Seaweed and seaweed components as novel protein sources in animal diets

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Paul Bikker, Marinus van Krimpen, Arjan Palstra, Willem Brandenburg, Ana López-Contreras, Sander van den Burg

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Background and problem

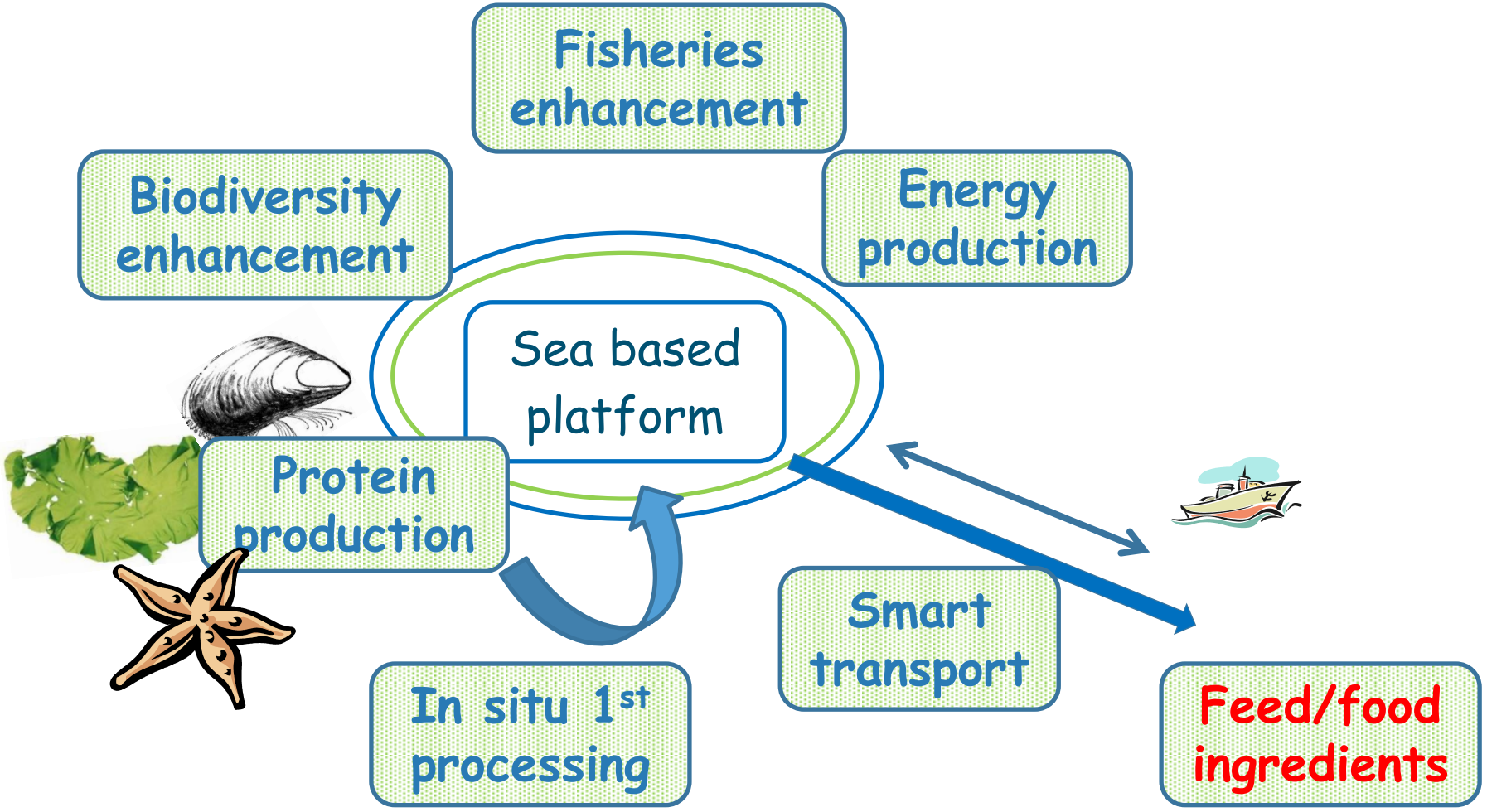
- Increasing world population
- Increasing demand for food, feed and non-food
- Scarcity of resources
- Increasing pressure on land use

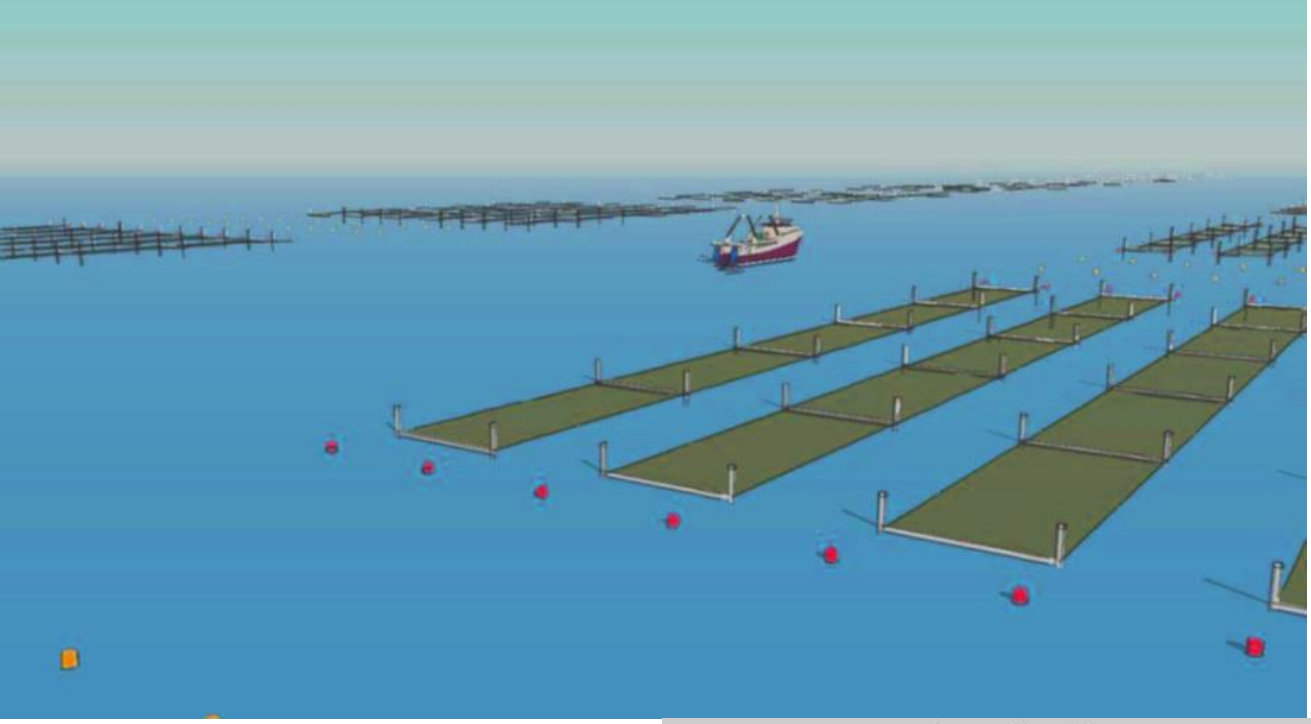
→ Potential for sustainable marine production

Challenge

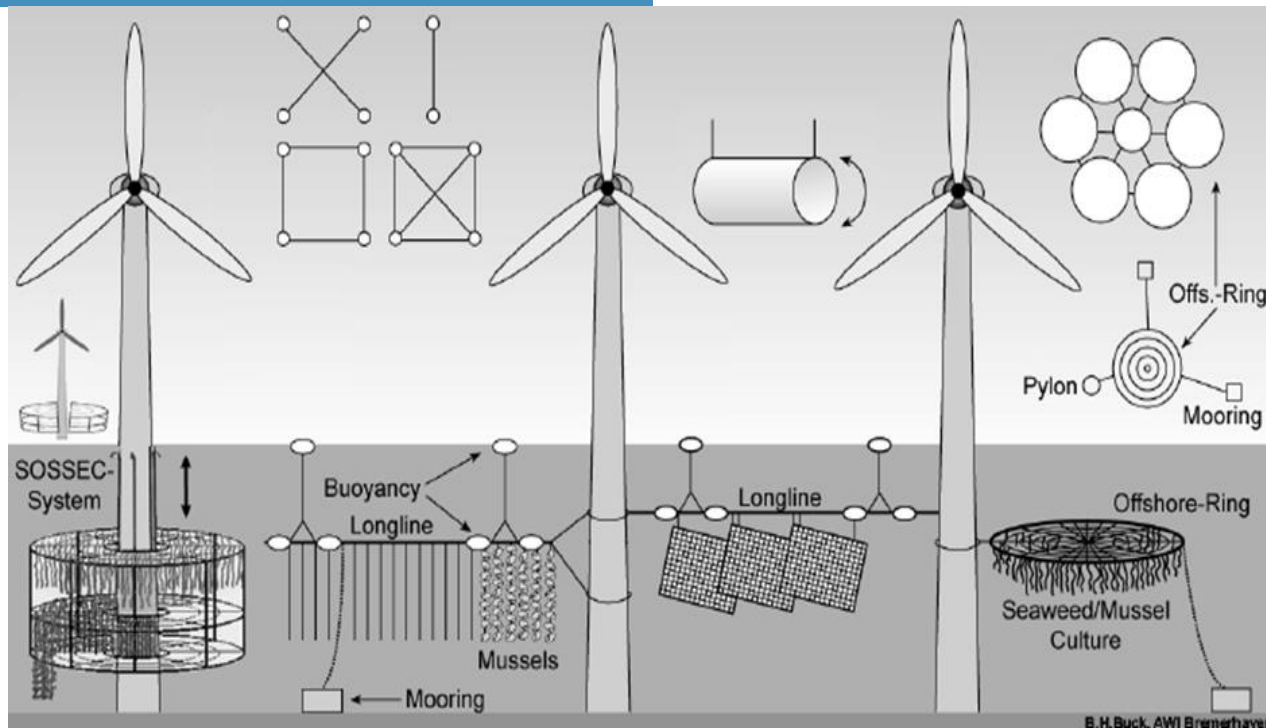
How to develop integrated sustainable marine production of food, feed and non-food (biofuel / chemicals) in the North Sea

MUPs North Sea





- Concepts of platforms



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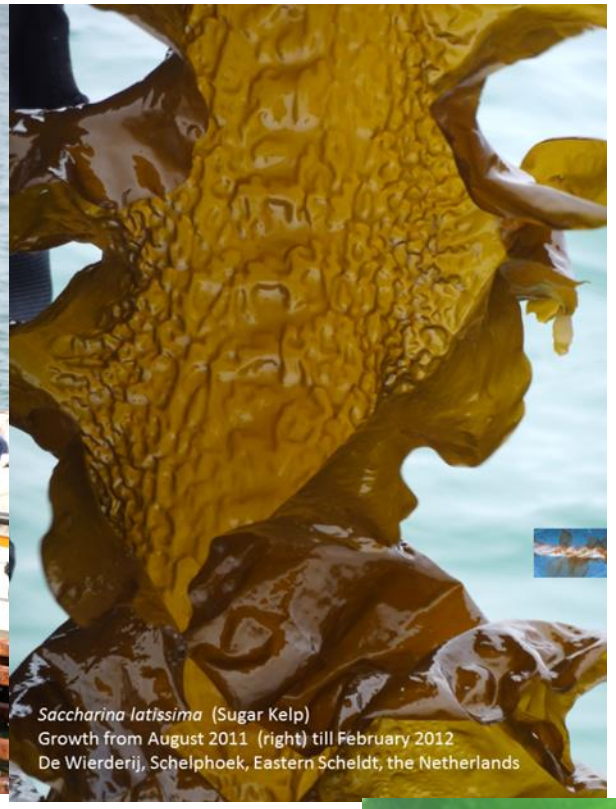
Simplified classification of seaweeds

Phylum	Common name	# of species	Examples
Phaeophyta	Brown algae	1500 – 2000	Ascophyllum Fucus: kelp **Laminaria digitata**: Finger kelp **Saccharina latisima**: Sugar kelp Sargassum: hijiki a.o. Undularia
Rhodophyta	Red algae	4000 – 10000	Chondrus Gelidium: agar Gracilaria: agar **Palmaria palmata**: dulse Polysiphonia Porphyra: laver, nori
Chlorophyta	Green algae	7000	Caulerpa: sea grape Cladophora **Ulva lactuca**: sea lettuce

Bold: applicable for cultivation in the North Sea

Laminaria



Saccharina

Palmaria

Ulva

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Composition of selected seaweeds, g/kg DM

Group:	Brown algae		Red algae		Green algae	
Genera:	Laminaria/Saccharina		Palmaria		Ulva	
	HK	LC	HK	LC	HK	LC
DM, %	6-27	–	16	–	20-22	–
Ash	150–450	270–363	120–270	190	110–550	194
CP[1]	30–210	108–124	80–350	178	40–440	235
Cfat	3–21	47–96	2–38	83	3–16	28
CHO	380–610	–	380–660	–	150–650	–
Sugars	–	145–176	–	405	–	113
Other CHO	–	240-430	–	140	–	450

(HK, Holdt and Kraan, 2011;

LC, Lopez-Contreras et al., 2012)

Past experience, literature 1940-1980

- Seaweed use in animal diets in coastal regions (Norway, Ireland, UK, France
- Up to 10% in diets for cattle, horses, poultry
- Mainly Ascophyllum nodosum, wild populations
- Norway: feeding value of 1 kg meal ~0.65 → 0.3 FU
- Low CP digestibility (fibre and phenolic compounds)
- No sound information on feeding value
- Studies with seaweed supplements difficult to interpret

Studies in pigs

- Complete seaweed
  - Limited information, low feeding value
  - In vitro Bosch et al., 2013 (next)

- Seaweed residue (Whittemore and Percival, 1975)
  - Low digestibility of A. nodosum residue after alginate extraction (50% inclusion!)
  - Diarrhoea in pigs
    - Carbohydrate (30% sulphated glucuronoxylofucan)
    - Phenolic residues
    - High mineral content

In vitro digestibility of Ulva lactuca

Table 1. Chemical composition of substrates (% of DM)[1].

Substrates	DM (%)	Ash	CP	Cfat	CHO
Sea lettuce	84.5	22.5	12.3	0.5	64.8
SBM	88.3	6.9	51.6	2.5	39.0

[1]DM, dry matter; CP, crude protein; Cfat, crude fat; CHO, carbohydrate; SBM, soybean meal.

Table 2. *In vitro* digestibility of substrates (%)[1].

Substrates	DM	OM	CP
Sea lettuce	53.6	57.7	67.4
SBM	79.2	80.6	94.7

[1]DM, dry matter; OM, organic matter; CP, crude protein; SBM, soybean meal.

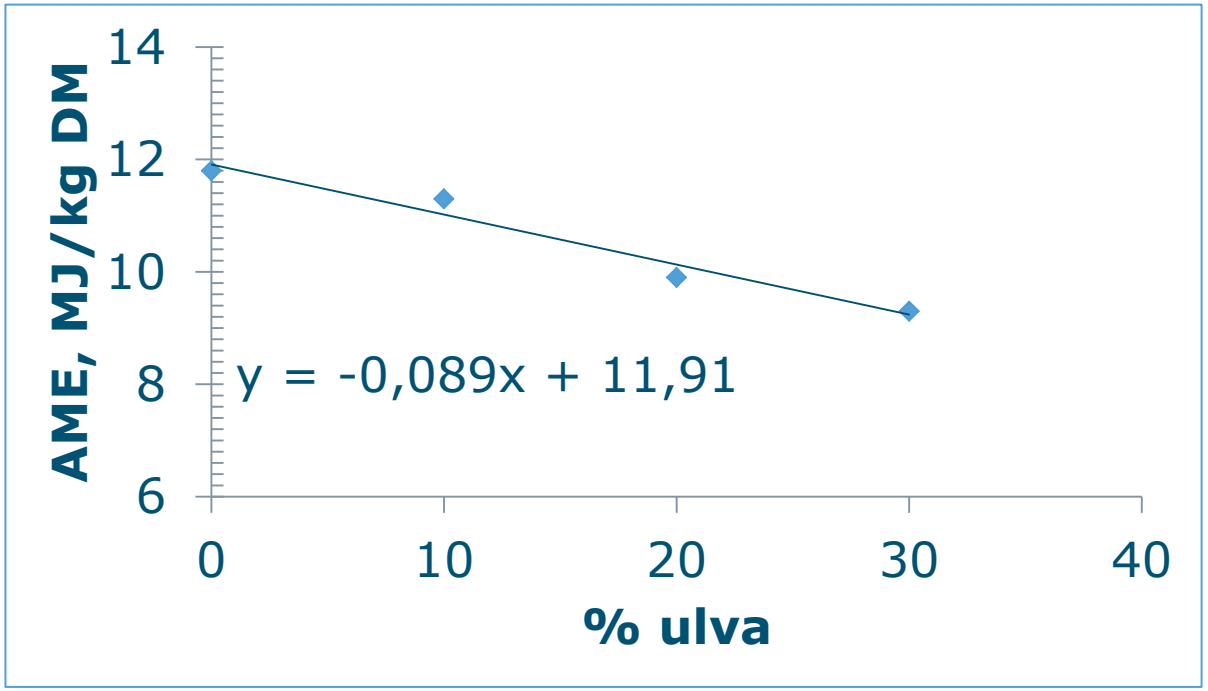
(Bosch et al., 2013, unpublished)

Studies in ruminants

- Ulva lactuca in sheep (Arieli et al, 1993)
  - 9.1 MJ DE/kg DM, low energy, high protein product
- Ulva lactuca in goat (Ventura and Castanon, 1998)
  - 10.2 MJ DE/kg DM, in vitro OM digestibility 62%
  - CP 211 g/kg DM, in vitro CP digestibility 70%
  - ~ medium quality alfalfa hay
- Ascophyllum nodosum, Alaria esculenta, Fucus Vesiculosis (Applegate and Gray, 1995)
  - 9-10 MJ DE/kg DM by chem. anal. + regression

Studies in poultry

- Ulva rigida (green)(Ventura et al., 1994)
- TME = 5.7
  AME = 2.9 MJ
  (20-40% of GE)



- Polysiphonia spp (red)(El-Deek and Brikaa, 2009)
- AME = 14,7 MJ ME/kg (approx. 70% of GE)
- Relatively low CP-utilisation (TPE)

Studies in fish

- Digestibility of IMTA produced seaweed (Pereira ea, 2012)

	Juv. tilapia		Juv. trout	
	REF	Ulva	REF	Ulva
CP	87	63	90	76
Cfat	95	91	98	88
Energy	88	57	91	73
DE, MJ/kg DM	18.1	14.5	22.2	18.2

- Promising results in several studies replacing other protein sources, including fish meal, by seaweed meal.

Studies into extracted seaweed components

- Seaweed polysaccharides (laminarin, fucoidan) may improve gut health, immune status and performance in weaned piglets (e.g. Dierick et al., 2009; O'Doherty et al.)
- Maternal supplementation of sows may have immuno modulatory effects (e.g. Leonard et al., 2012)
- Seaweed meal may influence microbial fermetation in the rumen (Leupp et al, 2005)
- Antioxidative properties
- Pellet binding and stabilisation (fish)
- Vitamines and minerals (animals?)

Conclusions and perspective

- Limited information on nutritive value in farm animals
- Promising results in selected species and studies
- Preliminary application: fish > cattle > pigs > poultry
- Large variation due to species, season, location, ... → opportunities and challenges
- Factors causing variation should be taken into account in further research and developments
- Developments required in processing (biorefinery) and available fractions → optimisation of use
- Attention: high mineral content, feed safety

Thank you for your kind attention