The Research Council of Norway

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Life cycle analysis from hatchery to product

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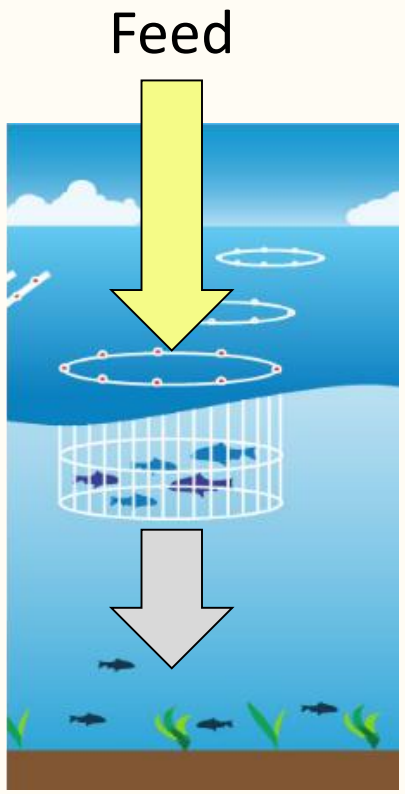
1. Protein from seaweed as a market?
2. Introduction to Life-Cycle Assessment, LCA
3. Seaweed farming to produce protein
    a. LCA of today’s production
    b. Improved drying
    c. Increased production volume and size
    d. Impact of yield and protein

Salmon production in Norway had a share of 60 % of world production in 2012.

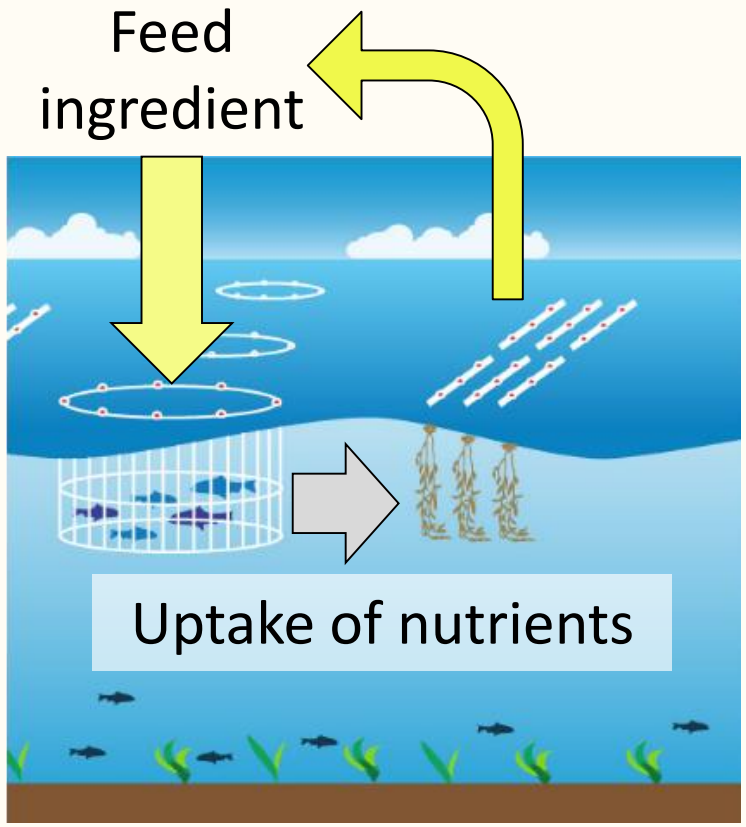


- Soy protein concentrate is an important feed ingredient
- For their production was about 675,000 t soy-beans needed
- Area in Brazil nearly: 2,300 km^2

Source:
Hughes et al. 2016
Beyond fish monoculture

Source:
Lundeberg and Grønlund 2017
Fra brasiliansk jord til norske middagsbord

Integrated Multi-Trophic Aquaculture (IMTA)



- Algae-farming close to fish farming
- Nutrient uptake by algae
- Algae protein as feed ingredient

Source:
Hughes et al. 2016
Beyond fish monoculture

1. Protein production as an important market for farmed seaweed
2. Seaweed as possibility to improve the environment:
    - Replace soy protein
    - No agricultural area needed
    - Nutrient uptake from fish farming

➢ Can seaweed protein be better for the environment than soy protein?

Seaweed: Phases from hatchery to protein

1 - Hatchery: Gametophyte culture

2 - Hatchery: Sporophyte culture

3 - Deployment & growth at sea

4 - Harvest

5 - Transport, storing

6 - Drying

7 - Extraction

8 - Transportation

1 t pure protein (calculated)

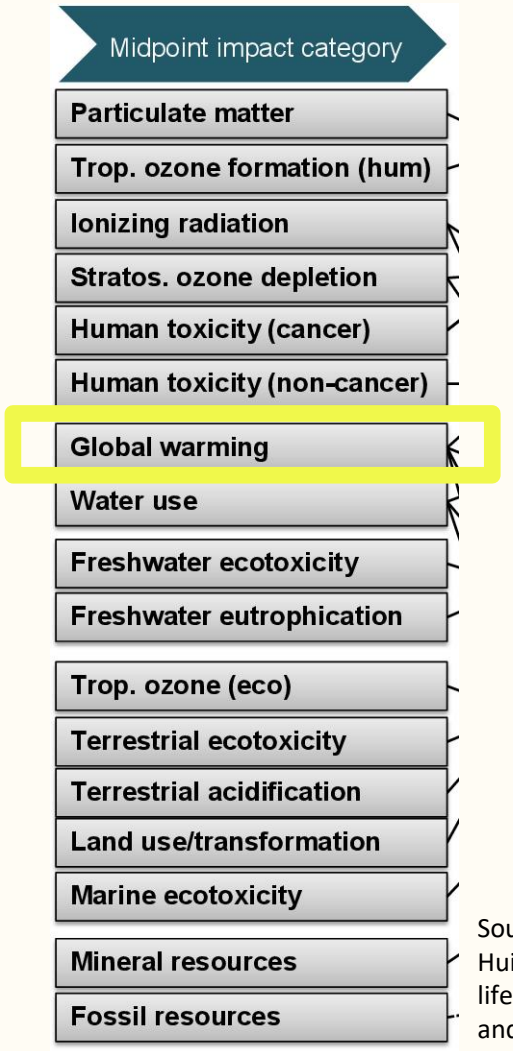
For the LCA - for each phase:

- All materials used
- All energy used

Life-cycle assessment (LCA)

Assess environmental impacts for all materials and energy used:

- Raw material extraction
- Materials processing
- Manufacture
- Distribution
- Use
- Repair and maintenance
- Disposal or recycling



Global Warming Potential
GWP in kg CO^2-equivalents

Source:
Huijbregts et al. 2016, ReCiPe 2016. A harmonized life cycle impact assessment method at midpoint and endpoint level. Report 1: Characterization.

Example:
Use of oil to produce electricity

Source: Marcus Merk

Source: www.n-tv.de

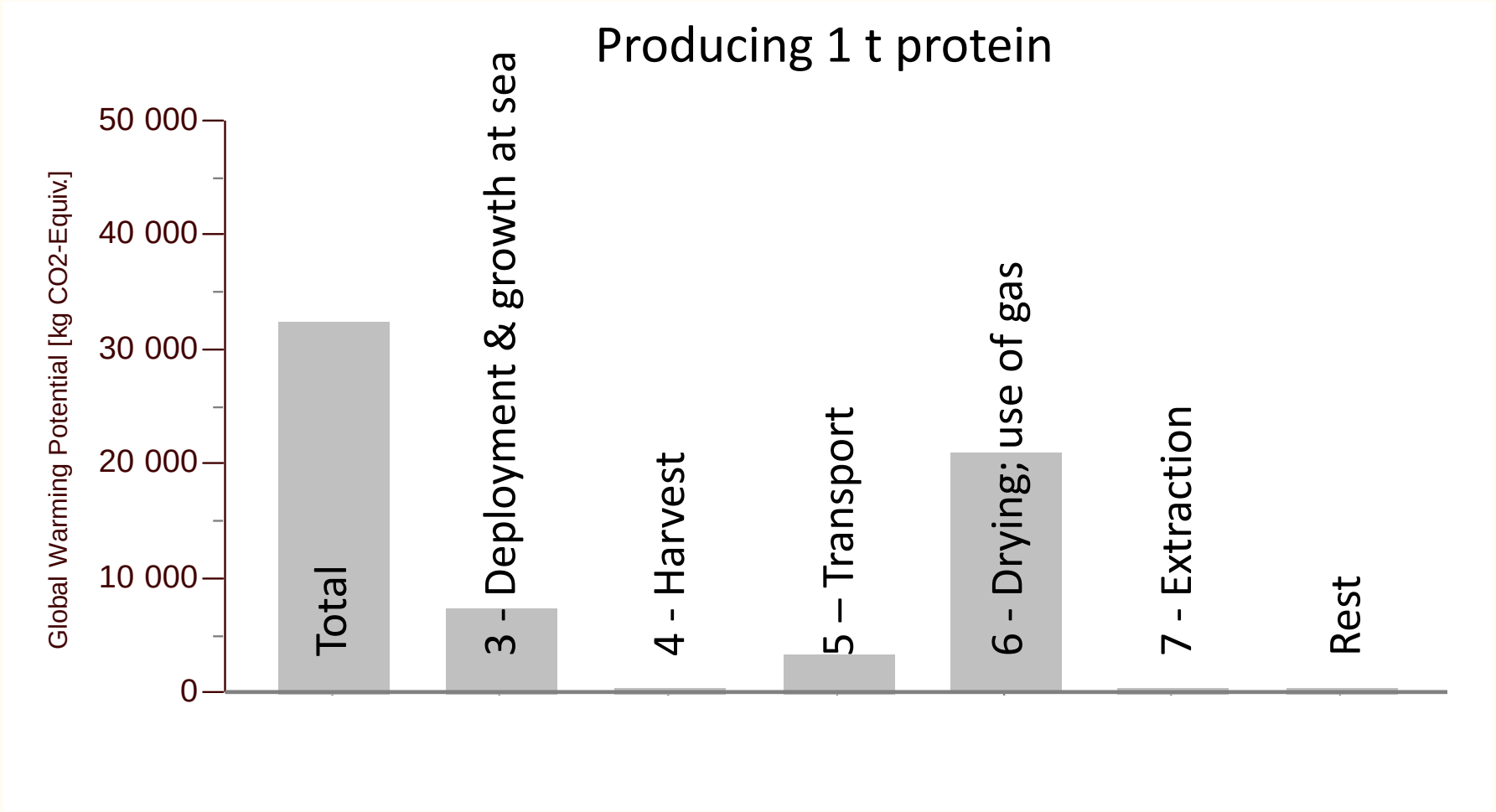
Source: www.z-freunde-krefeld.de

Source: www.beerenberg.com

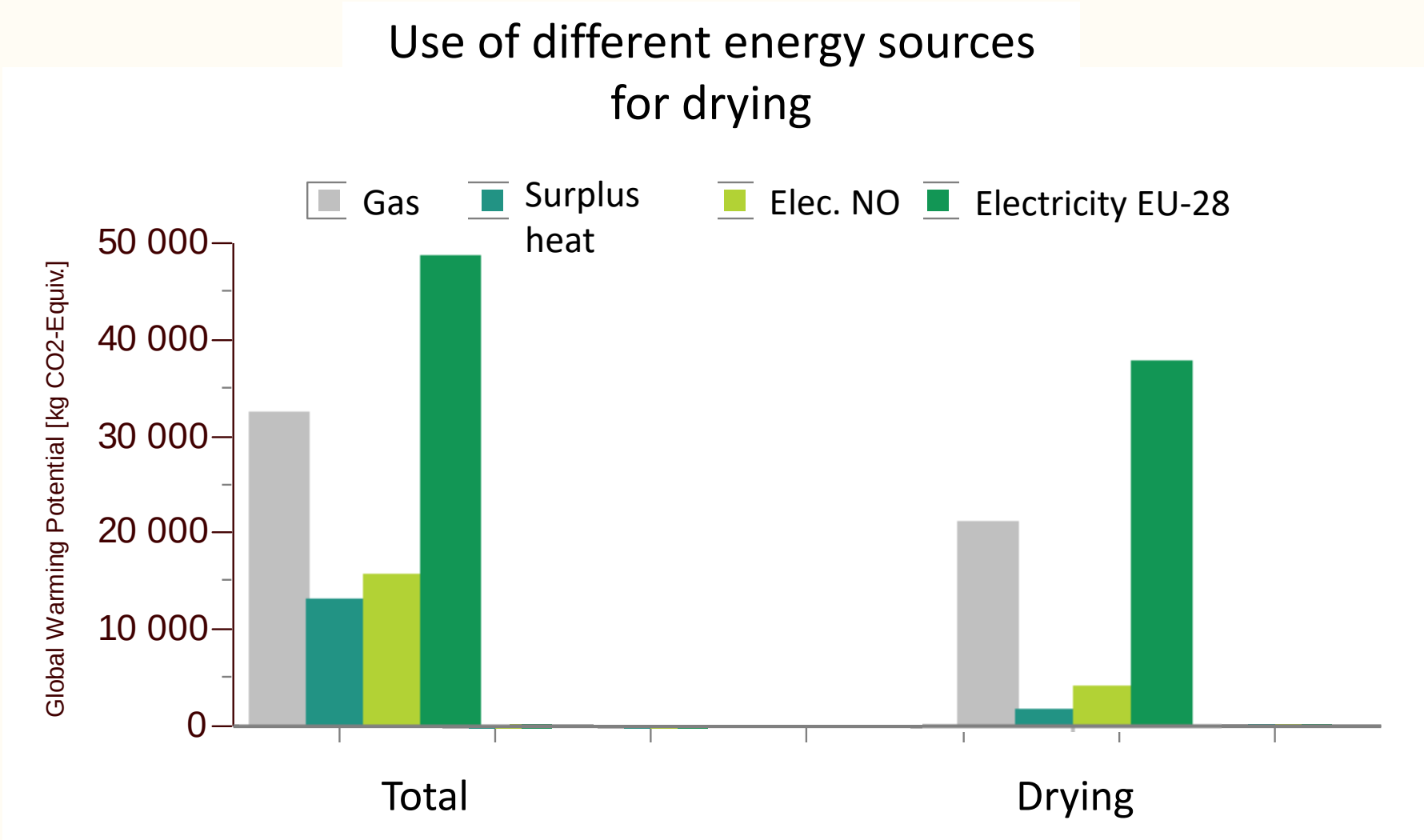
Source: Jason Blackeye, Powerpland Katerini, Greece

Source: https://partner.gira.de/

Global warming potential, today's production



Global warming potential, today's production



Production volume, size and transportation

Sum annual Production t WW	Number of locations	Area per location ha
60	1	1.0

1 ha is about 1.4 football pitches (standard pitch 105 x 68 m)

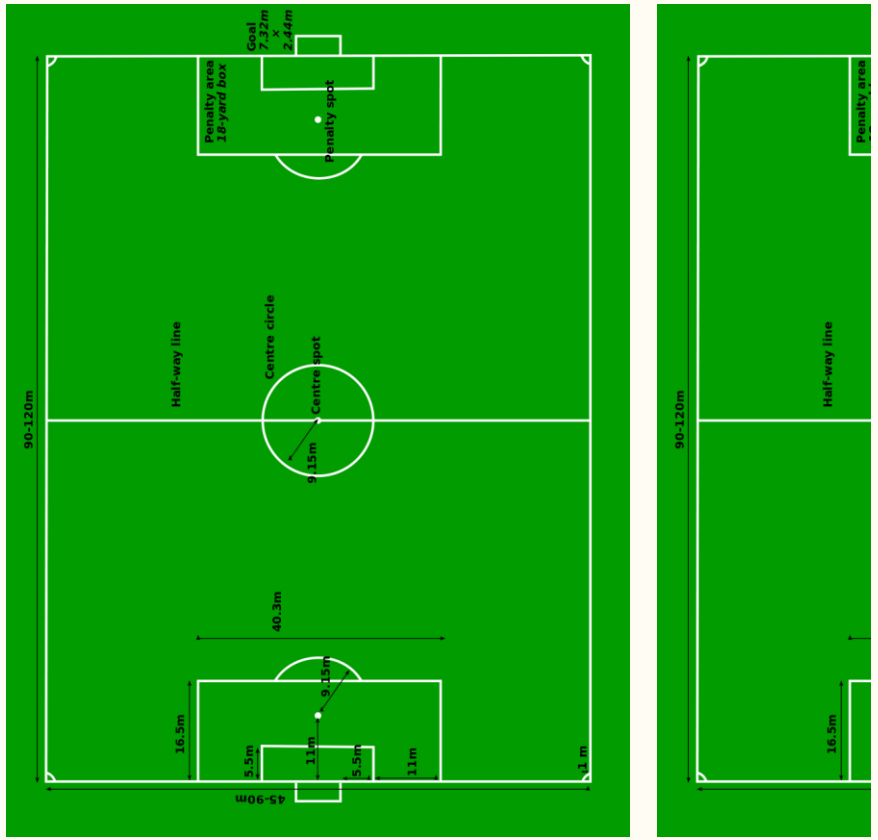


Figure by NielsF, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=779704

Production volume, size and transportation

Sum annual Production t WW	Number of locations	Area per location ha
60	1	1.0
170 000	1132	2.5
6 000 000	1000	100

Source: https://d-maps.com/carte.php?num_car=4876&lang=en

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Production volume, size and transportation

Sum annual Production t WW	Number of locations	Area per location ha
60	1	1.0
170 000	1132	2.5
170 000	90	32
6 000 000	1000	100
6 000 000	6	13 300

Source: https://d-maps.com/carte.php?num_car=4876&lang=en

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Production volume, size and transportation

Sum annual Production t WW	Number of locations	Area per location ha	Placement	Reduced trans-portation	Improved drying	Improved storing
60	1	1.0	+			
170 000	1132	2.5	+	+	+	+
170 000	90	32	+	+++	+	+
6 000 000	1000	100	?	+	++	++
6 000 000	6	13 300	??	++	++	++

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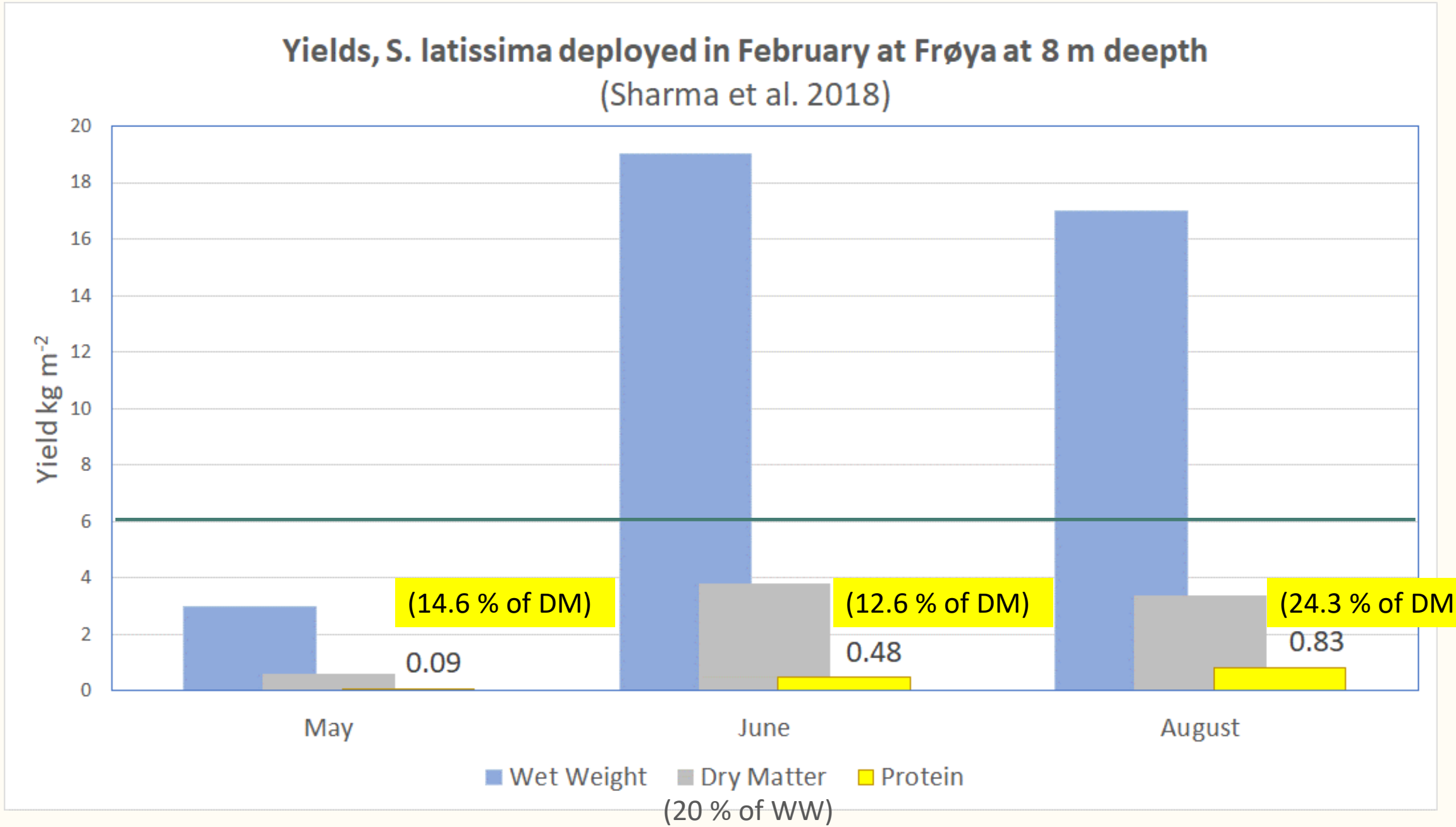
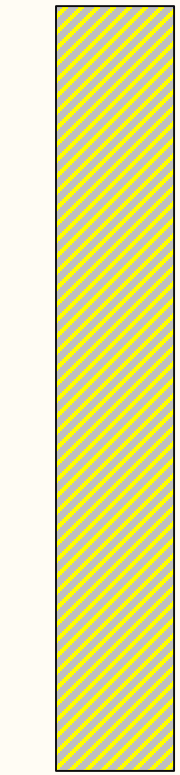
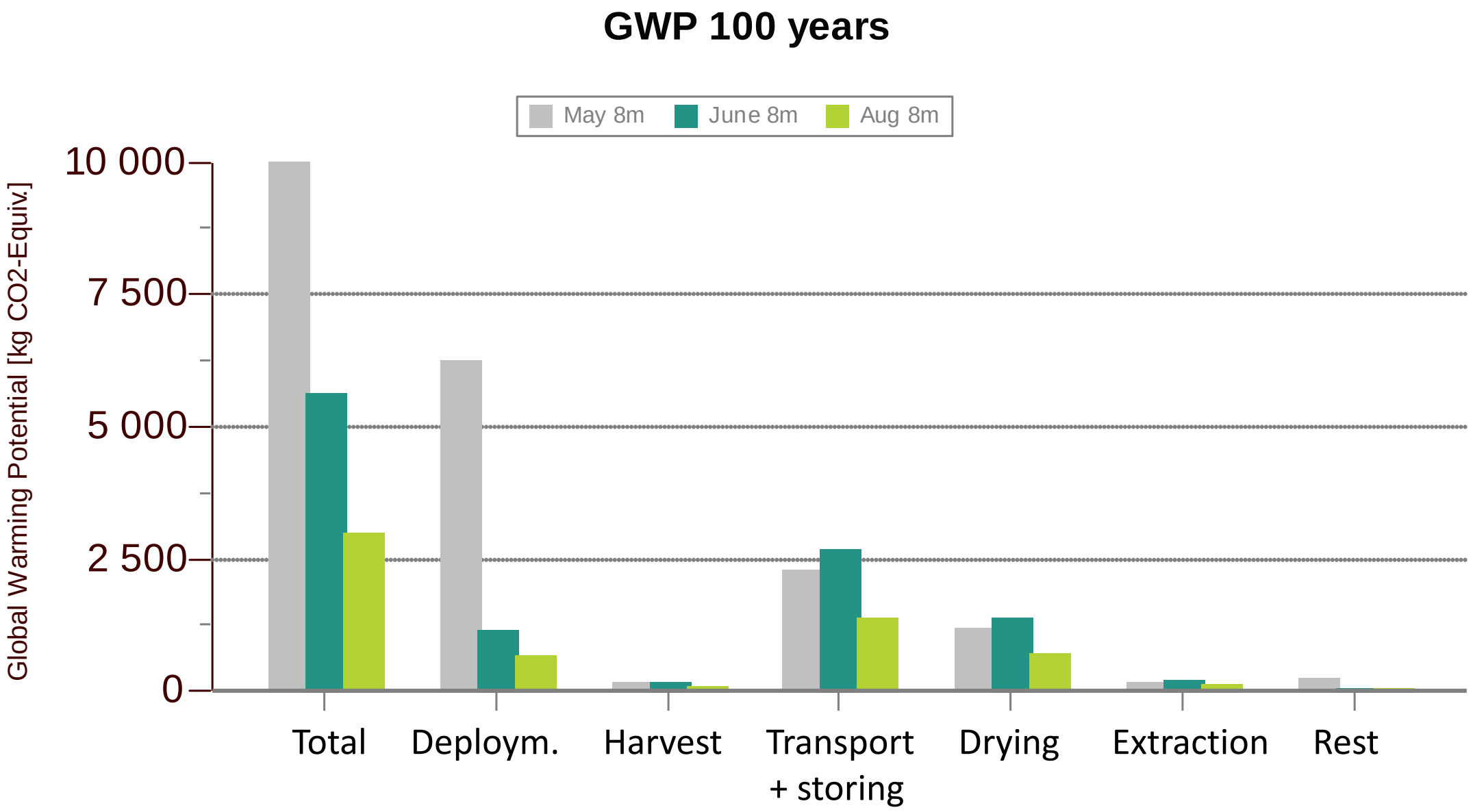

Yields, S. latissima deployed in February at Frøya at 8 m deepth
(Sharma et al. 2018)
Yield kg m-2
20
18
16
14
12
10
8
6
4
2
0
(14.6 % of DM)
(12.6 % of DM)
(24.3 % of DM)
0.09
0.48
0.83
May
June
August
Wet Weight
Dry Matter
Protein
(20 % of WW)

Impact of deployment depth and harvesting month



Total, soy



To succeed with seaweed protein production

- Ensure high and stable yields
    - Focus on dry matter and protein content
- Impact of
    - Deployment depth
    - Harvest time
- Improved extraction of protein
- Extraction of additional products

    To improve economic outcome and reduce environmental impact

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