



Germany: Helgoland ring used in two projects for offshore cultivation of *Laminaria saccharina* in 1990's

---Storm-safe polyethylene ring of 8 m diameter invented for coastal protection purposes by Prof. Jan Backhaus (University of Hamburg)

---Project of German Federal Ministry for Research (Klaus Lüning, Jan Backhaus, Cornelia Buchholz) near Helgoland

---Project of Alfred-Wegener Institute for Polar and Marine Research (Bela Buck) in southern North Sea

Sylter Algenfarm GmbH & Co.KG

List (island of Sylt, North Sea), Germany



Laminaria saccharina, cultivated on Sylt island (North Sea) in tanks, free-floating or on ropes



Palmaria palmata (dulse), cultivated by Sylter Algenfarm



Gracilaria vermiculophylla, cultivated by Sylter Algenfarm

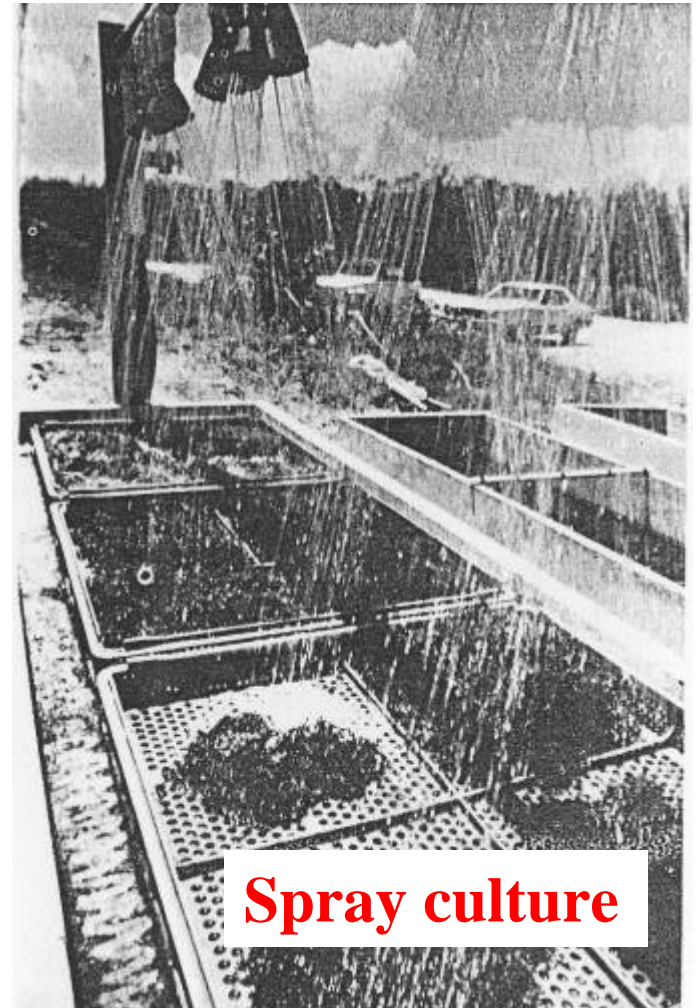
Parallel seaweed farm in the sea in northern Baltic (Kattegat) in cooperation with Danish company

Marifood ApS

**MASS CULTIVATION OF SEAWEEDS ON LAND IN FLORIDA:
John Ryther and Dennis Hanisak since 1974: pioneer work mainly
on red alga *Gracilaria* in tanks on land at Harbour Branch
Oceanographic Institution in Fort Pierce, Florida**



Harvesting



Bidwell, Mc Lachlan & Lloyd: Tank cultivation of Irish Moss, *Chondrus crispus* Stackh. Bot. Mar. 28, 87-95(1985)

Golden rules of tank cultivation:

- (1) High density:**
e.g., 10 kg per square meter
- (2) At least one water change per day**
- (3) strong aeration**

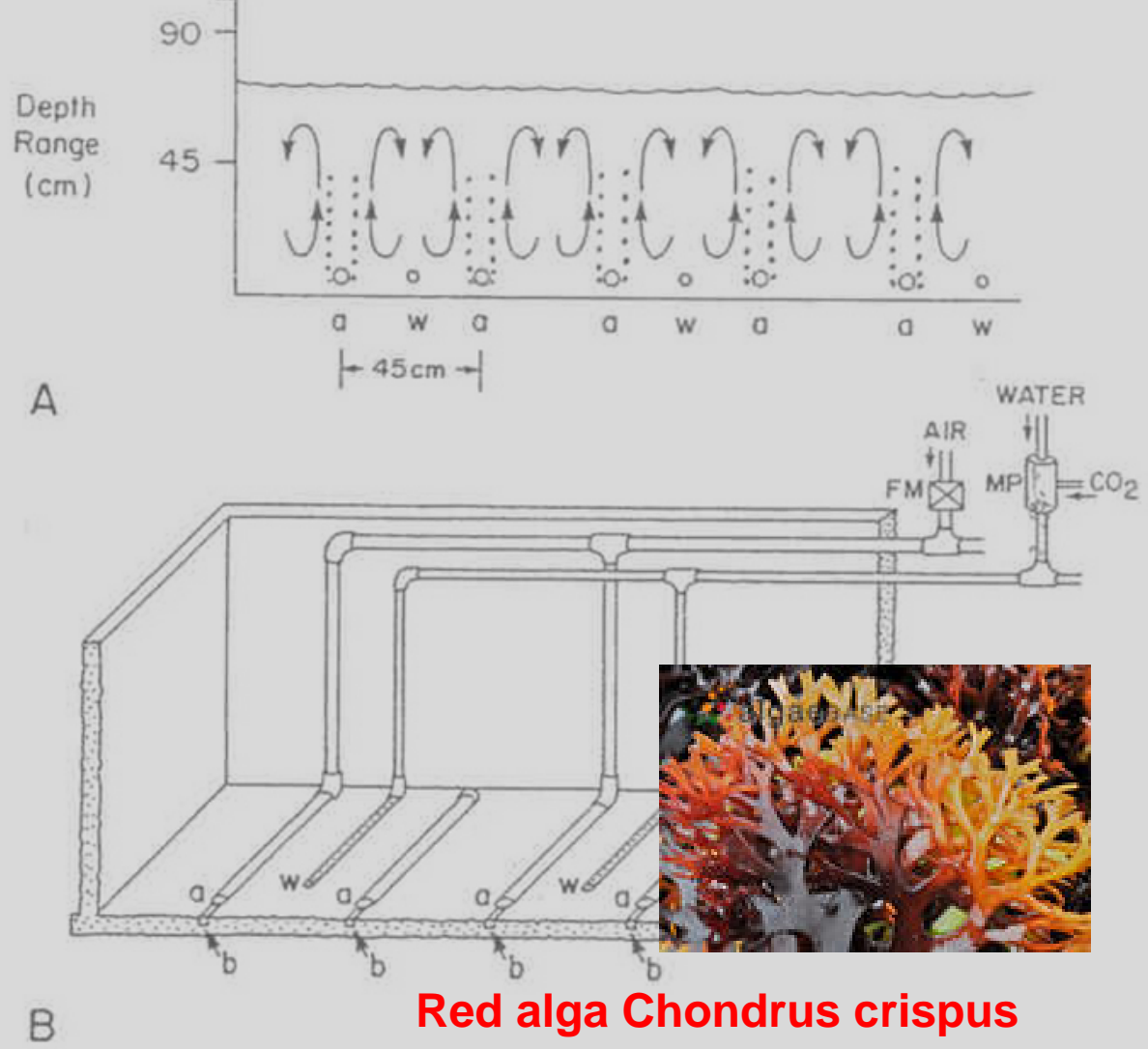


Fig. 2. Tank design for *Chondrus crispus* cultivation. A, Section; B, Plan. Key: a, air pipe; b, batten for attaching air pipe; FM, flow meter; MP, mixing pump; w, water pipe. Arrows show direction of water circulation induced by air bubbles.



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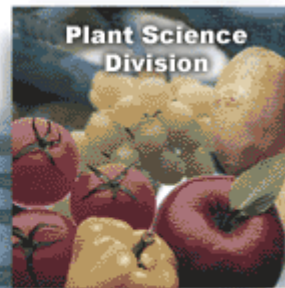
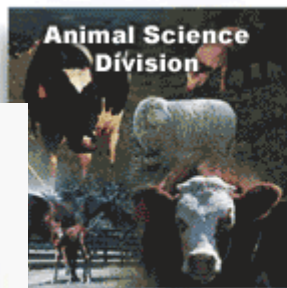


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Plant productivity

Highly productive natural vegetations on land or in the sea (data from international investigation programs on plant productivity since 1980's, e.g. ed. by Helmut Lieth):

--- maximum productivity at **1.8 kg C m⁻² year⁻¹**

--- maximum algal biomass of approximately 10 kg fresh weight m⁻² (corresponding to maximum chlorophyll content of 3 g per m⁻²)

Practical example from seaweed tank cultivation

--- 5 kg biomass fresh weight m⁻² of tank surface area

--- doubling every 4 weeks (winter and summer species must be alternated)
= 5 kg x 12 months = 60 kg biomass fresh weight m⁻² year⁻¹

--- 10% is dry weight = 6 kg dry weight m⁻² year⁻¹ = **16 g dry weight m⁻² day⁻¹**

--- 75% of dry weight is organic weight (25% is mineral ash) = 4,5 kg organic weight

--- C is 50% of organic weight = **2,3 kg C m⁻² year⁻¹**

Microalgal productivity (data from David Alan Walker („Biofuels, facts, fantasy, and feasibility“; J. Appl. Phycol. 2009, 21, 509-517) and Avigad Vonshak):

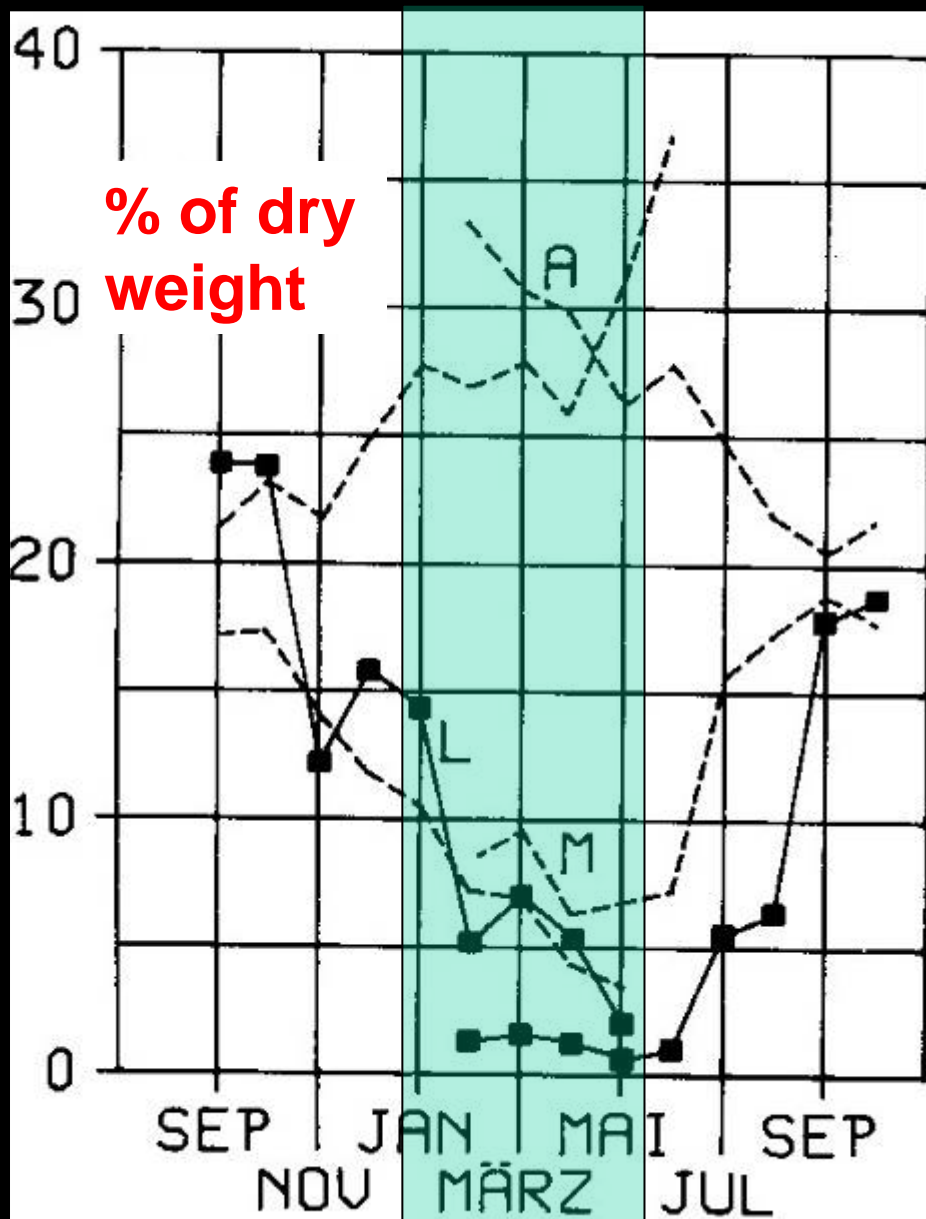
12-14 g dry weight m⁻² day⁻¹

Norway today

SINTEF Fisheries and Aquaculture
N-7465 Trondheim
Norway

Mass cultivation of *Laminaria saccharina* in Norwegian fjords
Project “Seaweed Biofuel”
Pending application to Research Council of Norway
In cooperation with Sylter Algenfarm GmbH & Co.KG
and Marifood ApS (Denmark)





A=alginate Fermentation study:
Adams et al. (2009) J. appl.
Phycol. 21, 569-574

M=mannitol → **Bio-Ethanol**

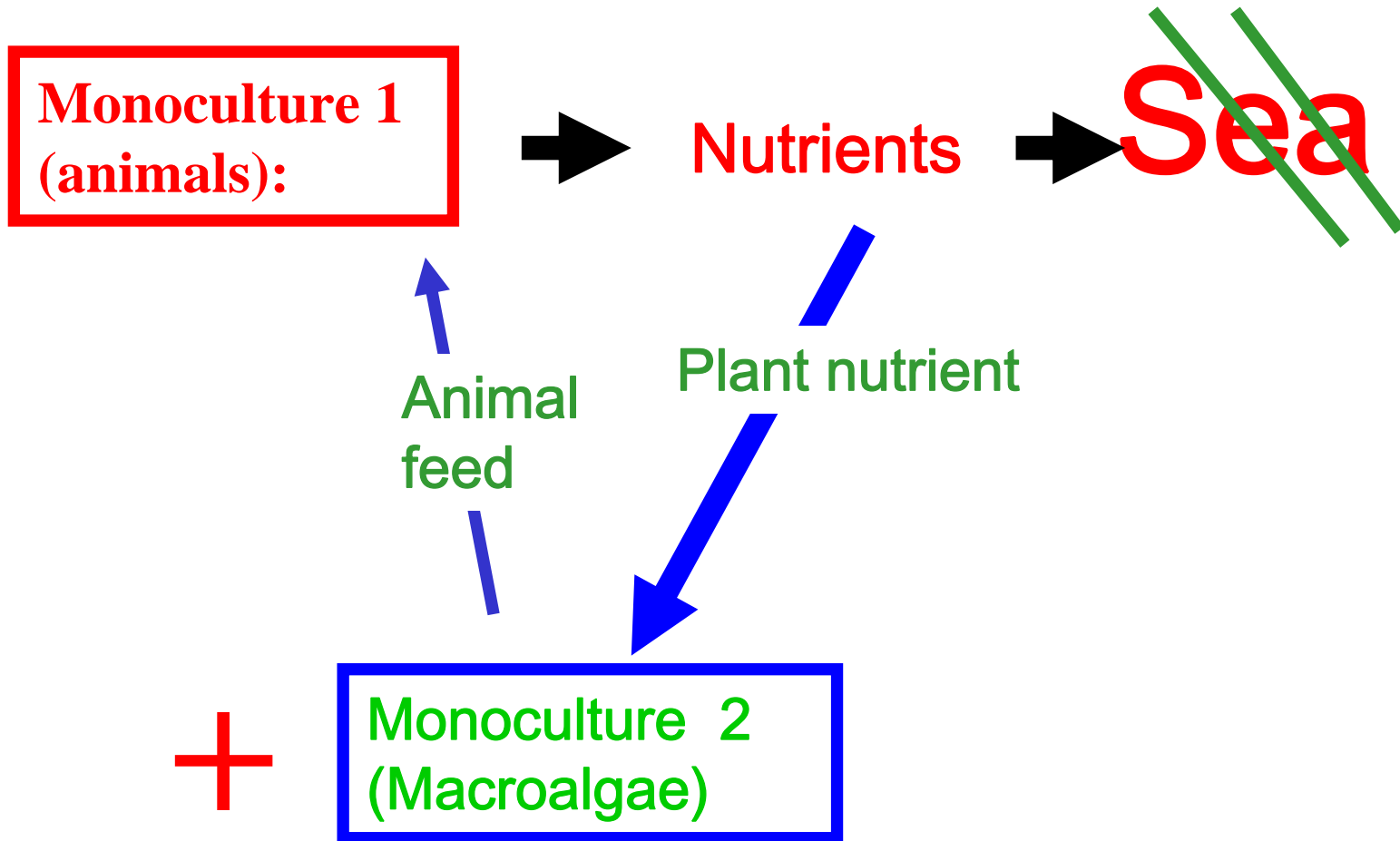
L=laminaran



Note: Buildup of carbohydrate reserve materials also in permanent red algae such as *Palmaria* and *Gracilaria*

Another driving force for seaweed mass cultivation:

Seaweeds for scavenging nutrient salts from marine animal aquaculture



= Polyculture = Integrated Aquaculture = Multitrophic aquaculture

1 m² of seaweed tank area / 10 kg fin fish (Result of SEAPURA project)

The Seaweed and Integrated Multi-Trophic Aquaculture (IMTA) Research Laboratory of Dr. Thierry Chopin :

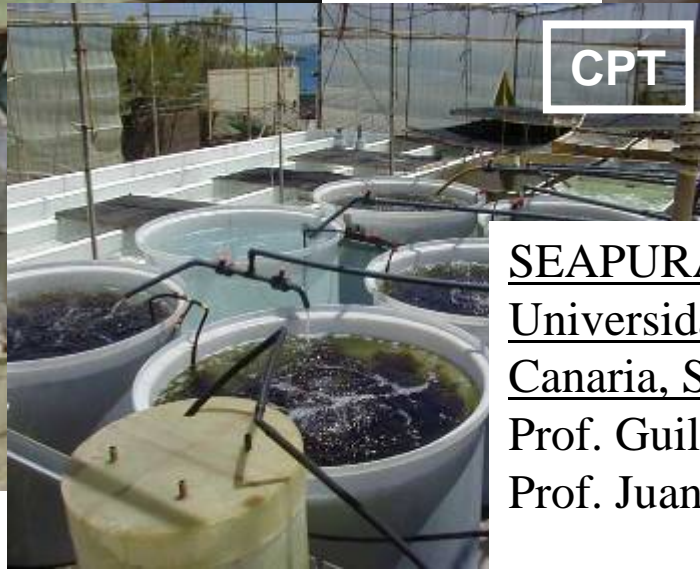
Laminaria „curtains“ around salmon farms in the sea

University of New Brunswick, Canada





SCT



CPT

SEAPURA Participant 2 ULPGC =
Universidad de Las Palmas de Gran
Canaria, Spain
Prof. Guillermo Garcia Reina /
Prof. Juan Luis Pinchetti

Serial tanks (cascade)

24 h experiments

Tank input

Hypnea spinella CPT (TR 4x)

Hypnea spinella SCT (TR 8x)

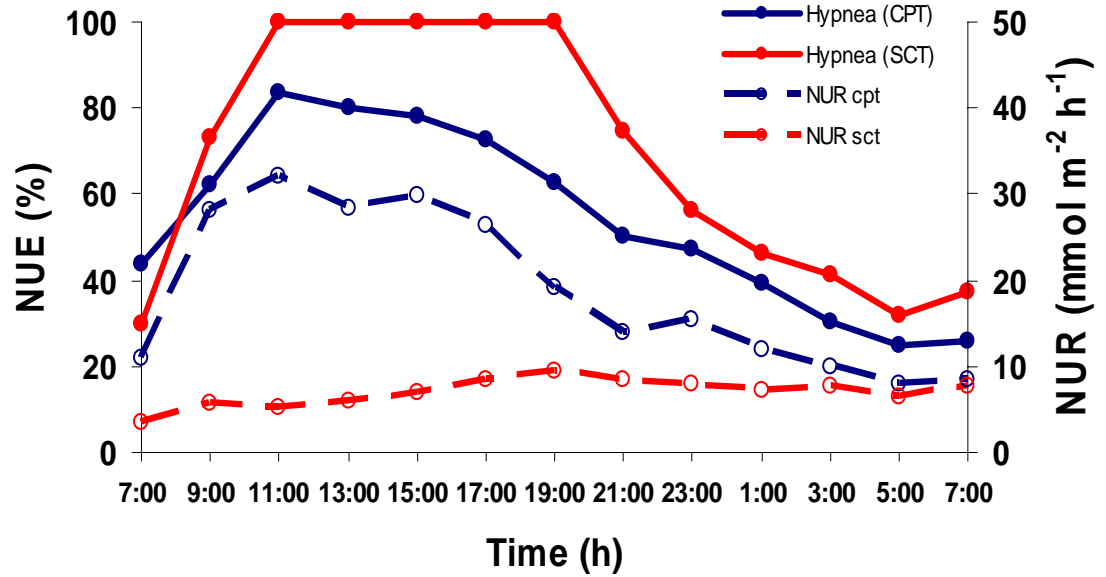
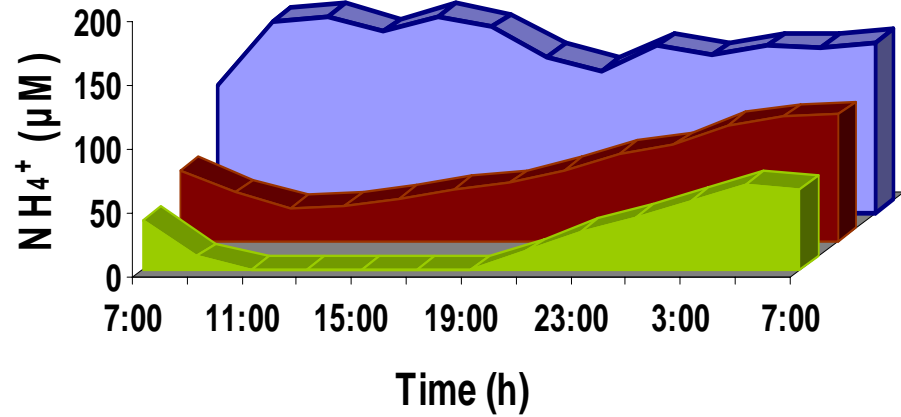


Fig. 13

Red Tides in China in 2002

Red tides:

79 times

Bo sea: 13

Yellow sea: 4

East sea: **51**

South sea: 11

Over 10,000 Km²

Lost **23** MD(RMB)

