Marine microalgae for meeting global needs for feed & energy

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Rehovot, Israel

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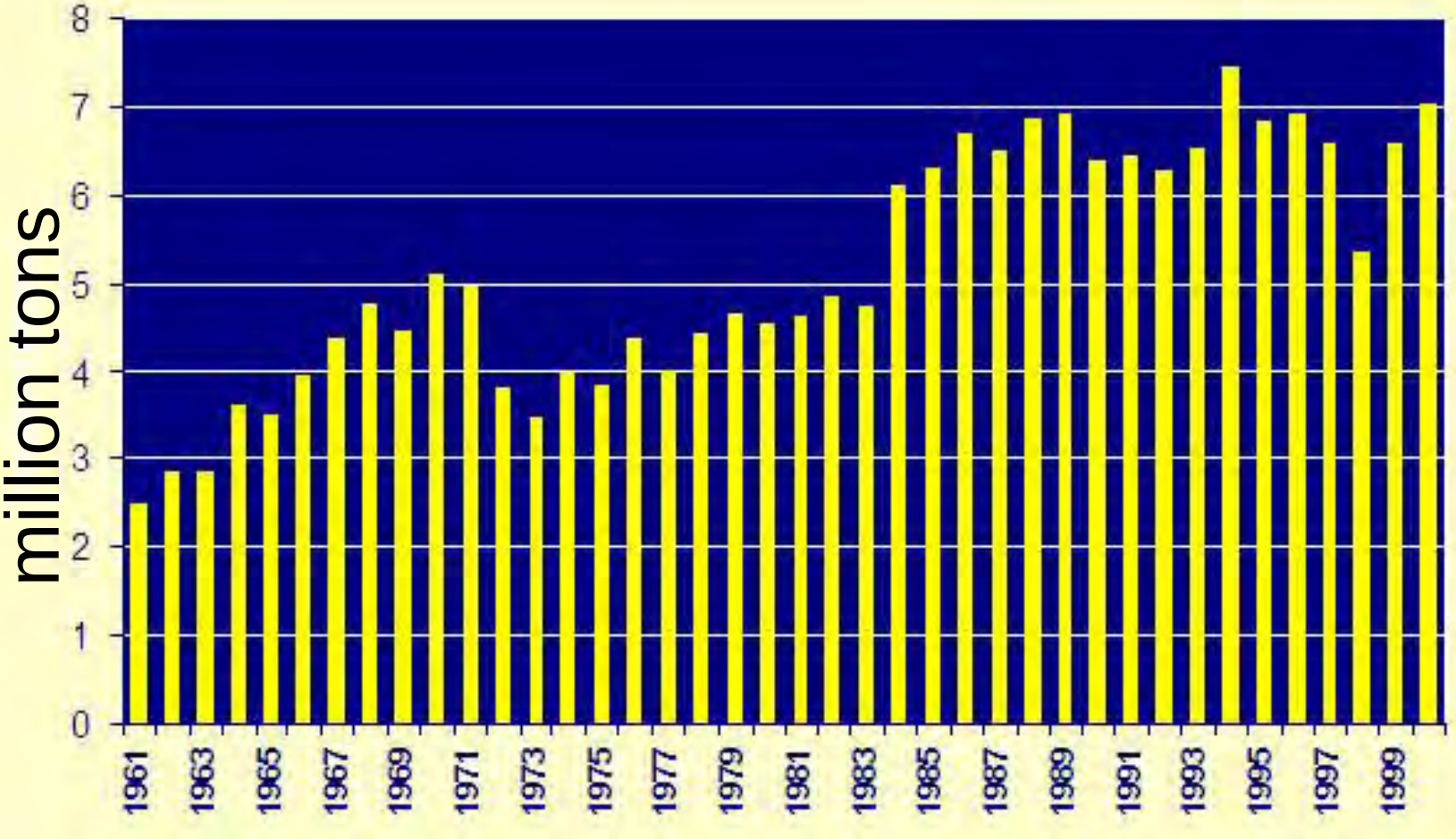
More than 40%

of grain is used for animal feed

But grain is missing key nutrients for monogastric animals – fish, poultry swine

Fishmeal is a major source for missing nutrients

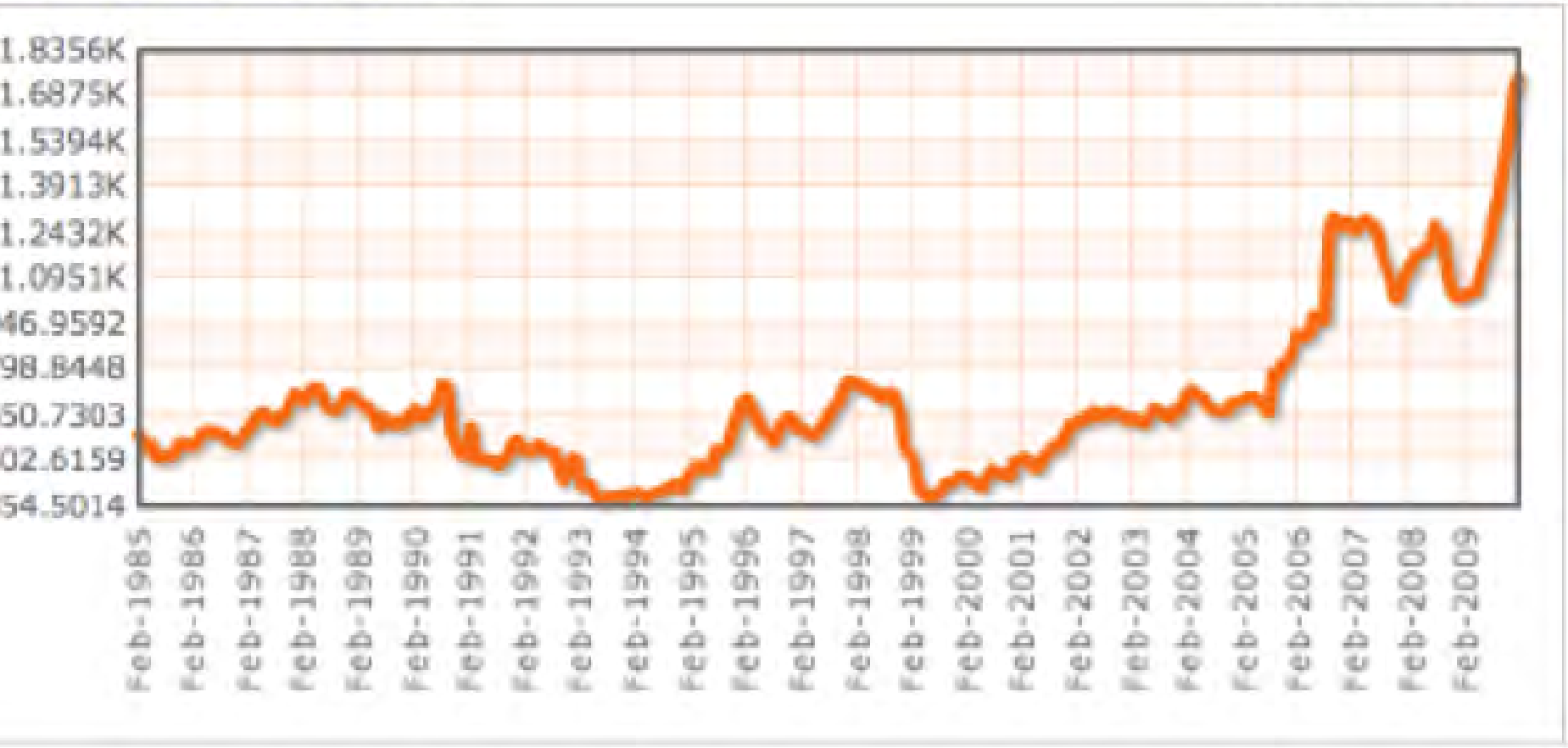
Supply of fishmeal is steady



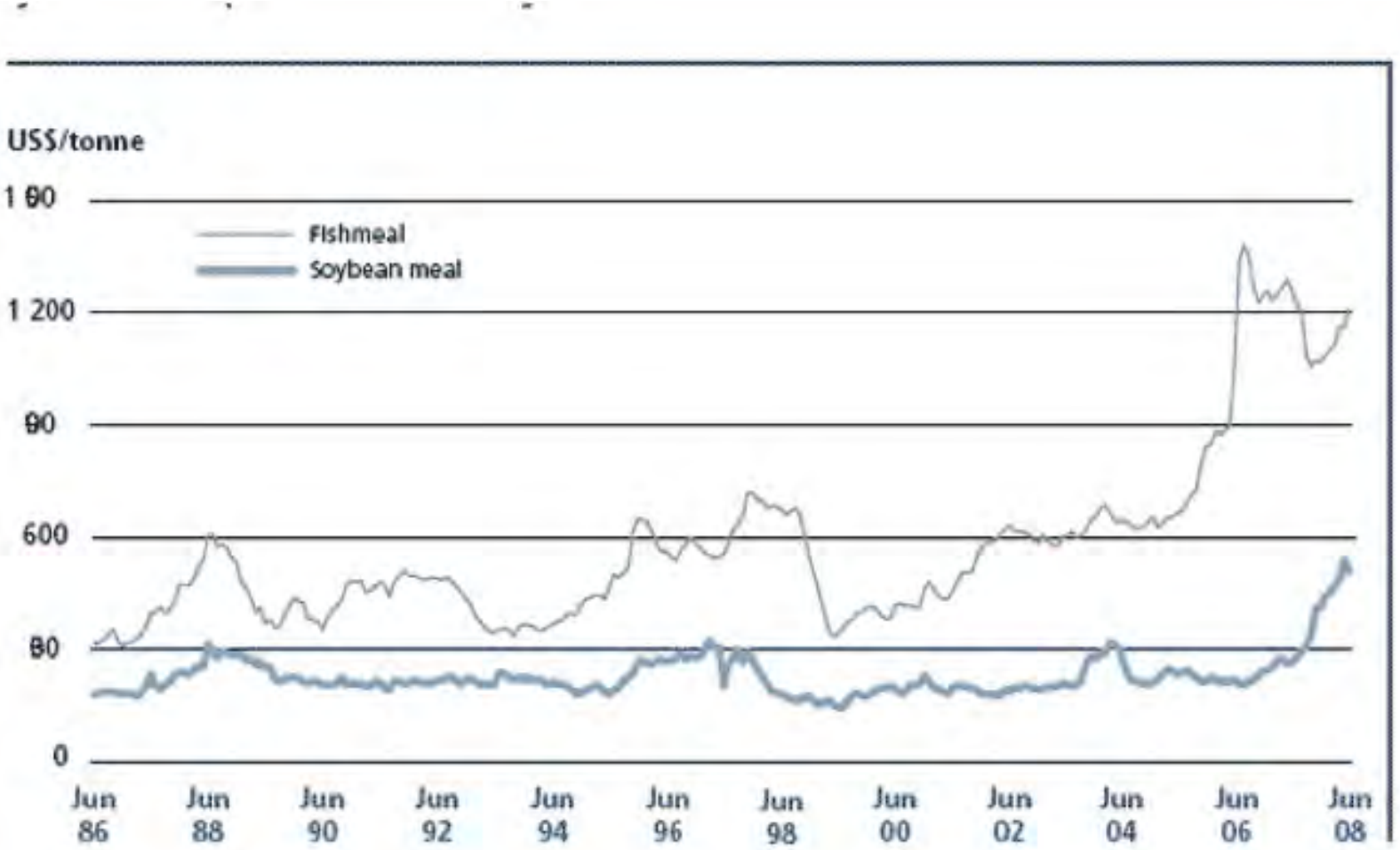
Due to demand – price is skyrocketing

6m 1y 5y 10y 15y 20y 25y

Feb 1985 - Jan 2010:



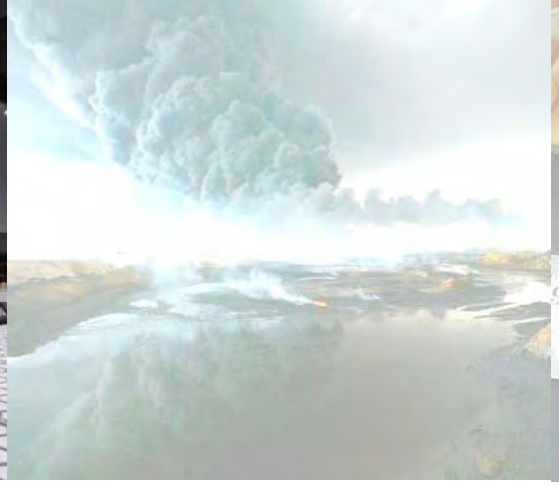
especially compared to soybeans



Source: FAO Fisheries – The State of World Fisheries and Aquaculture, 2008
PART 1: World review of fisheries and aquaculture, p. 58

Soy allergenic to carnivorous fish missing some essential amino acids






The Solution:

Algae-based Biofuels & Feed

>20x potential

algae yield compared to soy & corn

<1% freshwater, <5% land

<30% fertilizer, <10% pesticides

Many studies:
algae can replace fishmeal 1:1 by weight

Most peculiar:

- have excellent amino acid composition
- but less protein
- are less digestible

Algae have not been domesticated!

Domestication of grains took
5,000-10,000 years

TransAlgae using the methods of modern molecular biology to shorten the time to a few years

Year: 3000BC 1500 2009

To quickly domesticate

f

deals with further domesticating under-domesticated crops that lack genetic diversity. Analyzes and proposes where to get the genes

Developing world has many such crops

Domestication problems to be dealt with

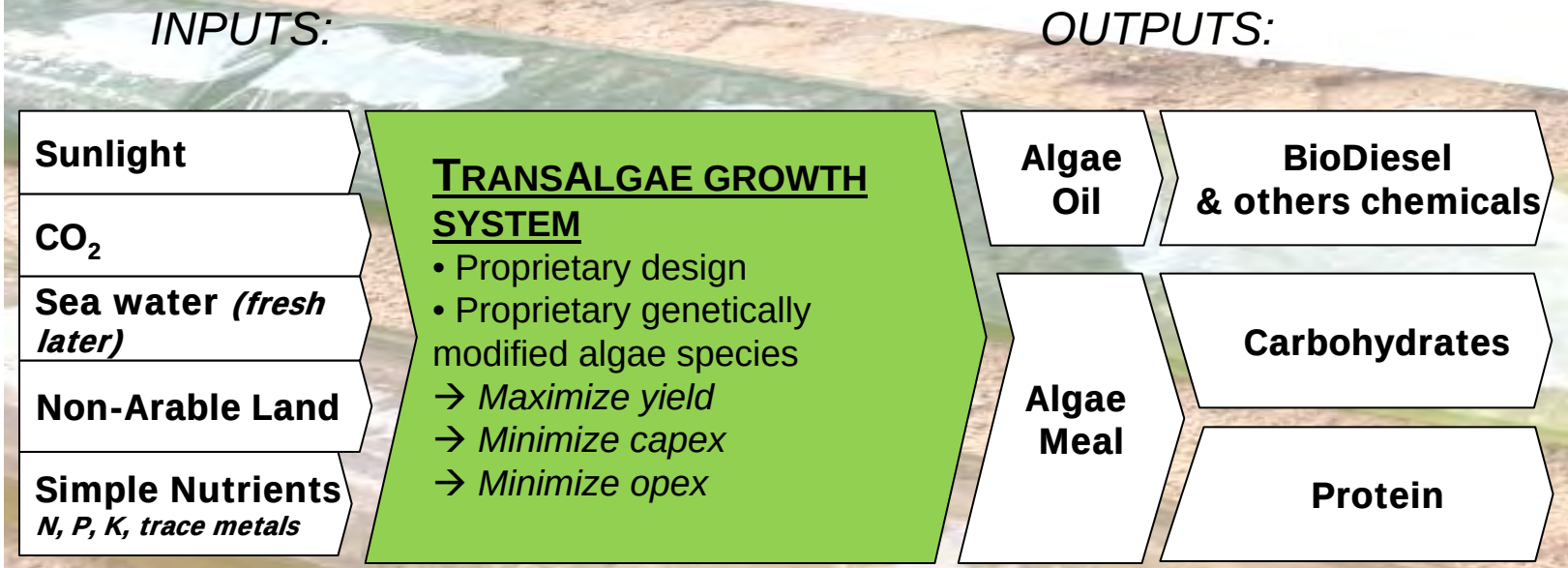
Process reliability

- Contamination
- Scalability
- Harvesting & extraction

Economics

- Production yields
- Capital & operational costs
- Multiple products

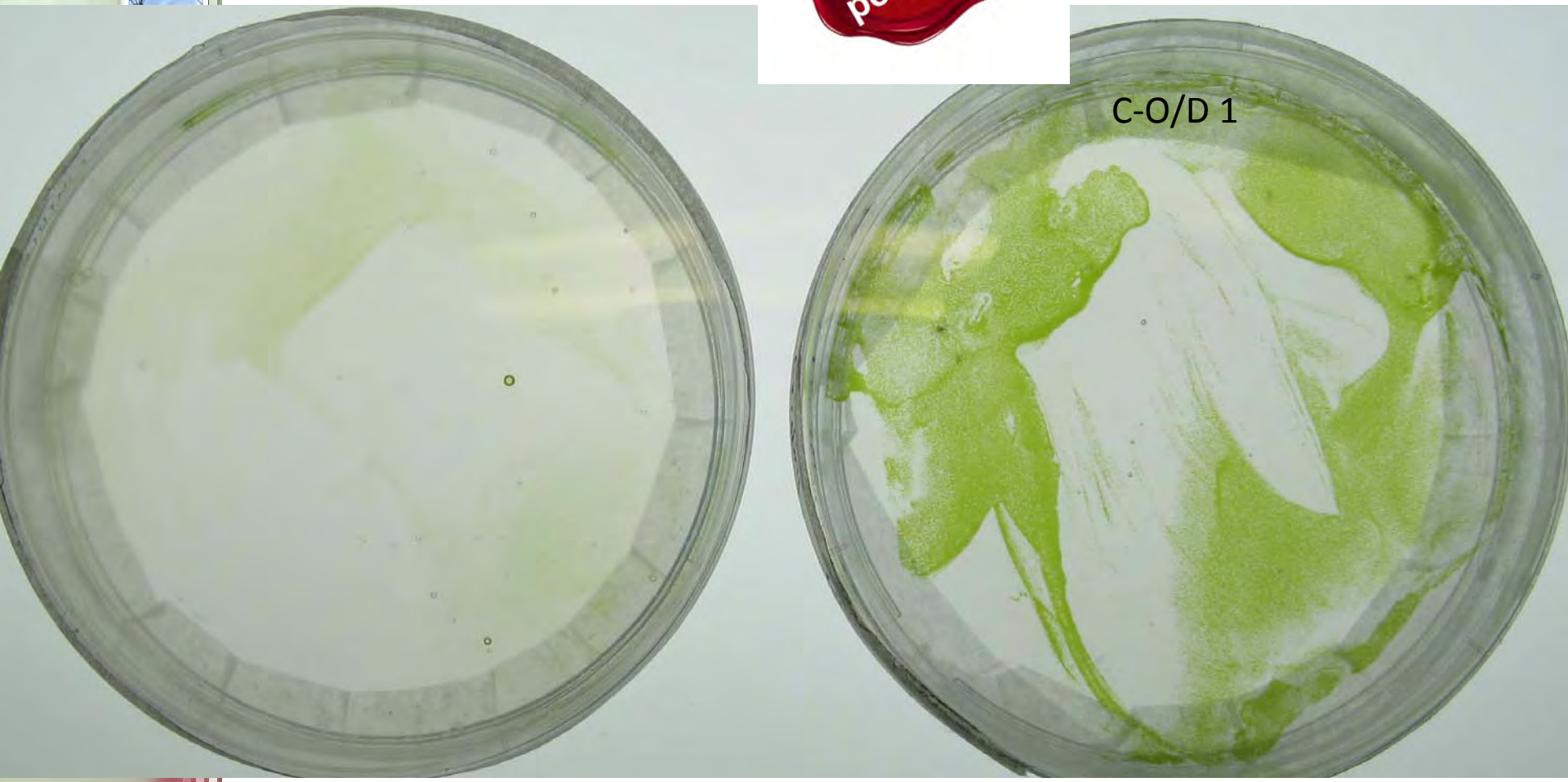
TransAlgae's Solution



Mock –Transformed (wild-type)

Patent pending

Transformed



Transformed algae are resistant to an inexpensive herbicide that kills other algae and cyanobacteria

Overcoming Barriers of Algae Domestication:

patent pending

solving system instability with **contamination-resistant genes**

Yield ($g/m^2/day$)	**TA strain**	**Wild type***
with herbicide	**27**	**dead**
without herbicide	27	26

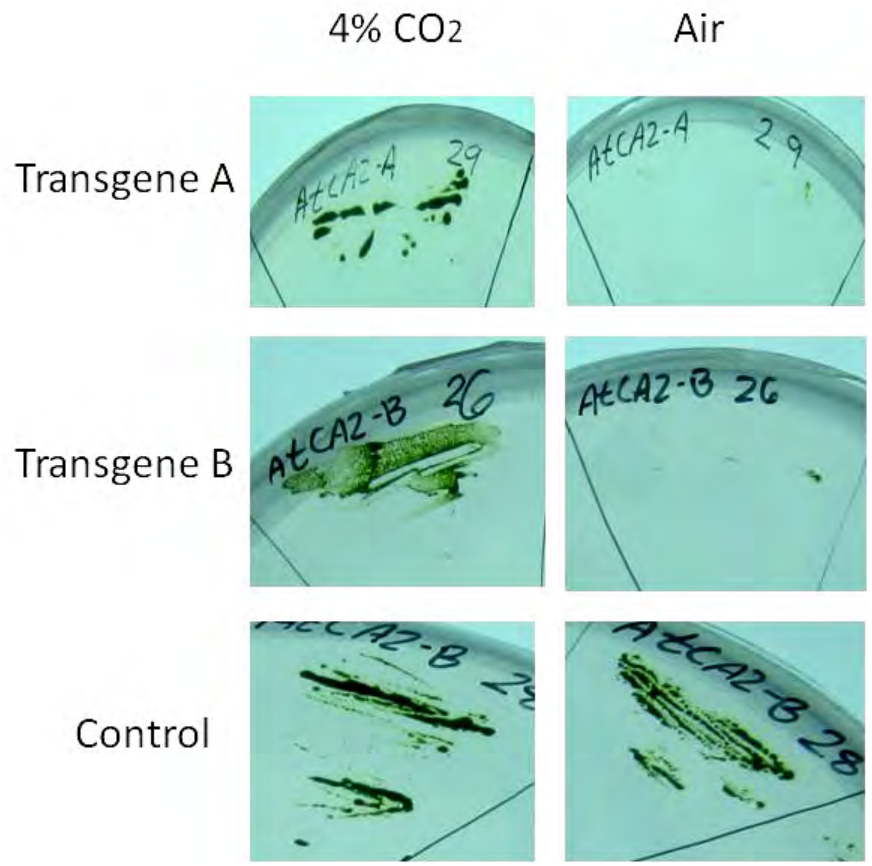
What if there is an inadvertent leak?

"Frankly, I think we'll regret introducing these organisms into the environment."

Mitigation – suppressed carbon capture

Patent pending

Engineer of high CO_2 requiring transgenic algae



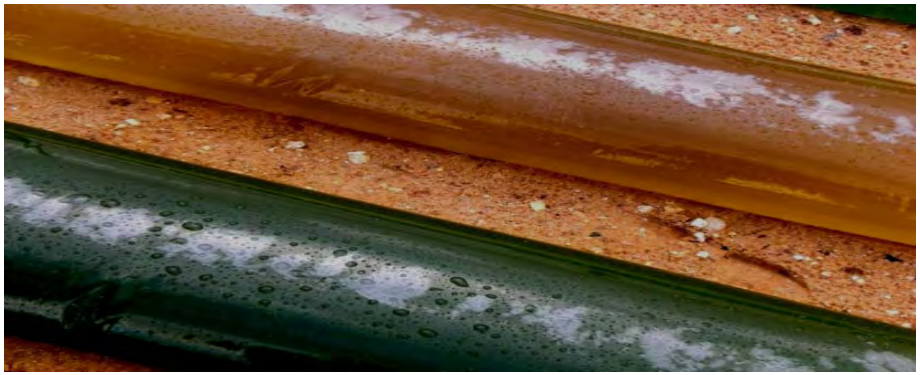
Overcoming Barriers of Algae Domestication:

patent pending

by providing

crop bio-safety using mitigation genes

	TransAlgae strain survival	Wild type survival
Within TransAlgae system	100%	100%
Within natural ecosystem	0	100%



Overcoming Barriers of Algae Domestication:

by providing

continuous harvesting & extraction technologies

patent pending

	TransAlgae continuous dewatering process	Conventional batch dewatering process
Time for separation of 90% of biomass	~15min	~ 12hr
% dry weight in volume	5%	1.3%

Control Trials – Dewatering process

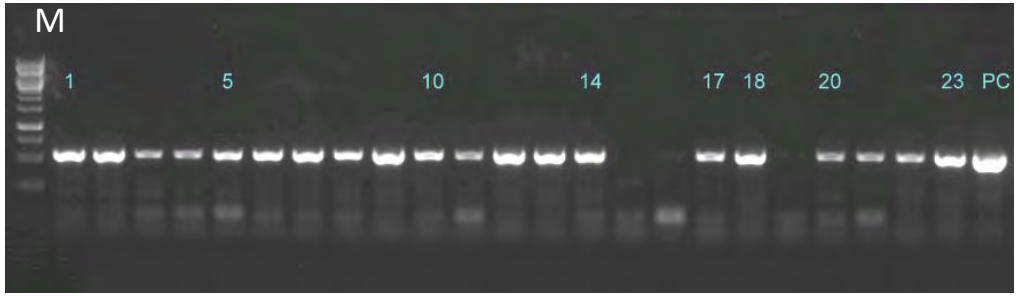
Methiosine
– increasing methionine and lysine

The following gene combinations were transformed

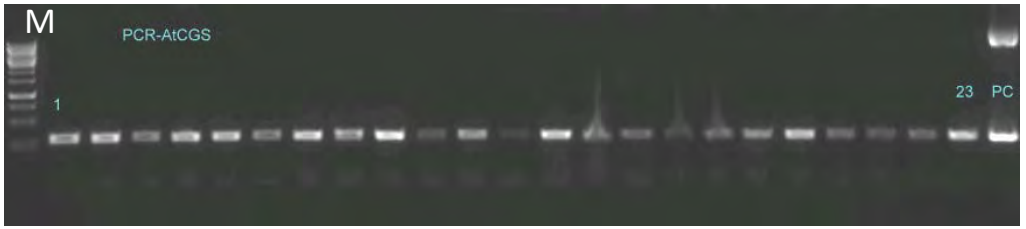
1. 15KD-10KD Zein fusion + AtCGS – **High Methionine**
2. 15KD Zein + AtCGS – **High Methionine**
3. BHL8 + DHDPS – **High lysine**

The presence of the 15KD Zein and AtCGS genes in the algae genome was confirmed by PCR:

15KD Zein



AtCGS



Can engineer in other genes: e.g. growth hormone

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Available online at www.sciencedirect.com
ScienceDirect
Aquaculture 277 (2008) 78–82

Aquaculture
www.elsevier.com/locate/aqua-online

Growth, feed efficiency, body muscle composition, and histology of flounder (*Paralichthys olivaceus*) fed GH transgenic *Synechocystis*

Shunmei Liu [a,b], Xuecheng Zhang [a,*], Xiaonan Zang [a], Bin Liu [a], K.K.I.U. Arunakumara [a], Di Xu [a], Xiaoqing Zhang [a]

Body weight with 0.5% and 2% transgenic cyanobacteria increased 32% and 49% - no differences in feed consumption

Algae have biodiverse metabolisms

Have a huge diversity of substrates
- can be engineered to produce novel products – if high value – prodn free
Two types:
Feed additives
e.g. vitamins, pigments, etc.
Extractables
e.g. pharma products, enzymes, lubricants, sweeteners, substrates
After extraction – rest for animal feed

Summary

Marine microalgae as fishmeal substitute

- do not compete for land and water
- sequester industrial carbon dioxide
- fertilizer efficient
- high productivity – multiple products
- need domestication – transgenically for:

  reliability – productivity- composition

Can be the next nail in Malthus's coffin