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

Rikke Nagell-Kleven
Innovation Advisor

rnagell-kleven@hethelinnovation.com

Hethel Innovation

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

14.1
Billion USD global commercial seaweed market (2020)

31.2
Million tonnes produced each year

95%
Seaweed produced by farming

291
Seaweed species commercially farmed

UK Seaweed Industry

~10
Commercial seaweed farms

~74
Seaweed related businesses

69%
Seaweed produced by wild harvest

~33%
Businesses with food & drink as the target market

19%
Businesses targeting the beauty industry

13%
Businesses producing nutraceuticals

Why the Focus on Seaweed in East Anglia?

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

Hethel Innovation

Thank You!

RNAGELL-KLEVEN@HETHELINNOVATION.COM

01953 859100

@Hethel-Innovation | @Rikke-Nagell-Kleven

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

Gill Malin

Reader in Biological Oceanography

School of Environmental Sciences

g.malin@uea.ac.uk

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Algae = Microalgae + Macroalgae/Seaweeds

Algae are hugely variable

Diverse evolutionary origins.

Size range: *Prochlorococcus* 0.5 μm
Ostreococcus 1μm
Macrocystis 60 m

Most are photosynthetic

$CO_2 + H_2O +$ *light* $\rightarrow CH_2O + O_2$
+ 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

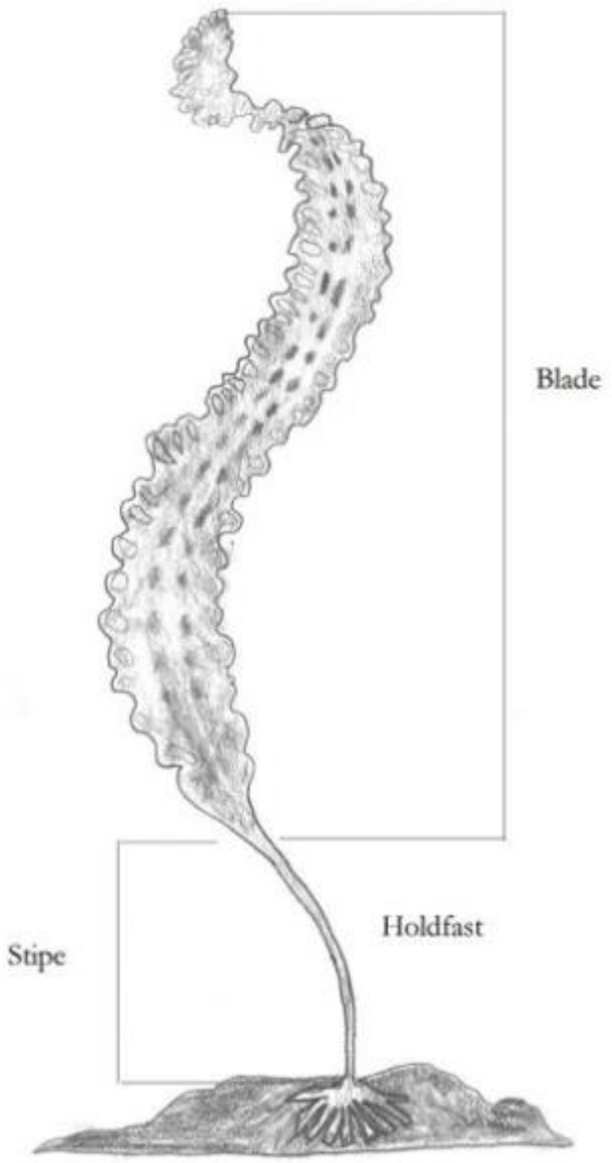
Green
(~1500 species)
Ulva lactuca
Chlorophyceae
Sea lettuce

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

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



Producing algal biomass

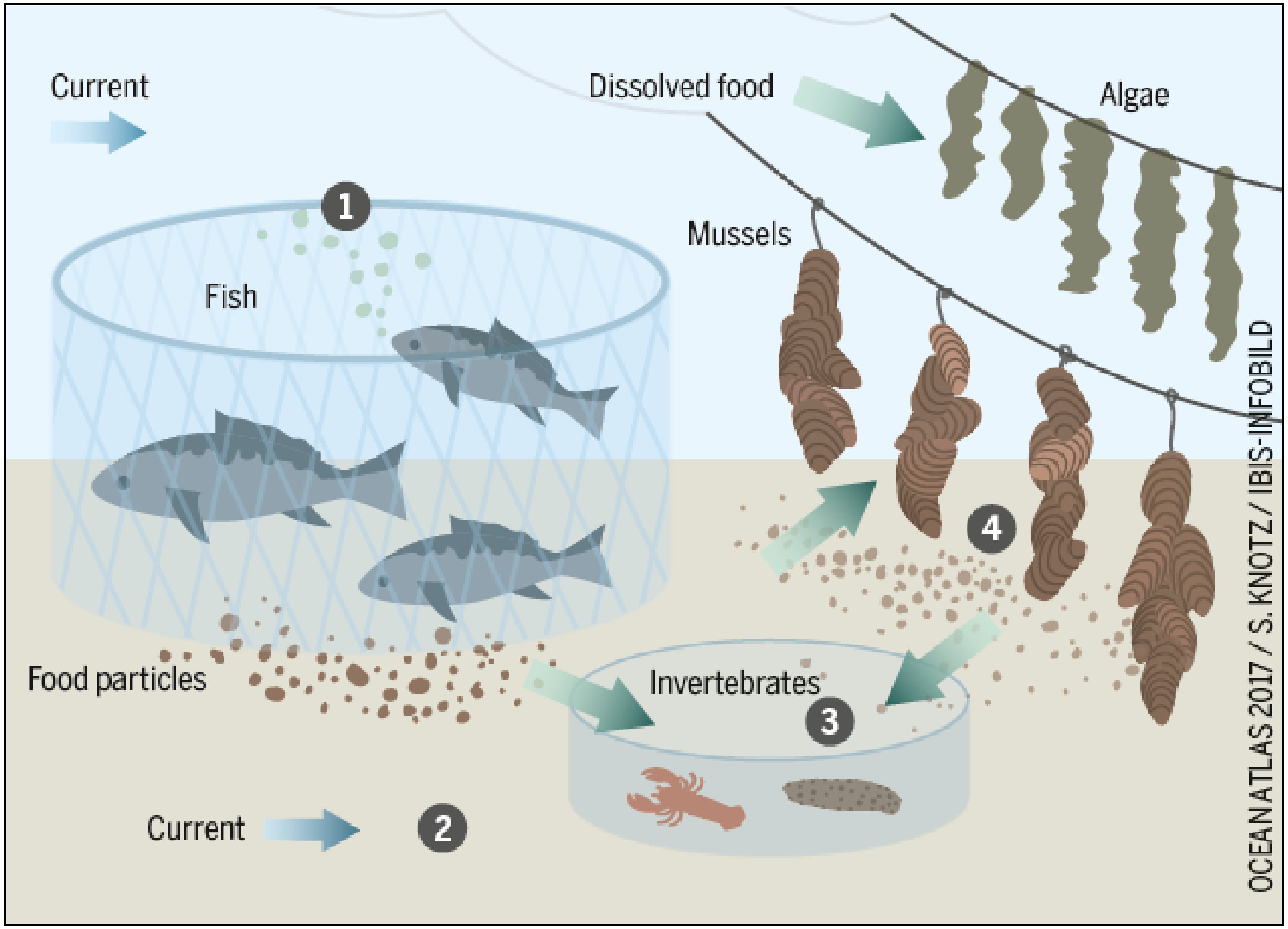
Small scale, fixed off-bottom, peg and line farming of *Eucheuma denticulatum and Kappaphycus alvarezii* in Tanzania, East Africa.

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

Outdoor tank / tumble culture of *Palmaria palmata* (Dulse), Oregon

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

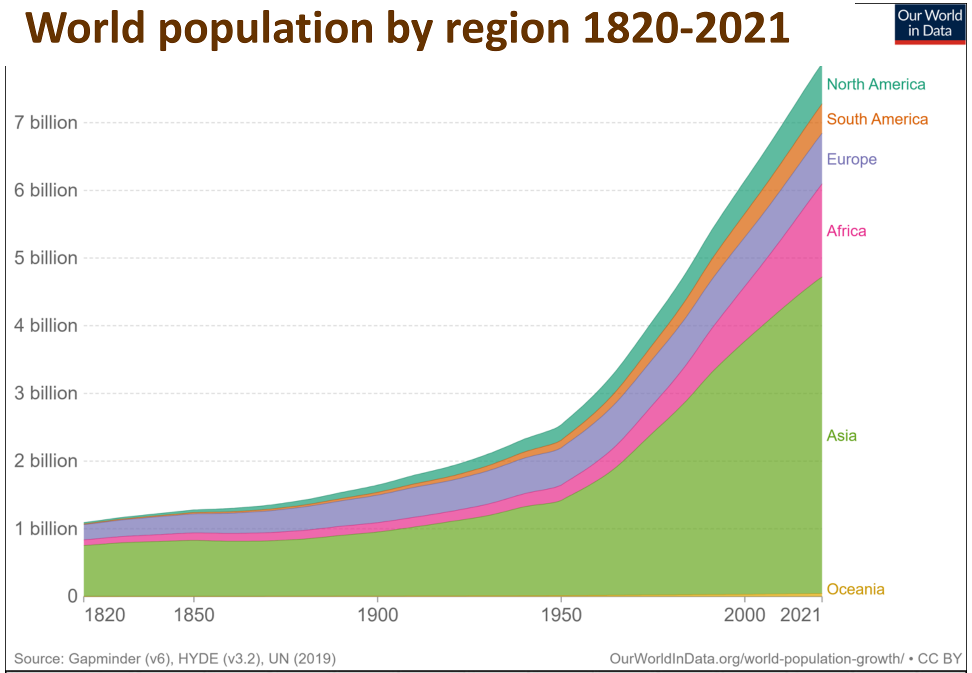
Integrated multi-trophic aquaculture (IMTA)

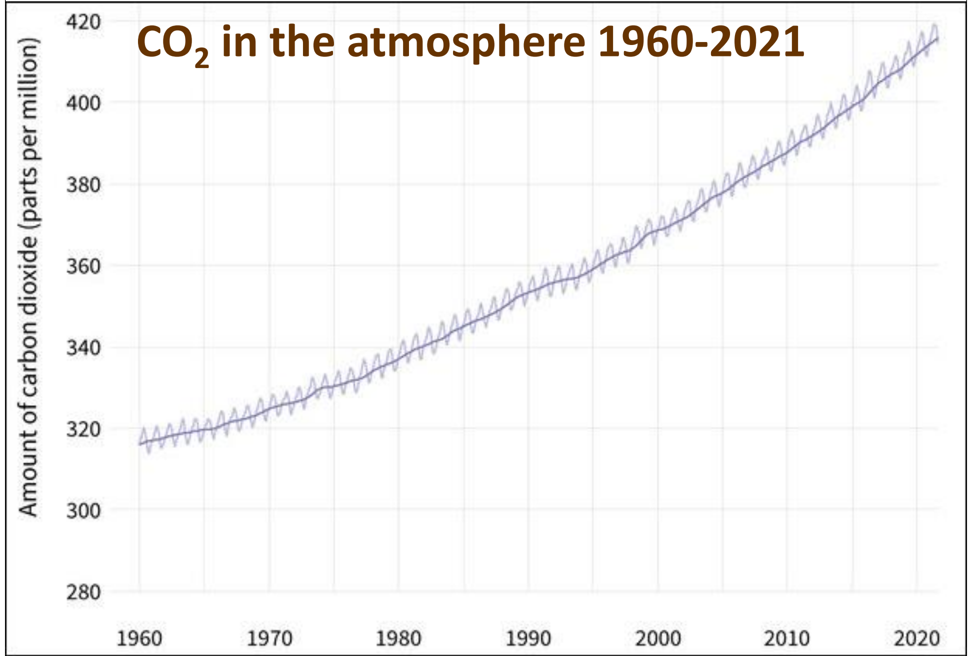


Waste from production of fish and shellfish becomes food or fertiliser for production of other species.

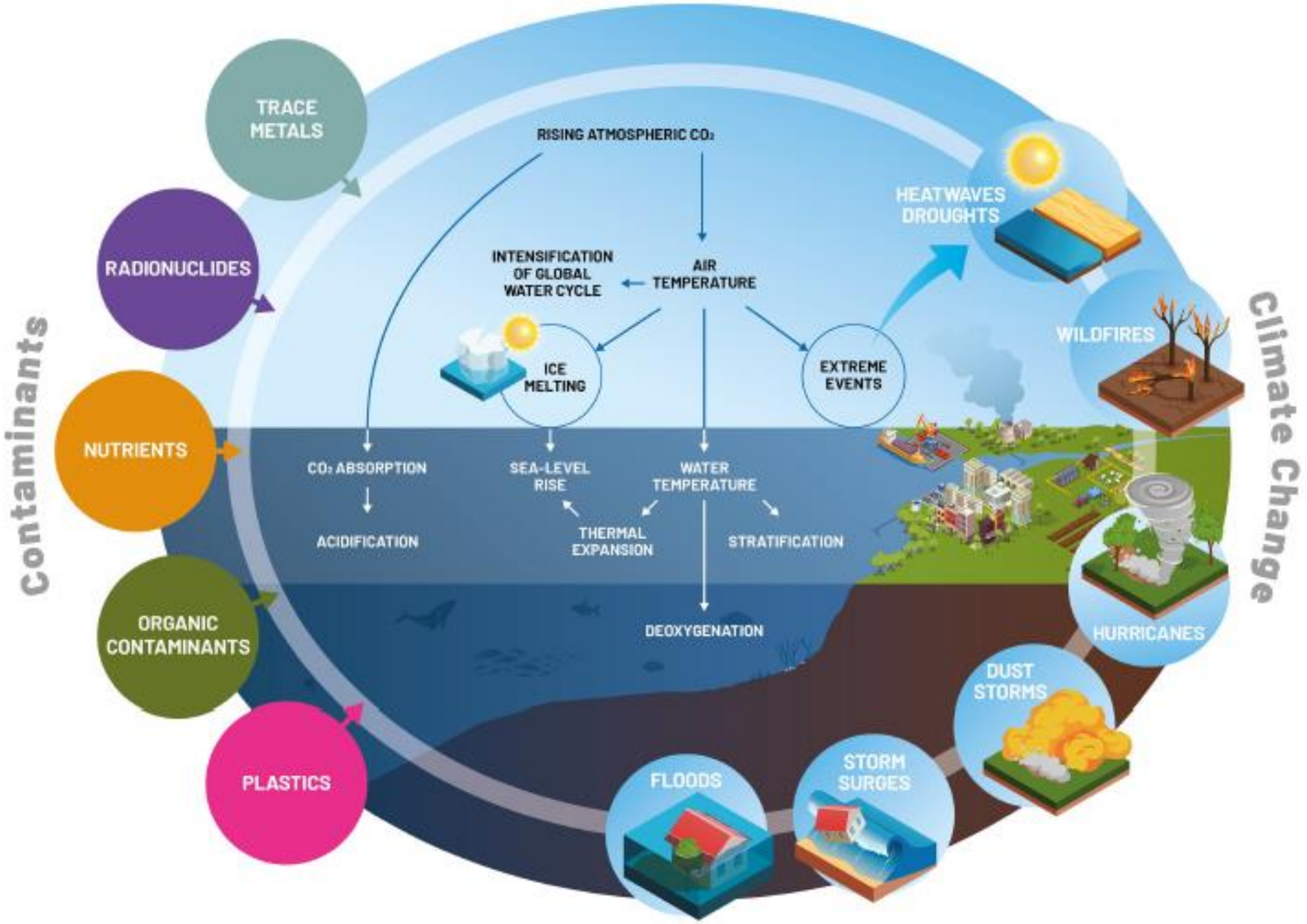
Time of unprecedented change

World population by region 1820-2021





Hatje et al Emergent interactive effects of climate change and contaminants in coastal and ocean ecosystems. Front. Mar. Sci. 2022

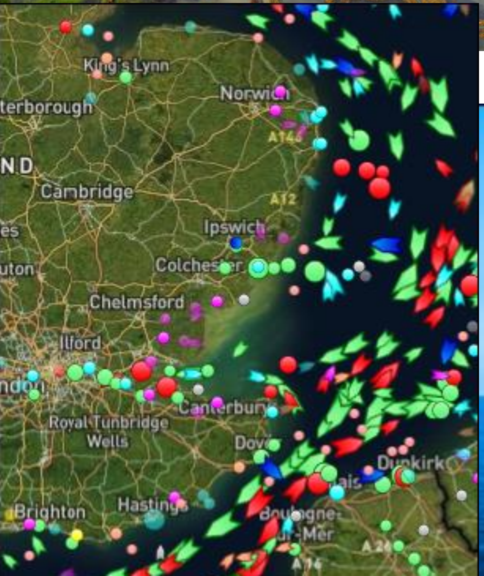


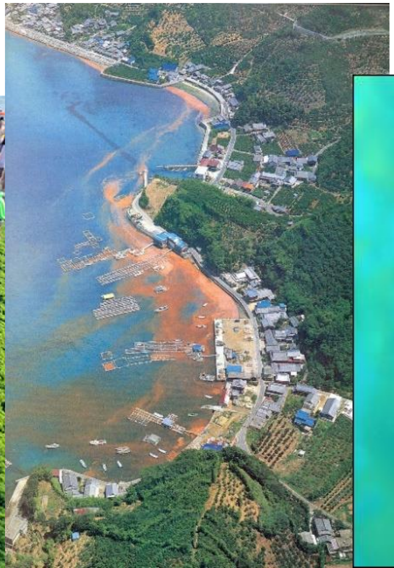
www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide

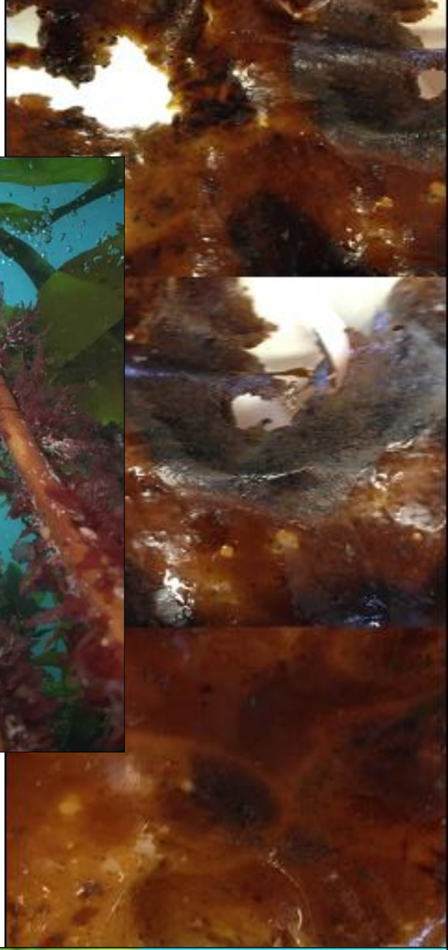
UN Goals for the 17 big challenges we face

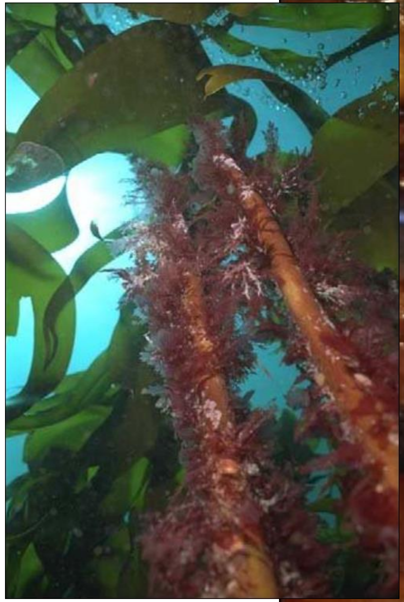
Potential but challenges.....

- 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









Gill Malin

g.malin@uea.ac.uk

UEA
University of East Anglia

COAS
Centre for Ocean and Atmospheric Sciences

CCSUS
Collaborative Centre for Sustainable Use of the Seas

MKEN
MARINE KNOWLEDGE EXCHANGE NETWORK

British Phycological Society
Understanding and using algae

NORFOLK SEAWEED

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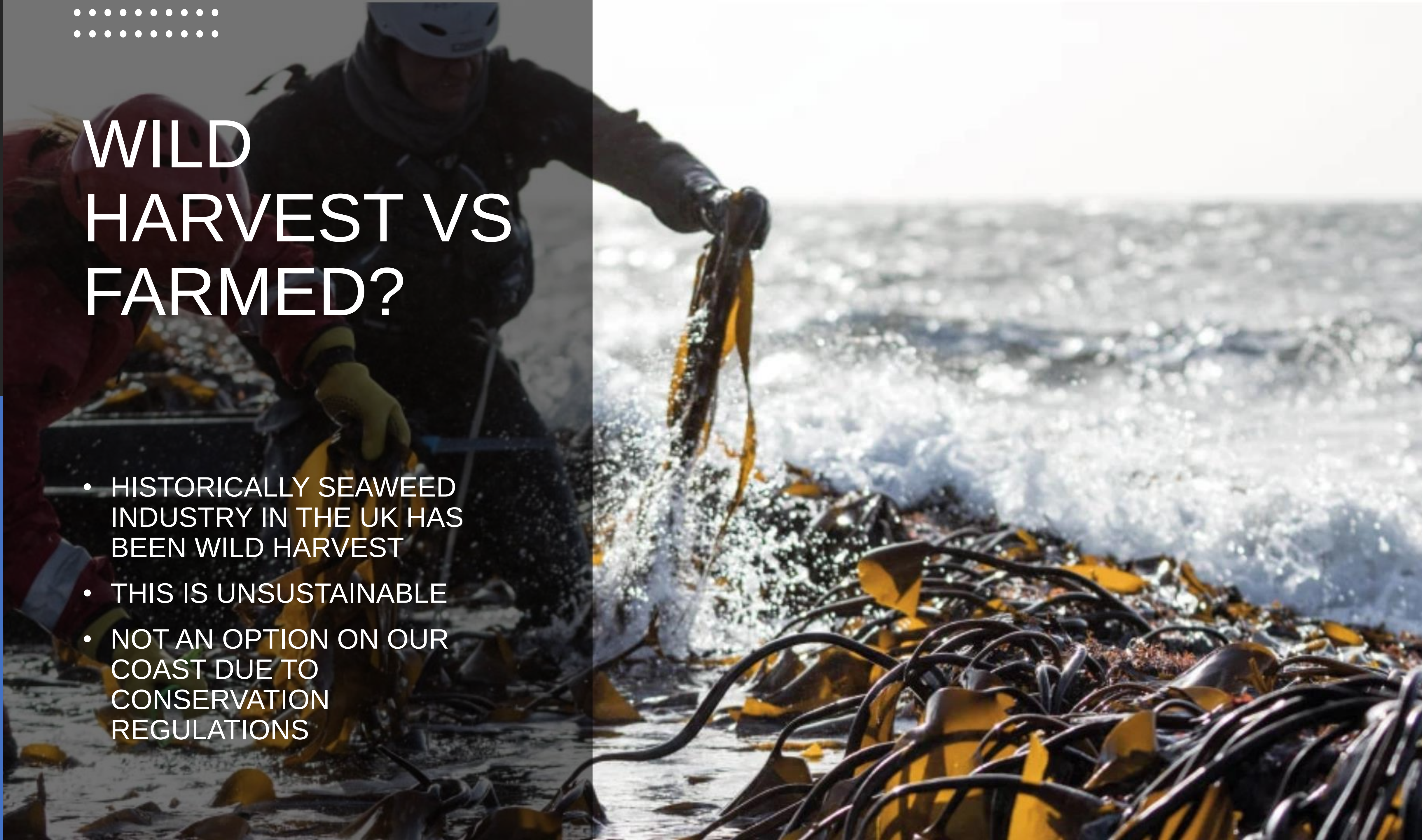
THE OCEAN FARMER'S PERSPECTIVE

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

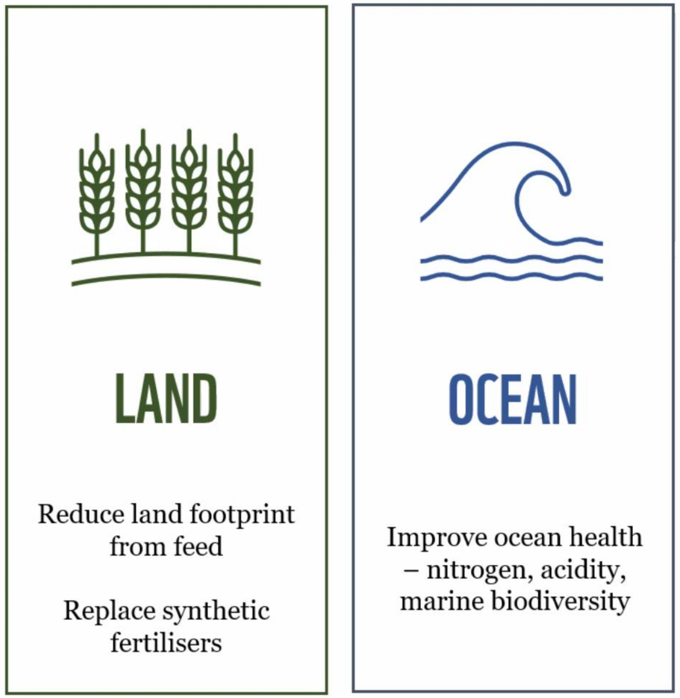
Provide a healthy, sustainable food ingredient

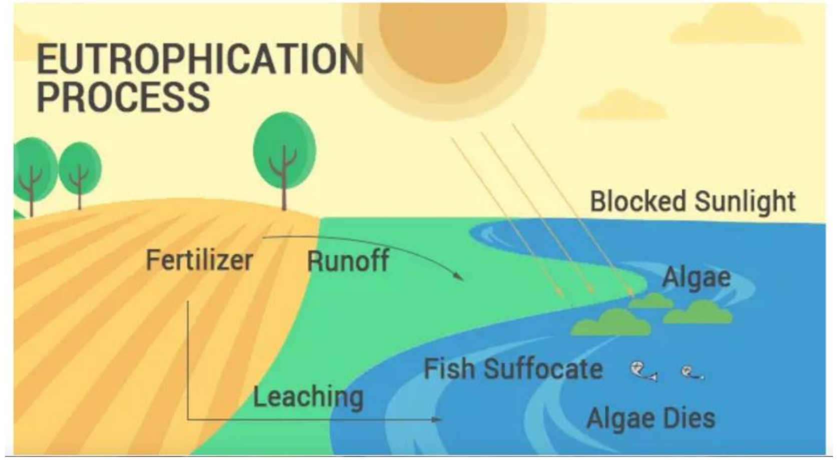
REPLACES SYNTHETIC FERTILISERS .

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

IMPROVES OCEAN HEALTH

COMBATS EUTROPHCATION PROCESS





COASTAL DEVELOPMENT

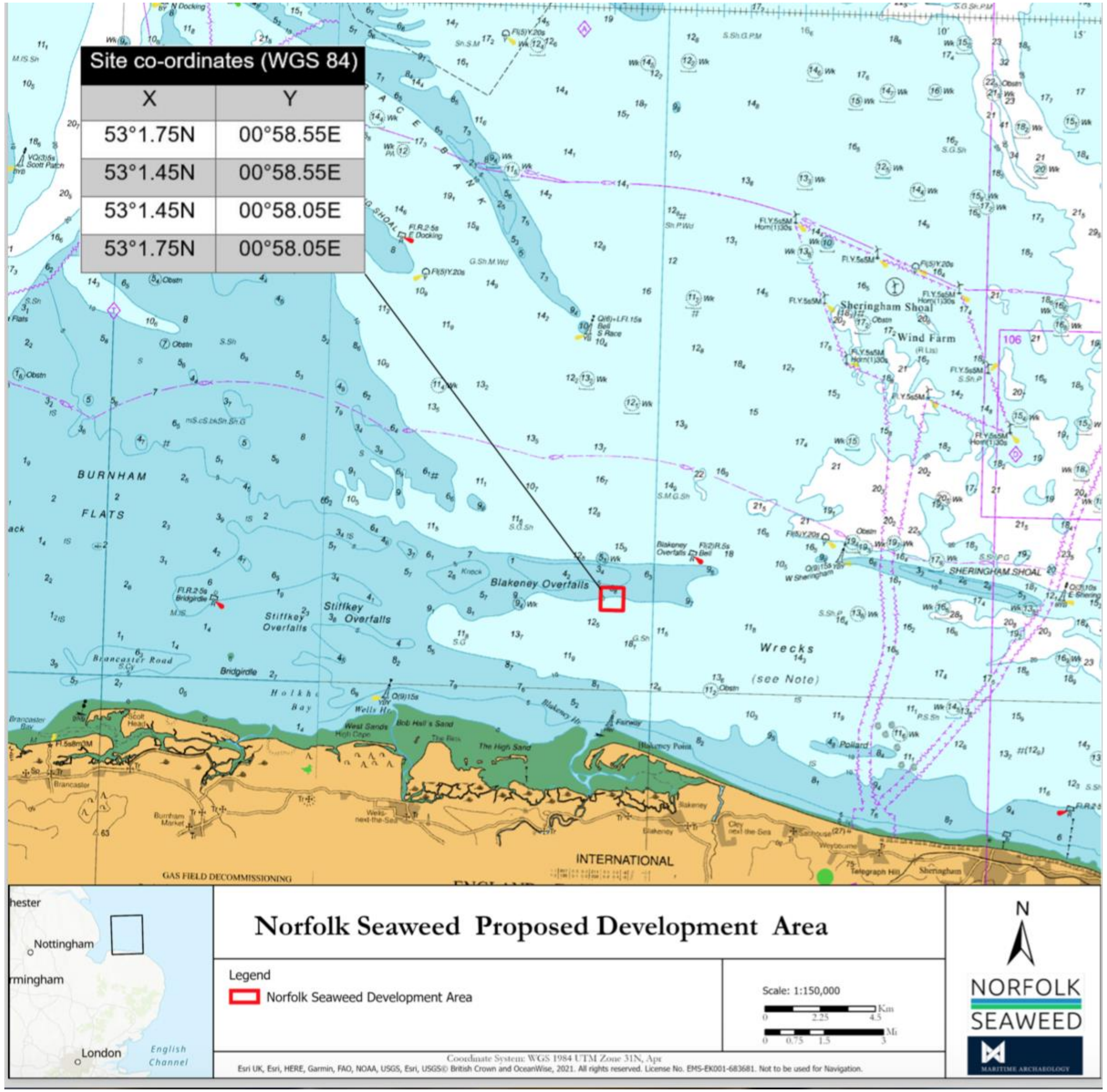
- CREATING A REGENERATIVE, SUSTAINABLE, SCALABLE BLUE ECONOMY BUSINESS WHICH PROVIDES JOB OPPORTUNITIES FROM THE HARD WORK AT SEA, TO THE FACTORY FLOOR, IN THE HATCHERY TO PhD LEVEL BIOCHEMISTRY.
- WORKING WITH THE EXTRACTIVE FISHING INDUSTRY TO TRANSFER SKILLS

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.

NORFOLK SEAWEED

WHERE WILL THE FARM BE?

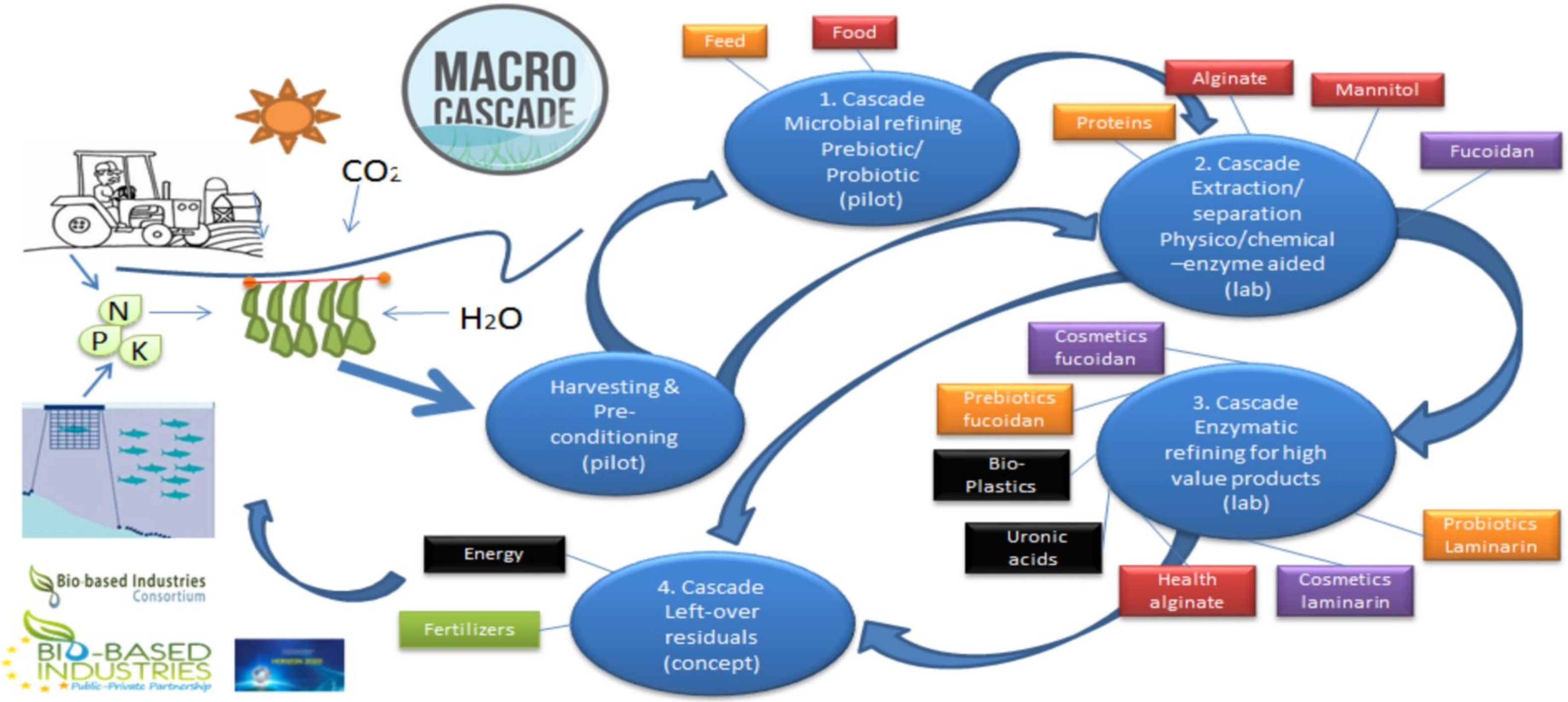


Site co-ordinates (WGS 84)	
X	Y
53°1.75N	00°58.55E
53°1.45N	00°58.55E
53°1.45N	00°58.05E
53°1.75N	00°58.05E

HOW DOES THE FARM WORK

TECH CHAIN FOR PROCESSING SEAWEED.

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

www.norfolkseaweed.com

willie@norfolkseaweed.com

01328 710003 / 07871823002

NORFOLK SEAWEED

Carbon dioxide removal potential from wind and kelp farm colocation in the Southern North Sea

Dr. Nigel Hargreaves

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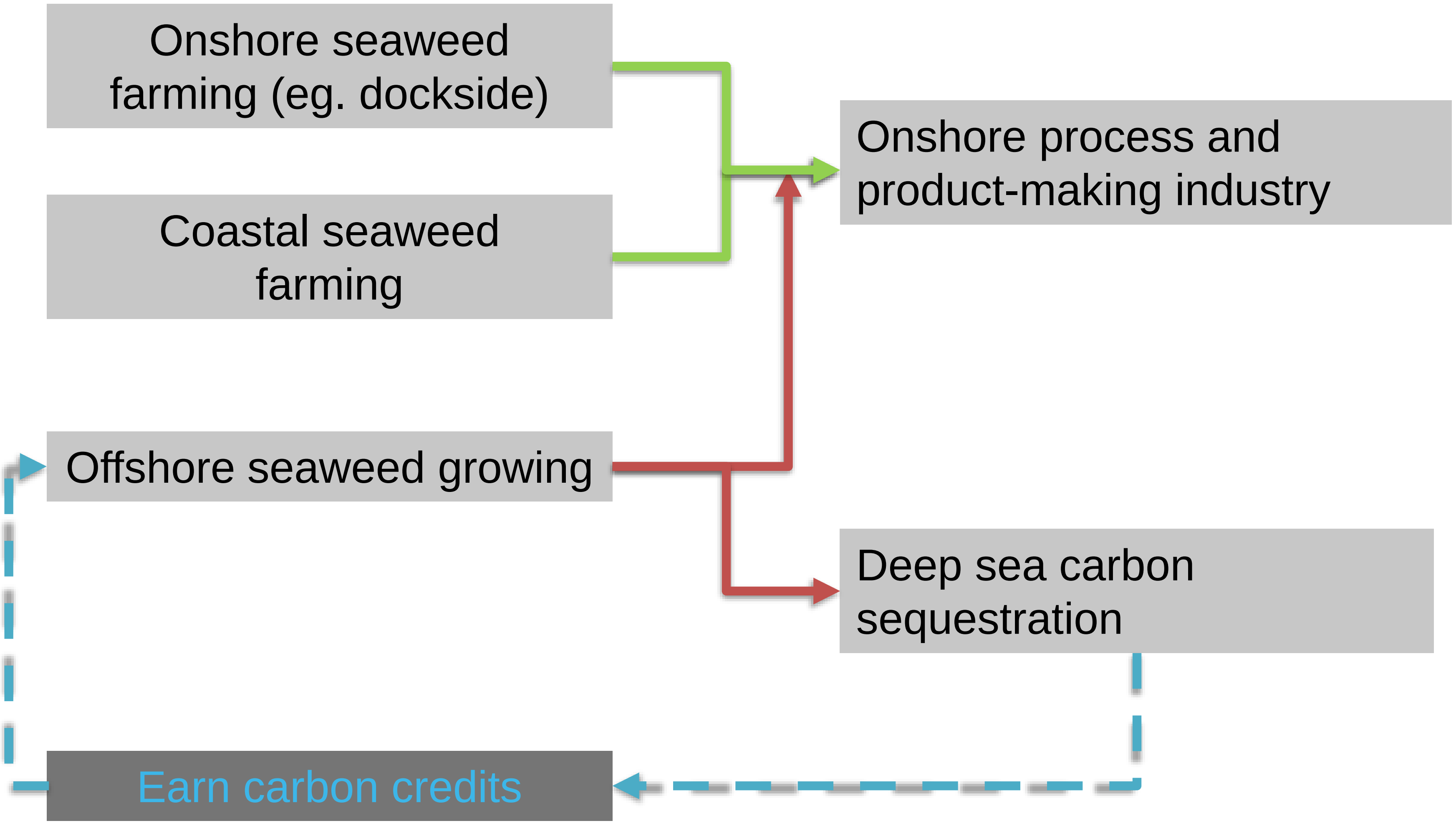
Sustainable coastal ecosystems and opportunities for regional development

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

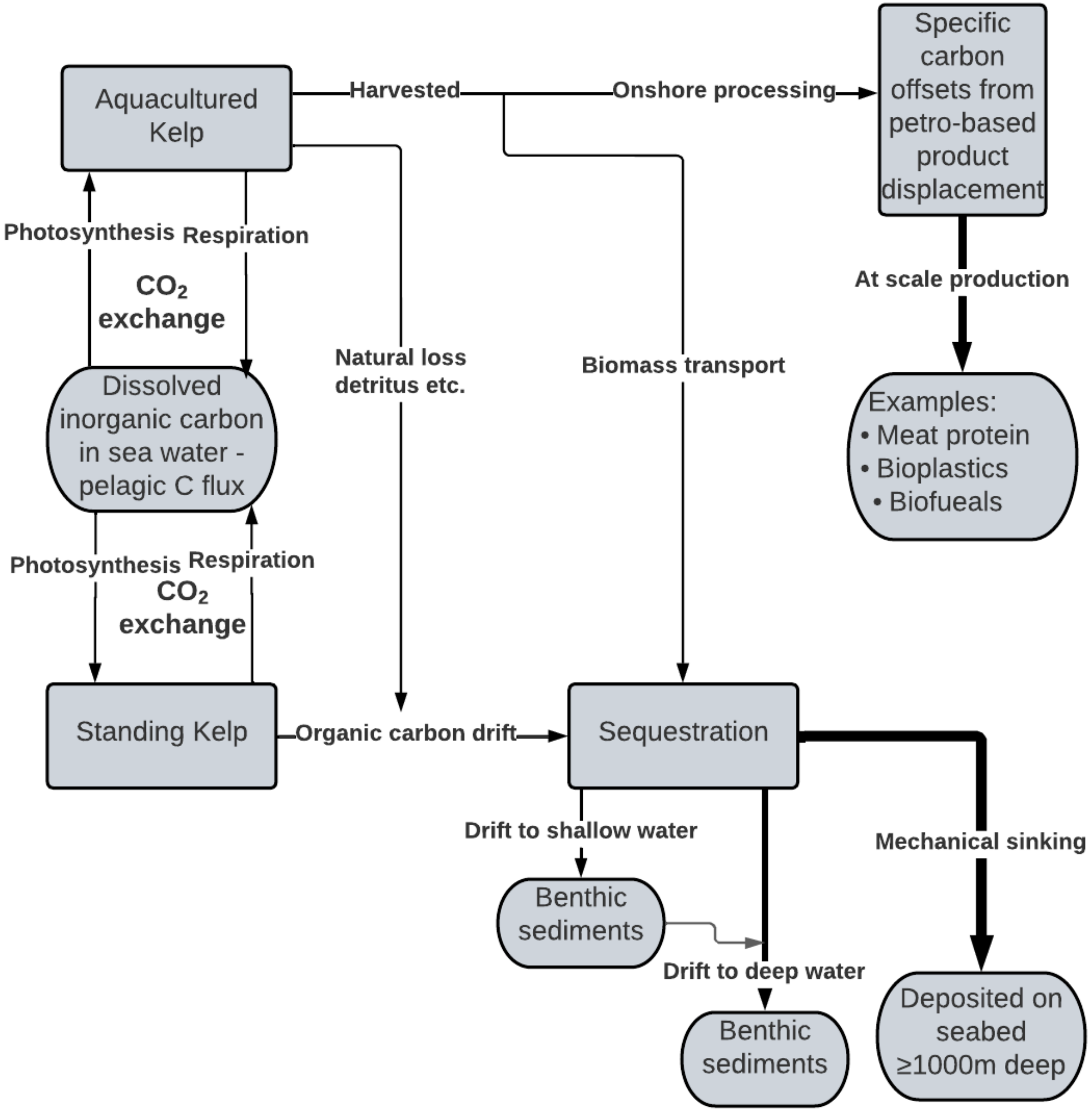
www.synfo.co.uk nigel@synfo.co.uk

Principal seaweed production pathways

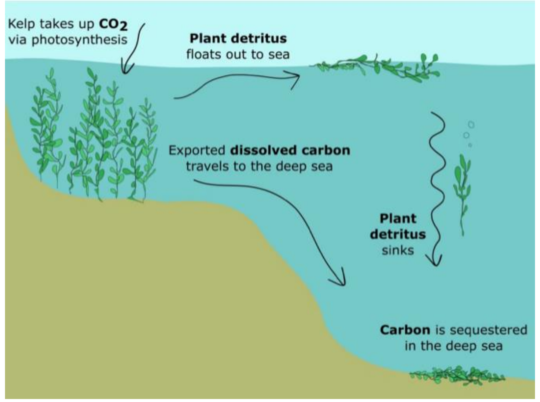


Synfo

Carbon capture & sequestration pathways



Natural Kelp carbon is sequestered in deep sea benthic sediments. We need to explore other ways.



Synfo

Growing kelp vs forest at scale

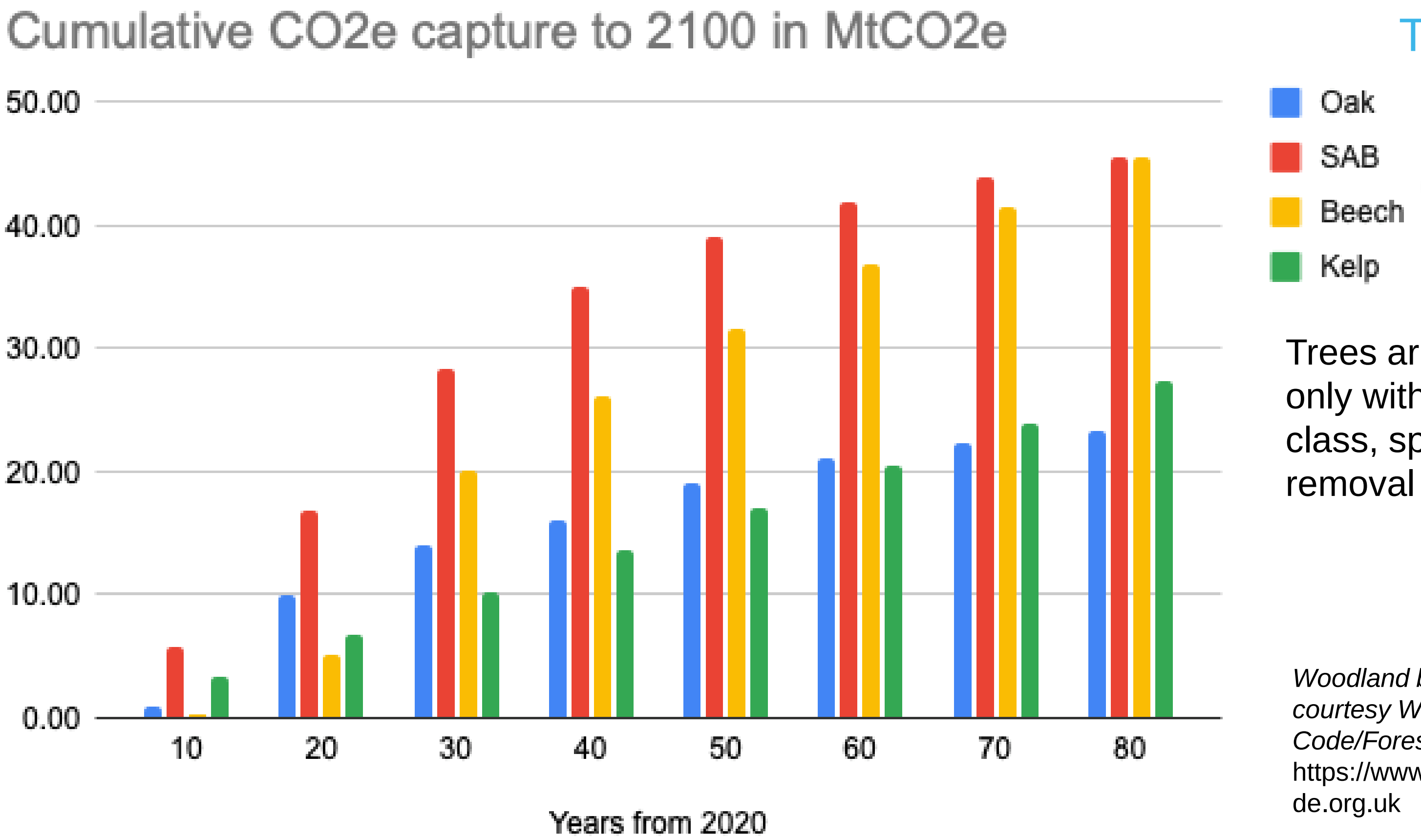
- 9 New wind farms by 2030
- Total capacity 11.3GW
- Power density 3MW/km^2
- Area = 3,800km^2 or, the size of Suffolk
- Estimate growing area of 10% & 20%
- = 380km^2 and 760km^2

- 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

Saccharina Latissima

Kelp -
Farm size: 380 km^2
Line spacing: 1.5m
Yield: 10kg/m^2
DW:WW ratio: 12%
DW C content: 30.6%
CO_2:C conversion: x 3.6663



Totals $MtCO_2$

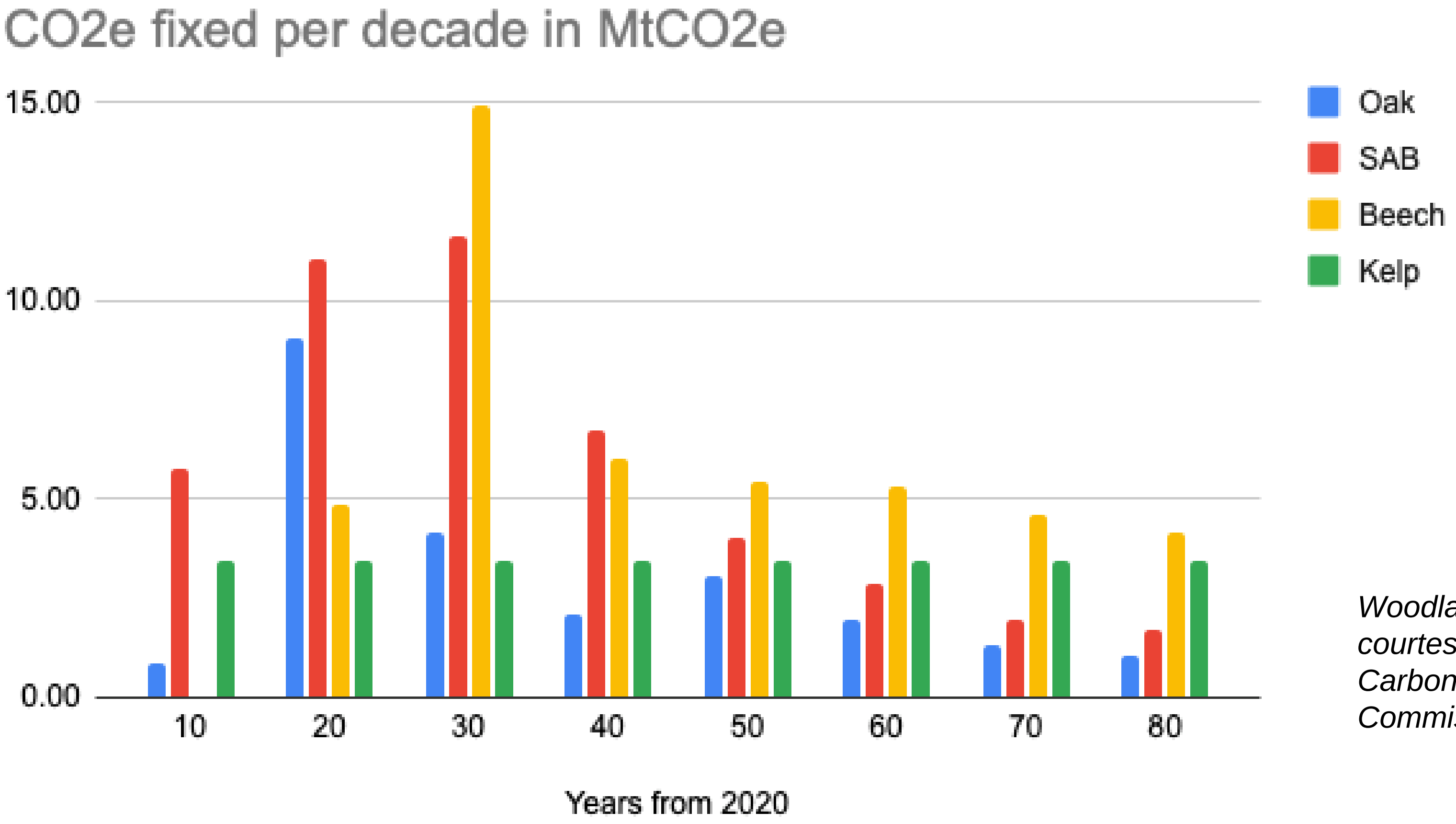
23.32
45.61
45.60
27.28

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

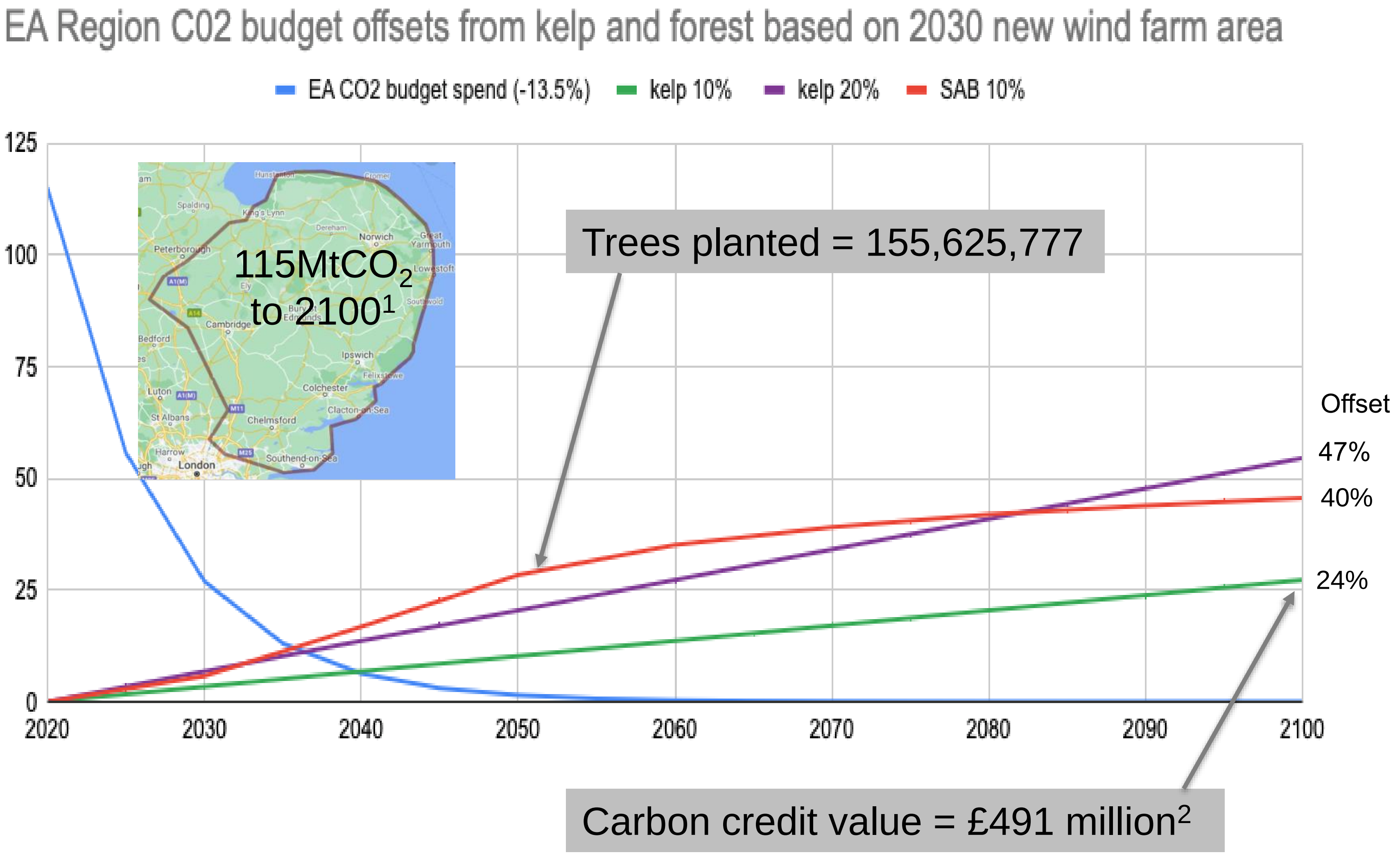
Kelp farm & forest carbon fixing profiles

Saccharina Latissima



Woodland biomass data courtesy Woodland Carbon Code/Forestry Commission

Impacts



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/tCO_2

Thank you

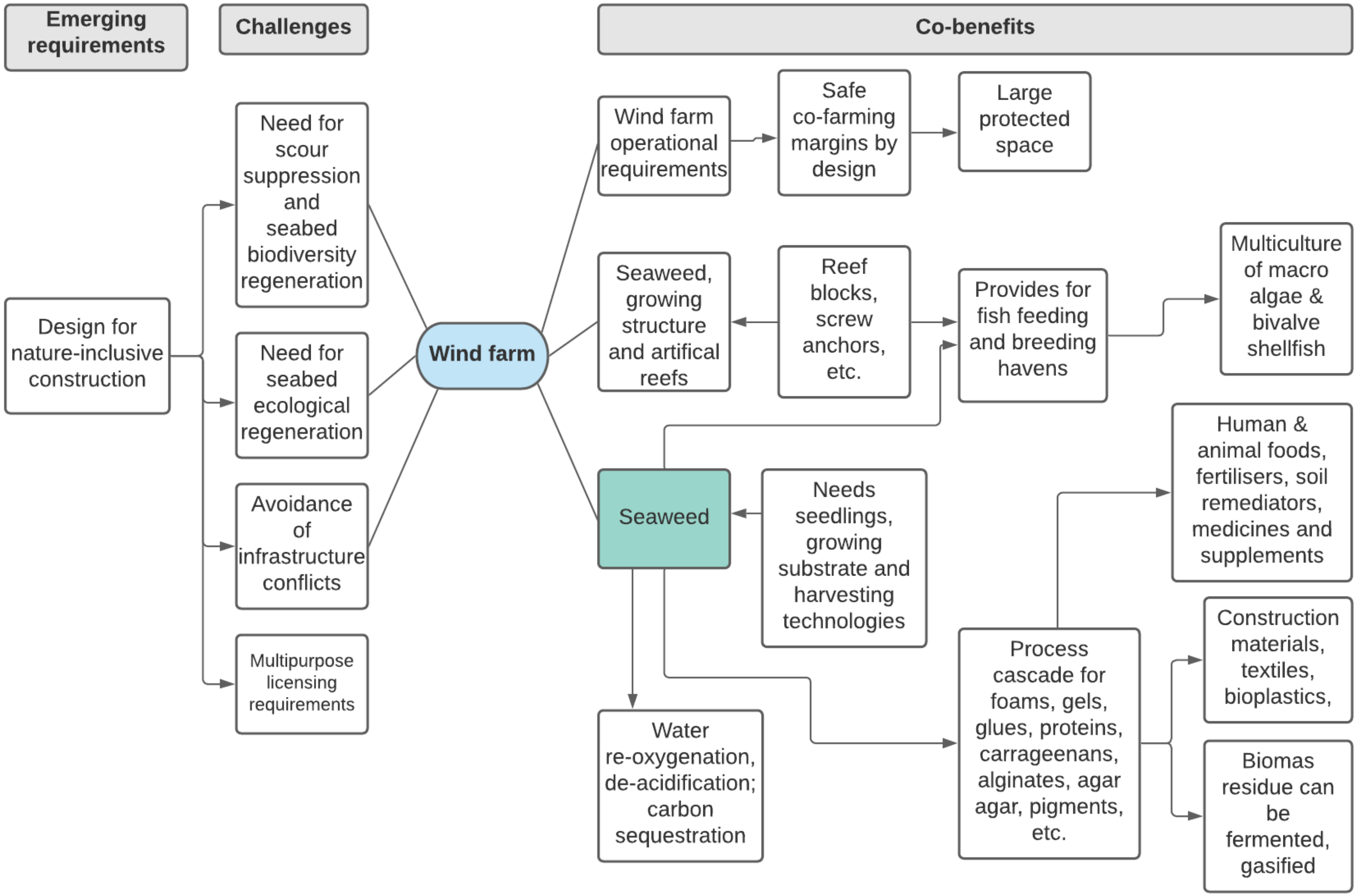
Contact -
Dr. Nigel Hargreaves CEng MIET

nigel@synfo.co.uk

07503 284 068

Multipurpose added value

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



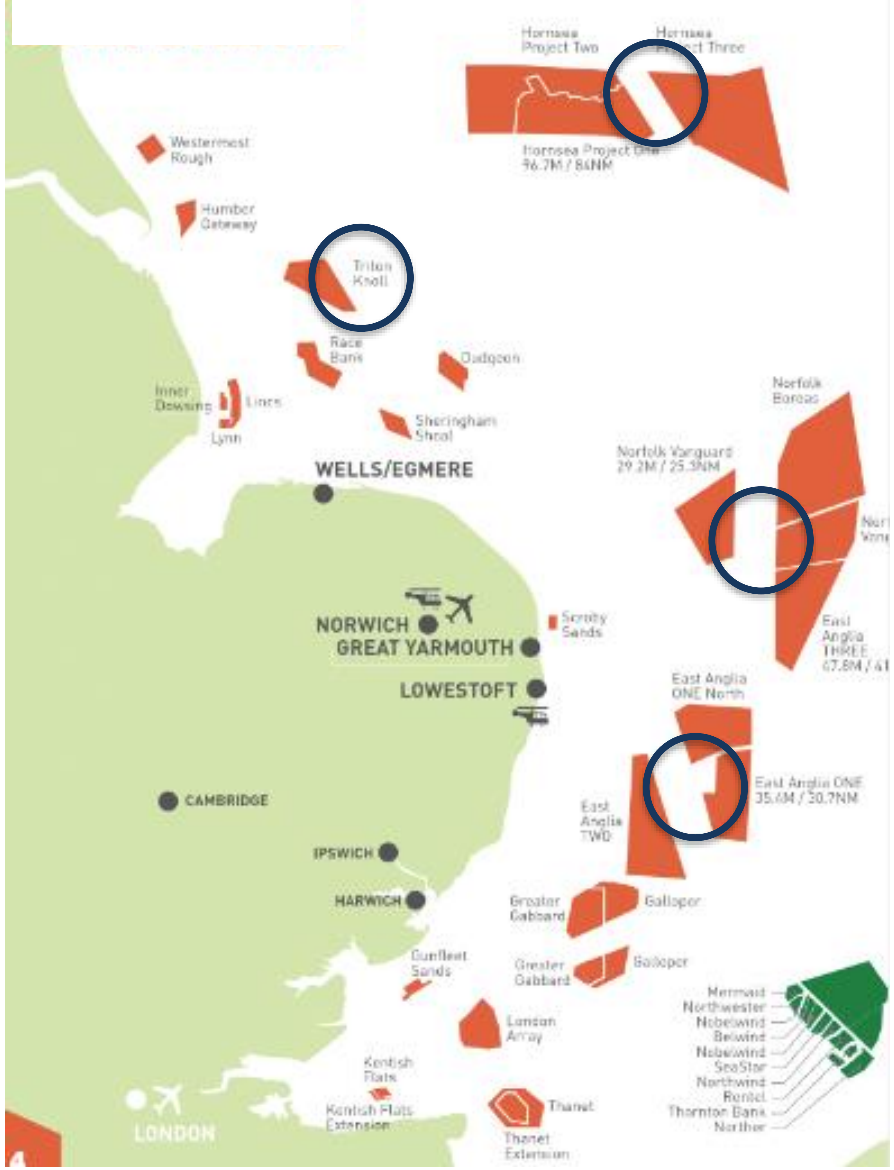
Supporting analysis

New wind farms under development by 2030 in EA region

Name	Capacity MW
Hornsea Project 2	1400
Hornsea Project 3	2400
Hornsea Project 4	100
Triton Knoll	857
Norfolk Vanguard	1800
Norfolk Boreas	1800
East Anglia One	714
East Anglia Two	900
East Anglia Three	1400
TOTAL CAPACITY	11371

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

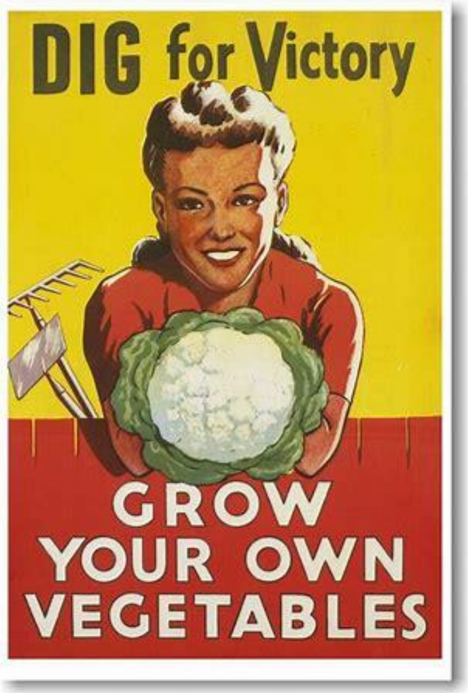
≈ area of Suffolk

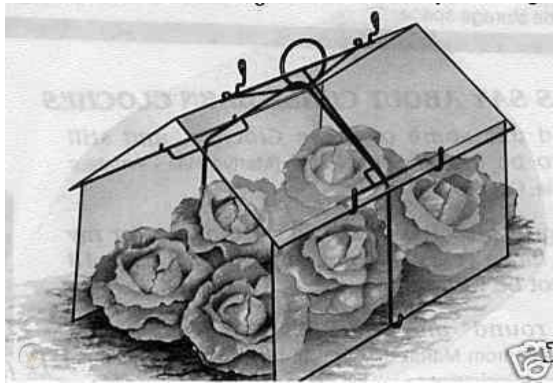


biotechnica

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

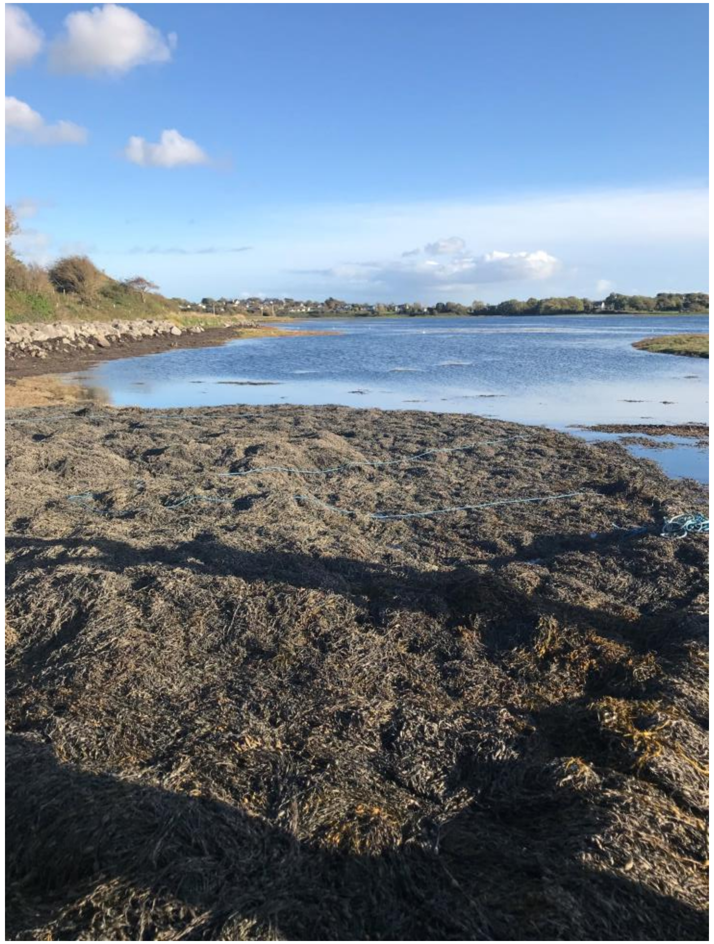
Present focus on Extracts

- 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 CO_2 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 (eg biopackaging).