a number of leading South West-based organisations working in this sector, demonstrating regional strength, and these working together could pioneer this new approach, driving the establishment of RAS throughout the UK.

Cefas

SUSTAINABLE AQUACULTURE FUTURES

ocean conservation trust

UNIVERSITY OF PLYMOUTH

UKRI Research England

APPLEDORE MARITIME INNOVATION CENTRE

The CORNISH SEAWEED Company

University of Exeter

Innovation Nursery

SOUTH WEST AQUACULTURE NETWORK

Ocean Greens

Footnotes

1. FarmingUK (2025) Prawn farms on UK farmland could power seafood shake-up.
Morello, T. *et al.* (2025) Sequestering carbon without reducing food production. Ecological Economics, 237, 108692. https://doi.org/10.1016/j.ecolecon.2025.108692
2. GOV.UK (2026) Fishing and Coastal Growth Fund. https://www.gov.uk/guidance/fishing-and-coastal-growth-fund
3. GOV.UK (2025) Tree canopy and woodland cover: Environment Act target delivery plan. https://www.gov.uk/government/publications/tree-canopy-and-woodland-cover-environment-act-target-delivery-plan
4. GOV.UK (2026) Nature security assessment on global biodiversity loss, ecosystem collapse and national security. https://www.gov.uk/government/publications/nature-security-assessment-on-global-biodiversity-loss-ecosystem-collapse-and-national-security
5. Laing, T., Neumann, N. & So, A. (2025) Just in Case: Narrowing the UK Civil Food Resilience Gap. National Preparedness Commission.
6. CIEH (2019) President's Bulletin: The UK Civil Food Resilience Gap.
7. Seafish (2021) Seafood 2040: A Strategic Framework for England. https://www.seafish.org/document/?id=36461
8. FAO (2022) Blue Transformation – Roadmap 2022–2030. https://www.fao.org/3/cc2260en.pdf
9. Stentiford, G.D. *et al.* (2020) 'Sustainable aquaculture through the One Health lens', Nature Food. https://doi.org/10.1038/s43016-020-0127-5
10. World Bank Group & WWF (2025) Harnessing the Waters: Sustainable Aquaculture. https://www.worldbank.org/en/topic/environment/publication/harnessing-the-waters-sustainable-aquaculture
11. Jeffery, K., Mangi, S.C., Conejo-Watt, H., Muench, A. & Hyder, K. (2021) The potential of the UK inshore fleet to integrate aquaculture.
12. Conejo-Watt, H., Muench, A., Mangi, S.C., Jeffery, K. & Hyder, K. (2021) Fishers' perspectives on barriers to diversifying into aquaculture. https://doi.org/10.1016/j.marpol.2021.104610
13. Waite, R. & Beveridge, M. (2014) Improving Productivity and Environmental Performance of Aquaculture. World Resources Report.
14. Froehlich, H.E. *et al.* (2021) 'Mind the gap between seafood consumption and aquaculture production', ICES Journal of Marine Science, 78, 468–477. https://doi.org/10.1093/icesjms/fsaa066
15. ScienceInsights (2025) What Is Chitin? Its Sources and Applications. https://scienceinsights.org/what-is-chitin-its-sources-and-applications
16. FishFocus (2020) English Aquaculture Strategy from Seafood 2040. https://fishfocus.co.uk/english-aquaculture-strategy
17. Ashton, E.C. (2008) The impact of shrimp farming on mangrove ecosystems. https://doi.org/10.1079/PAVSNNR20083003
18. Jiang, Y. *et al.* (2025) 'Restoring mangroves lost by aquaculture offers large blue carbon benefits', One Earth, 8(1), 101149. https://doi.org/10.1016/j.oneear.2024.12.006

This Policy Note was developed as part of **The UK Sustainable King Prawn Project** https://sites.exeter.ac.uk/kingprawn/ and is underpinned by this research: Morello, T. et al. (2025). **Sequestering carbon without reducing food production. Ecological Economics**, 237, 108692. https://doi.org/10.1016/j.ecolecon.2025.108692

The UK Sustainable King Prawn Project

TRANSFORMING UK FOOD SYSTEMS

Biotechnology and Biological Sciences Research Council

Global Food Security

Sustainable, healthy food for all

University of Exeter

Contacts:

Rod Wilson: R.W.Wilson@exeter.ac.uk

Robert Ellis: R.P.Ellis@exeter.ac.uk

Diana Tingley: D.M.Tingley@exeter.ac.uk

Website: https://sites.exeter.ac.uk/blue-transformation-land-based-aquaculture/

With thanks to Daphne White for coordinating the evidence and drafting the Policy Note, and to Martha Clarke for her professional graphic design work.