Turning to the Sea

John Forster

WAS New Orleans

"With Earth's burgeoning population to feed we must turn to the sea with new understanding and new technology.

"We must farm it as we farm the land"

Jacques Cousteau 1973

Cousteau didn't explain what he meant by this.

I'll try and explain today what it means to me.

Some of the ideas may seem distant or futuristic

But as we discuss ‘aquaculture issues’ are we losing site of the most important reason to develop it?

‘A bigger vision’?

Is it time to re-introduce the idea?

Unless the American people are convinced of the national importance of marine aquaculture, we will not achieve the policies needed to make it happen.

http://www.anglersbooksupply.com/book_images/0TAKUMGRT6.jpg

Not a new idea - Ocean Food and Energy Farms 1968

Giant kelp *M. pyrifera*

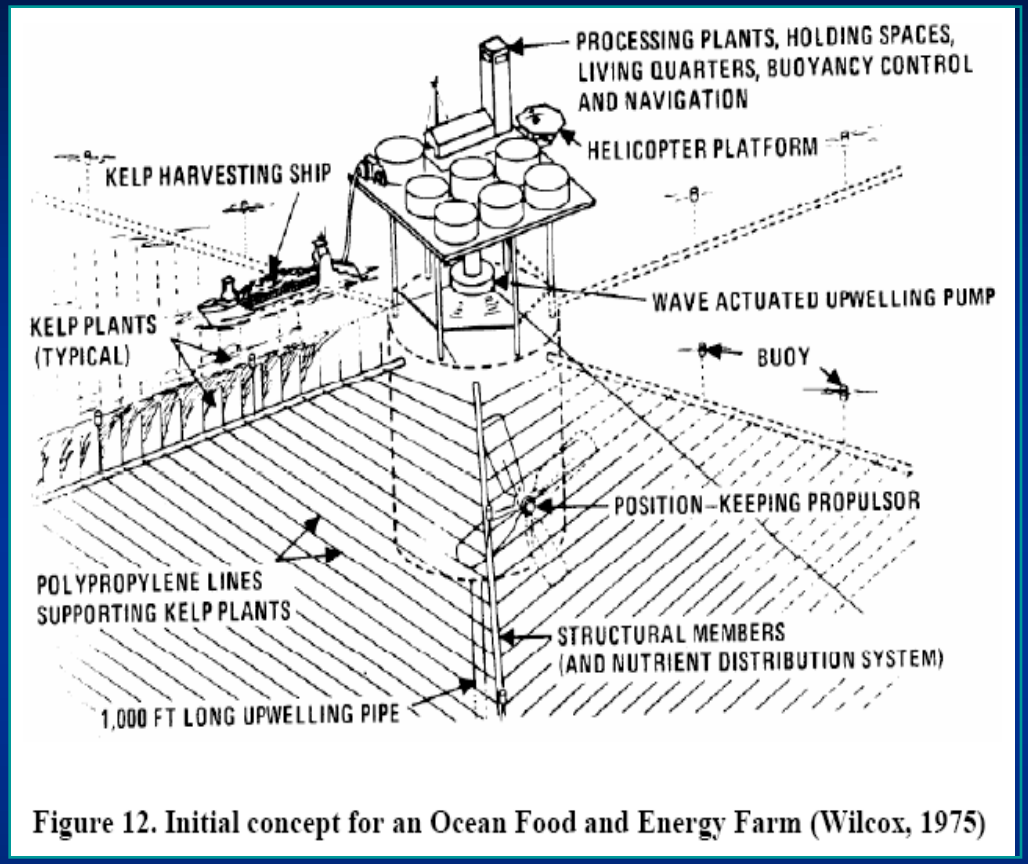
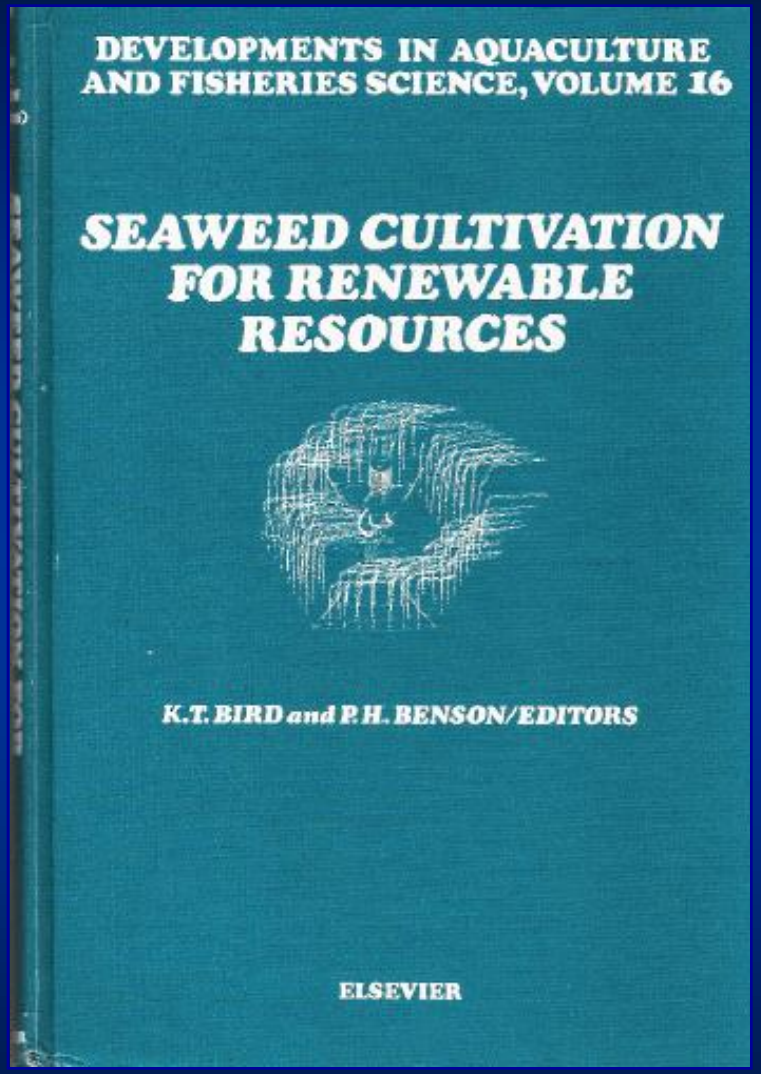


Figure 12. Initial concept for an Ocean Food and Energy Farm (Wilcox, 1975)

First proposed by Howard Wilcox in 1968

The U.S. Marine Biomass Program 1972 - 81



See also Chynoweth – 2002 & Battelle 2008

Reasons it lapsed

- Early in the technology
- Emphasis on bio-energy
- Need for large volumes
- Food & feed overlooked?
- Oil crisis ended

When it ended we lost a vision for marine aquaculture that reached well beyond most of our ambitions today.

It's hard to feel at ease now

Since 1980 there are:

- 2.4 billion more people
- Using more resources
- Chronic energy worries

By 2050 there will be:

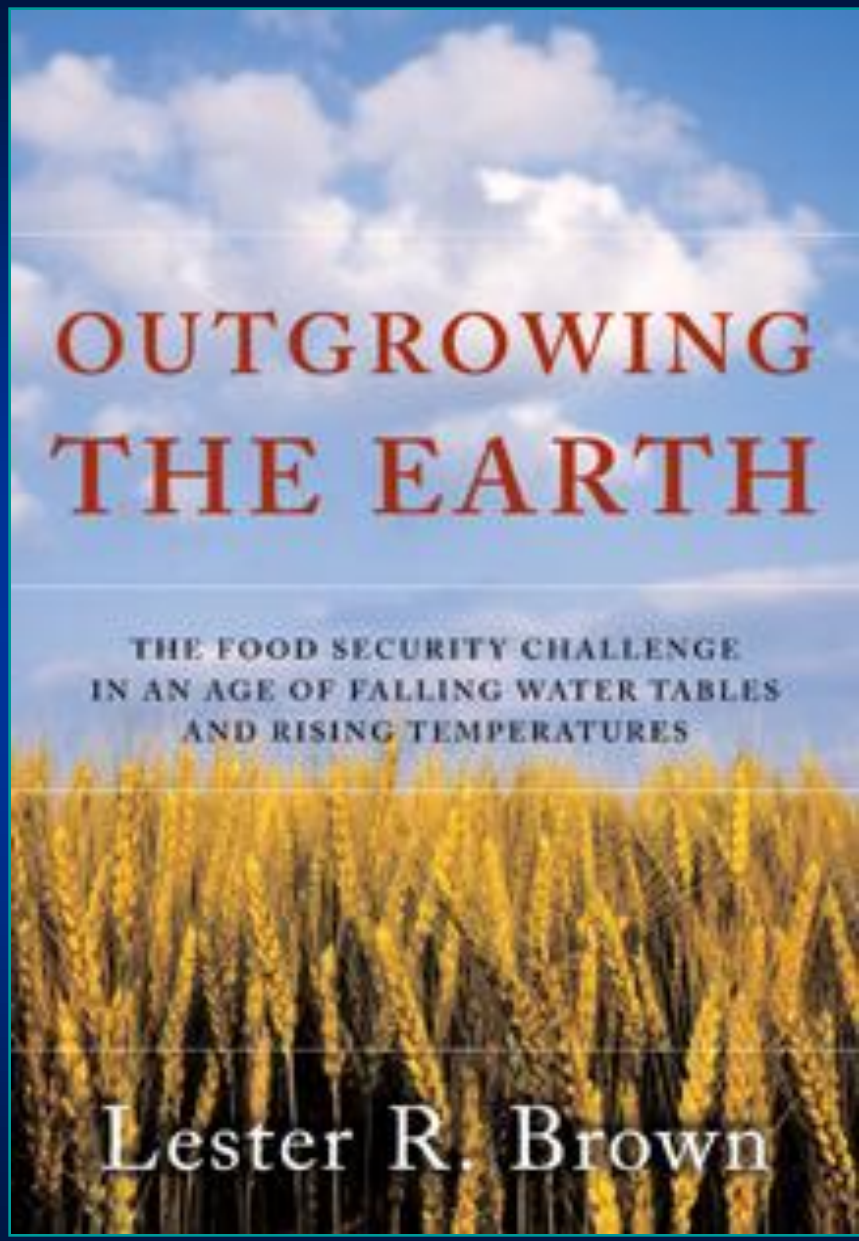
- 2 billion + more people
- Needing 70% more food

  –that's 5.5 billion mt.

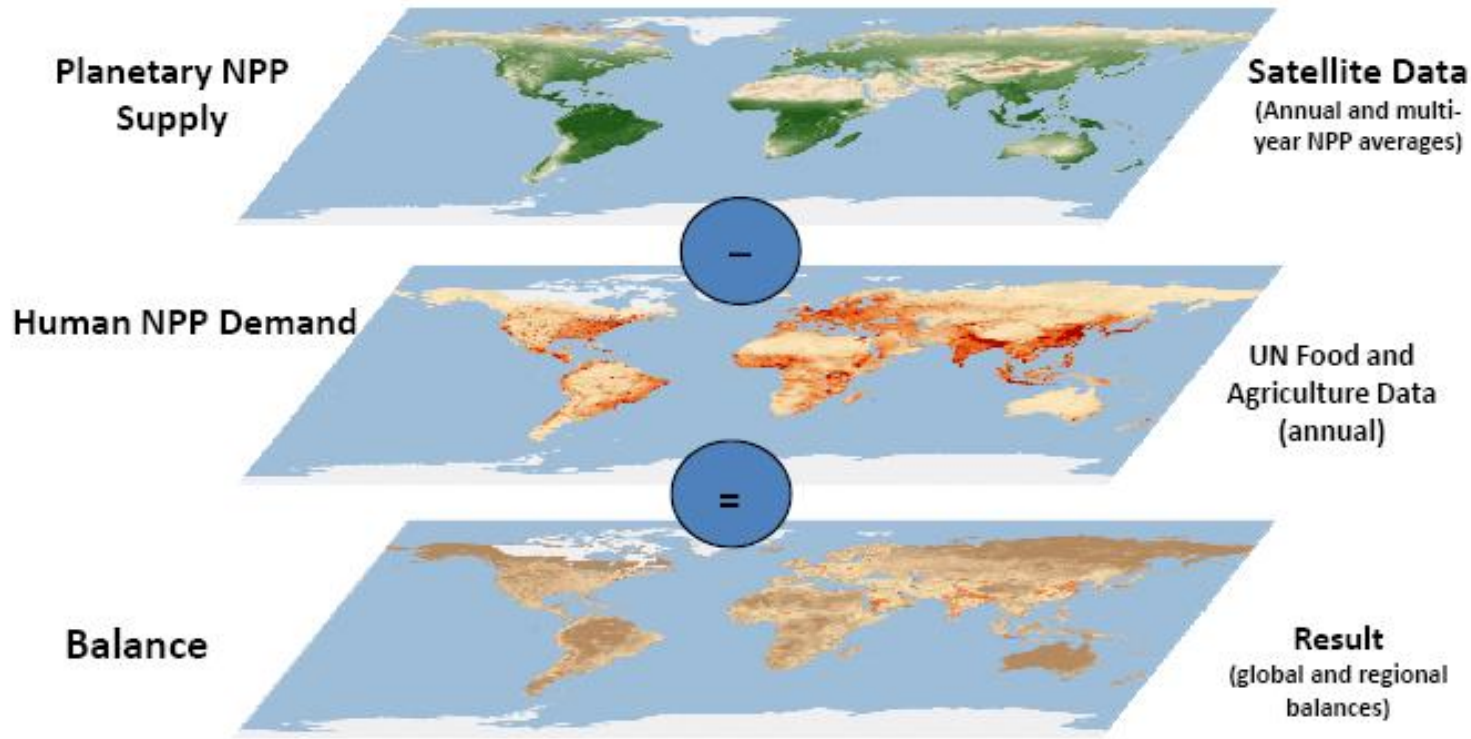
Reasons to worry

- Water tables falling
- Croplands eroding
- Grasslands to deserts
- Food for Biofuel
- Croplands for non-food
- The Earth is warming

'Global human appropriation of net primary production'



Creating the Balance Sheet: Can the Earth Keep Up?



M. L. Imhoff et al., Nature 429, 870, 2004 M. L. Imhoff et. al., JGR, VOL. 111, 2006

Satellite Supported Estimates of Human Rate of NPP Carbon Use on Land: Challenges Ahead. M. Imhoff1, et al 2010

Not the first time people have worried about this


Thomas Malthus

"The power of population is so superior to the power of the earth to produce subsistence for man, that premature death must in some shape or other visit the human race." *Malthus 1798*

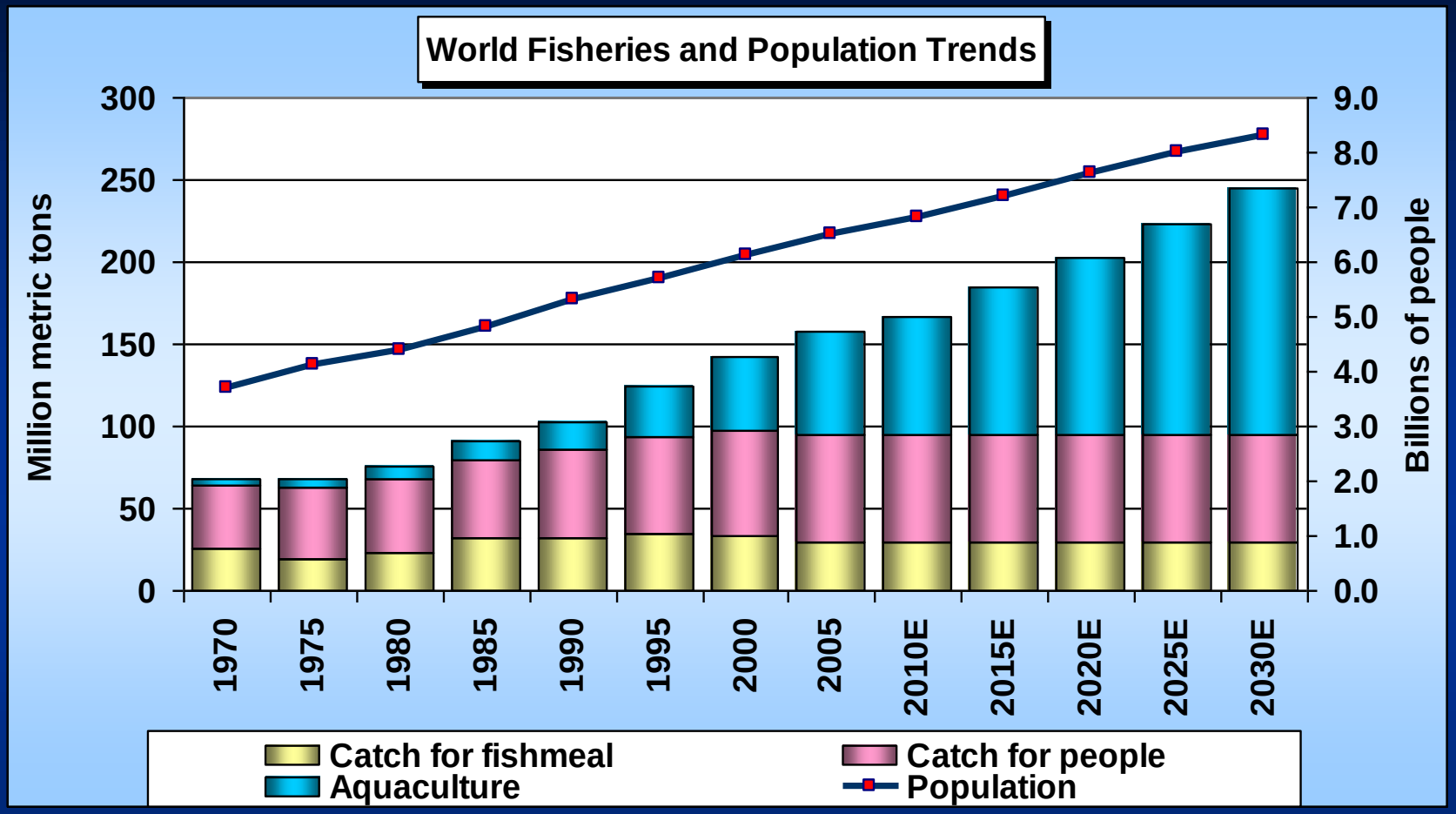
“Malthus delayed is not Malthus denied” *www.planetizen.com*

What does all this have to with aquaculture?

"Will the Oceans Help Feed Humanity?"

Duarte, Holmer, Olsen, Soto. BioScience 2009

Should we expect more than is now assumed?



Source: NOAA Fisheries, J Cho, personal communication.

Against 5.5 billion mt food needed, 70 mmt assumed in this projection is not much.

The oceans cover 70% of Earth's surface

Our Food Supply

	Mt million
Total food	7,700
Marine fisheries	80
Marine aquaculture*	36
Total seafood	116

*Includes plants

Seafood % of total 1.5%

If our food supply is in doubt, that doesn't make sense

Fisheries a vital food source – but low yield

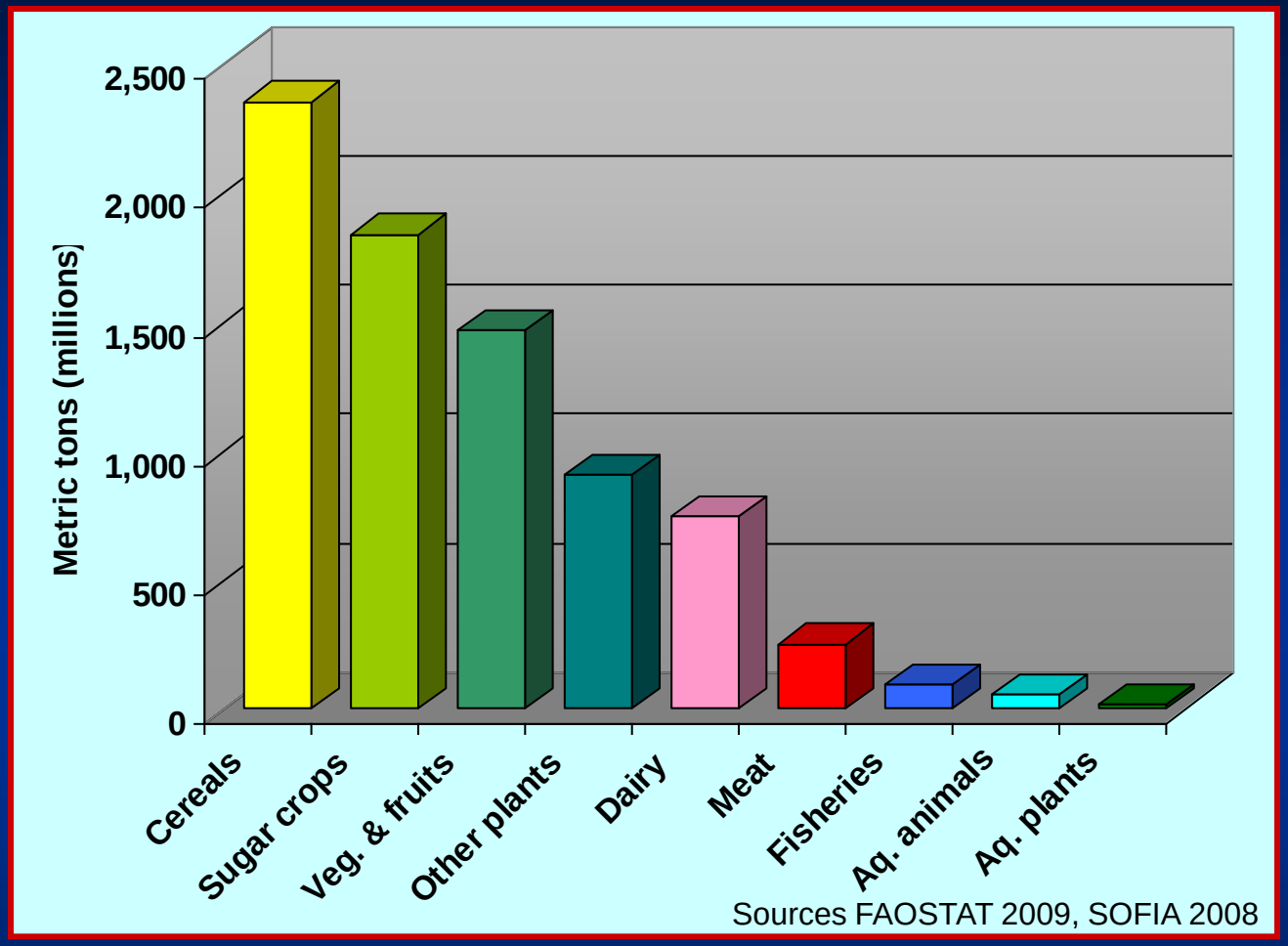
	Food yield per hectare / day		
	Marine	Freshwater	Terrestrial
Protein (g)	0.5	8.8	32
Calories	3.3	54	1,251
Total wt (g)	9.3	88	1,384

Source FAO STAT 2003 & Millennium Ecosystem Assessment

Do we have to accept this?

Can we not make better use of the sea?

World Food Production



Aquaculture ‘Feeding the world’? ‘Fastest growing food sector’? One day may be but a long way to go.

The Product Mix

Agriculture	Mt millions
Plants	6,560
Animal products	991
Aquaculture	
Plants	15.7
Animal products	55.0
Fisheries (FW & SW)	
Plants	1.1
Animal products	92

Plants %

→ 87%

→ 22%

→ 1.2%

Sources FAOSTAT 2009, SOFIA 2008

It's not that the oceans don't produce plants

At a trophic level of 3.1

80 mmt

from marine fisheries

derives from

10 billion mt

of phytoplankton

But we can't capture all that production. So we let the marine food web do it for us and accept the losses.

Can we build a marine agronomy on what we've begun?

And 'farm the sea as we farm the land'?

Benefits

- Needs no land
- Or freshwater
- Or nutrients?
- Captures some CO_2
- Net biomass gain + habitat
- Seaweed based feeds

Nor would it need that much space

L. japonica in China yields19.5 mt dry wt per hectare per year.

To grow 6.6 billion mt (the weight of terrestrial plants produced for food now) would need:

340 million hectares

That's only 1% of the oceans' surface

It’s still a huge area

Even if possible it will take decades to develop.

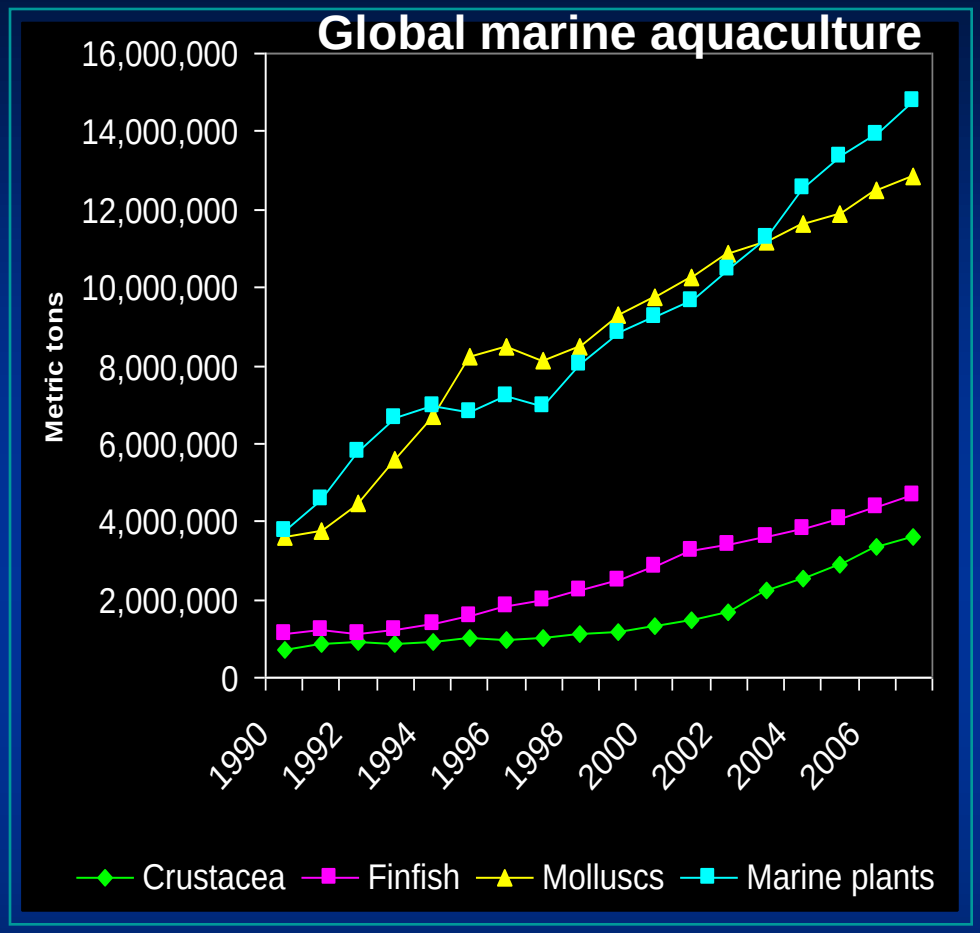
But the idea, that one day we could double the world’s harvest of food plants by farming less than 1% of the sea -

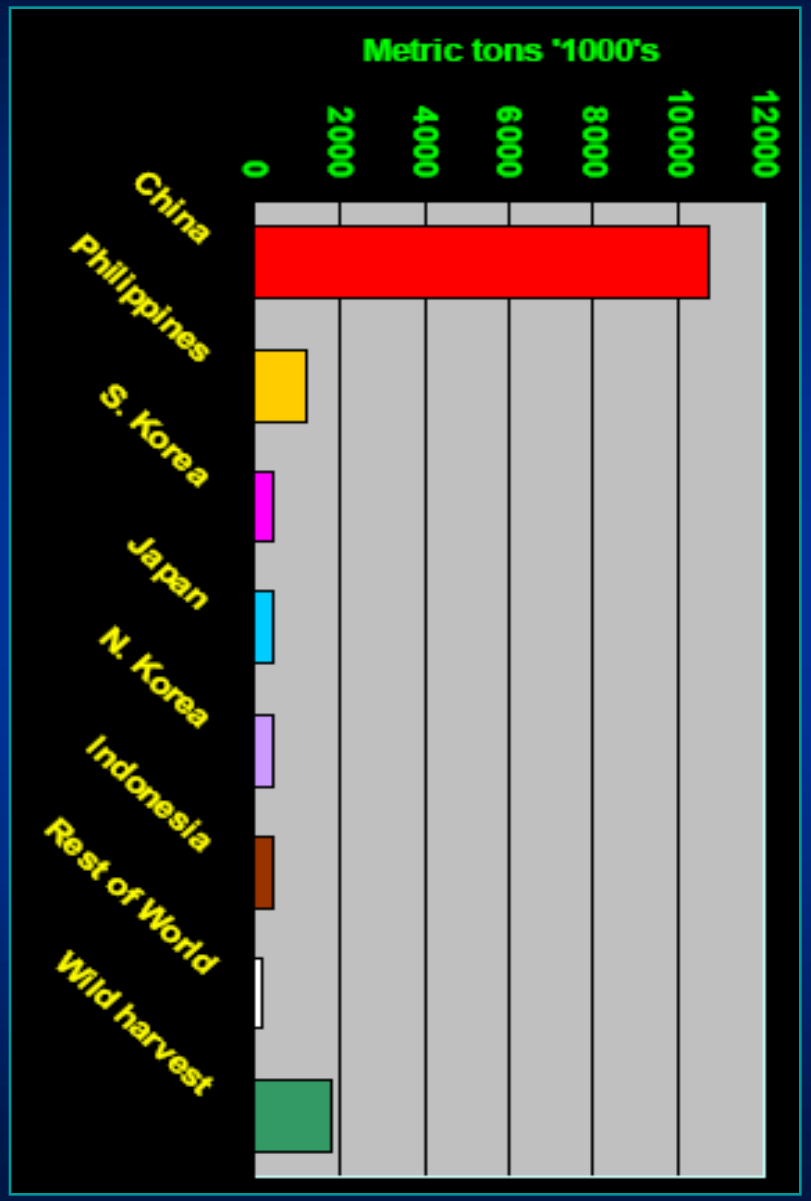
Offers a perspective on Earth’s productive potential that suggests a bigger role for aquaculture than now assumed.

That's the proposition

- To build on what we've begun.
- To develop it into a marine agronomy.
- Based on marine plants as the primary product.
- For bio-refining to food, feed and other products.
- That make a material contribution to our food supply.
- And better use of some of the other 70% of Earth.

How are we doing?



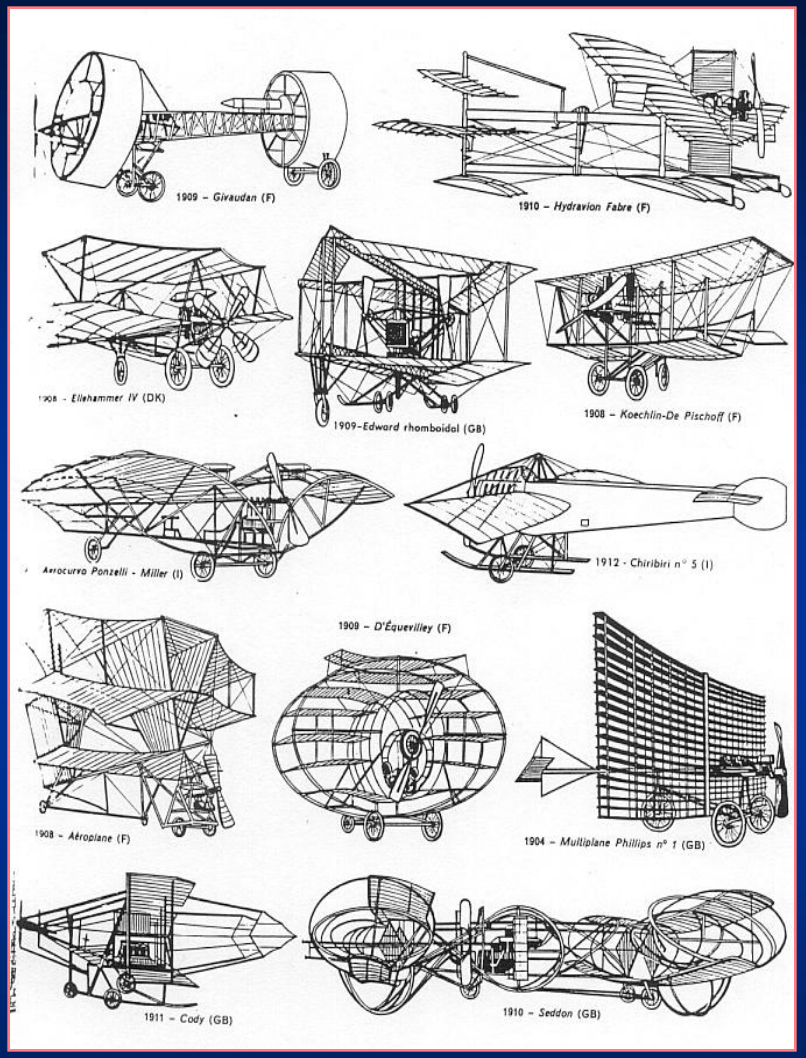


- 15.7 mmt seaweed in 2009
- 99.8% from E &SE Asia

How practical is it to expand – really?

Challenges / opportunities

1. Ocean weather
2. Depth
3. Nutrients and CO2
4. Species choice
5. Processing
6. Costs



"Heavier than air flying machines are impossible"

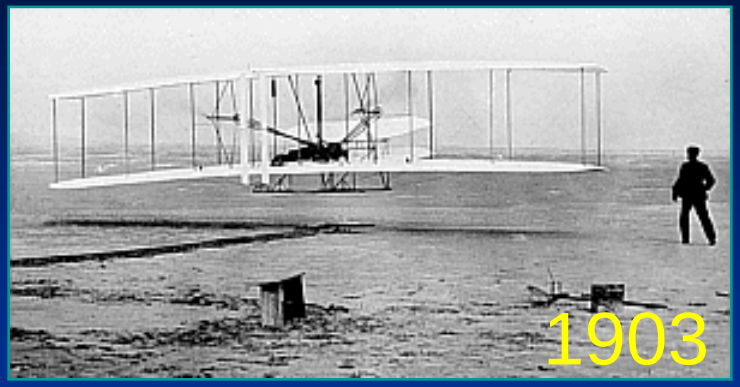
Lord Kelvin, Pres. Royal Society 1895

They were possible

- The Wright Bros proved him wrong in 1903.
- For the next 100 years aviation changed the world.
- Greatly benefitting America's economy and security.

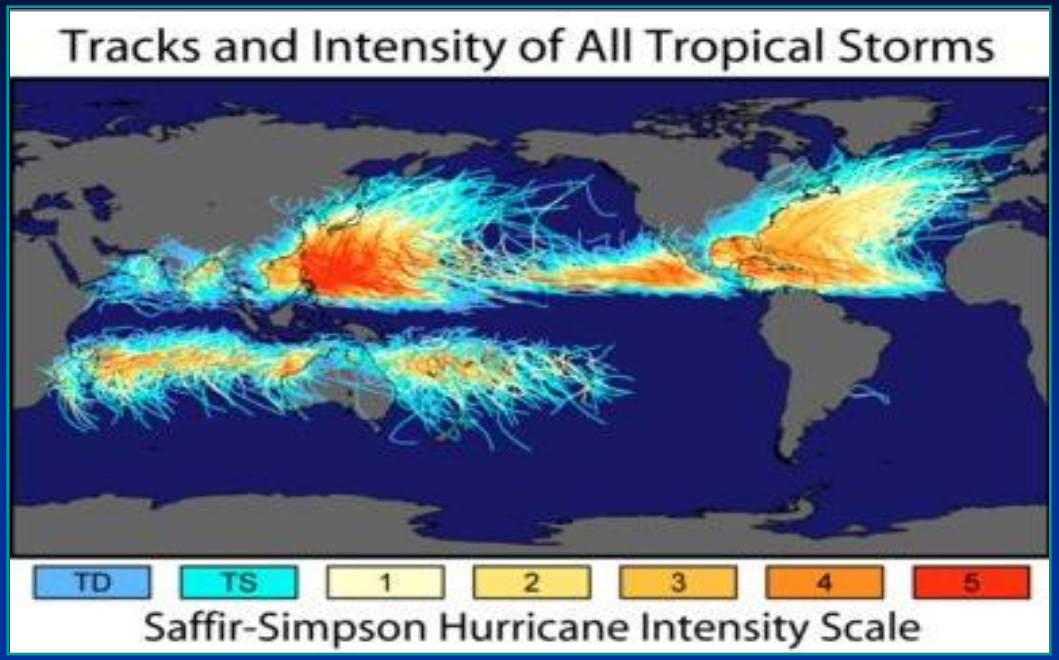
Man solves challenges when the opportunity is big enough.

But big developments need time to evolve.

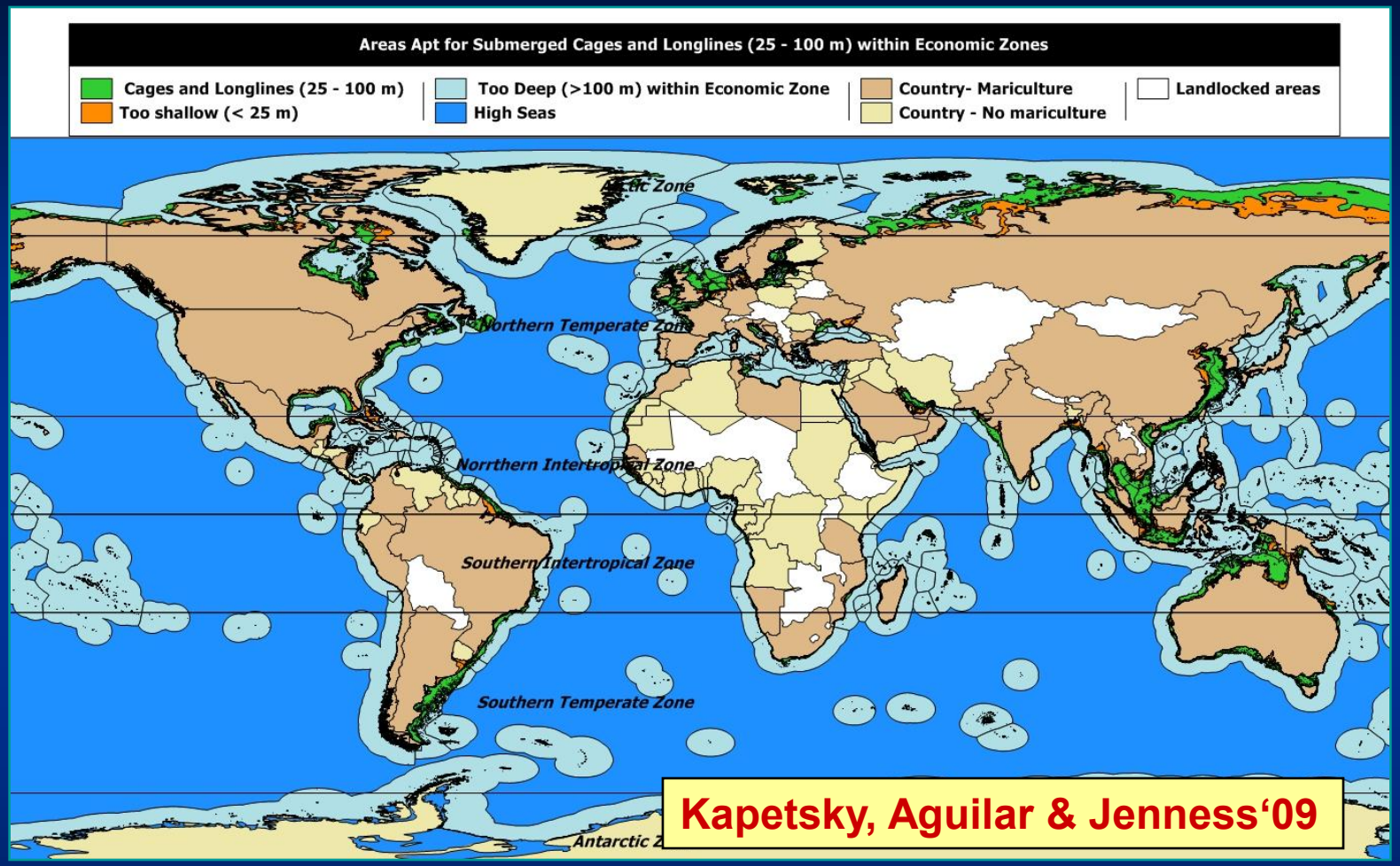


1. The challenge of weather

- Storm severity varies regionally.
- Select areas where storms less frequent – at least to start
- For example
  - East coast of Spain.
  - S. California.



2. The challenge of depth

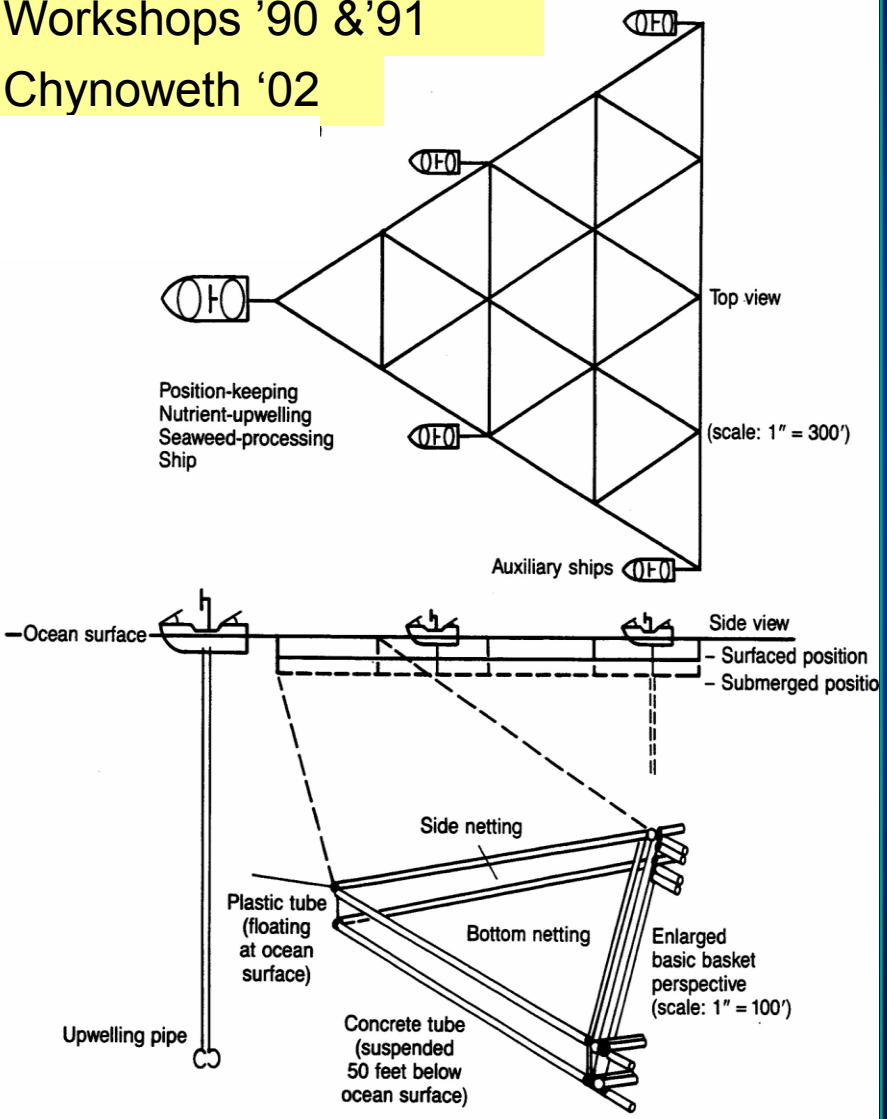


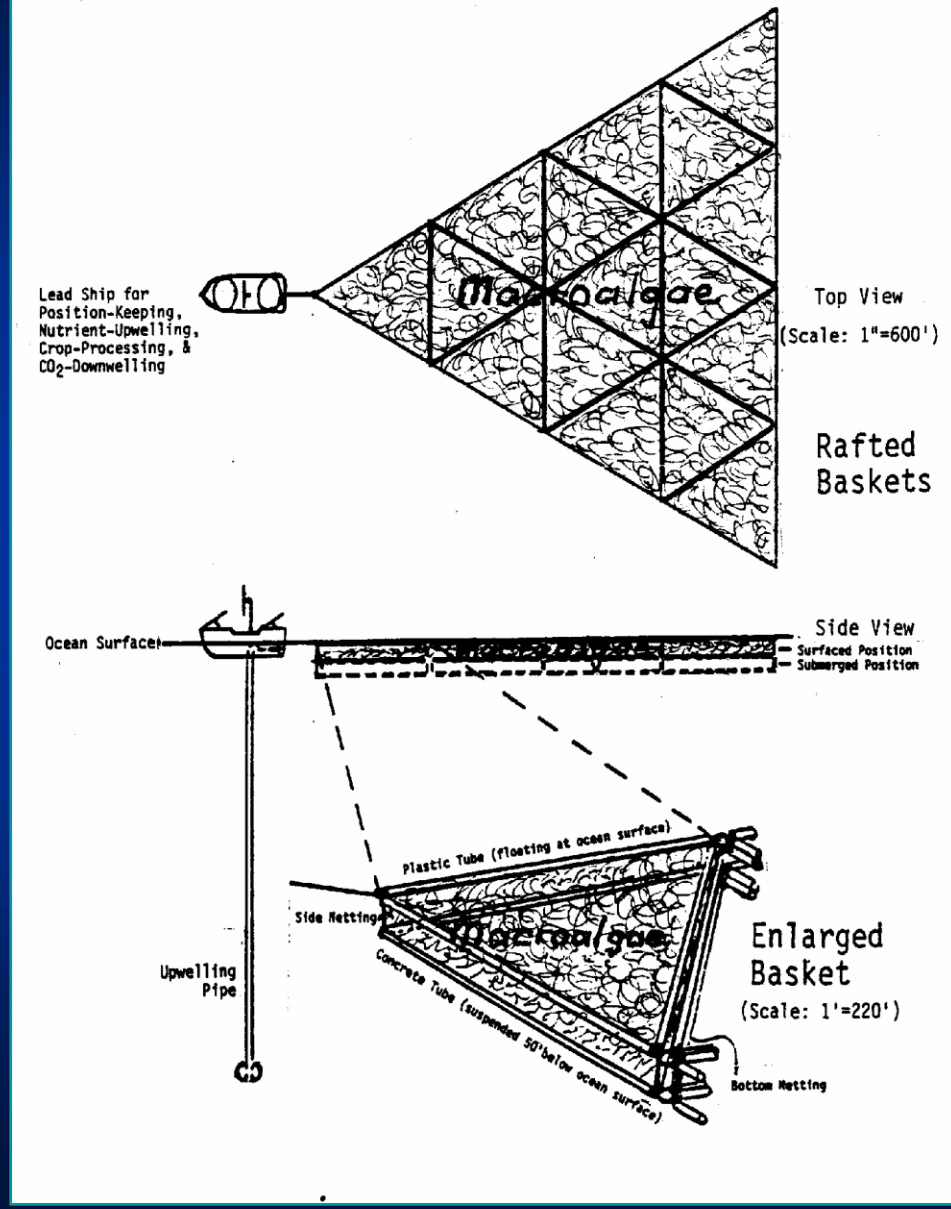
- Little space <100m above which mooring too costly.
- Free floating, self positioning ? Renewably powered?

Powered by wind, solar, current, wave, OTEC ?

From Marine Biomass Workshops ’90 &’91

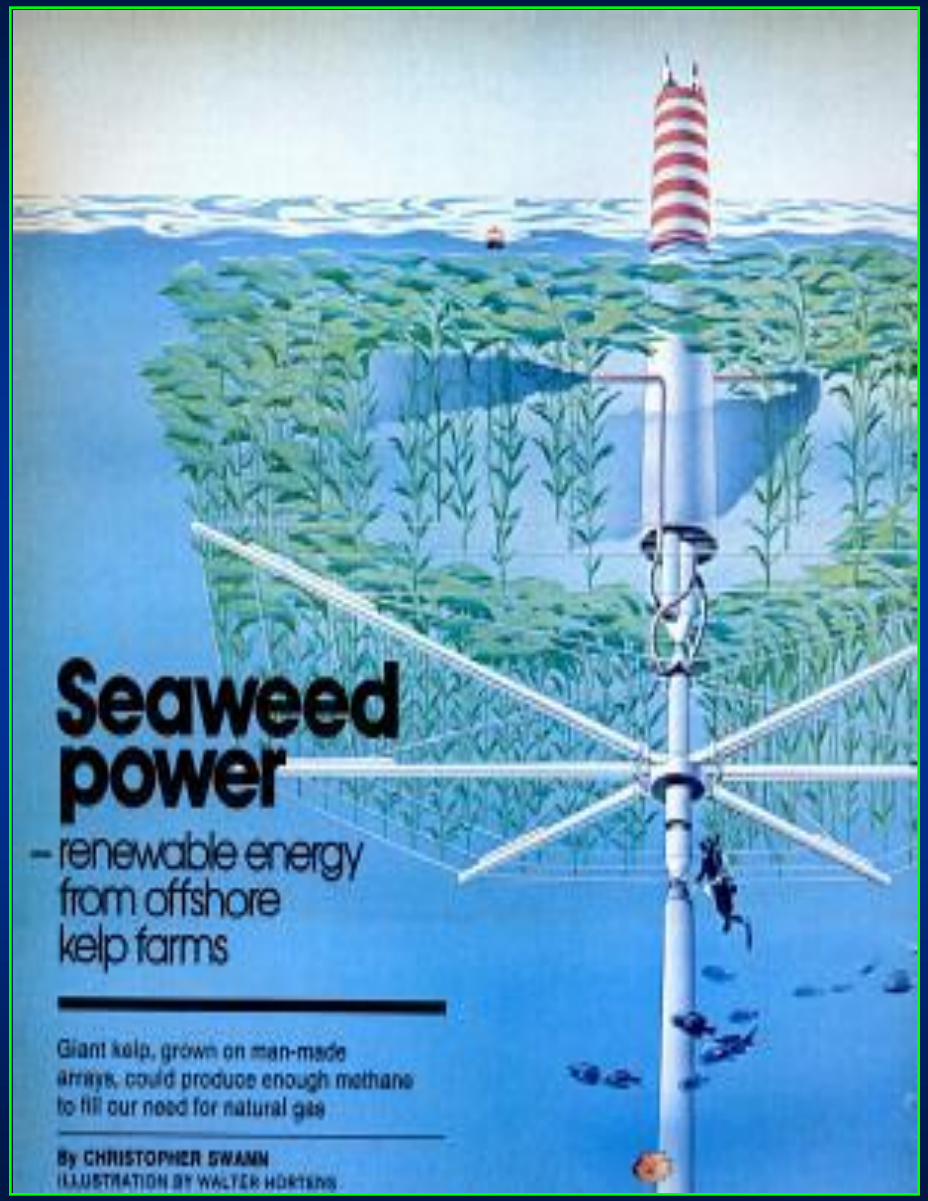
Chynoweth ‘02





3. Supply of Nutrients & CO_2

- Mass transfer in sea water is slow
- Concentration gradients must be kept as high as possible.
- Maintain water flow
- In a large plantation that will be difficult.
- Some species fix N_2



Popular Science 1981

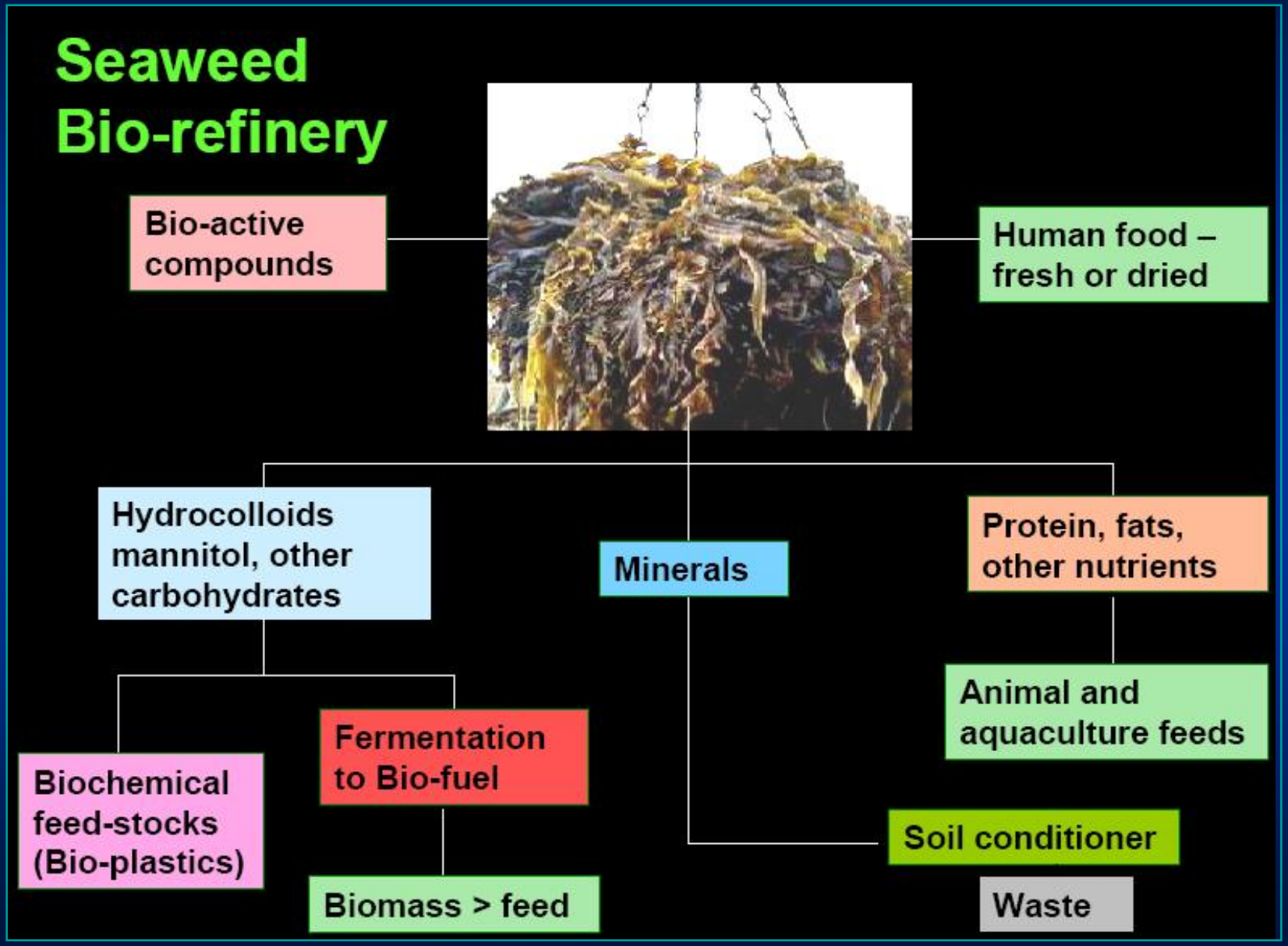
4. Species choice – An Opportunity

1. Climate zone
2. Growth rate, size
3. Floating, attached
4. Nutrient content
5. Reproduction
6. Harvest method
7. Breeding


Sargassum sp

Macrocystis sp

5. What could we do with the biomass?



6. Costs

- World seaweed harvest in 2009 @$0.47/kg.
- At 85% water content = $3.31/kg dry wt.
- Corn $0.30/kg dry wt. (4.5 cents/kg wet wt eq.)
- Start with high value products.
- Maximize value by bio-refining.

Corn farming then and now

Ocean Approved

- Wild harvest & now farming kelp *Saccharina latissima* for
- Kelp noodles, salad & slaw cut.
- Food for people – highest value

"Kelp waits to take its place in America's stomachs"

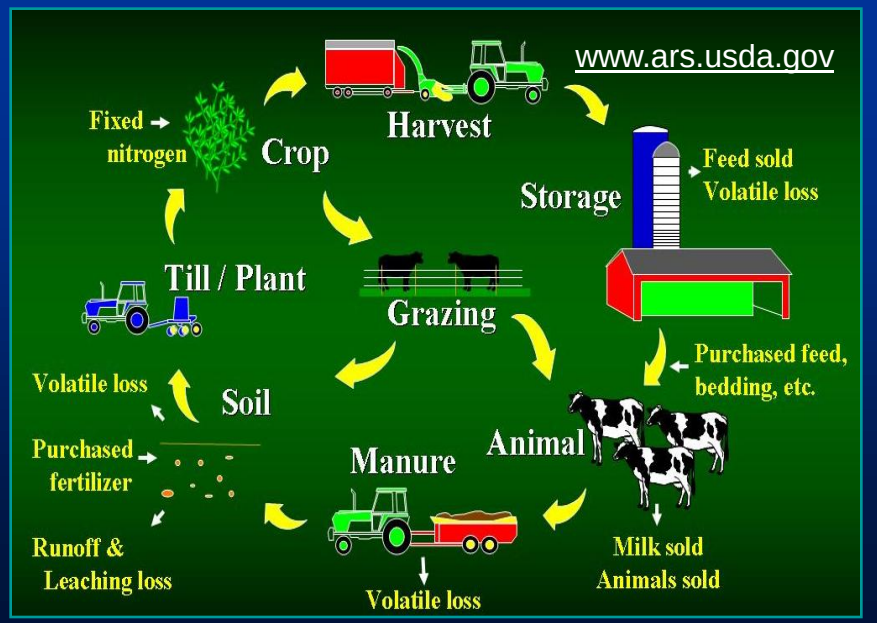
Going Green on msnbc.com

Integrated multitrophic aquaculture (IMTA)

- Will teach about seaweed farming & sales.
- Add value to near shore production.
- Feed driven.
- Trophic interdependency?

Integrated agriculture

- Plant driven
- Integrated but partitioned
- Trophic independence.



Biomara project

This project is generously supported by:

European Union
European Regional
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Investing in your future

A project supported by the INTERREG IVA Programme
managed by the Special EU Programmes Body

Highlands & Islands
ENTERPRISE

THE CROWN ESTATE

Northern Ireland
Executive

The Scottish
Government

Bio Architecture Lab www.ba-lab.com

- Synthetic biology > enzyme design
- Partnerships to biofuel from seaweed
- Norway, Chile, U.S. DOE ARPA-E prog.

"BAL and DuPont were awarded a $9m grant from the Department of Energy's ARPA-E program for the production of butanol from macroalgae."

Seaweed - aquaculture feeds

Could algae offer answer for the future of global fish feed?

"The Scottish Aquaculture Research Forum (SARF), in association with Marks and Spencer, has commissioned new research to look at the potential to use seaweed (macroalgae) and other microscopic algae as commercially viable sources of raw materials to feed fish."

www.sarf.org.uk – press release

Scottish Aquaculture Research Forum

Aquaculture feed an ideal co-product with biofuel.

Likely to be algal biomass available soon.

Conclusions

- No insurmountable obstacles.
- Obvious global need.
- Will happen somewhere.
- In the USA?
- Technical competence – yes.
- Political will?
- Maybe we don't agree that it can work or is a wise use of our sea?

But others do and will do it and, if they're right, we'll miss an opportunity to lead a new global industry.