The cost of carbon capture and the price for emissions

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USyd

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Outline

Climate engineering will be necessary

CDR is becoming economic

Iron and macronutrient fertilisation, CCS are candidates

What about the risks?

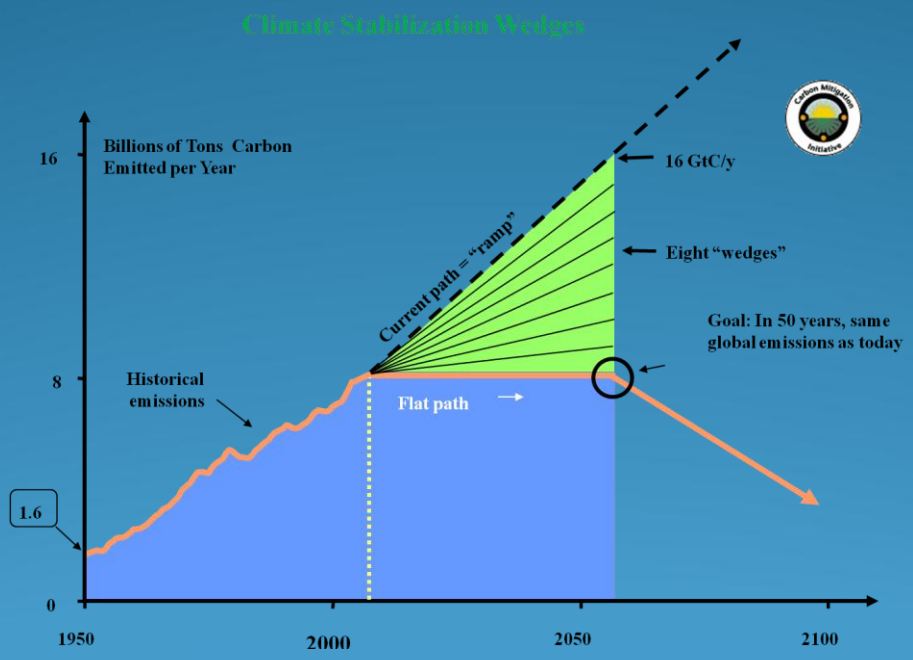
C

CDR

Carbon Dioxide Removal
(from the atmosphere)

Too dear, too risky?

Mitigation wedges



COST

Delivery

Chemical

overheads

assumptions

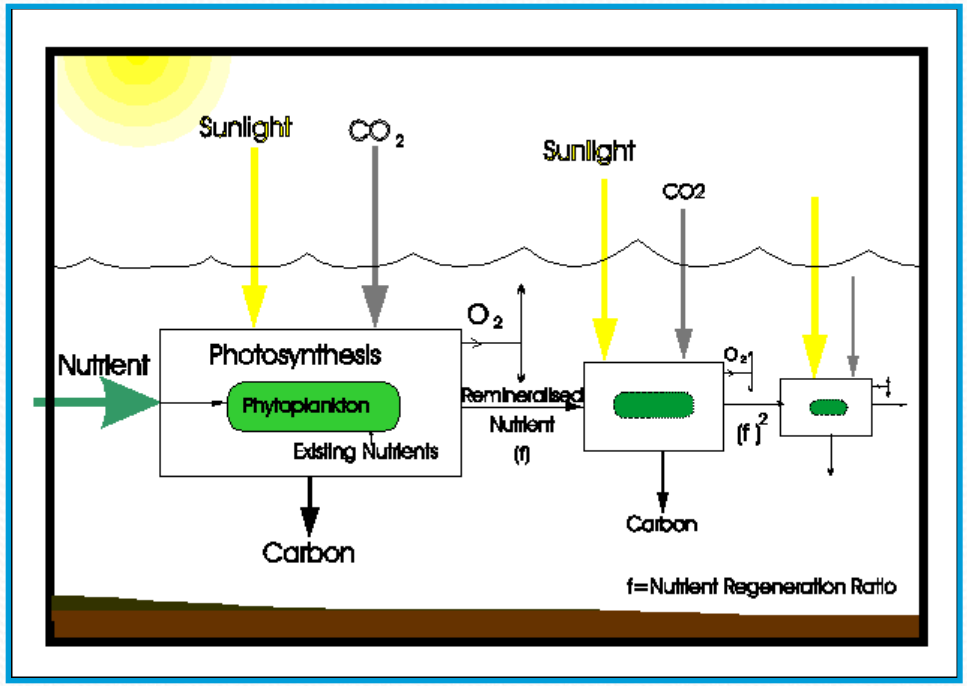
Iron draw down of nitrogen limited

No regenerative primary production

Nitrogen 100% export

Secondary production (fish) bottom up control

Photosynthesis



Three papers

Harrison, D P (2013) A method for estimating the cost to sequester carbon dioxide by delivering iron to the ocean. *International Journal of Global Warming*, **5**, issue 3, 231-254.

Jones, ISF (2014) The Cost of Carbon Management using Ocean Nourishment *International Journal of Climate Change Strategies and Management*, **6**, 391-400.

Lawrence, M W (2013) Efficiency of carbon sequestration per added reactive nitrogen in ocean fertilization. *International Journal of Global Warming*, **6** , 15-33.

Cost to fertilise

	iron	nitrogen	nitrogen	CCS
ref	*IJGW 2013*	*IJCCSM 2014*	*ECOR 2011*	*F&P 2011**
	Iron chloride	ammonia	urea	MEA
Cost US$ 2000	$457	$20	$32	$80^ - $140#
My guess		↑		↓

*Feron and Paterson 2011, CSIRO

^ not considering oxygen cycle

assume A$ = US$

Why the difference

	iron	macronutrient	ratio
N uptake	2 µM	16 µM	8
export	5%	100%	20
			160

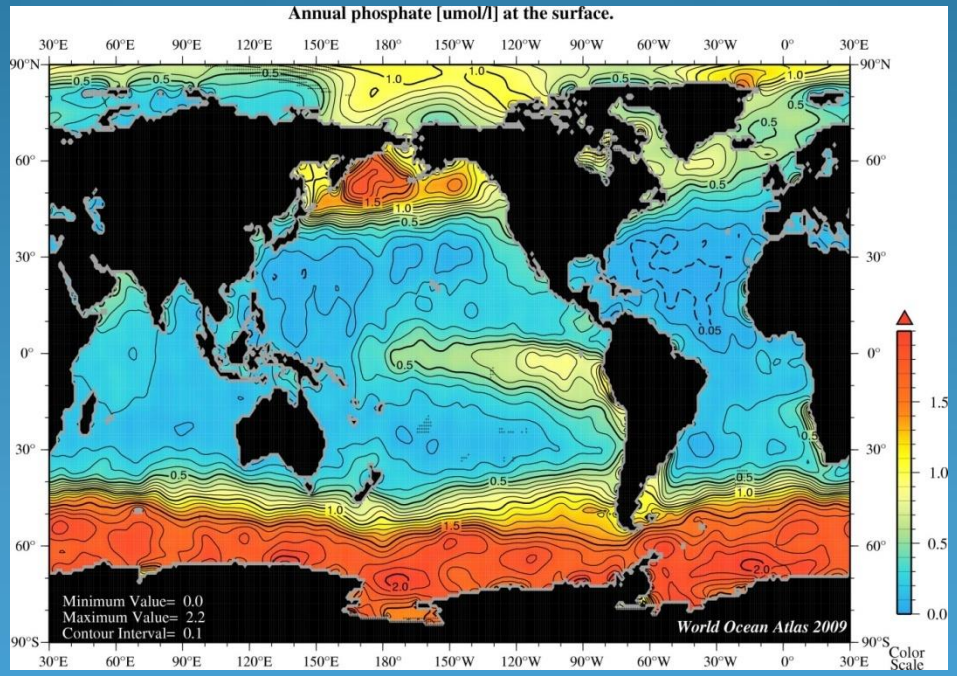
One pass produces 160 times as much organic carbon
Iron delivery costs about 160 times nitrogen

Nitrogen is $10 per tonne CO_2 - Iron cost is negligible

Phosphate

>0.2M

Allows one fertilisation



Carbon dioxide offsets

Expected income

Australia per tonne CO_2 avoided	US$23?
UK – Floor price to electric generators	US$35

Expected costs

Macro nutrient fertilisation	Urea	US$32

Reserves

One wedge requires mining phosphate

Demand increases 1.7% per year

In 2065 each year uses 1% USGS reserve

Cost will be more once existing P is consumed

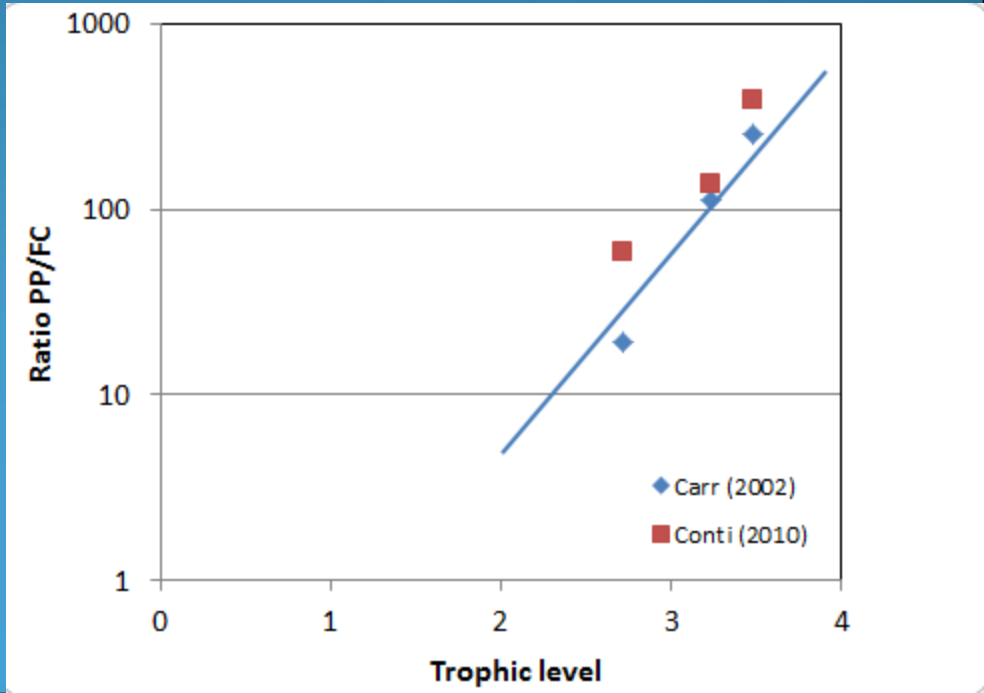
Fish

Adjacent to upwelling fisheries

With each tonne of CO_2 - 33 kg fish

[Beef substitution saves 600 kg CO_2]

Under review Fish &Fisheries



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Risk

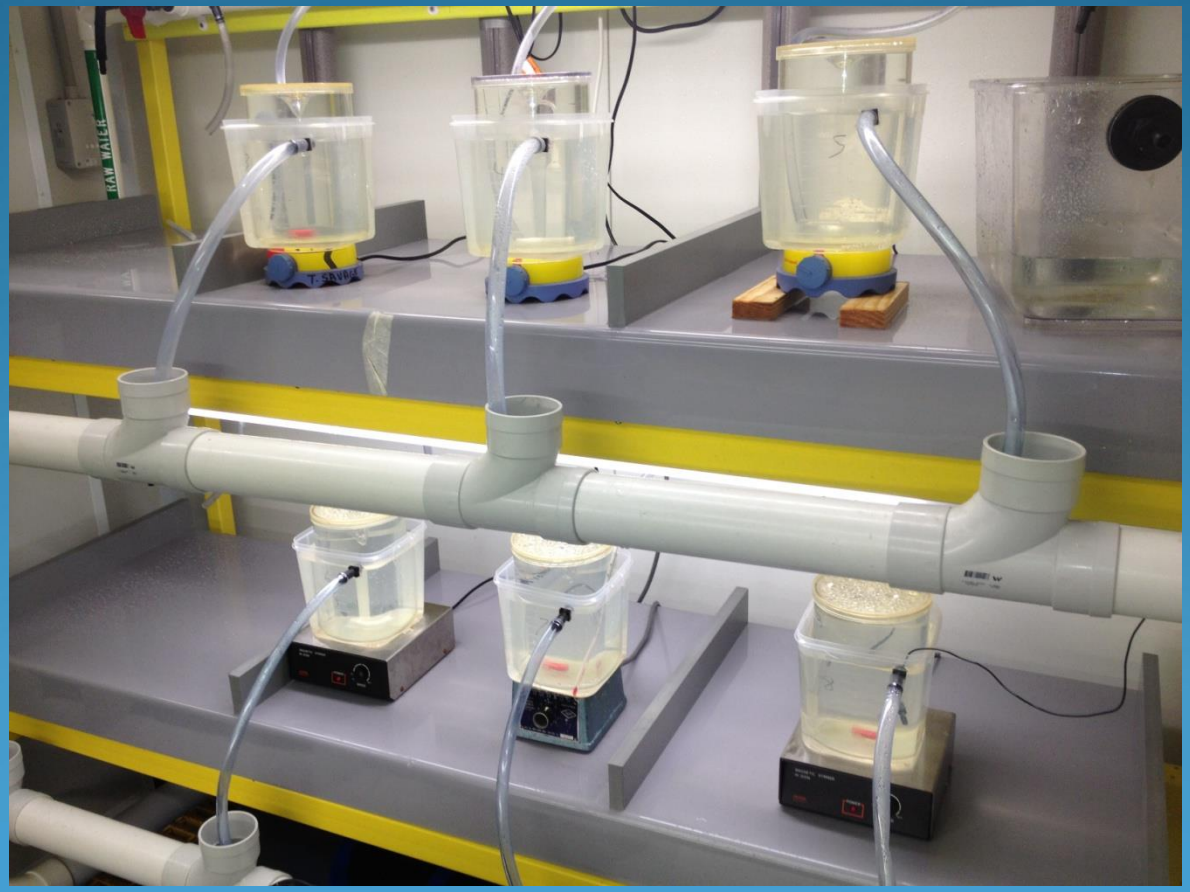
There are few analysis of risk.

Fuhrman and Capone (1991)

Mostly general assertions with no detail

Urea fertliser encourages dyno and HAB

Phytoplankton



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Conclusion

Macro and micro nutrient fertilisation are different

Macronutrient fertilisation costs are within range

More open ocean experiments would reduce uncertainties

Risks need to be made explicit