Why a Seaweed Circular Economy in the East of England?

Eastern Arc Conference 2022: The Collaborative Coast - Thursday 22 September

Breakout session 4: Sustainable coastal ecosystems and opportunities for regional development
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SPACE TO GROW
We give people the space they need to develop and grow businesses through provision of flexible hotdesking and office and workshop space at our sites.

BUSINESS INSIGHT
We help businesses overcome challenges by finding creative and innovative solutions, and help businesses access new opportunities through bespoke advice, workshops, and training.

CONNECTED COMMUNITIES
We bring together the skills, resources and ideas of our communities to work towards common goals.
Why the Focus on Seaweed?

- The growing world population means increased demand for food and land

- Wider applications in nutritional supplements, fertilisers, animal feed, biofuel, textiles, cosmetics, wastewater treatment, bioplastics...

- In the UK, seaweeds have been used for centuries as a food, feed, and soil enricher

- The growth in the seaweed market increases the pressure to accelerate local production

- Collaboration, knowledge exchange and innovation will be key to scale up the UK seaweed industry

(Capuzzo, 2022)
### Global Seaweed Industry

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Billion USD global commercial seaweed market (2020)</td>
<td>14.1</td>
</tr>
<tr>
<td>Million tonnes produced each year</td>
<td>31.2</td>
</tr>
<tr>
<td>Seaweed produced by farming</td>
<td>95%</td>
</tr>
<tr>
<td>Seaweed species commercially farmed</td>
<td>291</td>
</tr>
</tbody>
</table>

### UK Seaweed Industry

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial seaweed farms</td>
<td>~10</td>
</tr>
<tr>
<td>Seaweed related businesses</td>
<td>~74</td>
</tr>
<tr>
<td>Seaweed produced by wild harvest</td>
<td>69%</td>
</tr>
<tr>
<td>Businesses with food &amp; drink as the target market</td>
<td>~33%</td>
</tr>
<tr>
<td>Businesses targeting the beauty industry</td>
<td>19%</td>
</tr>
<tr>
<td>Businesses producing nutraceuticals</td>
<td>13%</td>
</tr>
</tbody>
</table>
Norfolk and Suffolk have over 140 miles of coastline, bordering the North Sea, which is currently being developed into a thriving energy- and raw-material-generating region.

(visitnorfolk.co.uk & visitsuffolk.com, 2021)
The Algae Innovation Platform

- Established after discovering a local interest for seaweed with a lack of a shared platform to communicate about initiatives
- Aims to collaborate to better understand what is needed to develop a viable and sustainable seaweed industry in the East of England and discuss current barriers for development
- Focuses on sharing expertise and experiences as well as networking
Next Steps & Vision for the AIP

- Work to minimise the barriers that are delaying development and raise awareness of the benefits of seaweed

- Support the development of a local strategy that encourages algae innovation and the establishment of local seaweed farms

- The vision is to develop/secure local supply chains to produce seaweed products in the region and encourage cross-sector collaboration, commercialisation, scale-up and spin-off projects from the platform
Thank You!

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Seaweeds: biology, environment and other considerations for the development of sustainable seaweed farming.

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Algae = Microalgae + Macroalgae/Seaweeds

Algae are hugely variable
Diverse evolutionary origins.
Size range: Prochlorococcus 0.5 μm
           Ostreococcus 1 μm
           Macrocystis 60 m

Most are photosynthetic
CO$_2$ + H$_2$O + light $\rightarrow$ CH$_2$O + O$_2$
+ Nutrients from the environment

Provide critical ecosystem services
Some have very fast growth rates

Seaweeds – classified in 3 major groups:

Red (>7500 species)
Porphyra
Rhodophyceae
Laver or nori

Green (~1500 species)
Ulva lactuca
Chlorophyceae
Sea lettuce

Brown (~2000 species)
Saccharina latissima
Phaeophyceae
Sugar kelp or kombu

red: www.seaweed.ie
green: www.algaebase.org
brown: @warren_maguire
Seaweeds v. land plants

<table>
<thead>
<tr>
<th>Seaweeds</th>
<th>Land plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blades and stipes</td>
<td>Leaves and stems</td>
</tr>
<tr>
<td>Photosynthesise across whole organism</td>
<td>Photosynthesise mostly in leaves</td>
</tr>
<tr>
<td>Take up water and nutrients across all tissue types. Withstand desiccation when the tide is out.</td>
<td>Combination of roots and complex water and nutrient translocation systems. Many are susceptible to drought and flooding.</td>
</tr>
<tr>
<td>Supported by the water, some have air filled floats.</td>
<td>Need structural tissue to hold them up against gravity</td>
</tr>
<tr>
<td>Reproduce by releasing eggs and sperm or spores</td>
<td>Produce seeds</td>
</tr>
<tr>
<td>Holdfasts to fix to rocks or manmade structures</td>
<td>Roots anchor plant in the ground</td>
</tr>
</tbody>
</table>
Producing algal biomass

Small scale, fixed off-bottom, peg and line farming of *Eucheuma denticulatum and Kappaphycus alvarezii* in Tanzania, East Africa.

Industrial Scale Cultivation of *Saccharina japonica* on ropes in China.

Indoor tank cultivation/hatchery for *Palmaria palmata* (Dulse), Wales.

Outdoor tank / tumble culture of *Palmaria palmata* (Dulse), Oregon.
Integrated multi-trophic aquaculture (IMTA)

Waste from production of fish and shellfish becomes food or fertiliser for production of other species.
Time of unprecedented change


CO$_2$ in the atmosphere 1960-2021

UN Goals for the 17 big challenges we face

1. No Poverty
2. Zero Hunger
3. Good Health and Well-being
4. Quality Education
5. Gender Equality
6. Clean Water and Sanitation
7. Affordable and Clean Energy
8. Decent Work and Economic Growth
9. Industry, Innovation and Infrastructure
10. Reduced Inequalities
11. Sustainable Cities and Communities
12. Responsible Consumption and Production
13. Climate Action
14. Life Below Water
15. Life on Land
16. Peace, Justice and Strong Institutions
17. Partnerships for the Goals
Potential but challenges.....

• Licencing and permitting complex. Policy and governance lagging behind developments in sector.
• Conflicts with other users of marine space, and environmental and social objectives.
• Public acceptability.
• Manpower.
• Environmental monitoring
• Extremes of weather
• Biodiversity gains and losses
• Epiphytes, disease and grazers
• Food & feed safety compliance e.g. iodine, arsenic
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**Breakout session 4:**
Sustainable coastal ecosystems and opportunities for regional development

**THE OCEAN FARMER’S PERSPECTIVE**

**Willie Athill**
Founder
Norfolk Seaweed Ltd
WILD HARVEST VS FARMED?

- HISTORICALLY SEAWEED INDUSTRY IN THE UK HAS BEEN WILD HARVEST
- THIS IS UNSUSTAINABLE
- NOT AN OPTION ON OUR COAST DUE TO CONSERVATION REGULATIONS
**WHAT REGENERATIVE OCEAN FARMING CAN DELIVER**

**CLIMATE**
- Carbon sequestration potential
- Reduce agricultural emissions – ie methane reduction

**FOOD**
- Provide a healthy, sustainable food ingredient

**LAND**
- Reduce land footprint from feed
- Replace synthetic fertilisers

**OCEAN**
- Improve ocean health – nitrogen, acidity, marine biodiversity

**LIVELIHOODS**
- Diversify livelihoods and increase resilience
**CLIMATE**

Carbon sequestration potential

Reduce agricultural emissions – ie methane reduction

**FOOD**

Provide a healthy, sustainable food ingredient
COMBATS EUTROPHICATION PROCESS

REPLACES SYNTHETIC FERTILISERS.

MORE FOOD FROM LESS LAND AREA. LESS FRESH WATER USE. BETTER MANAGEMENT OF SOILS

IMPROVES OCEAN HEALTH

COMBATS EUTROPHICATION PROCESS

LAND
- Reduce land footprint from feed
- Replace synthetic fertilisers

OCEAN
- Improve ocean health – nitrogen, acidity, marine biodiversity
COASTAL DEVELOPMENT

• CREATING A REGENERATIVE, SUSTAINABLE, SCALABLE BLUE ECONOMY BUSINESS WHICH PROVIDES JOB OPPORTUNITIES FROM THE HARD WORK AT SEA, TO THE FACTORY FLOOR, IN THE HATCHERY TO PhD LEVEL BIOCHEMISTRY.

• WORKING WITH THE EXTRACTIVE FISHING INDUSTRY TO TRANSFER SKILLS
OBJECTIVES

• SUPPORT THE UK GOVT MARINE PLAN TO CREATE A “CLEAN, HEALTHY, SAFE, PRODUCTIVE AND BIOLOGICALLY DIVERSE OCEANS AND SEA.”

• A SMALL PILOT TO PROVE THAT MACROALGAE CAN BE CULTIVATED IN THE WATERS OFFSHORE NORTH NORFOLK

• TO UNDERTAKE RESEARCH AND DEVELOPMENT TO ASSESS THE BENEFITS OF THE FARM; FINDINGS WILL BE SHARED AT THE END OF THE TRIAL AND TO PROVE SCALEABILITY OVER TIME

• WORK WITH COASTAL COMMUNITIES AND LOCAL LANDOWNERS.
WHERE WILL THE FARM BE?
HOW DOES THE FARM WORK
MACRO CASCADE will prove the concept of the cascading marine macroalgal biorefinery. This is a production platform that covers the whole technological chain for processing sustainable cultivated macroalgae biomass – also known as seaweed – to highly processed value added products.
ENVIRONMENTAL CONSIDERATIONS
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Carbon dioxide removal potential from wind and kelp farm colocation in the Southern North Sea

Dr. Nigel Hargreaves

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Solving system complexity for sustainable energy, transport, food and natural resources

www.synfo.co.uk nigel@synfo.co.uk
Principal seaweed production pathways

- Onshore seaweed farming (eg. dockside)
  - Coastal seaweed farming
  - Offshore seaweed growing
    - Deep sea carbon sequestration
  - Earn carbon credits
    - Onshore process and product-making industry
Carbon capture & sequestration pathways

Natural Kelp carbon is sequestered in deep sea benthic sediments. We need to explore other ways.
Growing kelp vs forest at scale

- 9 New wind farms by 2030
- Total capacity 11.3GW
- Power density 3MW/km²
- Area = 3,800km² or, the size of Suffolk
- Estimate growing area of 10% & 20%
  - = 380km² and 760km²

- Suited to North Sea conditions
- Grows up to X20 faster than trees
- Requires no fresh water or land use
- Fire proof!
- Valuable source of protein, carbohydrates, vitamins and minerals
C-capture kelp & forest species

Kelp -
Farm size: 380 km²
Line spacing: 1.5m
Yield: 10kg/m²
DW:WW ratio: 12%
DW C content: 30.6%
CO₂:C conversion: x 3.6663

Woodland biomass data courtesy Woodland Carbon Code/Forestry Commission
https://www.woodlandcarboncode.org.uk

Cumulative CO₂e capture to 2100 in MtCO₂e

Trees are for illustration only with different yield class, spacing and debris removal rates

Woodland biomass data courtesy Woodland Carbon Code/Forestry Commission
https://www.woodlandcarboncode.org.uk
Kelp farm & forest carbon fixing profiles

CO₂e fixed per decade in MtCO₂e

Woodland biomass data courtesy Woodland Carbon Code/Forestry Commission
Impacts

EA Region CO2 budget offsets from kelp and forest based on 2030 new wind farm area

Trees planted = 155,625,777
Carbon credit value = £491 million

1 University of Manchester, Tyndall Centre, 2021. Setting Climate Commitments for East Anglia. Generated by SCATTER.
2 Based on 2022/23 price on UK ETS of £18/tCO2
Thank you

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Multipurpose added value

Offshore wind farms as instruments for energy, nature regeneration & carbon capture
## Supporting analysis

**New wind farms under development by 2030 in EA region**

<table>
<thead>
<tr>
<th>Name</th>
<th>Capacity MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hornsea Project 2</td>
<td>1400</td>
</tr>
<tr>
<td>Hornsea Project 3</td>
<td>2400</td>
</tr>
<tr>
<td>Hornsea Project 4</td>
<td>100</td>
</tr>
<tr>
<td>Triton Knoll</td>
<td>857</td>
</tr>
<tr>
<td>Norfolk Vanguard</td>
<td>1800</td>
</tr>
<tr>
<td>Norfolk Boreas</td>
<td>1800</td>
</tr>
<tr>
<td>East Anglia One</td>
<td>714</td>
</tr>
<tr>
<td>East Anglia Two</td>
<td>900</td>
</tr>
<tr>
<td>East Anglia Three</td>
<td>1400</td>
</tr>
<tr>
<td><strong>TOTAL CAPACITY</strong></td>
<td><strong>11371</strong></td>
</tr>
</tbody>
</table>

Total area occupied by new EA regional wind farms = 3790 km$^2$ @ 3 MW/km$^2$

~ area of Suffolk
Building a sustainable seaweed Biorefinery
History of seaweed enriching soils

1912 - 1950s: Chase Cloches
1950s onwards: Seaweed extracts.... From 1990s produced by Biotechnica!
Present focus on Extracts
Present focus on Extracts

- Seaweed extracts, microbials, bioadjuvants
- $2.5 billion 2020 (Allied Market Research 2021) CAGR 10%

- A plant biostimulant is any substance or microorganism applied to plants with the aim to enhance nutrition efficiency, abiotic stress tolerance and/or crop quality traits, regardless of its nutrients content

- Why?
  - Fertilizers: expensive, environmentally damaging. REDUCE fertilizer use with biostimulants (improve uptake efficiency)
  - Improve plant resilience to abiotic stress e.g. drought, high temperature. More frequent with climate change.
  - Improve soil health, more CO₂ capture through microbes and healthier plants
Limited sustainability with wild harvestings
Future is Cultivation
But holistic and scaleable processing required

- Seaweed cultivation need scale to be economically viable.
- Wild harvest around £1.30 per kg dried vs £5 per kg dried cultivated.
- Further applications need to be developed for by-products
  - For each 4 tons of seaweed processed, only around 1 ton is used.
  - Spent material will increase dramatically with scale
  - This requires new industries
  - Typical examples are biopolymers
  - New fibre related products to be formulated
Global seaweed market

- $14 billion, CAGR 7.5% - Fortune Business Insights 2021
- Food, animal feed, fertilizers, cosmetics, pharmaceuticals and nutraceuticals
- Key Opportunity: Use of advanced techniques to scale up cultivation
- Biorefinery required to balance valuable products in small quantities to less valuable but in large quantities (e.g., biopackaging).