



Salmon feed raw materials: Roadmap to industrial production in Norway

Shraddha Mehta, Karl A. Almås and Ida Aursand
SINTEF Ocean | Oct 2023



Norways' national targets for feed and salmon production



Bjørnar Skjæran

The goal of 5 million tons of salmon in 2050
 → Annual growth 4,4 % , approx. 2,2 million tons in 2030

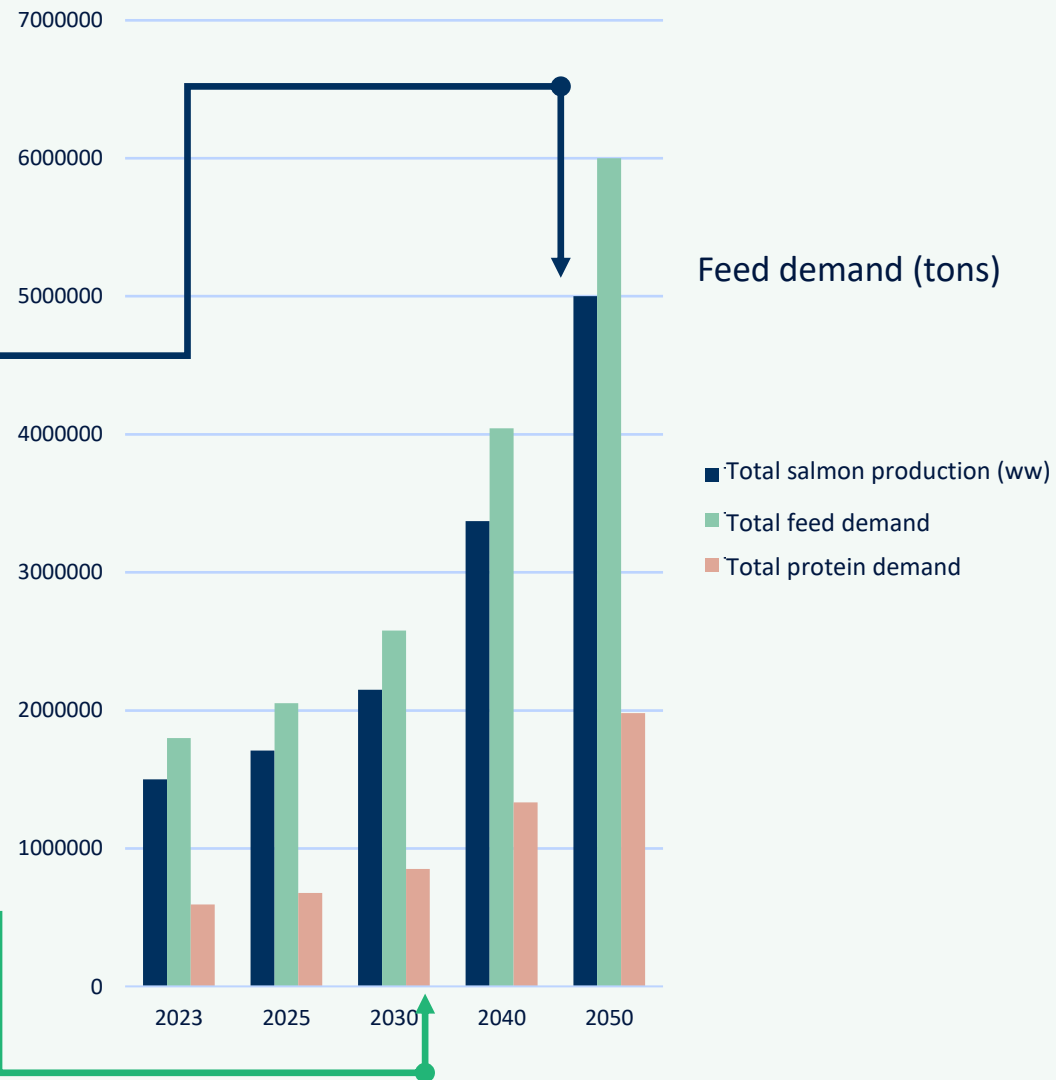
TEKMAR, Dec. 2022



Ola Borten Moe

Norwegian food production (warm blooded animals and aquaculture) will be based upon sustainable Norwegian feed raw materials within 2030.

(Targeted social mission, Meld.St.5, Long-term plan for research and higher education 2023-2032)



The supply of feed raw materials will be challenged

2/3 of the raw materials come from south of equator

- Soy from Brazil
- Pelagic fish, Anchoveta from Peru
- Wheat
- Fava beans, Guar meal etc.

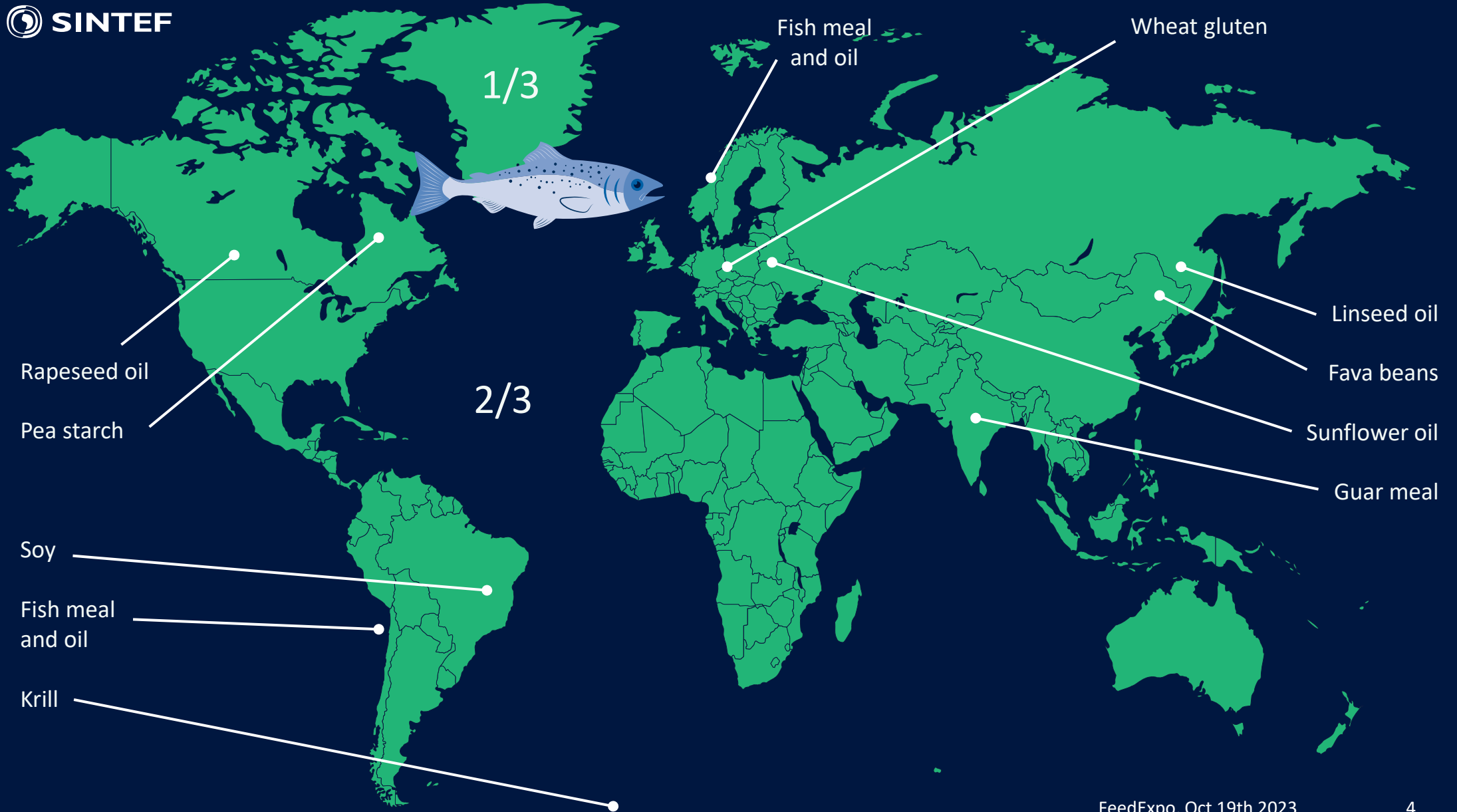
Ethical dilemma (Food crisis > 800 millions under starvation)

- Raw materials that can directly be used for human consumption must be prioritized for humans.
- We cannot surpass Africa's need to produce a high-cost products like salmon.

Others are paying more ?

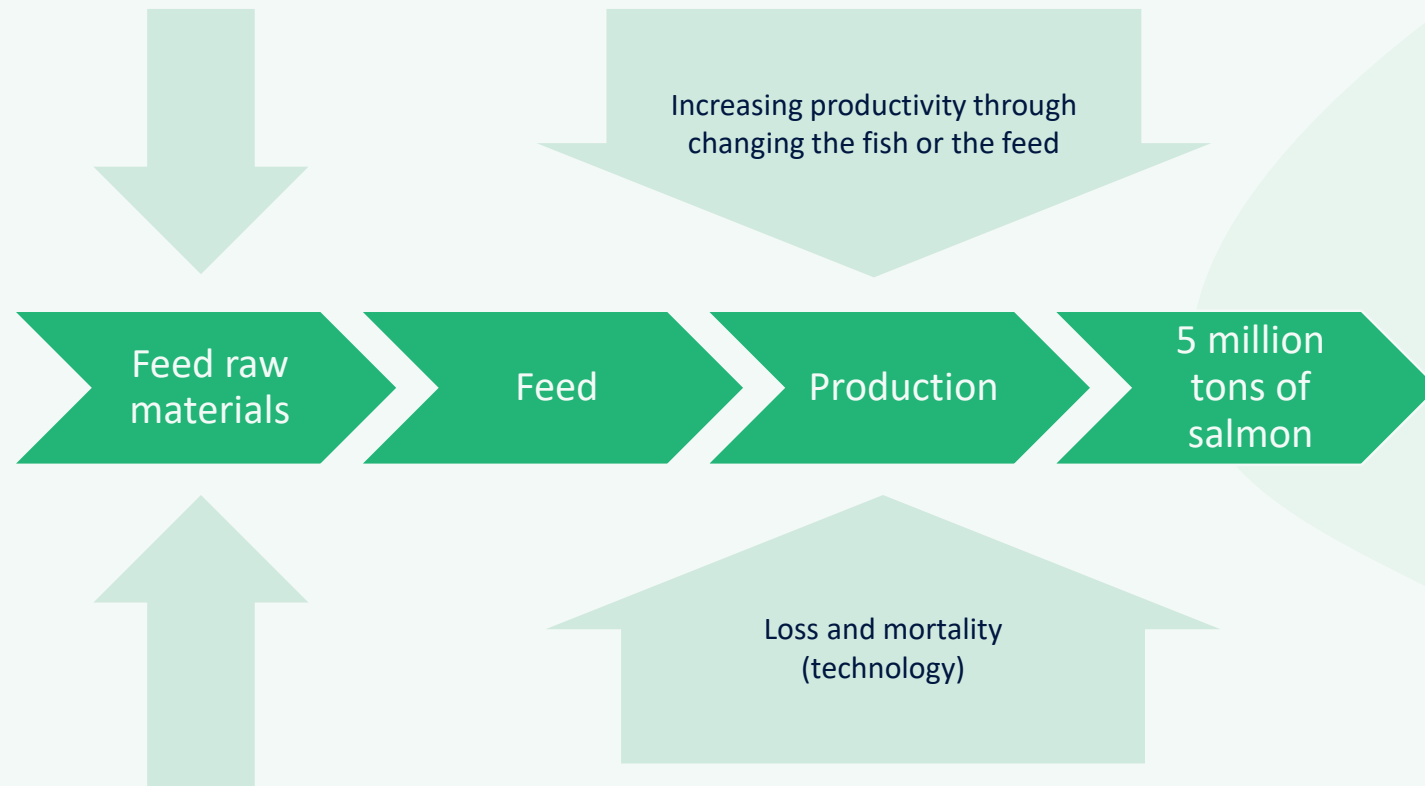
- "Wild bird feed"-market: 40 MRDNOK in USA
- Pet food: 900 MRDNOK (globally in 2019)
 - 9 million tons dry feed
 - 4,6 % CAGR towards 2027





Where do the raw materials come from?

Before stepping up the production of new feed raw materials....



What else can we do?

- Other species (herbivores)
- Feed utilization
 - Nutritional programming
 - New genotypes
 - Improving the microbiome
 - Functional ingredients
- Reducing mortality
- FCR

Loss of protein as a result of mortality

Total salmon mortality in Norway in 2022:

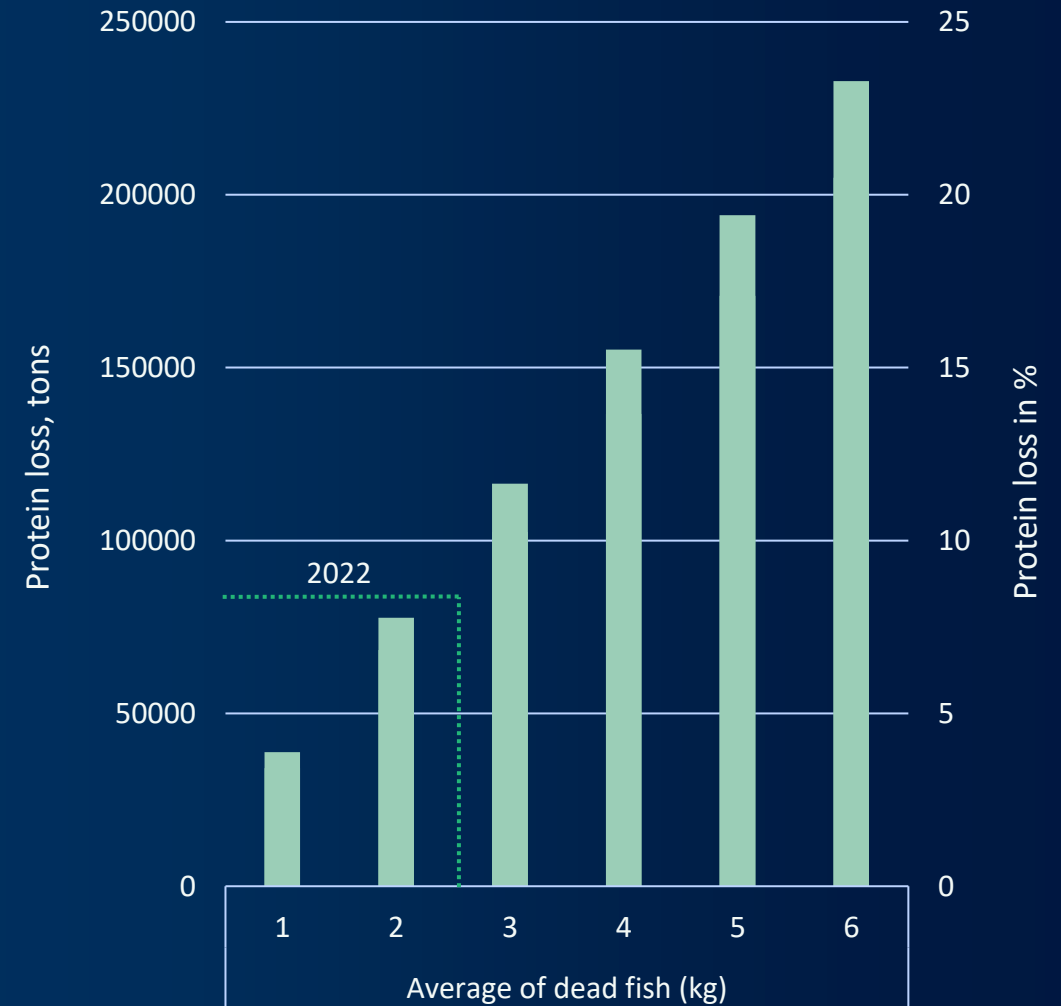
- 67,5 million fish (out of cage)
- 16,8 % of all fish in the sea phase

"Standing biomass"

- approx. 880 000 tons
- Total number of fish: Approx. 400 million

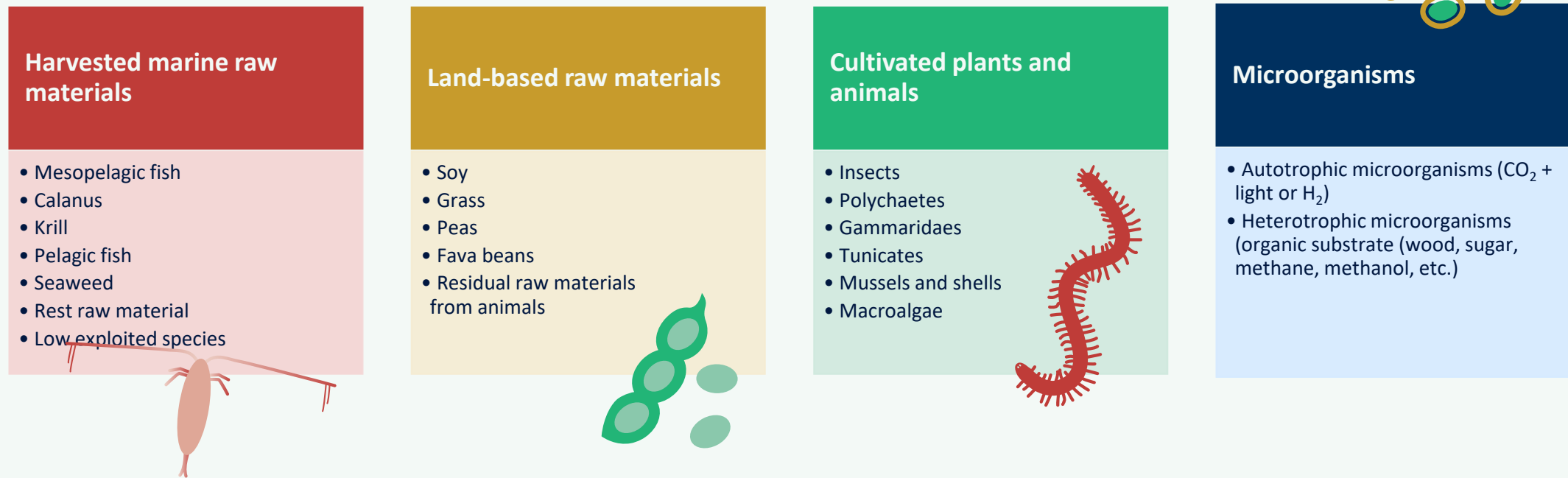
"Loss of protein"

- Average weight of 2,2 kg gives a "total loss of protein" on 70-80 000 tons in 2022.
- If we need 2 million tons of protein in 2050 we must produce 180-200 000 tons extra protein to compensate for the mortality (if the average weight of the dead fish is 2,2 kg)



Numbers from the Directorate of Fisheries (2022)

Raw material sources



Marine raw materials harvested: Norwegian marine protein contribution (tons dry weight)

Other marine organisms (e.g. sea urchins, unknowns, etc.)

Too little is harvested

Well utilized, but still some whitefish

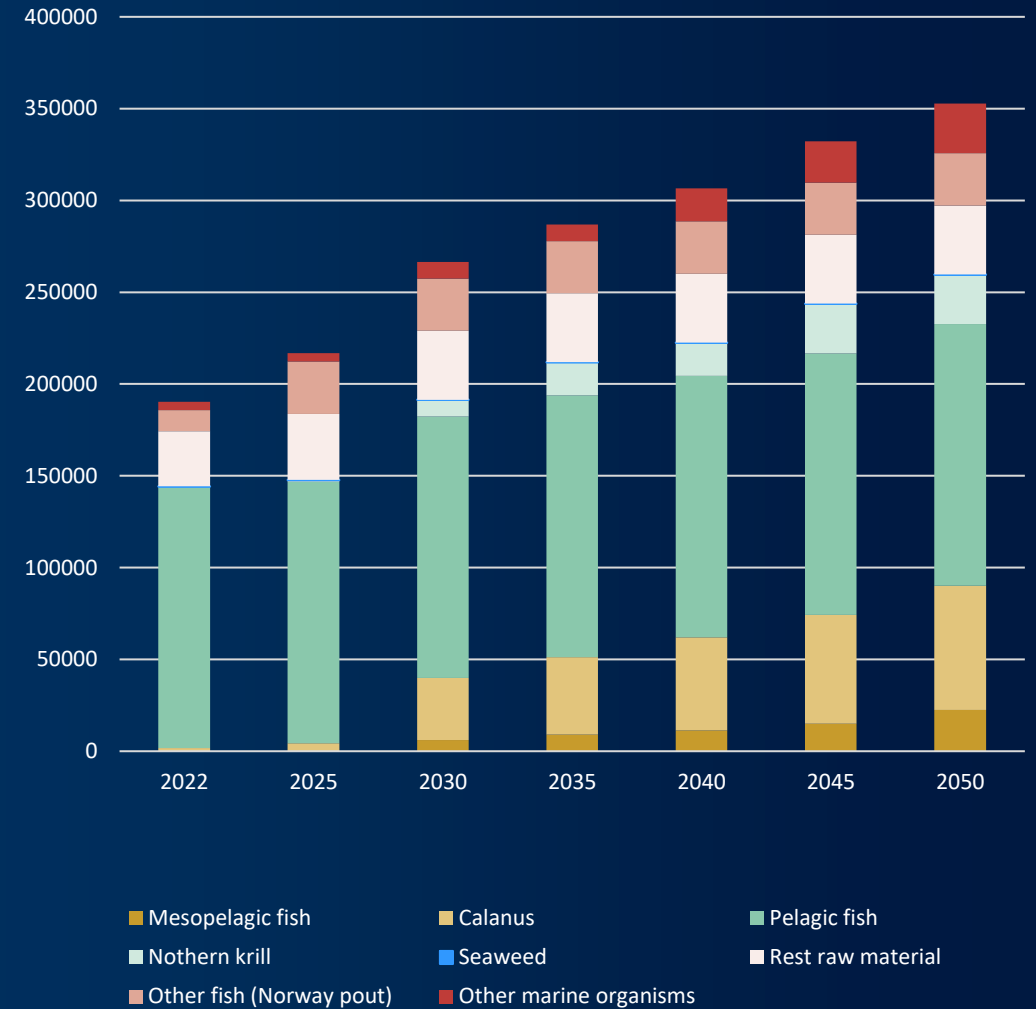
Needs development, but possible to achieve

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Good opportunities, but must succeed with catch

Difficult to find, harvest and process

Low protein in seaweed



Land-based raw materials : Norwegian contributions from agriculture (tons dry weight)

Residual raw materials from animals: Little to be gained

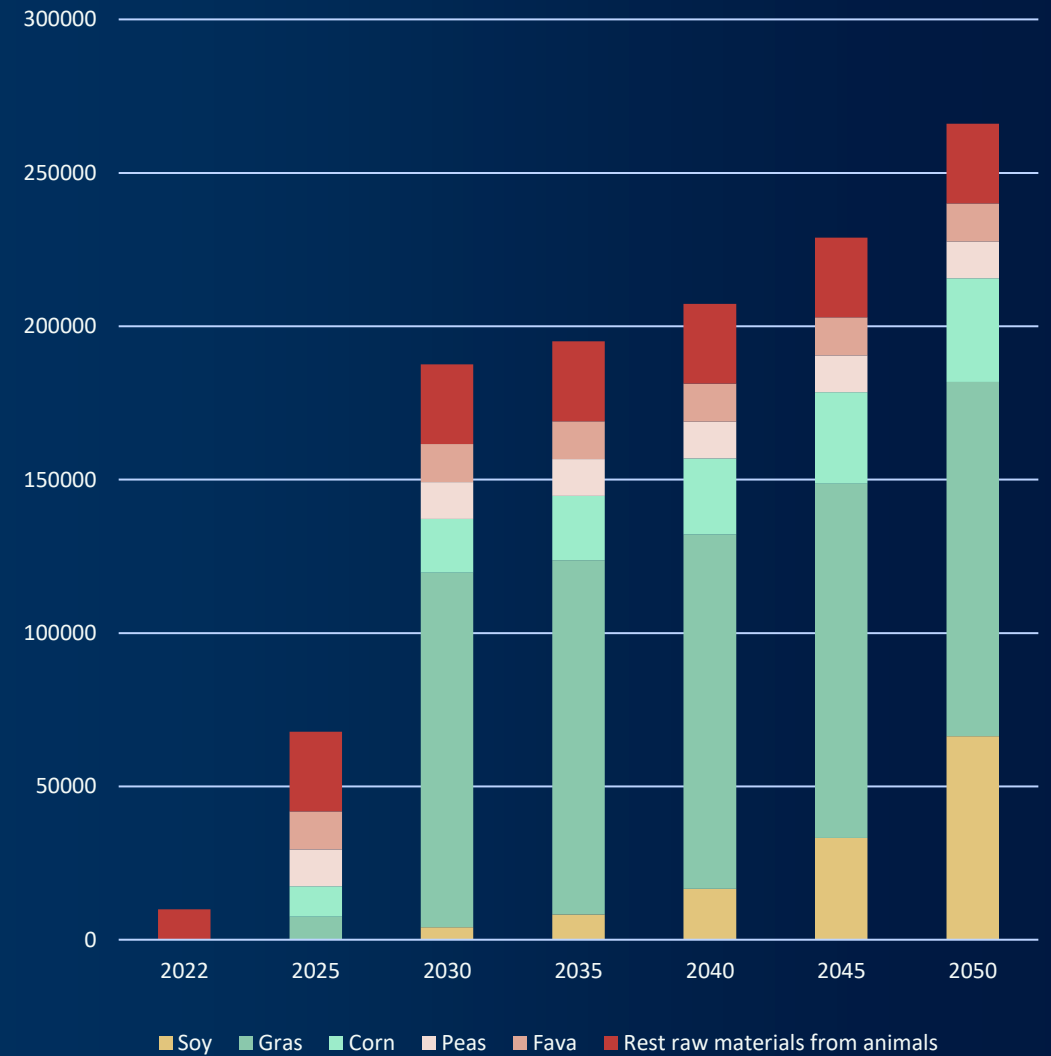
Cultivation of fava beans: Opportunity for some growth

Cultivation of peas: Opportunity for some growth

20% increase in grain production in Norway provides opportunities

Protein from grass: Interesting, but politically complicated

Climatic changes can create soy production Norway



Cultivated plants and animals: Norwegian protein contribution from cultivated animals and plants (tons dry weight)

Macroalgae: Low content

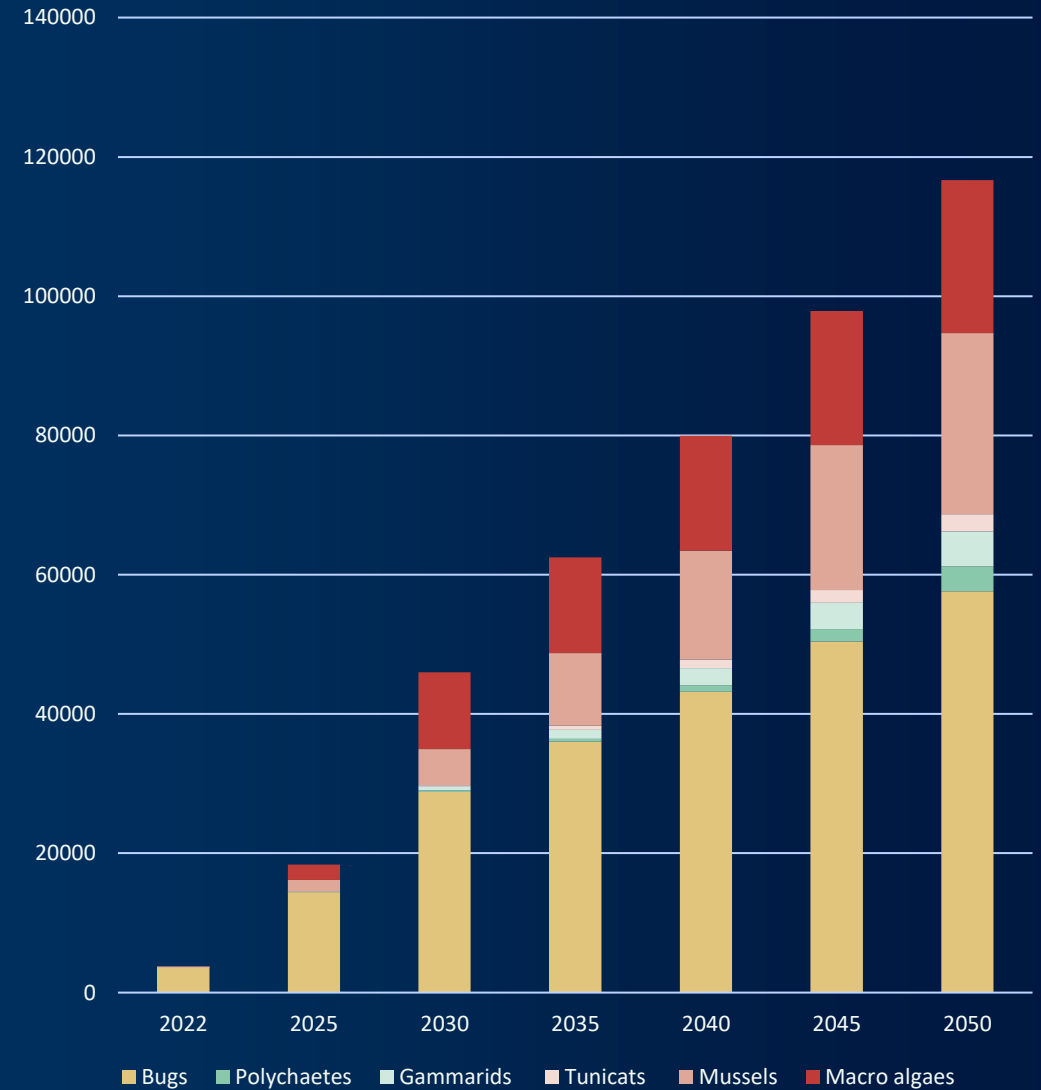
Blue mussels: Easy to manufacture. Area consuming.

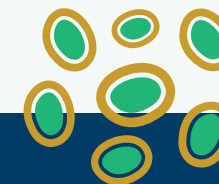
Tunicates: Marginal contribution (< 1%)

Gammaridaes: Marginal contribution (< 1%)

Polychaetes: Marginal contribution (< 1%)

Insects: Can make contributions up to 3-4%

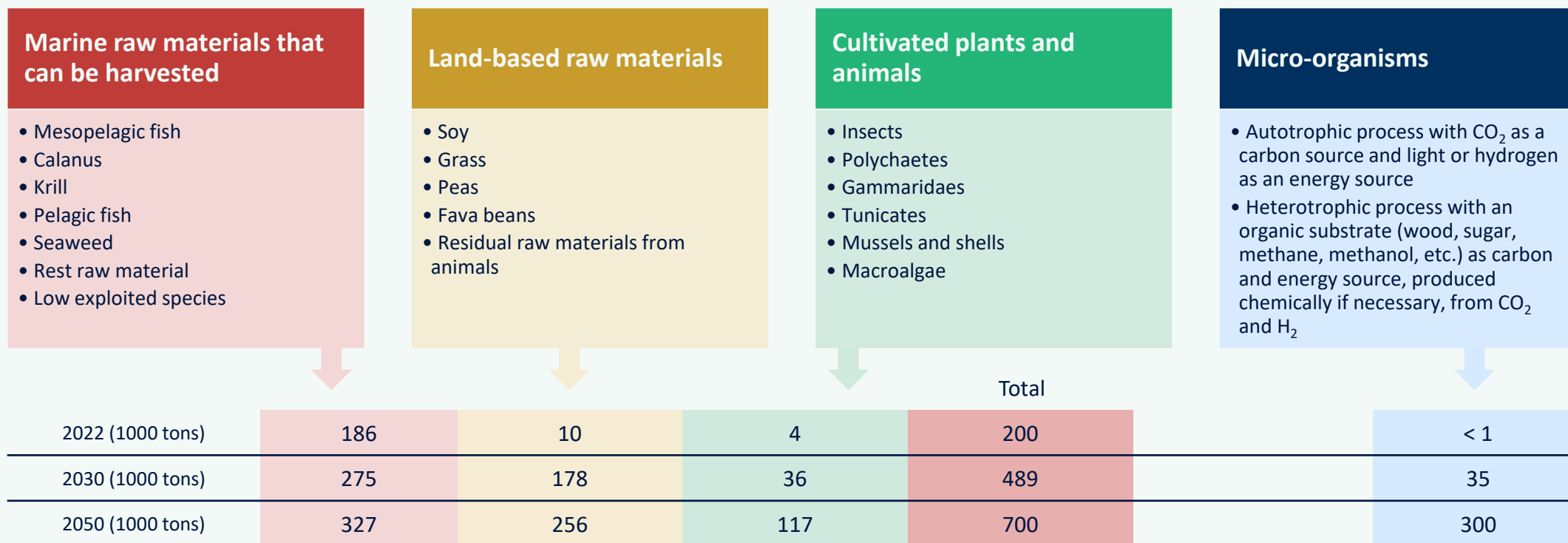




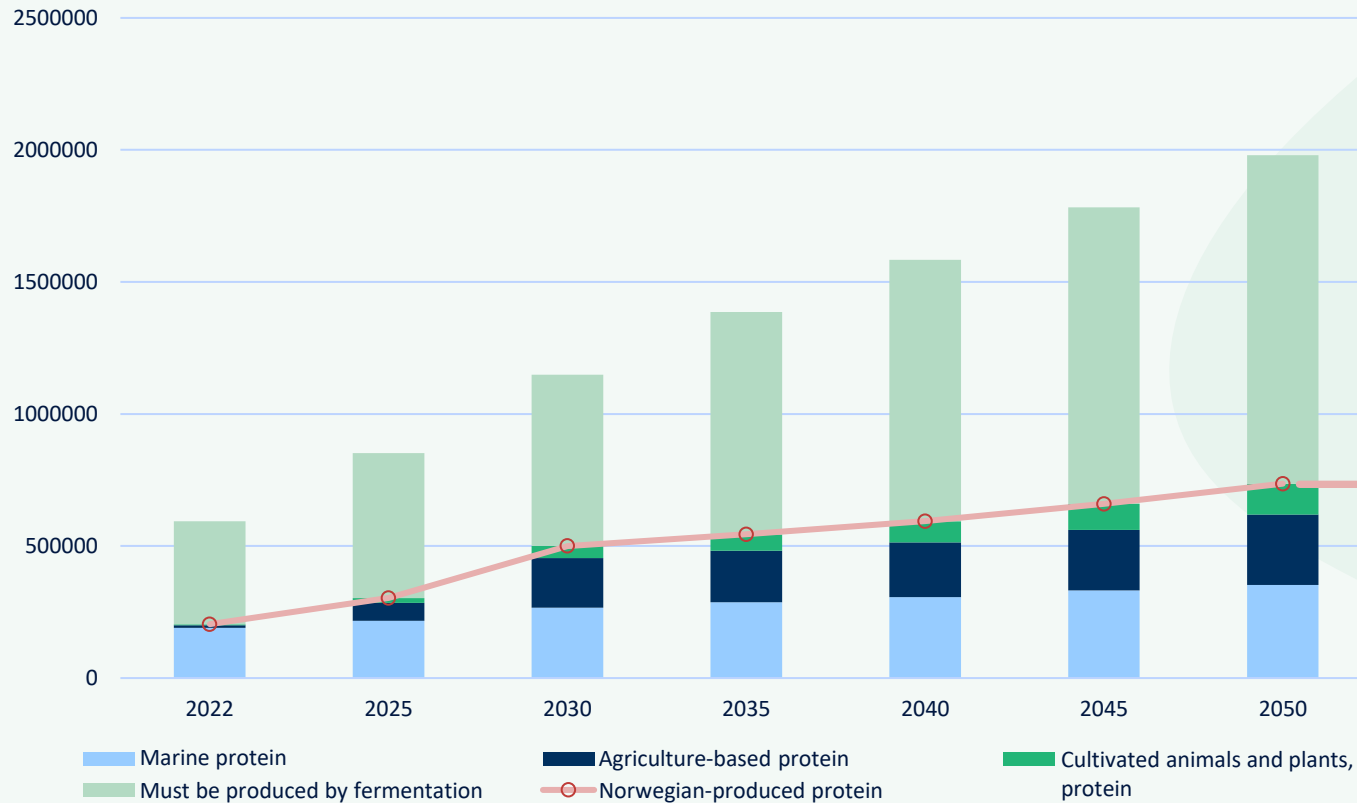
Single cell protein

Method	Production (1000 tons of protein)		
	Production in 2023	Potential in 2030	Potential in 2050
Heterotrophic fermentation of glucose and/or sucrose	0	12	100
Extraction and heterotrophic fermentation of sugars from wood	0	5	50
Phototrophic cultivation of microalgae with CO ₂ as carbon source	<1	5	20
Heterotrophic fermentation of raw materials such as methane, acetic acid and methanol produced from CO ₂ + H ₂ , alternatively autotrophic fermentation of CO ₂ + H ₂	0	5	50
Heterotrophic fermentation of methane from natural gas or biogas	0	8	80
Sum	<1	35	300

Raw material sources



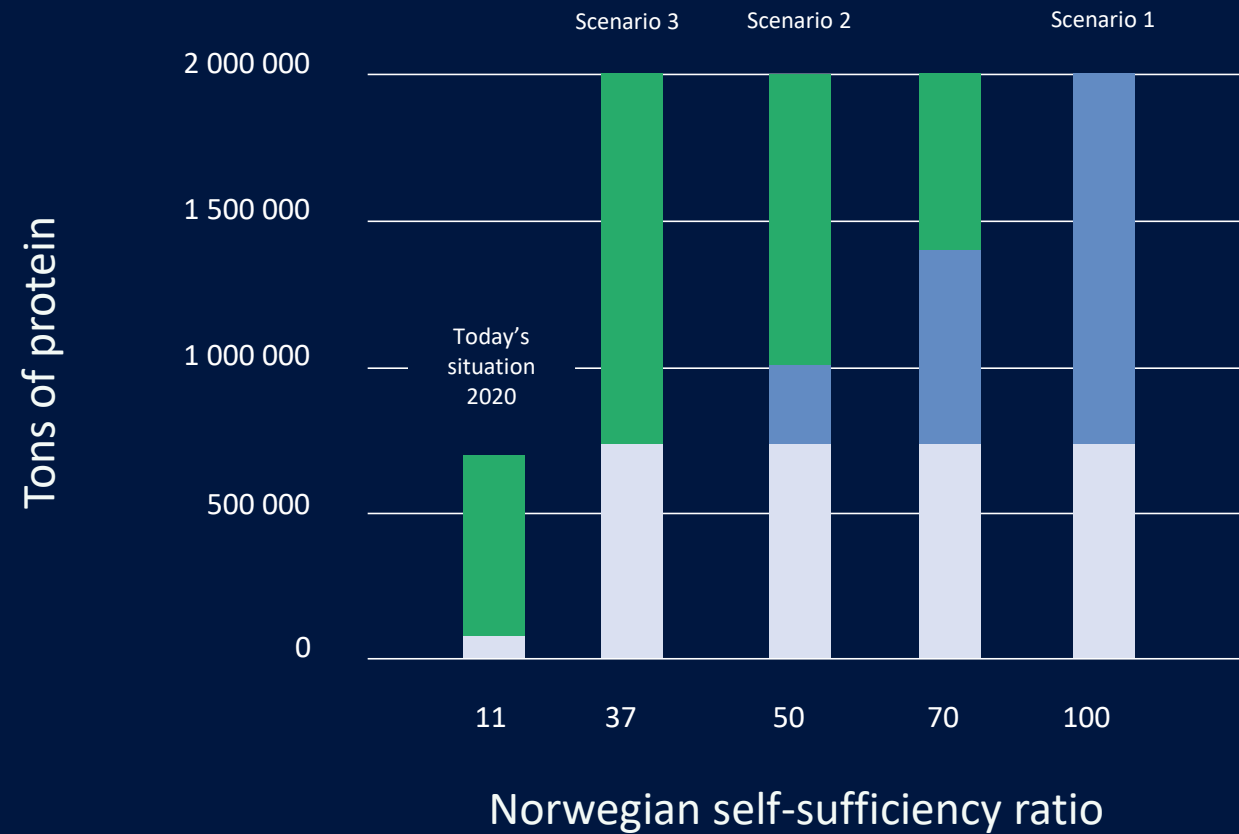
Feed sources for Norwegian salmon production: Summary (tons)



Production of "New cells by fermentation" through the establishment of new industry

"Utilizing known cells"

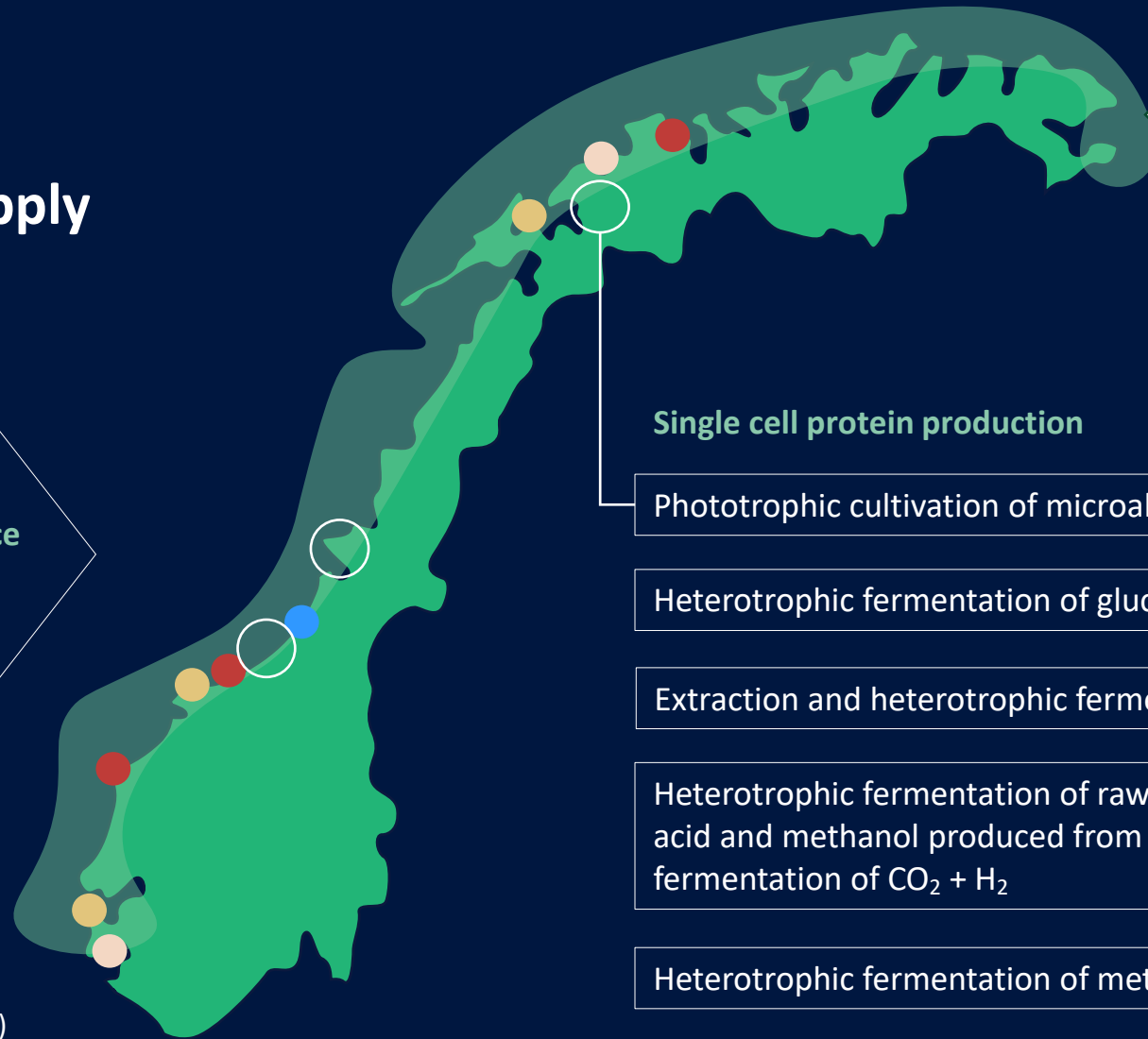
Different scenarios to produce 2 million tons of protein



Future feed supply

Less access to long-distance feed raw materials?

- **Mowi**
(Bjugn)
- **Biomar**
(Karmøy og Myre)
- **Cargill**
(Florø, Halså, Bergneset)
- **Skretting**
(Stokmarknes, Averøy, Stavanger)



Total utilization of "local biomass"

- Marine raw materials (120,000 tons Øyepål)
- Land-based raw materials
- Cultivated plants and animals

Single cell protein production

Phototrophic cultivation of microalgae with CO₂ as carbon source

Heterotrophic fermentation of glucose and/or sucrose

Extraction and heterotrophic fermentation of sugars from wood

Heterotrophic fermentation of raw materials such as methane, acetic acid and methanol produced from CO₂ + H₂, alternatively autotrophic fermentation of CO₂ + H₂

Heterotrophic fermentation of methane from natural gas or biogas

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