The Shellfish Centre RD&I is part-funded by the EU's West Wales and the Valleys European Regional Development Fund (ERDF) Operational Programme through the Welsh Government.

ERDF
Llywodraeth Cynulliad Cymru
Welsh Assembly Government
Ewrop & Chymru: Buddsoddi yn eich Dyfodol
Cronfa Datblygu Rhanbarthol Ewrop
Europe & Wales: Investing in your Future
European Regional Development Fund

Shellfish Centre

PRIFYSGOL BANGOR UNIVERSITY

'What the shell?!'

What is the Shellfish Centre and how can you get involved?

Maria Hayden-Hughes

28th November 2019 Endeavour Society

www.shellfish.wales @shellfishcentre

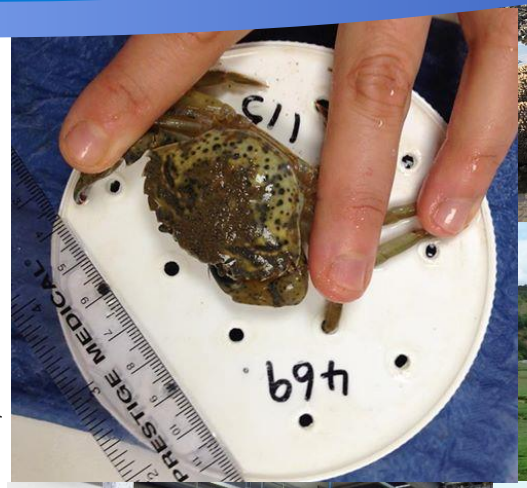
Who I am?

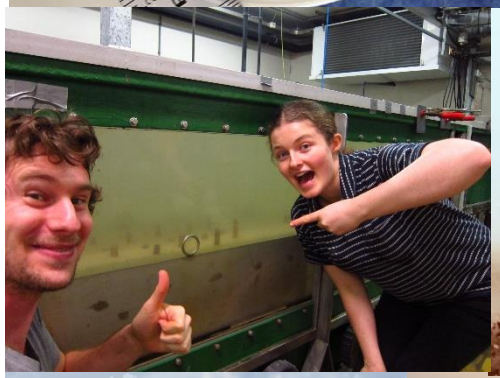
GWYDDORAU EIGION OCEAN SCIENCES

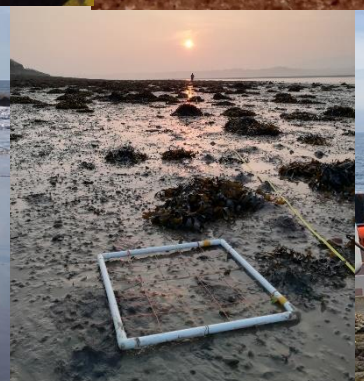
PRIFYSGOL BANGOR UNIVERSITY

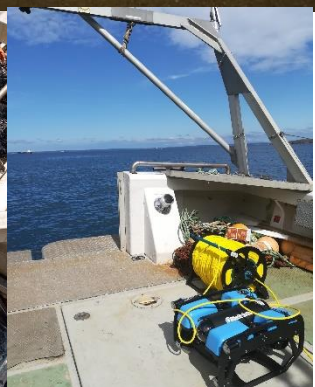
NIOZ

Shellfish Centre





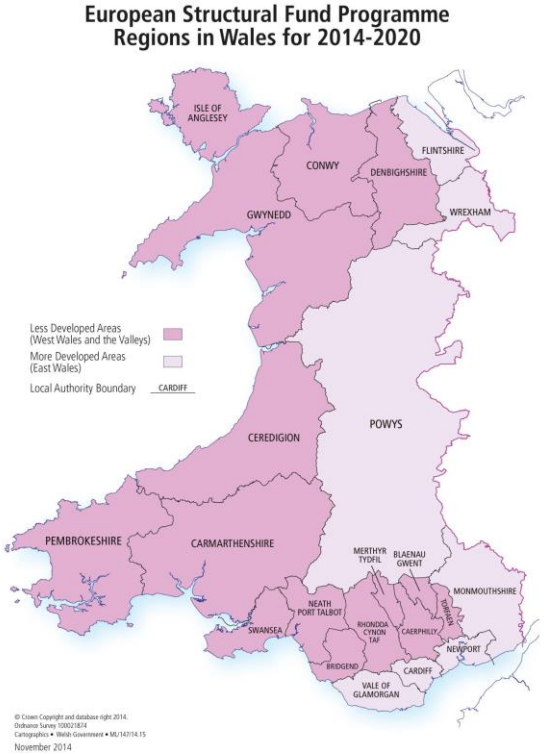




The Shellfish Centre

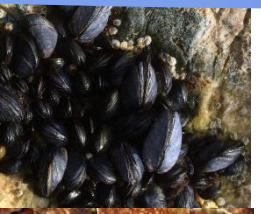
Shellfish Centre

- A new centre for shellfish science and innovation
- £3.9M project
- Builds on a history of collaborative research



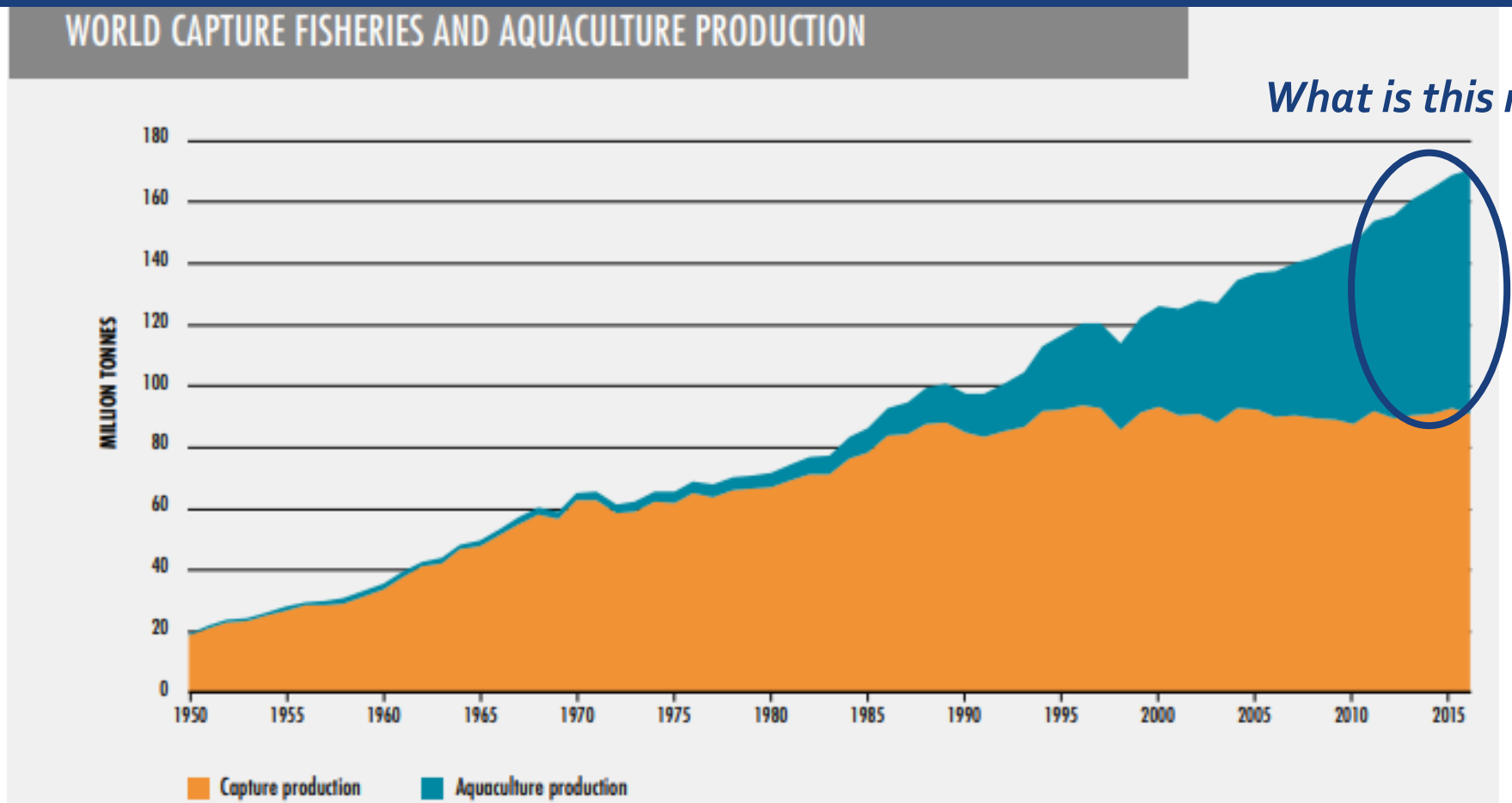
Why shellfish?

Shellfish Centre





AQUACULTURE= 9% growth/yr
TERRESTIAL ANIMAL PRODUCTION= 2.4% growth/yr

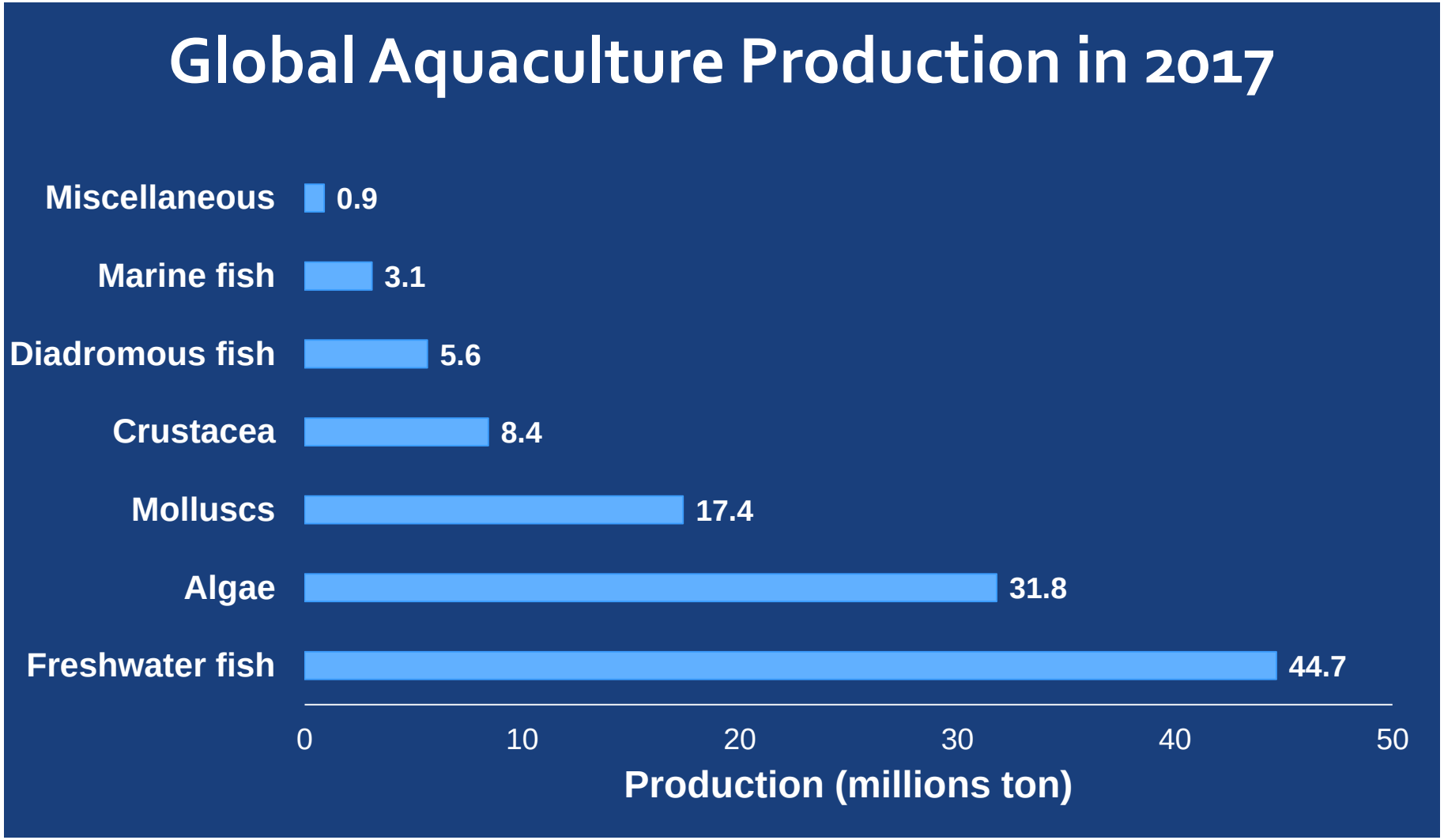


What is this made up of?

FAO, 2018

Why shellfish?

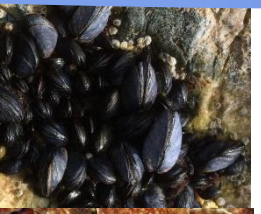
Shellfish Centre



http://www.fao.org/fishery/statistics/global-aquaculture-production/en

Why shellfish?

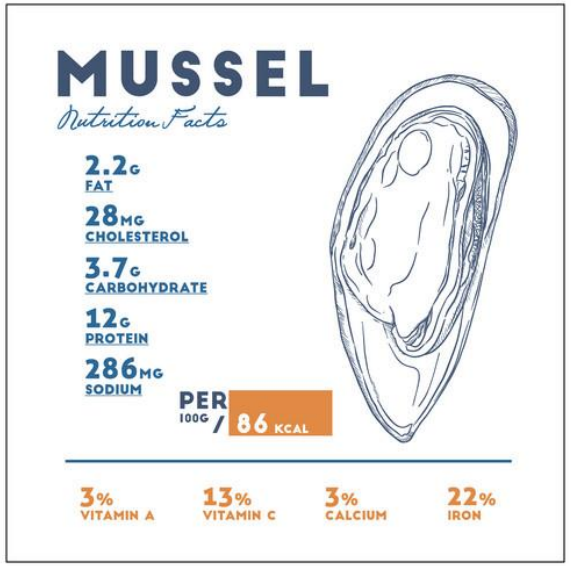
Shellfish Centre

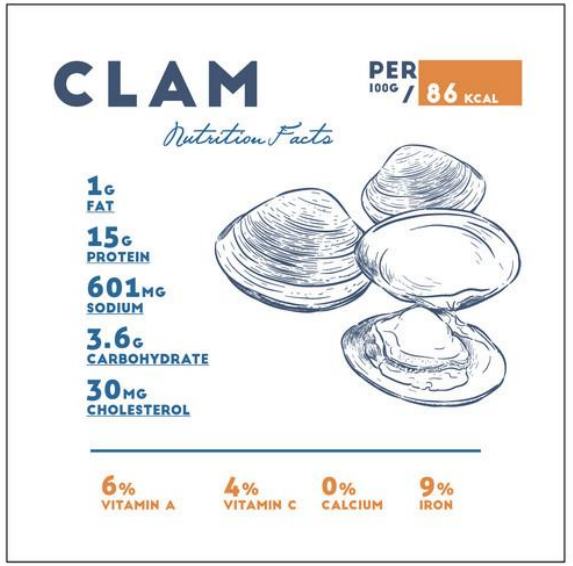


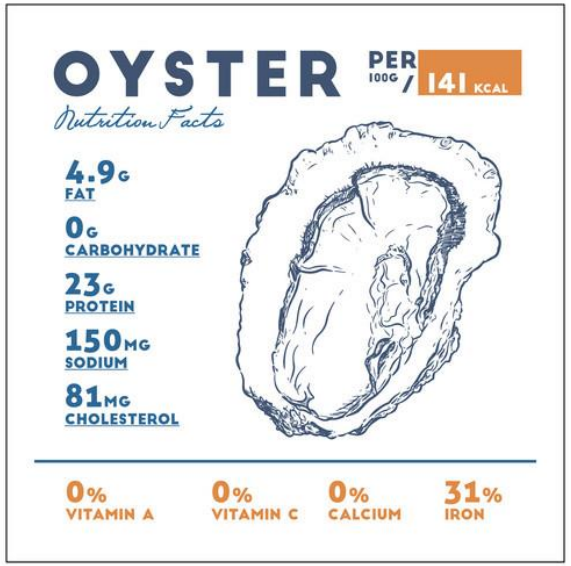


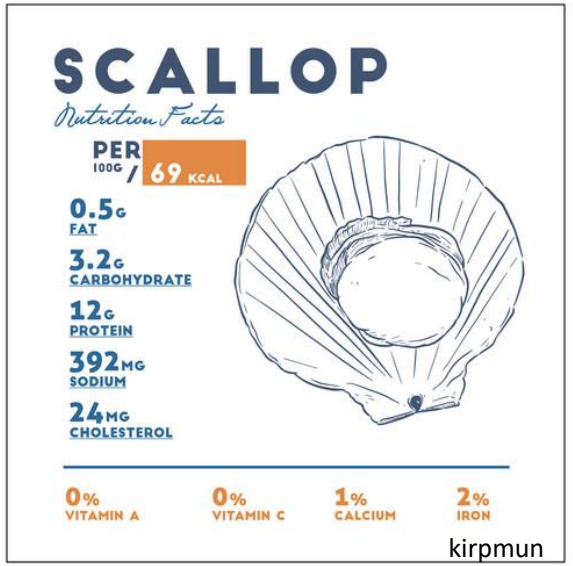
1) Healthy Food

- High protein – balanced amino acids
- Omega-3 fatty acids
- Low in fat
- Low in saturated fat
- Iron, zinc, copper, B-12









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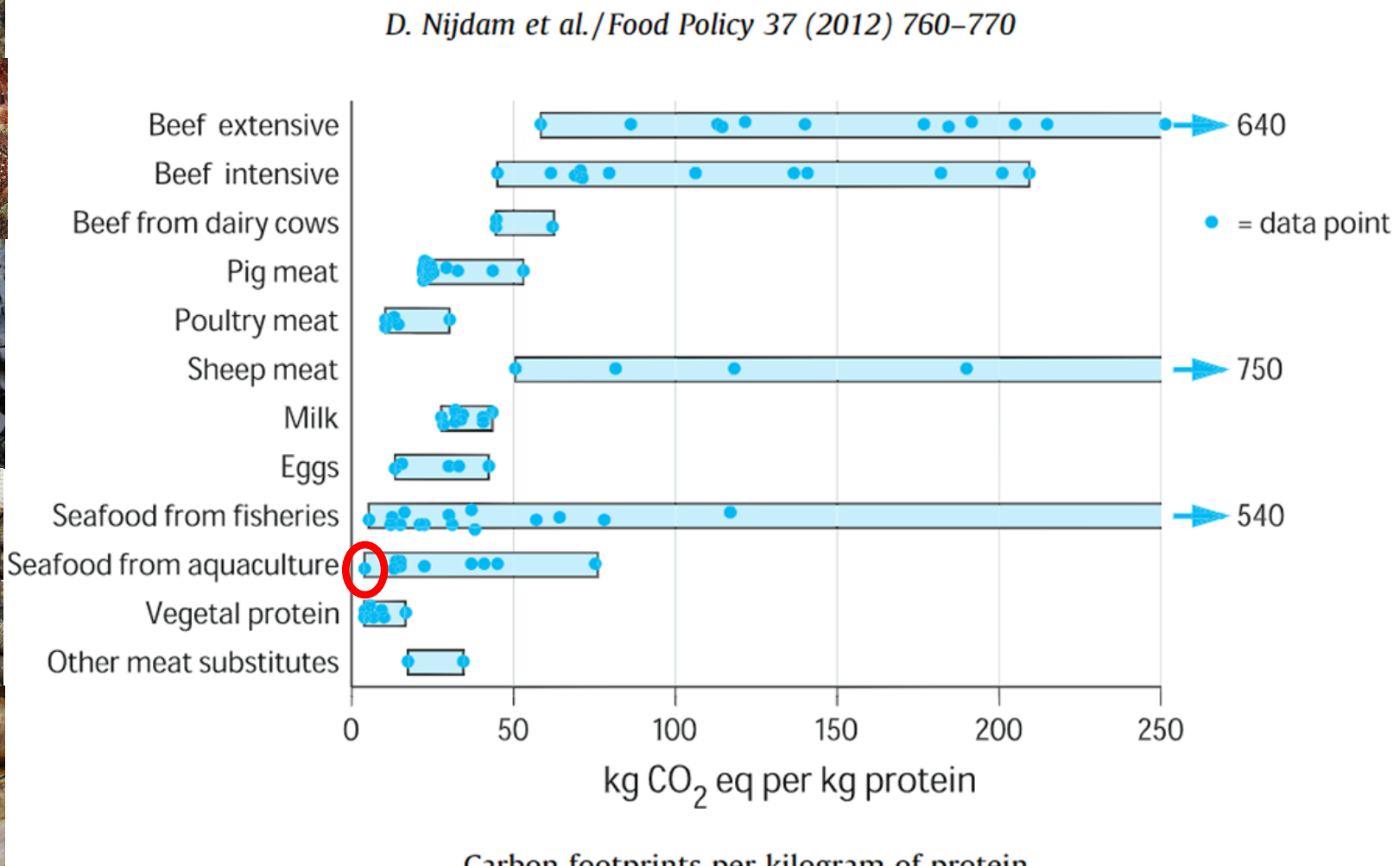
Why shellfish?

Shellfish Centre

2) Low GHG production



Carbon footprints per kilogram of protein.

kg CO_2 -eq. kg^{-1} protein

Vegetarian substitutes= **1-6**

Mussels aq. = **4**

Shrimp aq. ponds= **75**

Trawled lobster= **86**

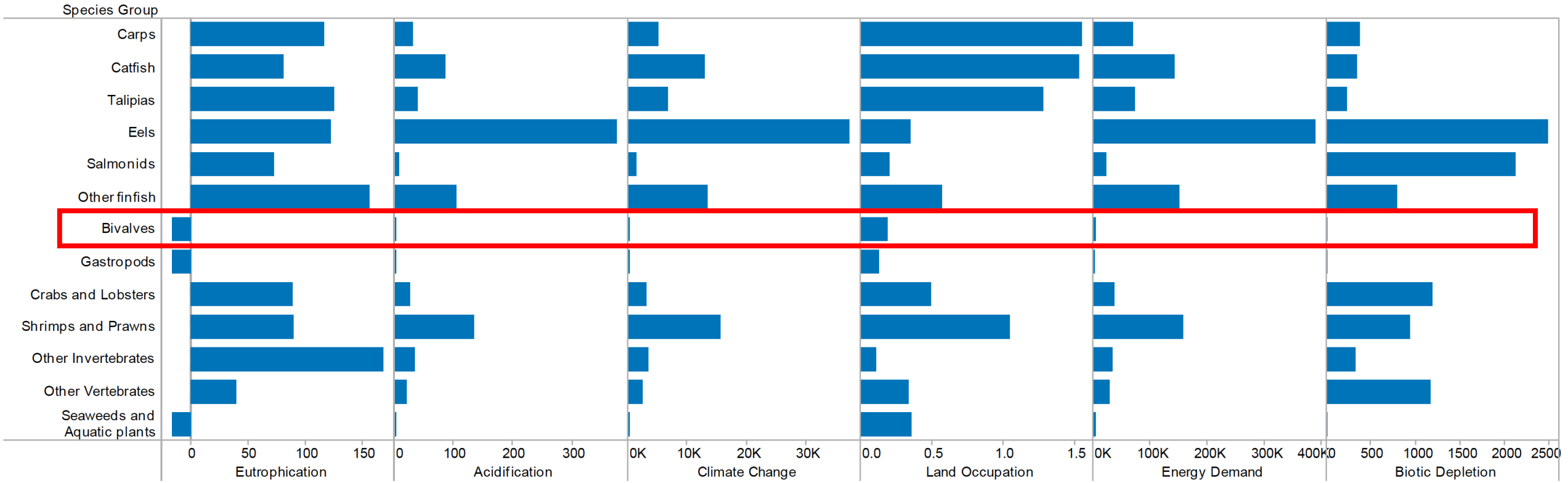
Beef= **45-640**

Lamb= **51- 750**

Why shellfish?

Shellfish Centre

3) Low & positive environmental impacts



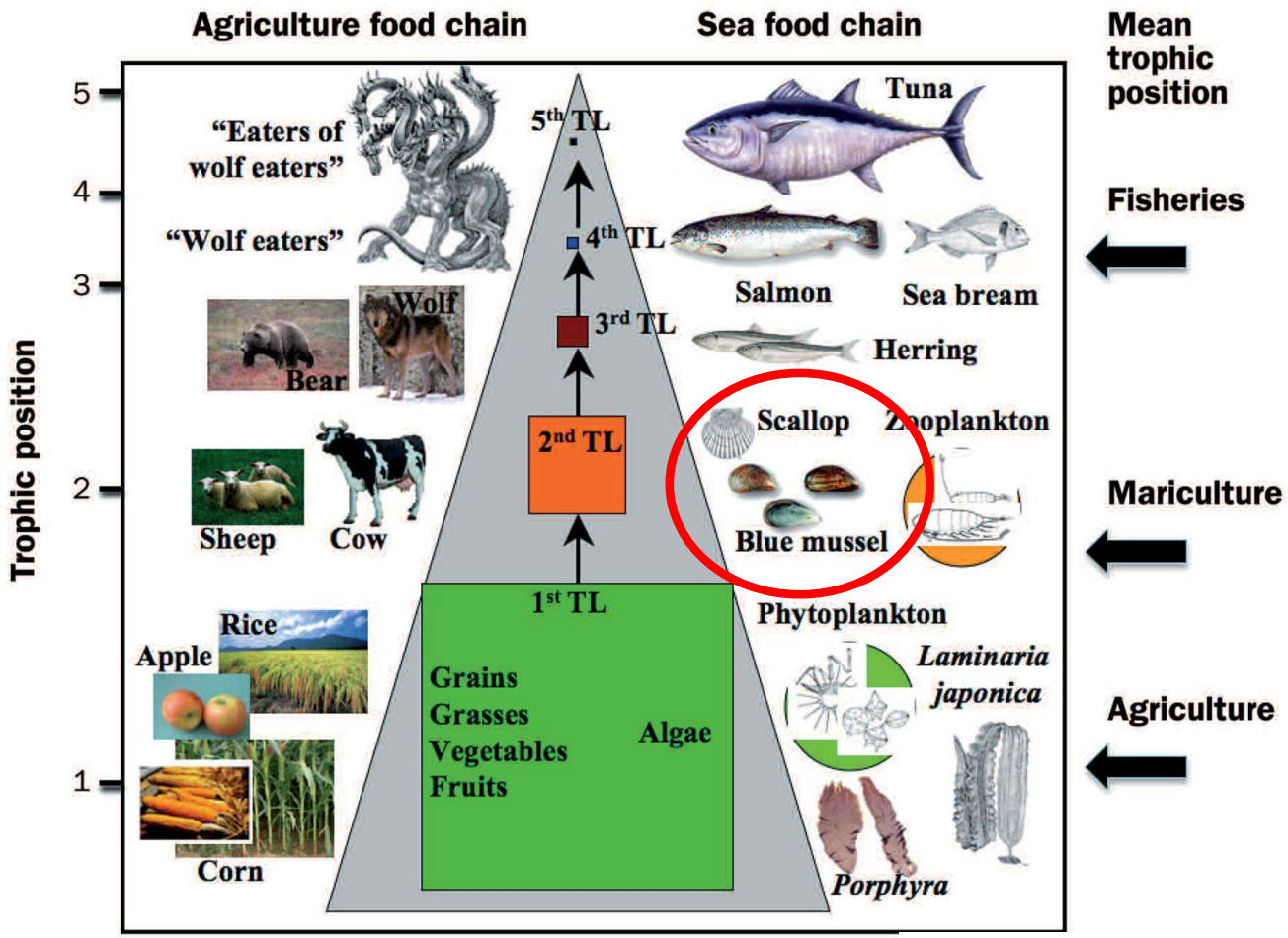
Life Cycle Assessment– aquaculture by species groups

World Fish 2011

Why shellfish aquaculture?

Shellfish Centre

4) Ecological efficient form of animal food production



Duarte et al., 2009

Fish in: Fish Out ratios

- **Extractive/unfed species ZERO**
- **Fed species – 0.3 : 1**

Environmentally integrated aquaculture

Shellfish Centre

- Farming down the food chain
- Low-impact activity
- Net food production
- Provides ecosystem services
- Low carbon footprint

But…

→ Externally dependent on **environmental integrity**

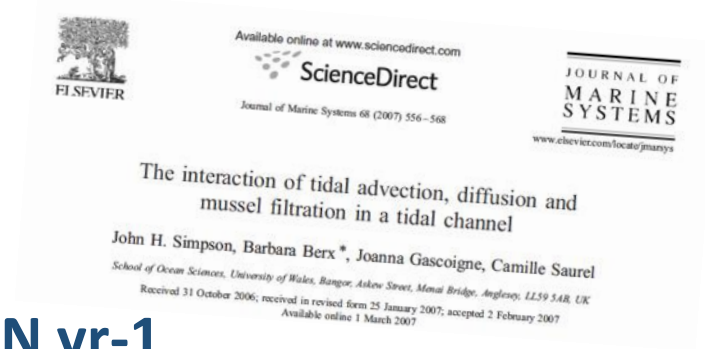
→ Marine space: **policy/legislative framework** needed

Ecosystem Services

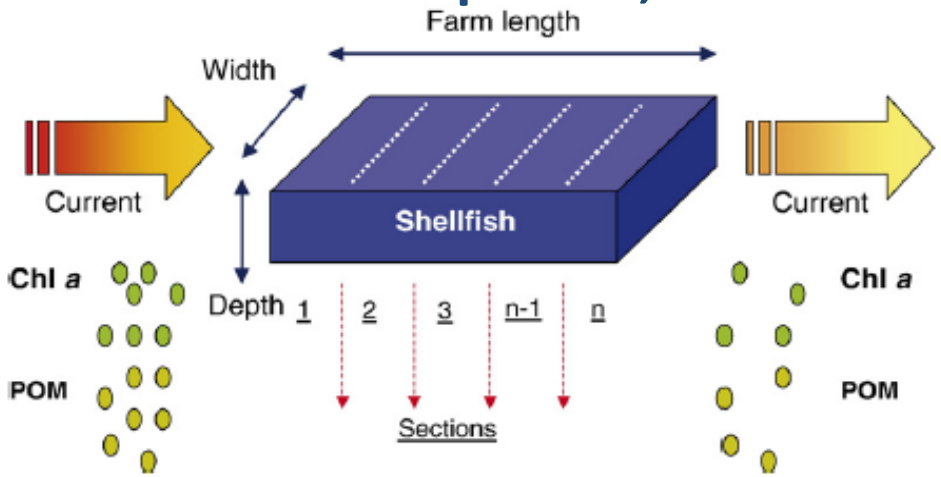
Shellfish Centre

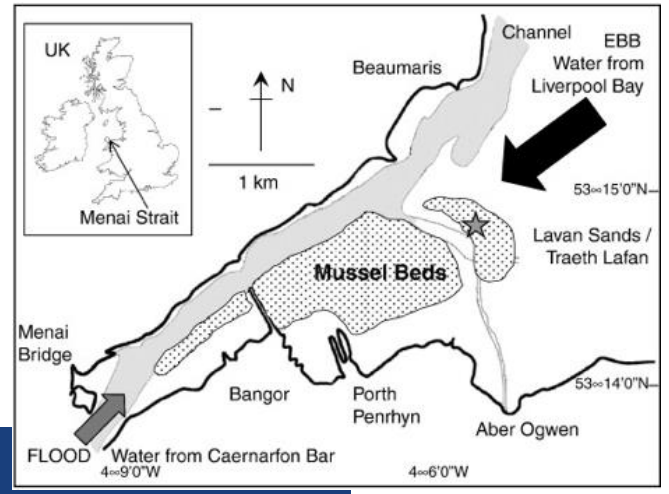
REGULATING SERVICES:

- Filter-feeding **extractive species**
- Shellfish can help achieve **clean seas**



1ha of mussels can filter up to 30,000 m3 d-1 = up to 1 t N yr-1





GLOBALLY cultivated bivalves **remove**:

- **49,000 tonnes** of **nitrogen**
- **6,000 tonnes** of **phosphorus**

→ worth a potential **$1.2 billion**

Ecosystem Services

Shellfish Centre

SUPPORTING SERVICES:

- **Habitat and Biodiversity**

MARINE ECOLOGY PROGRESS SERIES
Mar Ecol Prog Ser
Published September 12
Vol. 259: 173–183, 2003

Effects of intertidal mussel cultivation on bird assemblages

R. W. G. Caldow[1,*], H. A. Beadman[2], S. McGrorty[1], M. J. Kaiser[2], J. D. Goss-Custard[3], K. Mould[4], A. Wilson[5]

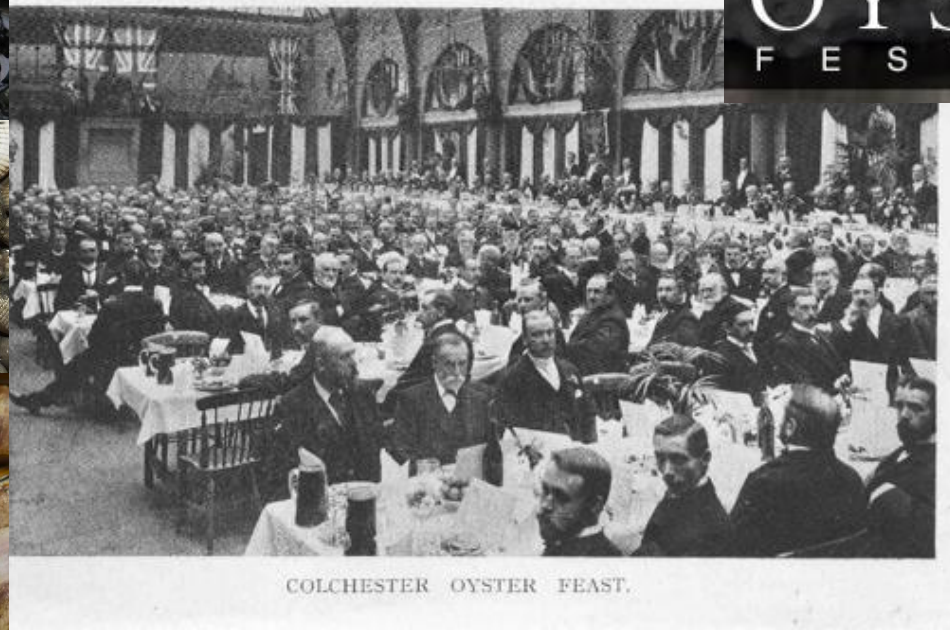
Ecosystem Services

Shellfish Centre

CULTURAL SERVICES:

Mikebisson, 2013

© British Film Institute (BFI), 1909



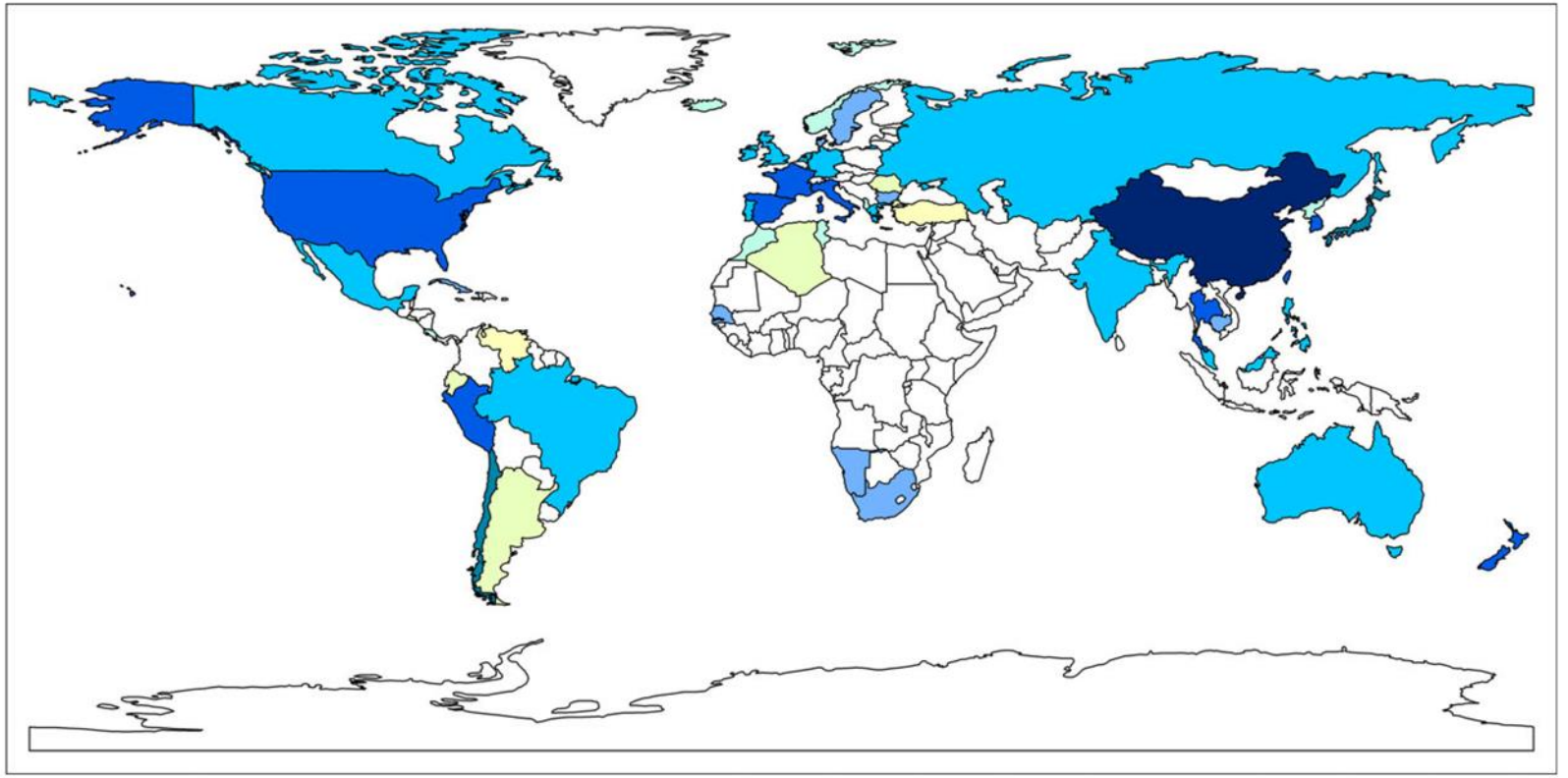
COLCHESTER OYSTER FEAST.

A HISTORY OF MUMBLES

A bowler-hatted oyster merchant selling Cleethorpes oysters, Lancashire, c.1900. © Mary Evans Picture Library/Alamy

Ecosystem Services

Shellfish Centre



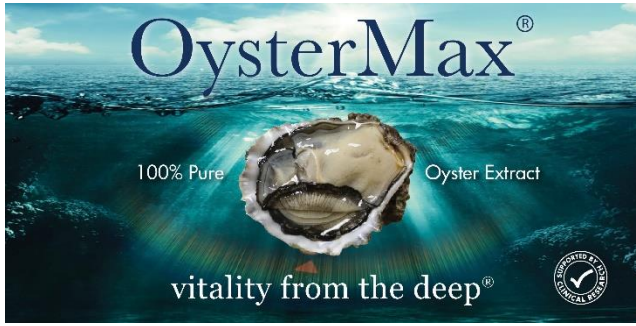


Figure 2 World map showing the potential combined value of carbon sequestration, nitrogen and phosphorus remediation and the use of oyster shells for aggregate ($). (□) No FAO data; (□) ≤ 10,000; (□) 10,001 – 100,000; (□) 100,001 – 1,000,000; (□) 1,000,001 – 10,000,000; (□) 10,000,001 – 100,000,000; (□) 100,000,001 – 1,000,000,000; (□) 1000,000,001 – 10,000,000,000; (□) 10,000,000,001 – 25,000,000,000

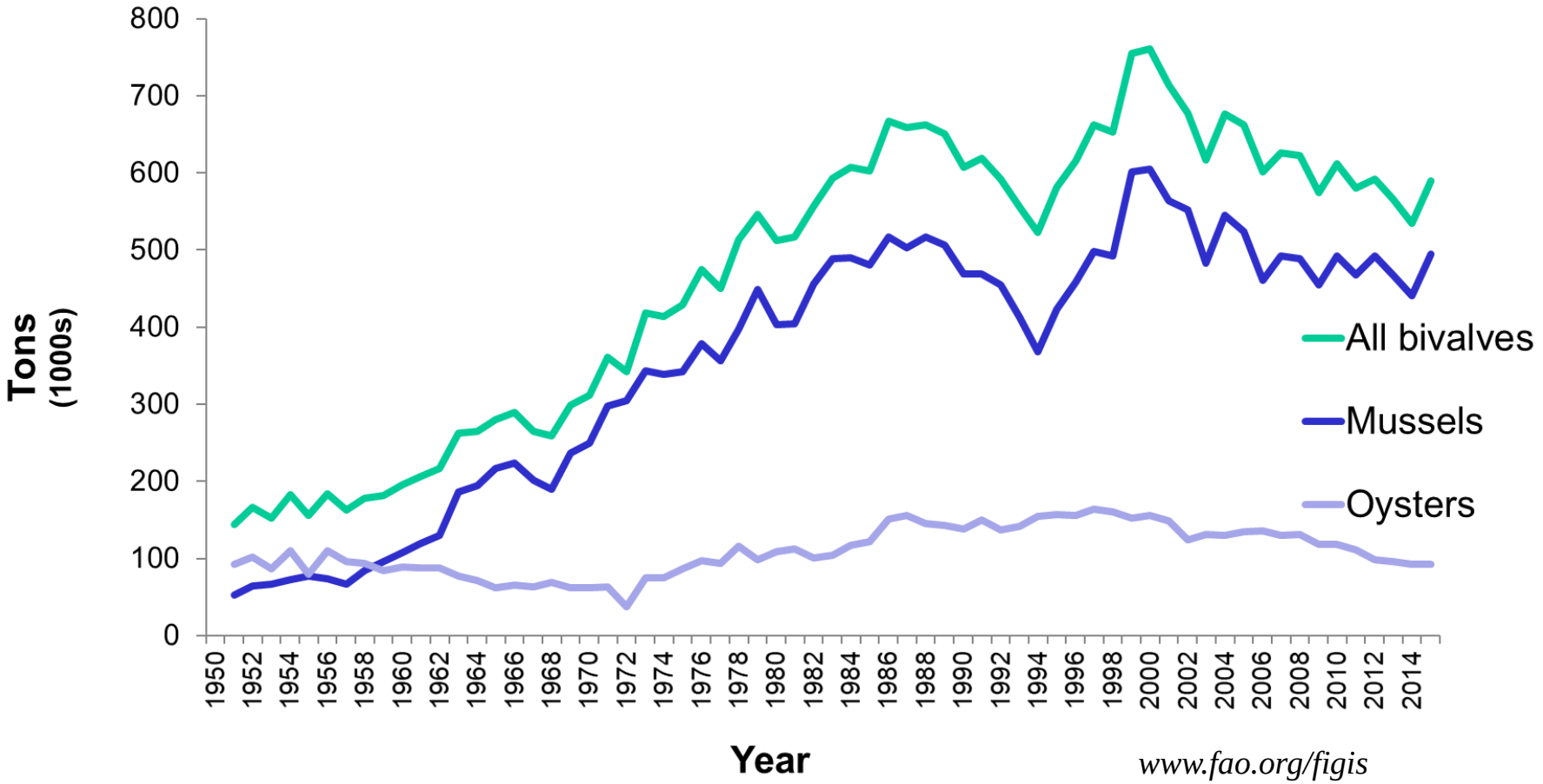
Non-food ecosystem services from shellfish farming **globally = $3-10 billion**

Van der Schatte Olivier et al (2018) Reviews in Aquaculture

Shellfish Production

Shellfish Centre

EU shellfish production 1950-2014



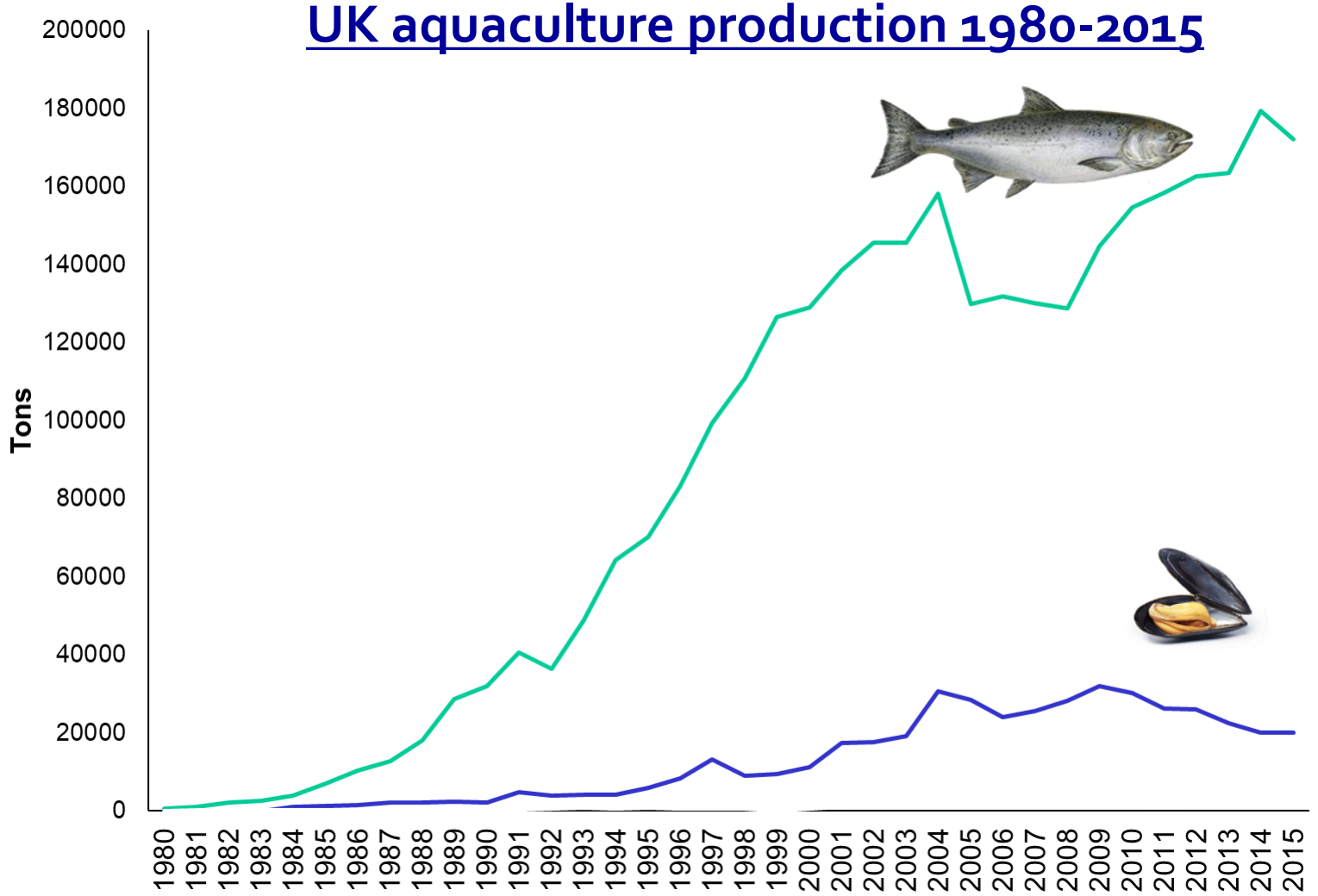
www.fao.org/figis

- **>50% shellfish**
- **€1.12 billion, > 60,000 jobs.**
- **Global shellfish output increased x 8**
- **No change for last 30 years, recent ↓**

Shellfish Production

Shellfish Centre

UK aquaculture production 1980-2015



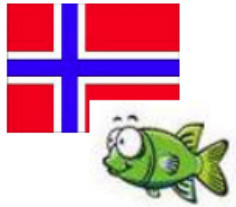
Very young sector – innovation - scope for change – may look very different another 20 yrs

Restrictions

Shellfish Centre

In coastal waters access to sites (i.e. space) can be a limitation

- Time to get a licence for a new…
  - Agricultural farm: **4-6 months**
  - Offshore wind farm: **18 months**
  - Aquaculture farm in Norway: **6 months**
  - Aquaculture farm in the EU: **often 2-3 years, sometimes even 7 years**



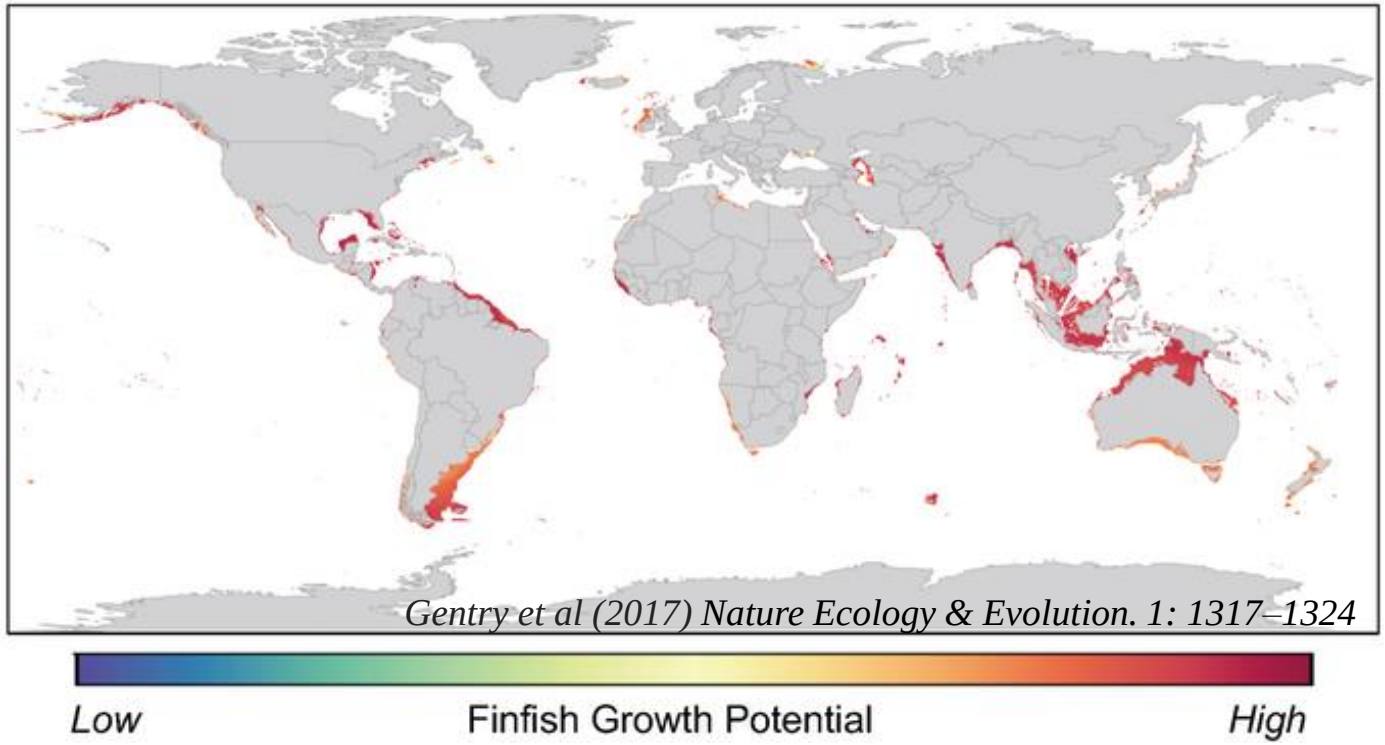
or… up to XX years in Wales

Restrictions

Shellfish Centre

Is space the problem globally?

- Current total landings of **capture fisheries** could be **produced in <0.015% of global ocean area**

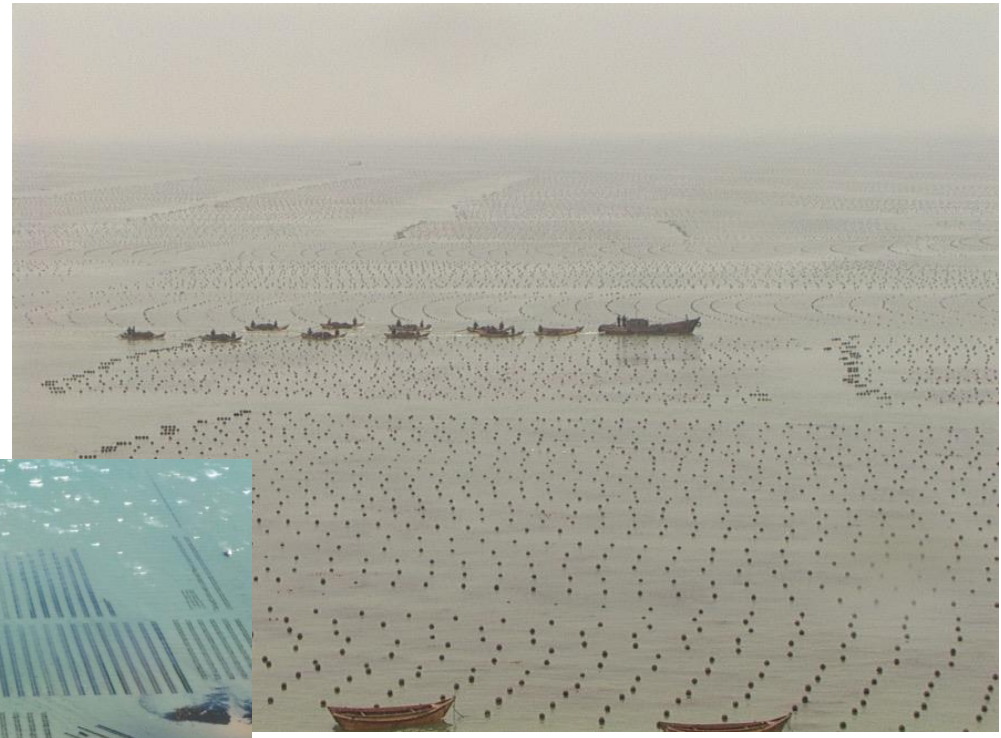


- **11 M Km²** ocean space **suitable for aquaculture** could **produce 15 billion MT = 100 times annual consumption**

Restrictions

Shellfish Centre

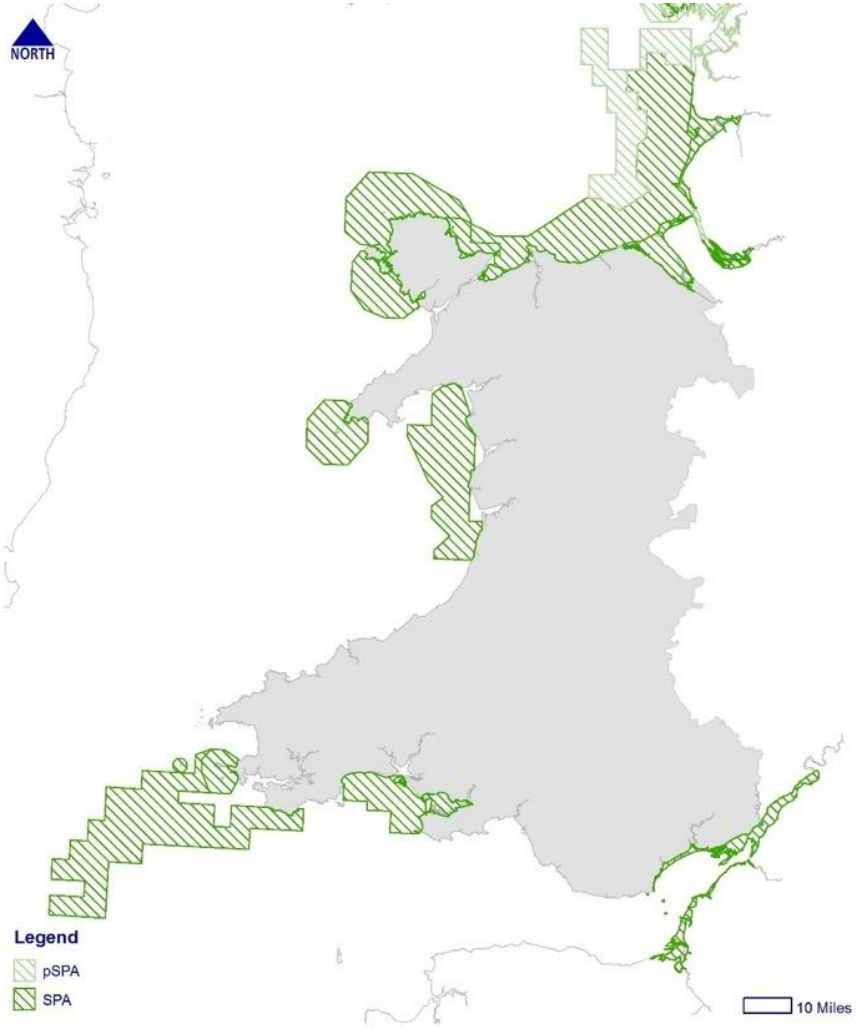
Coastal space limitations – or access to sites?

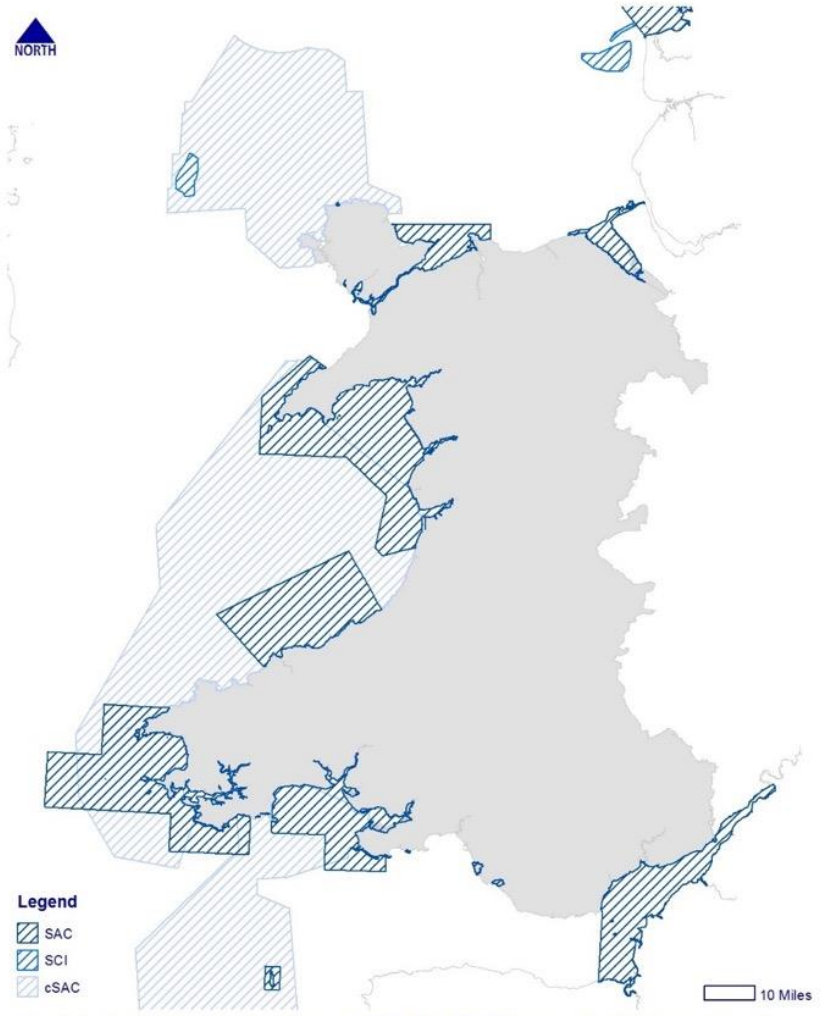


Restrictions

Shellfish Centre

Conservation designations around the Welsh coast

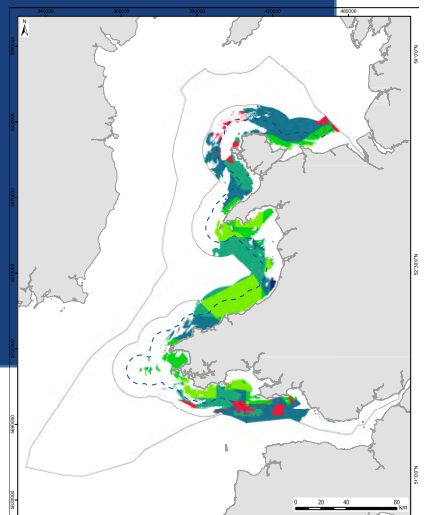




Welsh Potential

Shellfish Centre

- Welsh Government aim to **double shellfish production**
- Welsh **coastline 1,680 miles**, **Welsh Marine Area** to 12nm **15,000 km²**
- Shellfish productivity *circa* 30 tons Ha^{-1} = 3,000 tons km^{-2}
  - 0.02% of Welsh Marine Area could support doubling of shellfish production
- Not just about a few large farms; also **increasing diversity and resilience**…
  - ***More producers, more diverse products***
  - ***More related supply chain opportunities***
  - ***Higher profile, more coherent identity***
  - ***Strong research relationships***



The Shellfish Centre

- Science to support shellfish from Wales:
- An innovative and growing industry
- Evidence-based sustainability
- High quality products from high quality environment

Delivered through collaborative partnerships

Shellfish Centre

£3.9m CANOLFAN PYSGOD CREGYN SHELLFISH CENTRE

Mae'r Ganolfan Pysgod Cregyn, sydd wedi'i lleoli yng Nghanolfan Môr Cymru ym Mhrifysgol Bangor, yn ganolfan wyddoniaeth ac arloesi sy'n helpu diwydiant pysgod cregyn Cymru i dyfu drwy ddatblygu ymchwil wyddonol a thechnoleg gyda busnesau. Mae hyn yn cynnwys helpu i wella ansawdd dyfroedd arfordirol, mabwysiadu dulliau technoleg a chynhyrchu newydd ac ehangu i farchnadoedd newydd - y cyfan yn flaenoriaethau i ddiwydiant pysgod cregyn Cymru.

The Shellfish Centre, based at Bangor University's Marine Centre Wales, is a science and innovation hub which is helping to grow Wales' shellfish industry through scientific research and technology with business. It includes supporting improvements to coastal water quality, the adoption of new technology and production methods and expansion into new markets – all priorities for Wales' shellfish industry.

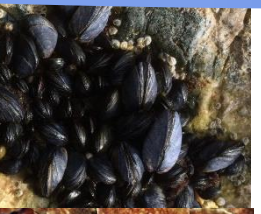
£2.8m
Cronfeydd yr UE / EU Funds

Cronfeydd yr UE: Buddsoddi yng Nghymru
EU Funds: Investing in Wales

UNDEB EWROPEAIDD EUROPEAN UNION
Llywodraeth Cymru Welsh Government
Cronfa Datblygu Rhanbarthol Ewrop
European Regional Development Fund

The Team

Shellfish Centre





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Director of CAMS

Shelagh Malham
Reader

Jonathan King
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David Smyth
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Julie Webb
Researcher

Claire Szostek
Researcher

Kata Farkas
Researcher

Esther Howie
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Karen Tuson
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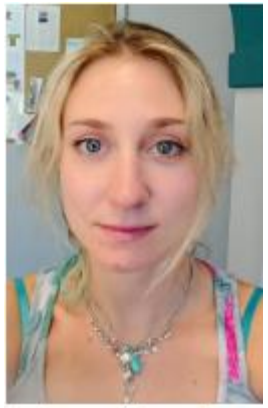
Susan Allender
Laboratory Manager



Jenna Alexander
Researcher

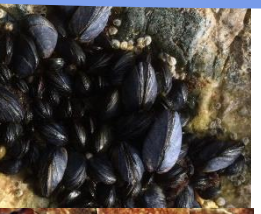
Sophie Ward
Researcher

Philippa Bayford
Researcher

Maria Hayden-Hughes
Researcher

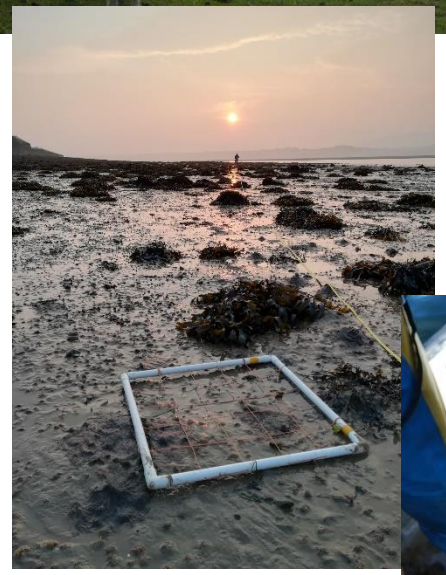
Projects

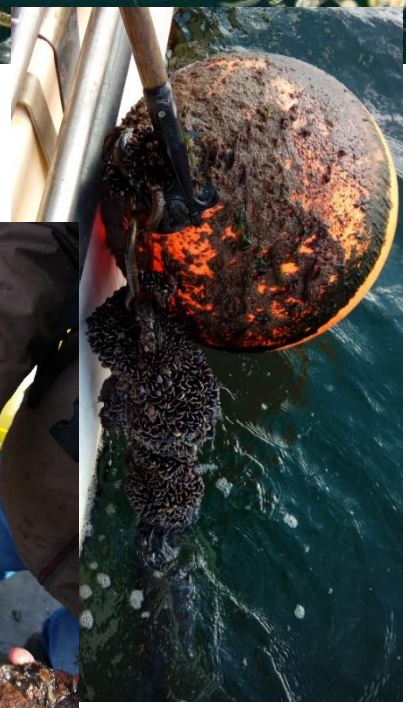
Shellfish Centre





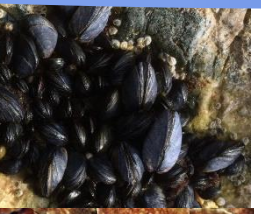
1. Water Quality
2. Seed supply limitations
3. Space
4. Diversification
5. New Fisheries

1) Water Quality

Shellfish Centre





Human impact

Sources of contamination

- Domestic wastewater: treated and raw
- Industrial activities
- Agriculture

Types of contamination

- Physical: Plastics, microplastics, debris
- Chemical: toxins, nitrate, phosphate
- Biological: antibiotics, pathogens

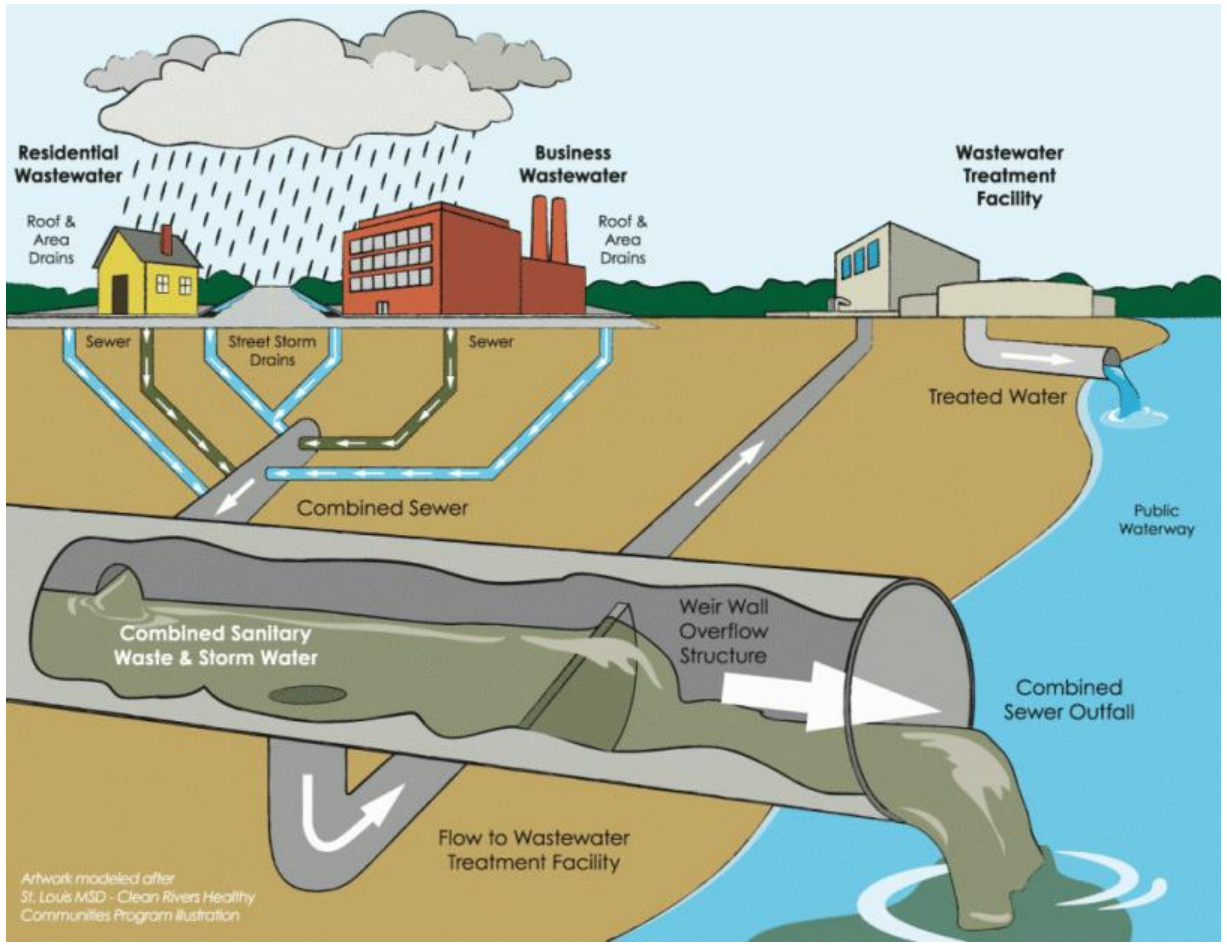




1) Water Quality

Shellfish Centre

Environmental Transmission of Human Pathogens



- Contamination
  - Rivers, lakes, sea, sediment
  - Groundwater, aquifers
  - Drinking water
  - Soil
  - Fruit and vegetable (irrigation)
  - Shellfish
- Outbreaks

Water and food safety:

1. **Quantity and survival**
2. **Diversity**
3. **Transport**

1) Water Quality

Shellfish Centre

Quantity and Survival

Detection

- Molecular methods
- Culturing

Survival

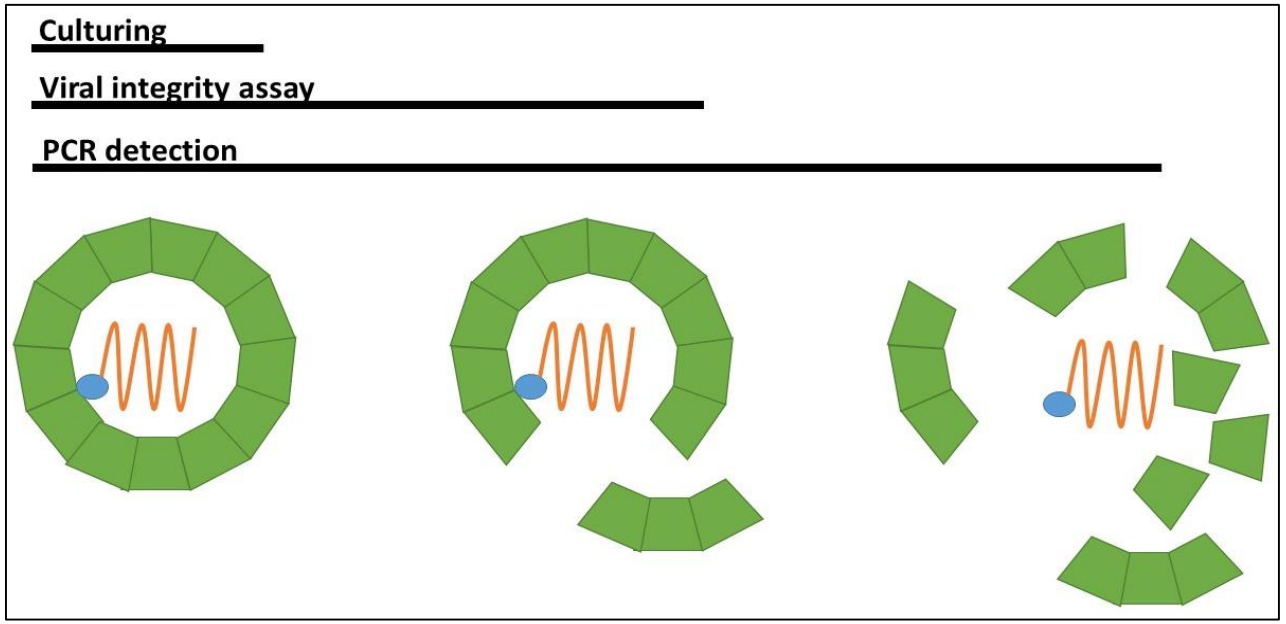
- How long do pathogens survive in the environment and in shellfish?
- Do pathogen vs indicator concentrations correlate?
- Are the methods used for detection accurate?
- Can we distinguish human and animal source of pollution?

Farkas et al (2018) *Environmental Science and Pollution Research*. 25:33391–33401.
Farkas et al (2018) *Science of the Total Environment*, 634:1174-1183.
Farkas et al (2019) *Food and Environmental Virology*, 6:113-119.

1) Water Quality

Viral Infectivity- Norovirus

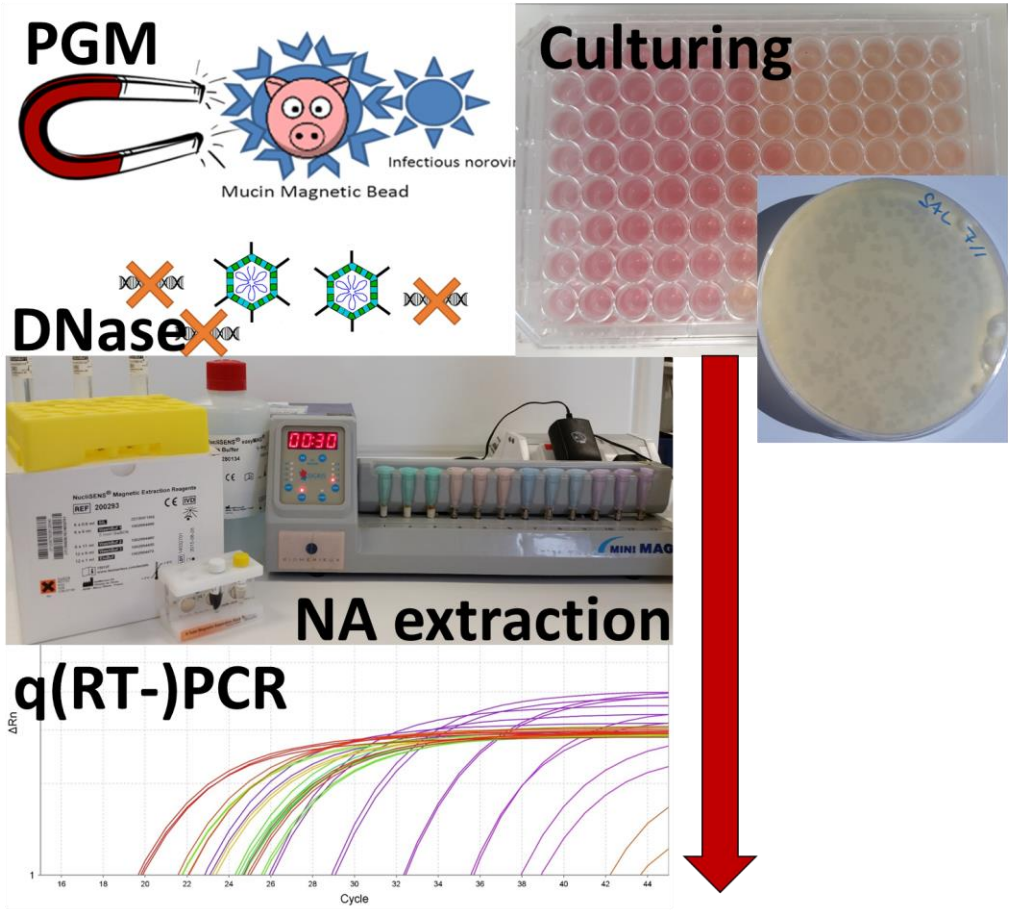
- **Viruses decay** in the environment if **host not present**; how long they survive?
- Norovirus infectivity: not feasible for environmental studies
- Porcine Gastric Mucin (PGM) assay: **Estimating viral infectivity via integrity**



1) Water Quality

Shellfish Centre

Viral Infectivity



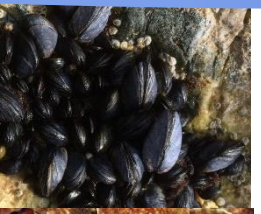
Capsid Integrity Assay

Direct detection

Infectivity assay

1) Water Quality

Shellfish Centre





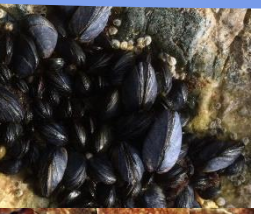
Offshore Water Quality Sentinels

Sites of interest to industry for offshore aquaculture require characterisation by:

- **Water quality**
- **Seed Settlement**
- **Food Availability**
- **Growth Rate / Mortality / Condition of commercial shellfish species.**

1) Water Quality

Shellfish Centre





<u>Quantify in caged mussels</u>
(time series)

1. F.I.Bacteria
2. Virus
   - NoV GI, GII
   - Adenovirus
3. Toxins
   - Saxitoxin
   - Tetrodotoxin
   - Potential to include okadaic acid and domoic acid

1) Water Quality

Shellfish Centre

<u>Quantify in water samples</u>
(time series)

1. Plankton
2. Chlorophyll-a
3. Turbidity
4. Nutrients

- Log Water temperature
- Quantify seed settlement
- Measure Condition commercial species

1) Water Quality

Shellfish Centre

Microplastics

- **Limited research** comparing microplastic load from **different culture sites** and the effect of **depuration time**.
- Develop methods of best practice to **benefit public health** and to **sustain the credibility** of mussels as a healthy food source.
- Benefit commercial growers, industry and public health –support new product/process and market access for **"plastic-free" shellfish.**

1) Water Quality

Shellfish Centre

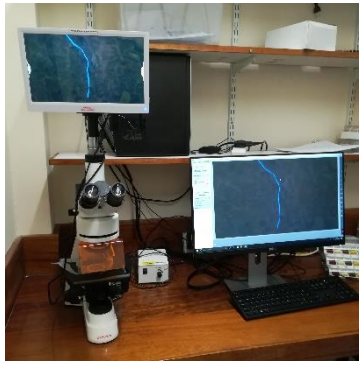




Aims

Determine microplastic load in rope-grown and on-bottom cultured mussels

- Strict lab protocol- limit contamination
- UV microscope- classify and measure
- Raman spectroscopy- classify polymer type



Understand the effect of depuration on microplastic load and microbial assemblages.

- Small-scale depuration unit
- Temporal sampling

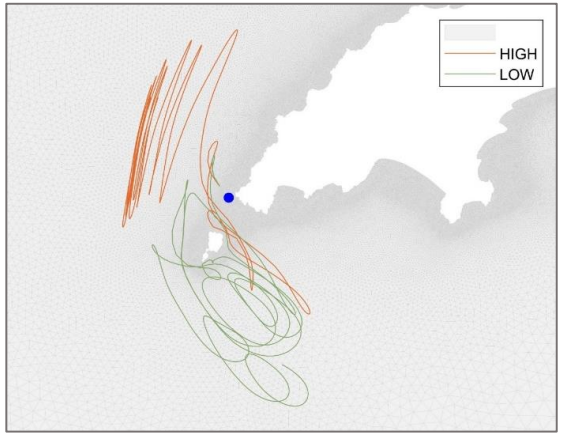
2) Seed supply

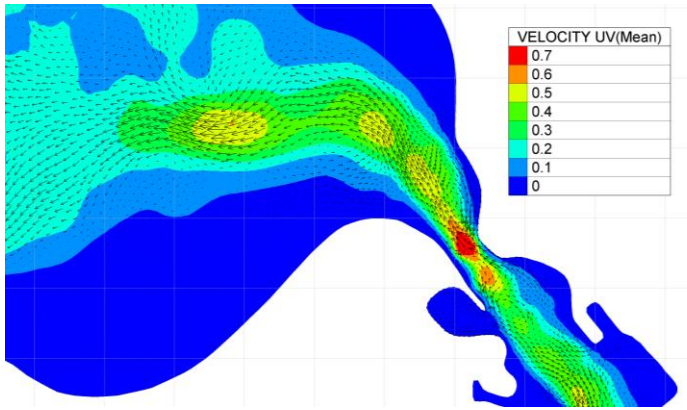
Shellfish Centre

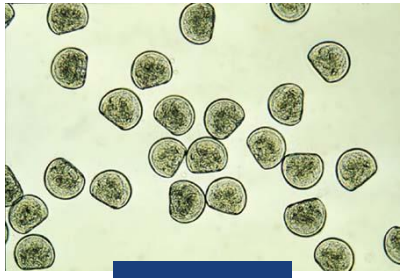
Using molecular methods to monitor bivalve larvae in plankton samples

- **Shellfish production** in the Menai Strait and Wales is **limited**:
  - **availability** of juvenile bivalves for relaying
  - **knowledge** on the location of **standing stocks**.

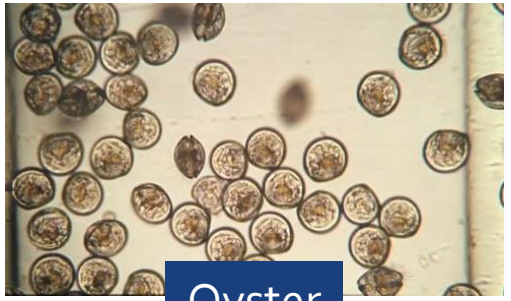
- **Determine** the **most suitable locations** for the collection of adults and seed requires study of **juvenile settlement and survival**.
  1. **Development** of rapid, specific **molecular identification tools** to determine **species of bivalve larvae**
  2. **Modelling and monitoring** seed settlement






Mussel


Scallop

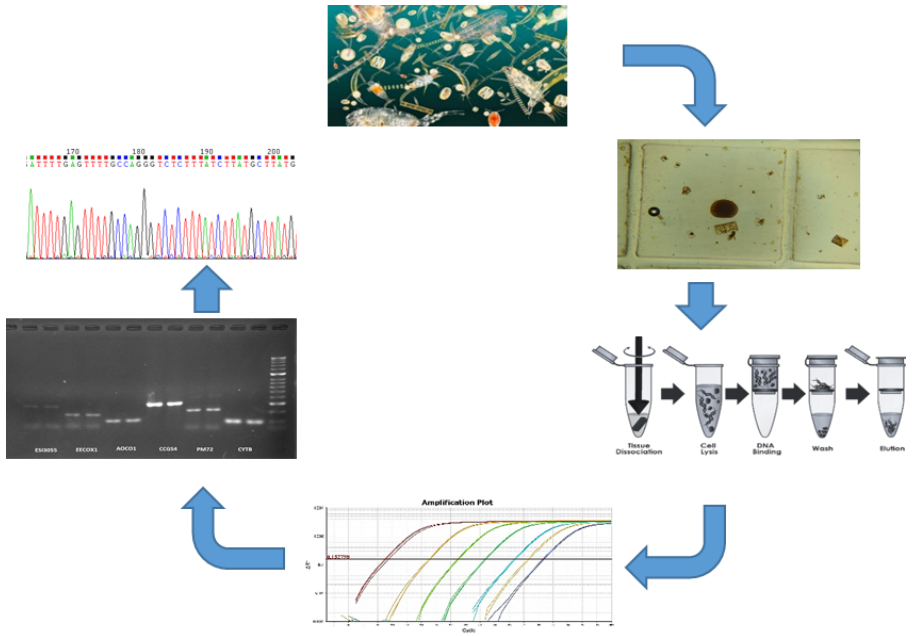

Oyster

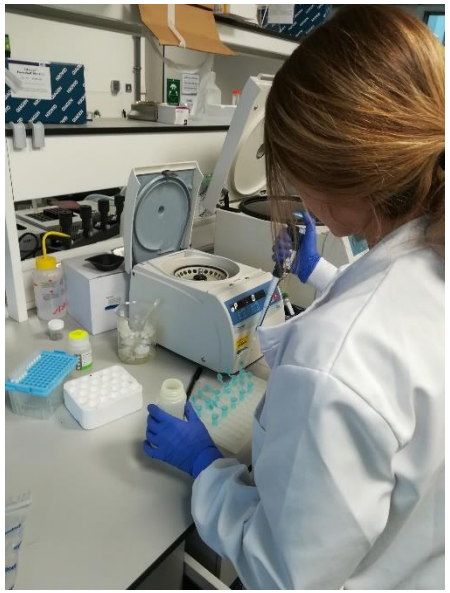
2) Seed supply

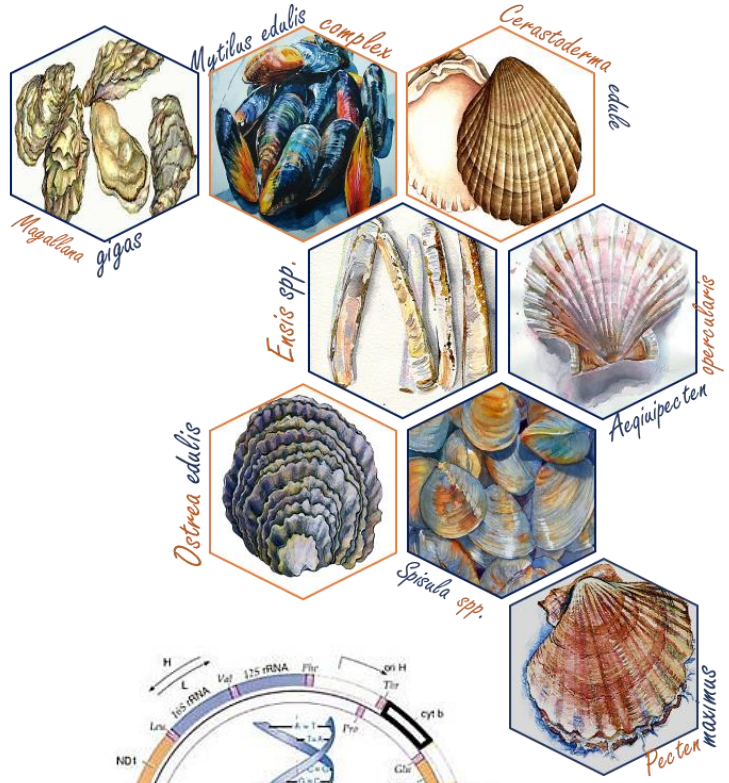
Shellfish Centre

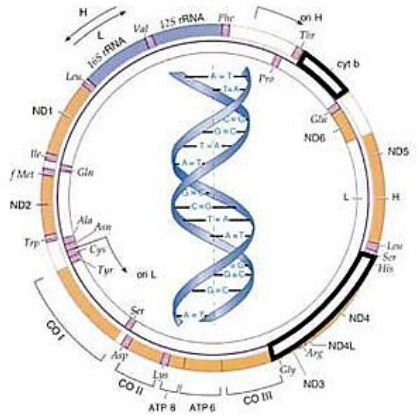
Using molecular methods to monitor bivalve larvae in plankton samples

- Designated **DNA sequence** = unique **species identifier**
- Barcodes for **commercial species of interest** were generated
- Explore potential for **quantitative analysis of larvae**
- Analyse samples **throughout bivalve spawning season**



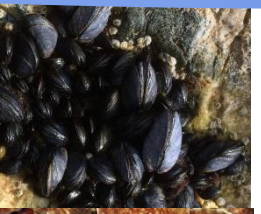






2) Seed supply

Shellfish Centre





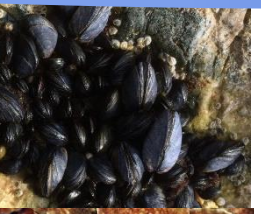
Bivalve larvae distribution around Welsh Coasts

Early this year Prince Madog Cruise collected:

- Water samples from discrete layers using a novel multi-depth plankton pump
- Visual ID bivalve larvae
- PCR/qPCR
- Chlorophyll
- Nutrient (Nitrate and Nitrite, Phosphate, Silicate, Ammonia)
- CTD

2) Seed supply

Shellfish Centre



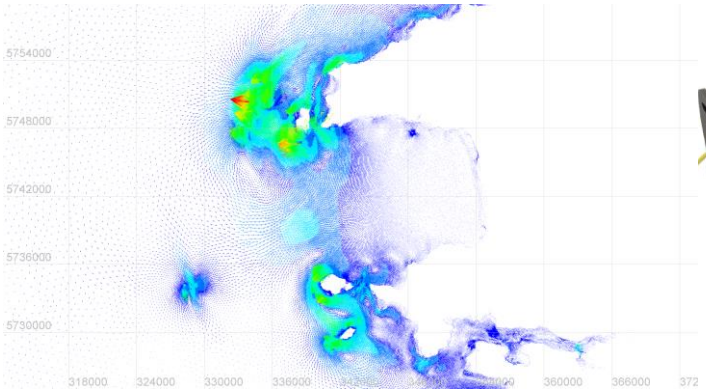


Inshore scallop stock assessment

1. **Do scallop populations in MPA act as a source or sink to local, unprotected stocks?**
2. **What time of year do scallops spawn?**
3. **Can hydrodynamic models predict spat-fall location?**
4. **Can video-survey methods be used as a non-invasive method to quantify stocks?**

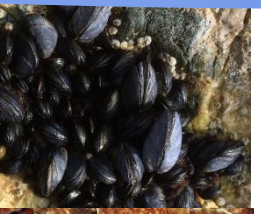
Sampling determine spawning:

- **Seasonal water sampling**
- **adult gonad assessment**
  - Immature, Developing, Differentiated, Recovering, Filling, Half-full, Full, Spent



2) Seed supply

Shellfish Centre





Maintaining Species Integrity

The hybridisation of culture species by non-indigenous aliens can cause serious problems within the aquaculture industry;

- thinner shells
- reduced meat yield
- loss of commercial integrity in the product

Monitor culture sites and species susceptible to hybridisation

- Water sampling
- PCR analysis of planktonic larvae and adult mussels to investigate possible hybridisation by the Mediterranean mussel.

Mediterranean mussel

Blue mussel

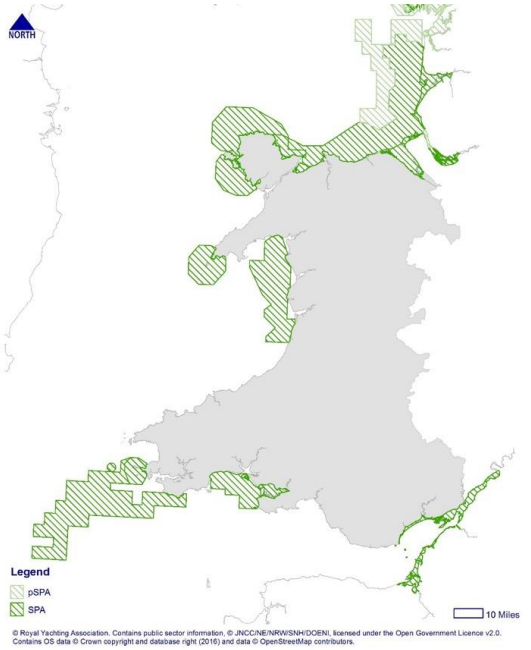
3) Space

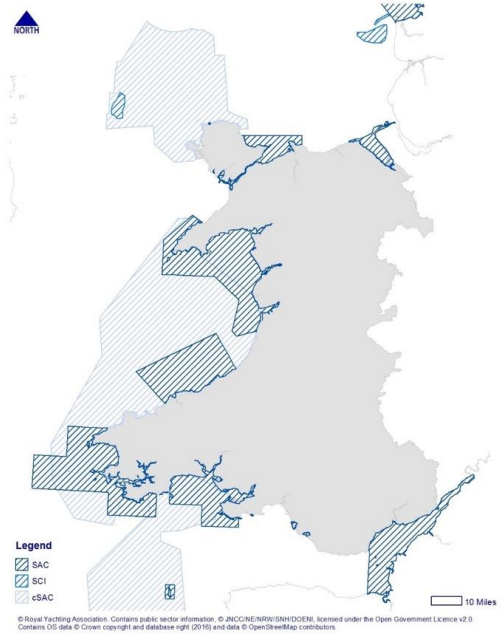
Shellfish Centre

Potential for long-line mussel farm production

- The biggest single limiting factor on growth in the sector across all of Europe and UK
- High proportion of Welsh coast under some form of Natura 2000 protection
- Driver for moving offshore

Need for environmental evidence and data





3) Space

Potential for long-line mussel farm production

Assess the viability of the mussel fishery in its current form and determine the potential of the area for **diversification into longline mussel culture**.

- Traditional mussel fisheries **rely on harvesting wild mussel beds** that are **in decline**
- Industry is now **exploring the potential for roped mussel cultivation** in more **exposed sites**.

- An alternative production system based on rope culture of mussels in deeper areas may represent an **opportunity for diversification** to **increase both collection of seed mussels** and **production** of ready-for-market mussels

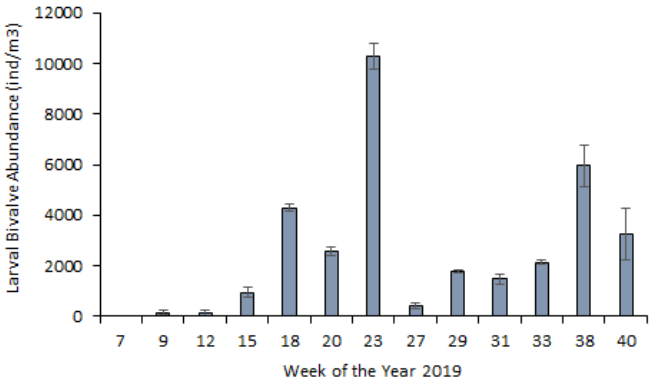
3) Space

Shellfish Centre

Potential for long-line mussel farm production

1) MONITORING

- Seasonal patterns in **planktonic mussel larvae** assessed fortnightly
- Collection of data on **water quality and environmental conditions correlate with patterns** of larval supply, settlement and growth.



2) MODELLING

- A **particle tracking model** developed to help **identify potential areas** for mussel spat settlement
- **Drogue release** will help validate and **refine the model**

3) TRIALS

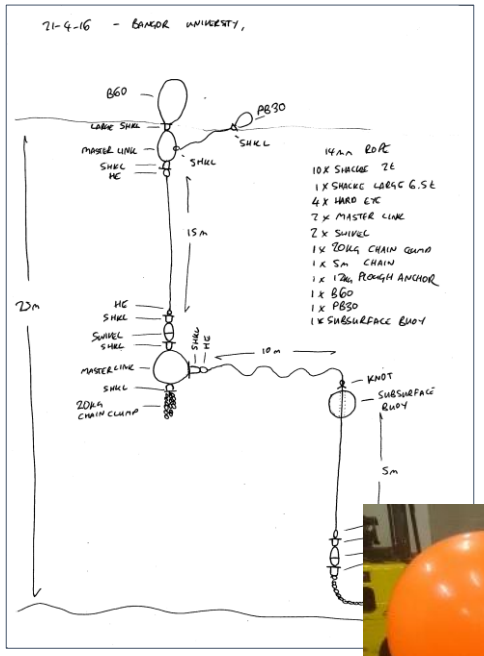
- **Year 1**: Individual test collectors collect data on temporal and spatial patterns of mussel spat
- **Year 2:** Pilot longline system deployed at optimal locations collect data on spat settlement and growth

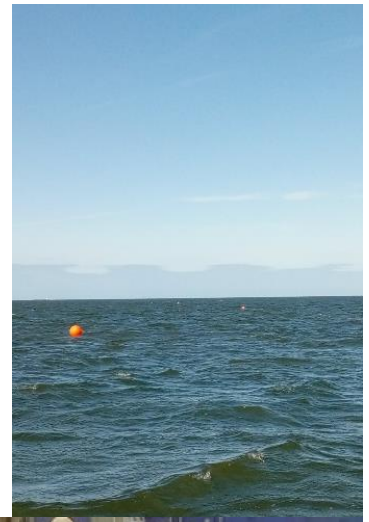
3) Space

Shellfish Centre

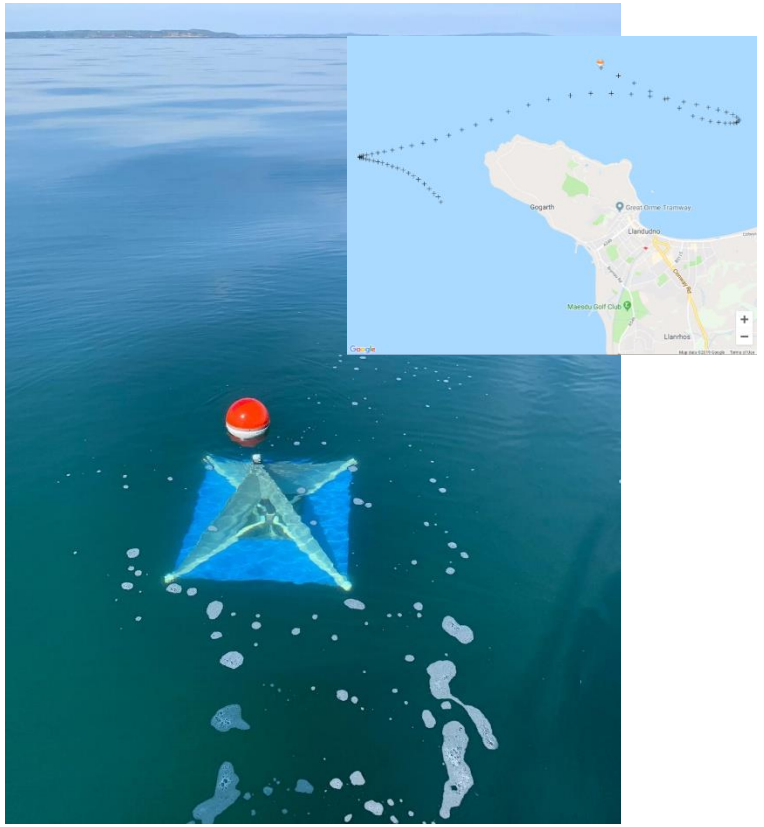
Year 1 trials

Test collectors were deployed in April





Drifter release in May



Spat settlement observed July/August

4) Diversification

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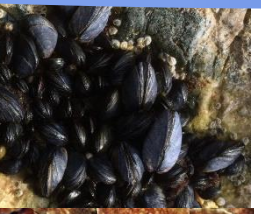
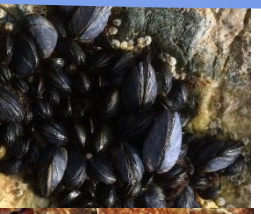




- Diversification allows the grower to **increase market output and demand**, provides culture species alternatives
- **Over 95%** of shellfish aquaculture production in Wales is from **bottom-cultured mussels** in the Menai Strait East several order.
- **Potential** for farming of **other species** including:
  - Scallops, oysters, abalone, shrimp
- Also – can extend to non-shellfish but **compatible species** e.g. macroalgae

4) Diversification

Shellfish Centre





Investigate the potential to introduce the following products to Welsh growers as single cultures or in a multi-trophic format:




Native Oyster

- High commercial value
- ecological enhancement

Abalone

- lucrative returns per/m2
- constant export market

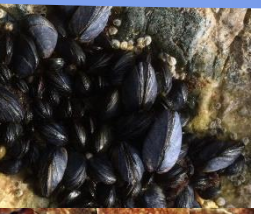
Shrimp

- high-end commercial species

Algae

- stand alone or as part of a multi-trophic approach

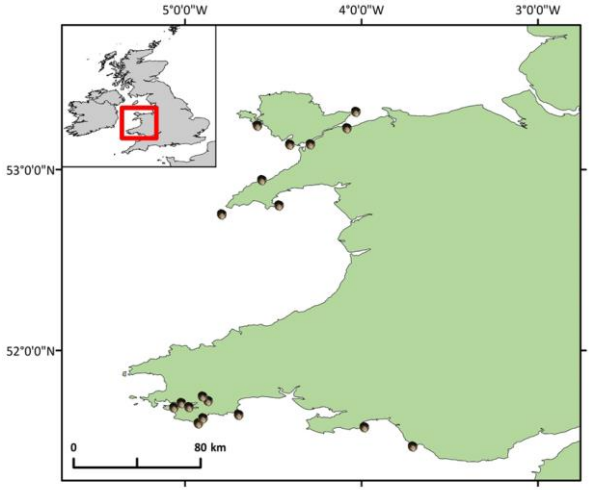
4) Diversification





Historical native oyster fisheries

- **Once sustained a productive Native oyster fishery** for the rural communities along its coastline.
- Now, wild native oyster populations are **biologically extinct**.
- **UK and European-wide effort to restore** native oyster populations for ecological enhancement
- **Fill in knowledge gaps** of high value product to **promote to general public and stakeholders.**



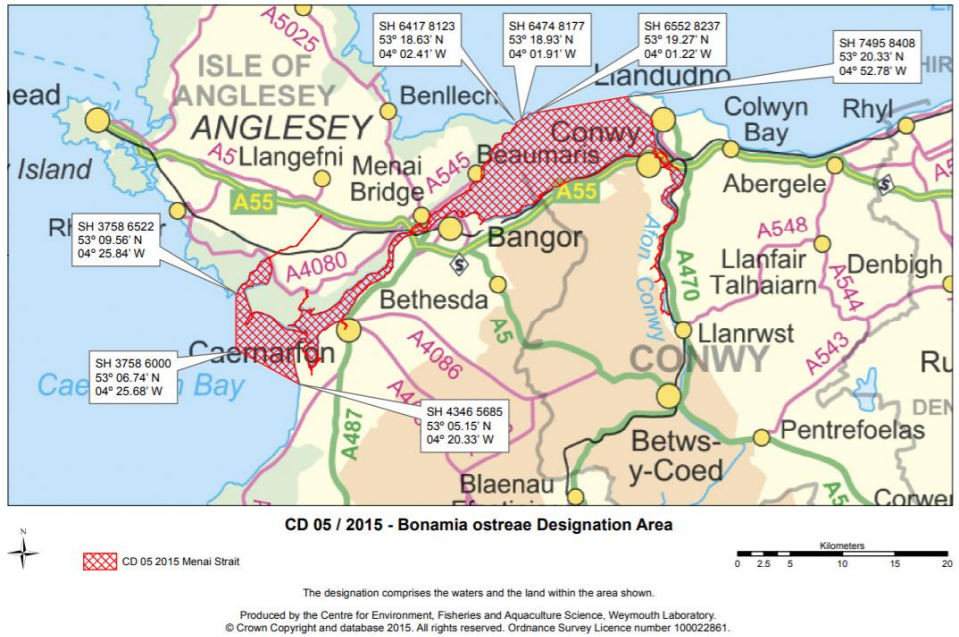
Historical oyster fishing grounds in Wales


© British Film Institute (BFI), 1909

4) Diversification

Screening for disease

- **Sampling vector species** within *Bonamia ostreae* designation area.
- Running **PCR's to determine presence** of *B. ostreae* within samples



5) New Fisheries

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Assessment of a potential razor clam fishery

- **Is there a population of razor clams in Liverpool Bay to support a sustainable commercial fishery?**
- **What species are present and at what distribution/density/spatial scale?**
- **Do razor clams have specific habitat preferences?**
- **Can an electro-dredge be optimised for collection of razor clams?**

Electro fishing

+ ve

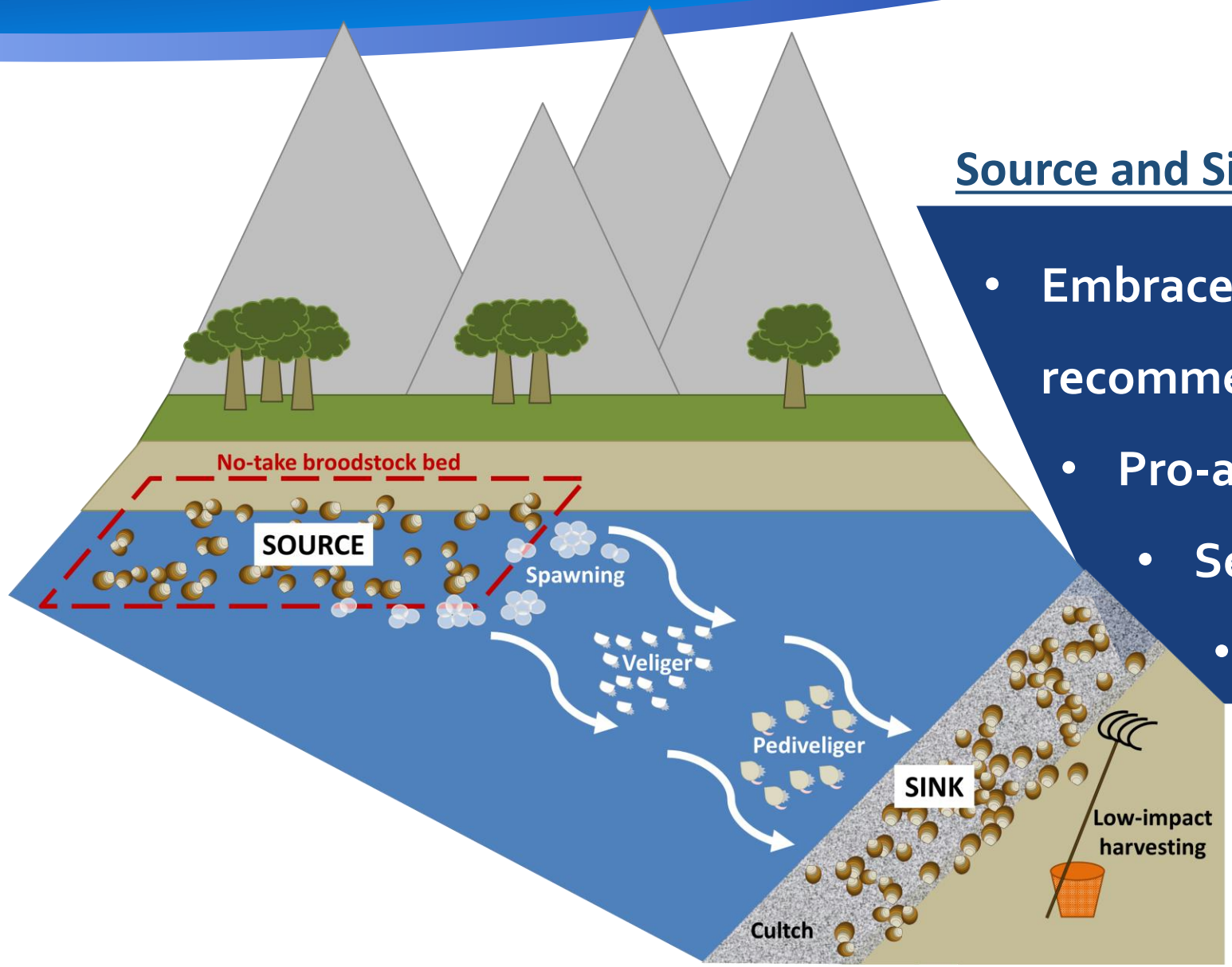
- Less bycatch
- Reduced environmental impact

-ve

- Unknown short/long-term impacts
- Sustainable with increased fishing intensity?
- Heavy metal release

5) New Fisheries

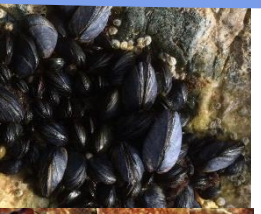
Shellfish Centre



Source and Sink Native Oyster Fishery

- Embrace OSPAR & UKBAP recommendations
- Pro-active management
- Self-sustaining fishery
- Ecological Enhancement

Get Involved!

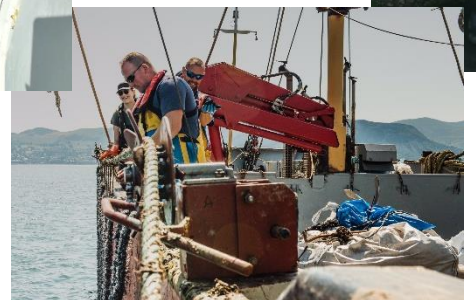




Volunteers always welcome

- Gain invaluable work experience
- Apply skills and knowledge
- Learn what interests you
- Transferrable skills for future career.

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ERDF
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Cronfa Datblygu Rhanbarthol Ewrop
Europe & Wales: Investing in your Future
European Regional Development Fund

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Shellfish Centre

Thanks for listening

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