

Ocean Forest Cultivation in Pacific Island Countries

Environmental and Economic Benefits and Strategies

State of the Pacific 2014 New Directions
New Directions in Research - Environment and Resources
Australian National University

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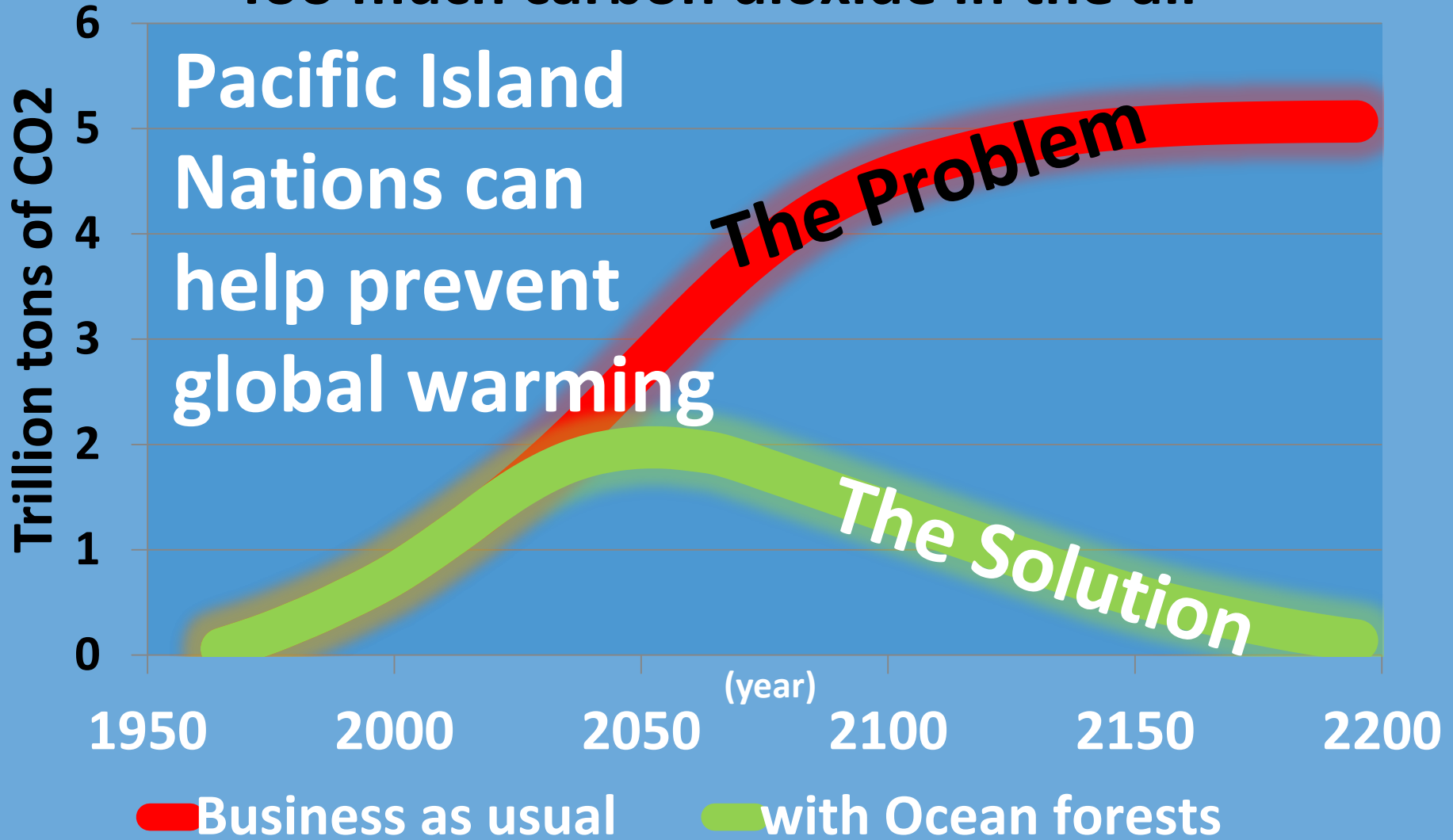
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Acknowledgements: Dr Jonathan Trent (NASA), Mr Terry Spragg (Waterbags)

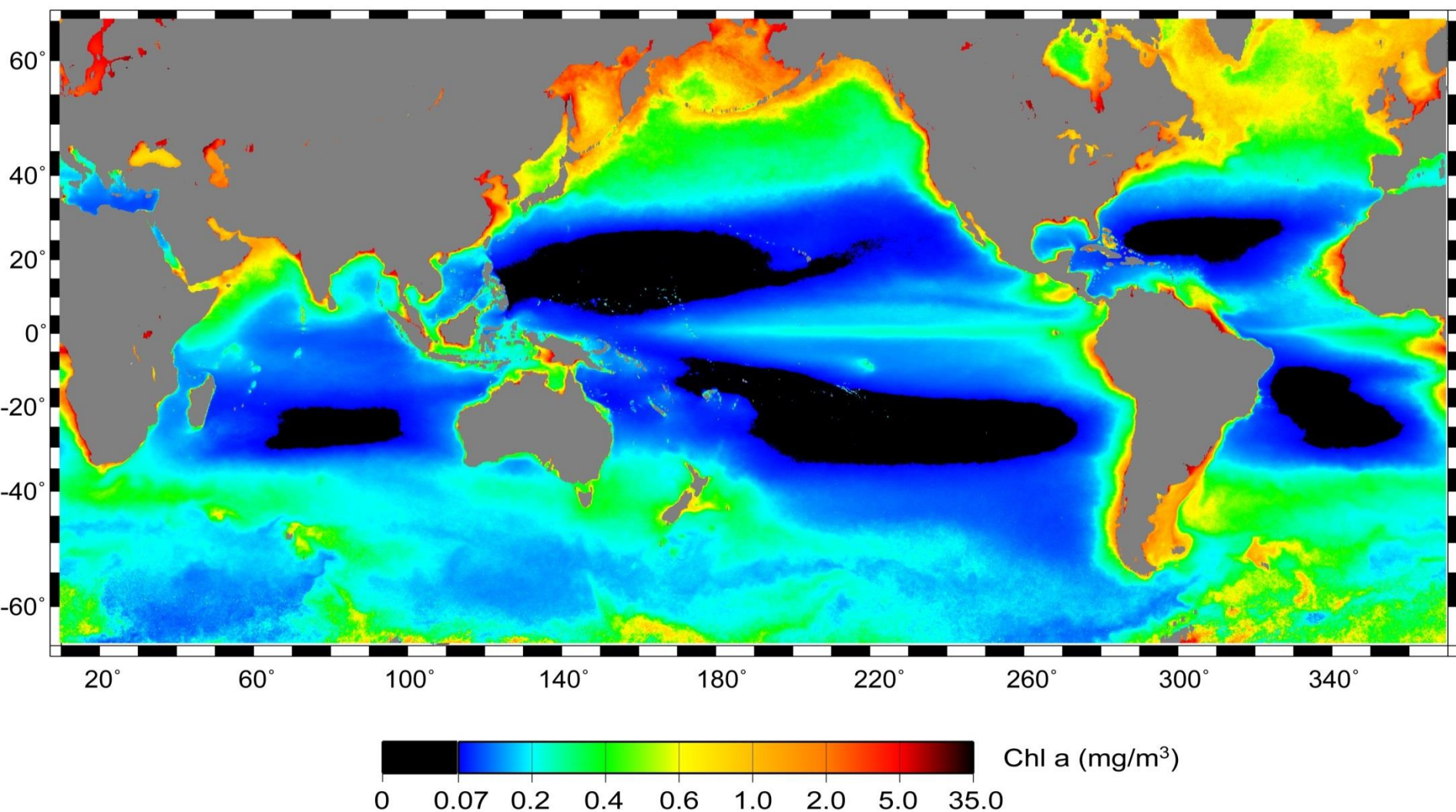
Presenter: Peter Johnston

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Too much carbon dioxide in the air



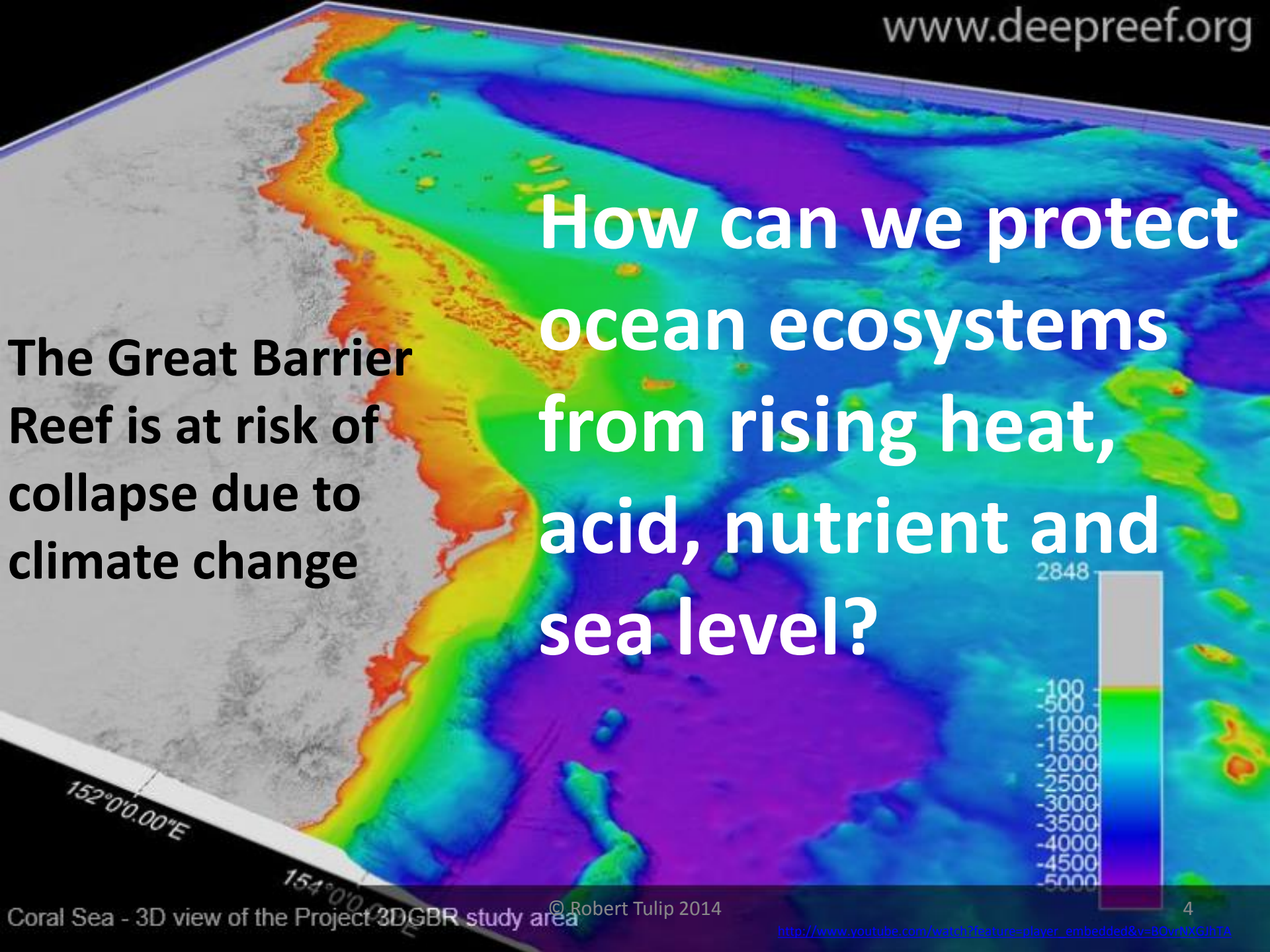
Source: OceanForesters.org



The Problem: Area of low surface chlorophyll in world ocean in 2009 (black) was 50 million square kilometres and growing. Can Pacific Nations start a global ocean algae industry to reverse global warming and sea level rise?

The Great Barrier Reef is at risk of collapse due to climate change

How can we protect ocean ecosystems from rising heat, acid, nutrient and sea level?

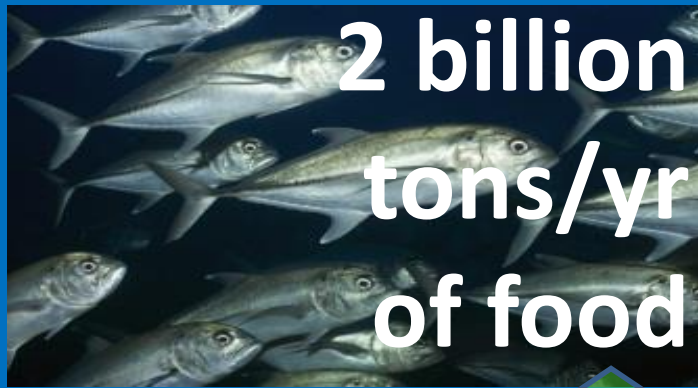


BIODIESEL CROPS AND PRODUCTION



- Algae could have ten times the oil production yield of the fastest growing land based crops
- Ocean based algae systems can store carbon more effectively than land forests or geo-storage
- Algae has fast growth rate, suitable ocean sites, potential for profitable commodity production and ecological benefits
- Algae factories on 2% of the world ocean could be enough to reduce CO2 to stable level and provide local cooling
- Where to start?





**2 billion
tons/yr
of food**

OceanForesters.org



**Aim to
Replace all
fossil fuels**



**Ocean Seaweed
Algae Forests**

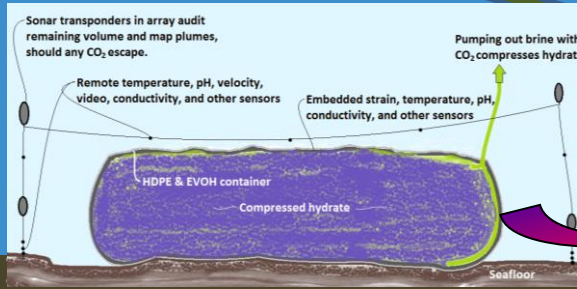
**Carbon
Dioxide**

nutrients

**Harvested
macroalgae**

**Anaerobic
digester or
hydrothermal
process**

8 billion tons/yr of recycled nutrients



19 billion tons/yr
captured bio-CO₂
Seafloor



PODenergy

APPLIED RESEARCH AGENDA

➤ Economics and Technology:

Adapted from USP/ OceanForesters.org

- Can gas from seaweed replace imported diesel as a main power source for the Pacific?
- What materials and techniques improve industrial productivity of ocean forests while maximizing environmental benefits?

➤ Ecology:

- How, and by how much, do algal forests change local water acidity, heat, oxygen level and fish production?
- How do those changes affect the microbiology, nutrient availability, eutrophication level, nitrate, etc.?
- How does microbiotic life support macroalgal forests?
- How does nutrient distribution affect forest production, biodiversity and sustainability?
- What proportion of herbivores and predators evolves or is ideal for maximum production of energy and food?

Kinoya Sewage Treatment Plant (KSTP): Flared biogas can generate electricity at much less cost than diesel - Laucala Bay, Fiji.

KSTP

Existing digester

effluent and algae return pipes

Source: OceanForesters.org

approximate location of 2-ha OMEGA startup

Potential Fiji Location for Offshore Membrane Enclosure for Growing Algae

200 m

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Google earth





OMEGA System

Solar Energy

Biofuels
Fertilizer
Food
Algae Products

NASA Research
Project
Offshore
Membrane
Enclosure for
Growing
Algae



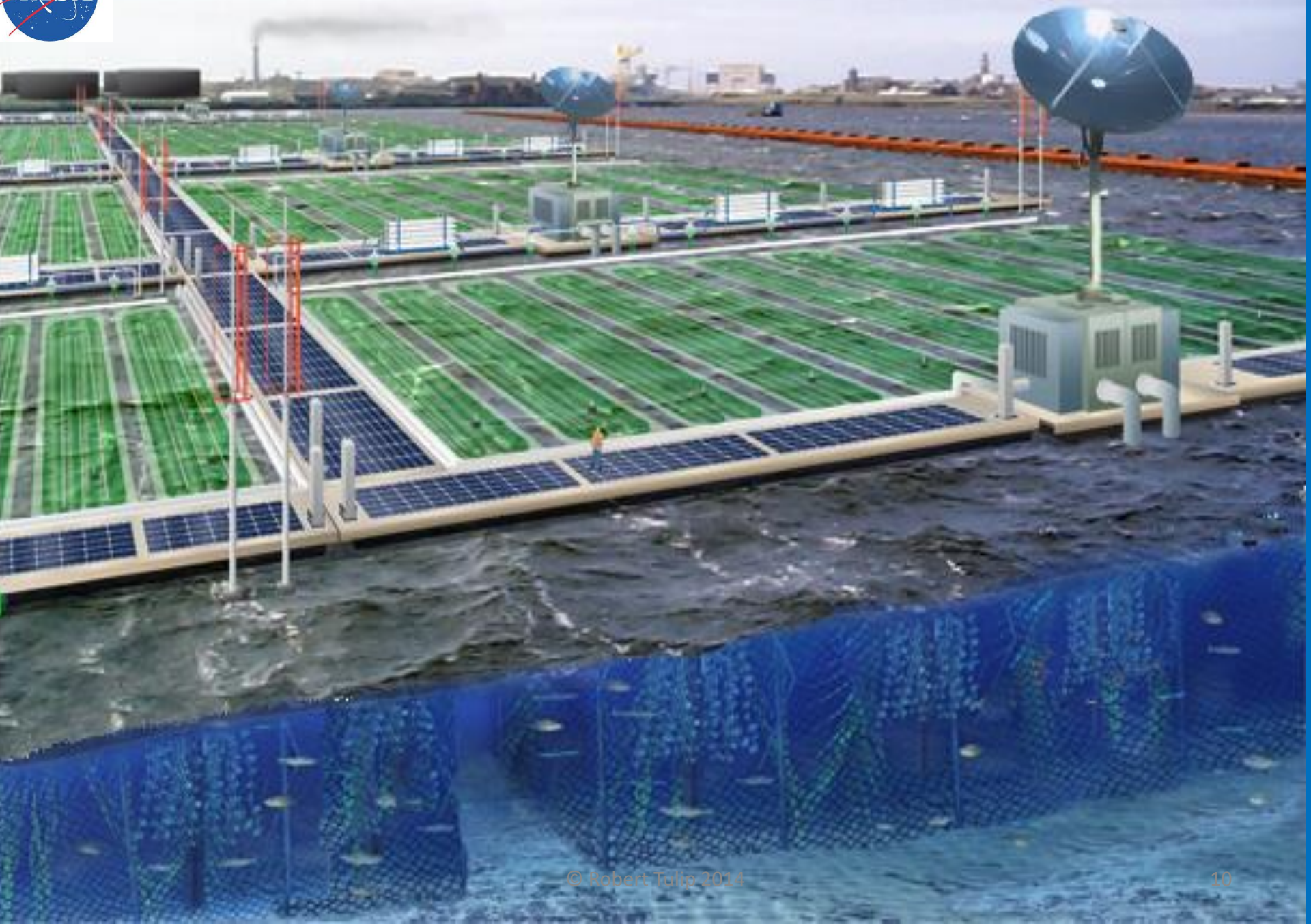
A scalable solution?

Treated Wastewater/CO₂

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Artistic diagram of OMEGA System



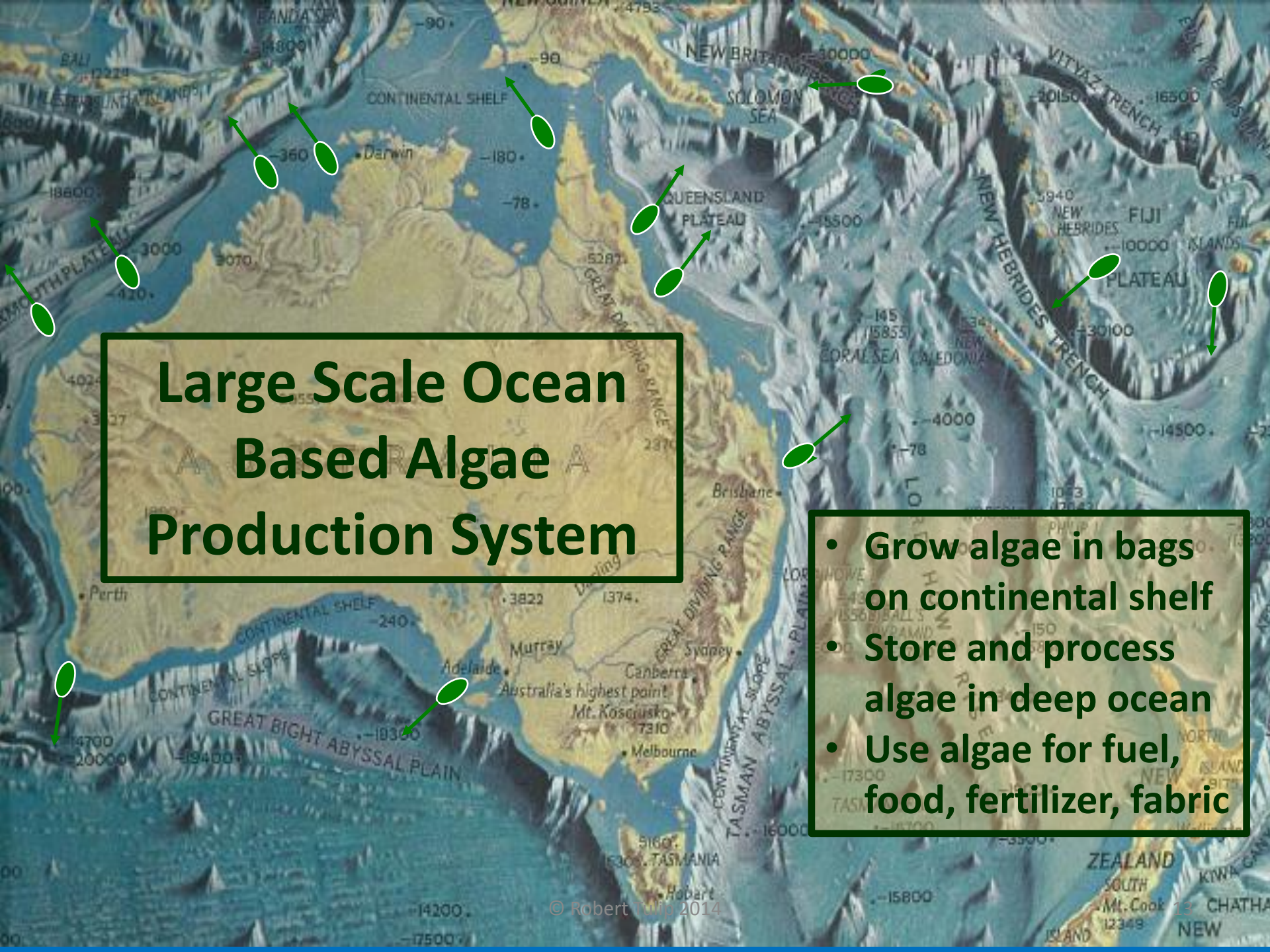


**OMEGA and Ocean Forests could clean lagoons
in countries such as Tonga and Kiribati**

CONCEPT RESEARCH AGENDA

Ocean seaweed forests are close to being market ready. How can we scale up and deliver even greater environmental and economic benefits.

- **Microalgae**
 - ✓ **Industrial production**
 - ✓ **floating bags of fresh water for stability, buoyancy and energy**
- **Interdisciplinary laboratory, desk and field research**
 - ✓ **energy, algae science, hydrology, ecology, materials**
- **Ocean Floor systems – use of high pressure in deep sea**
 - ✓ **dewater algae**
 - ✓ **hydrothermal oil and gas production**
- **Tidal pumping using waterbags**
- **Move production from sheltered locations to open ocean**



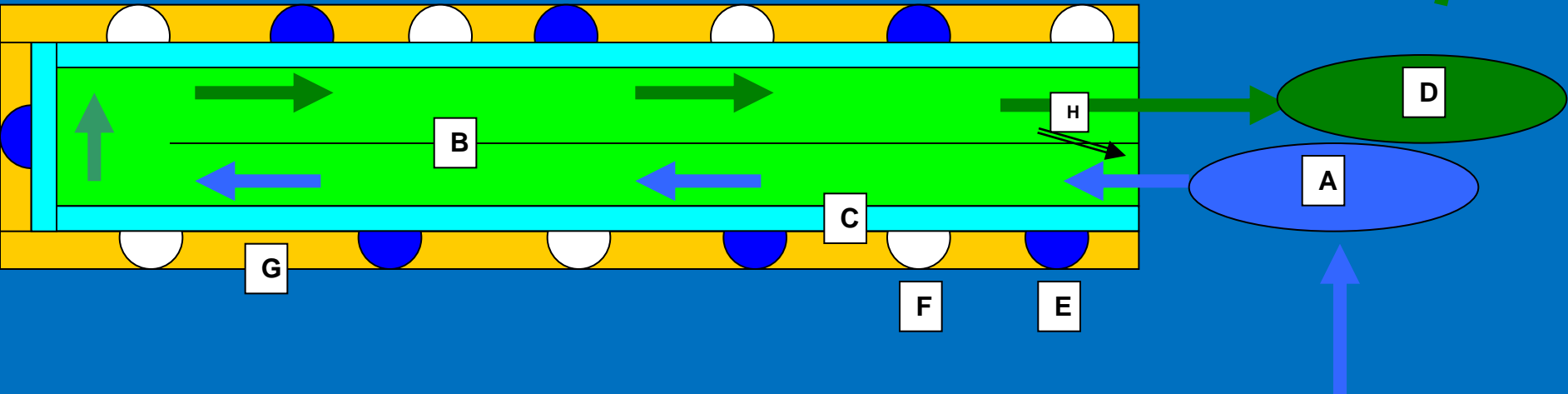
Large Scale Ocean Based Algae Production System

- Grow algae in bags on continental shelf
- Store and process algae in deep ocean
- Use algae for fuel, food, fertilizer, fabric

Ocean-based Algae Production System

Schematic Top View of photo-bioreactor component

Drawing C



A: Polymer bag containing CO₂, fresh water or ocean water with high nutrient level

B: Continuous flow algae photo-bioreactor chamber with arrows showing direction of liquid flow

C: Polymer bag containing fresh water for buoyancy, pumping and stability

D: Polymer bag containing algated water output from chamber (B)

E: Submarine chamber pumping water from source (A) into chamber (B). (Note, chamber E can be replaced by a tidal pump as described in separate drawing).

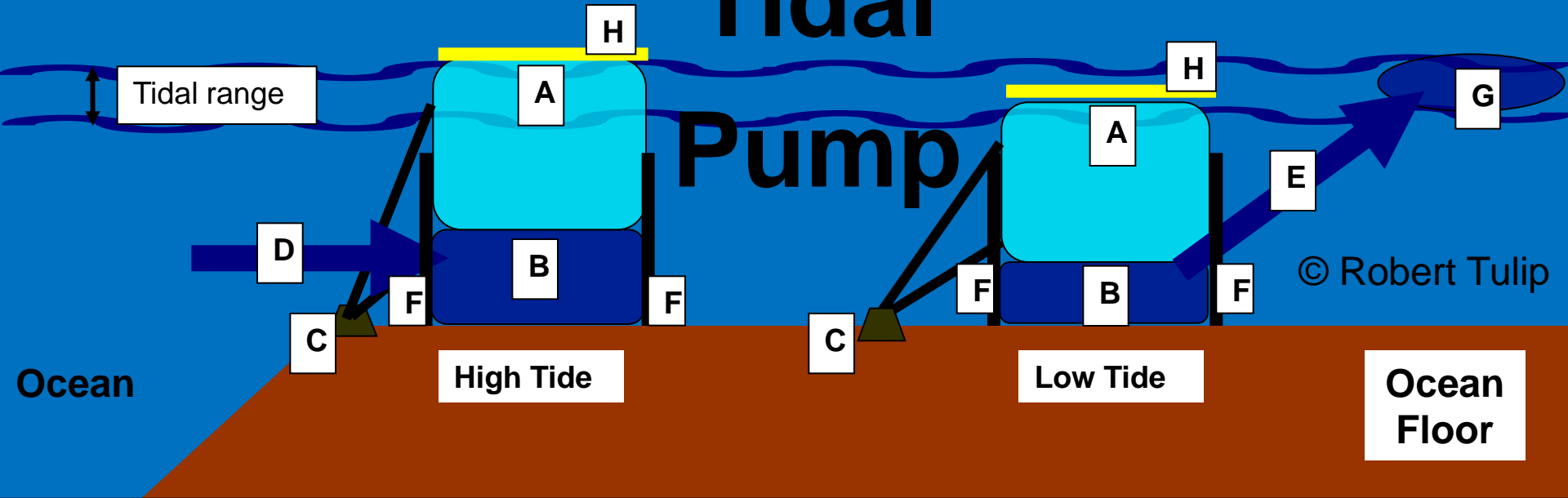
F: Submarine chamber pumping air or CO₂ into chamber below chamber B as shown at side and front views

G: Rigid submarine platform at base of chambers E and F providing pumping resistance.

H: Return pipe transferring algated water to mix with nutrient-rich water from bag (A).

Tidal

Pump



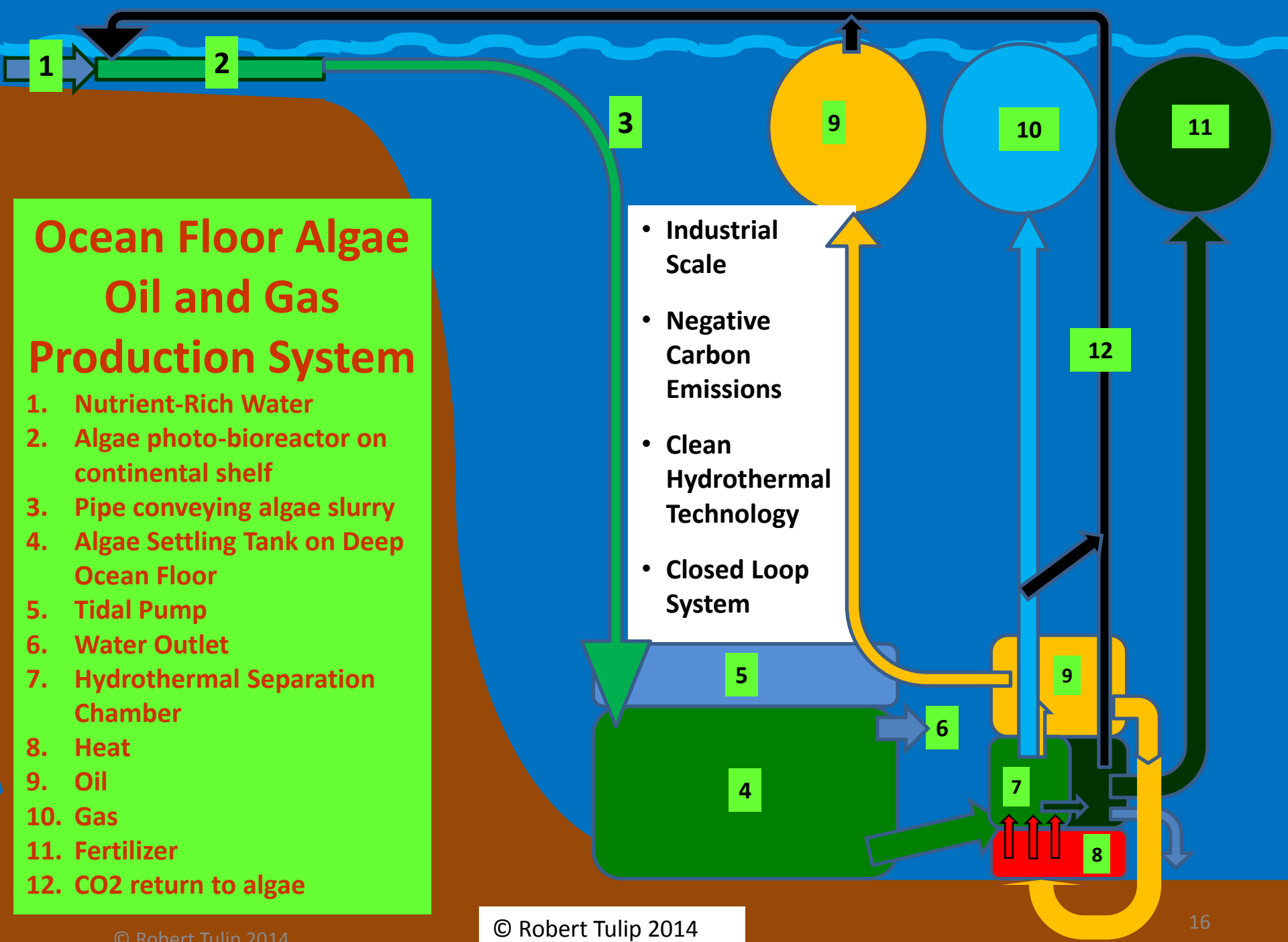
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1. The tidal water pump is a pumping system made of two connected upper and lower fabric bags containing liquid and tethered in position on the ocean floor or flat platform.
2. Upper fabric bag (A) contains constant volume of liquid floating at constant depth from ocean surface, for example fresh water sitting at ocean surface or brackish water at constant ocean depth eg 180 metres.
3. Lower fabric bag (B) is a pumping inlet-outlet chamber.
4. A mooring point (C) on the ocean floor tethers the pumping system in place.
5. During rising tide, bag A rises with the tide, causing liquid to enter bag B through inlet valve from pipe D.
6. During falling tide, upper bag A falls with the tide, placing weight and pressure on lower bag B and causing liquid to leave lower bag B through outlet valve into pipe E.
7. Bag B is enclosed by and connected to barrier (F) to prevent horizontal expansion or contraction of bag B and enable pressure from bag A to transmit pumping energy via bag B to pipes D and E.
8. The inlet and outlet pipes D and E connect to fresh water dam, deep ocean water, waterbag, algae bioreactor or other liquid source or destination.
9. Floating polymer bag (G) can mix output with CO₂ or air to enable flotation for towing to algae bioreactor.
10. Triple layer polymer sheet (H) over surface of bag (A) at ocean surface separates input salt water into fresh water and brine (separate drawing attached).

Ocean Floor Algae Oil and Gas Production System

1. Nutrient-Rich Water
2. Algae photo-bioreactor on continental shelf
3. Pipe conveying algae slurry
4. Algae Settling Tank on Deep Ocean Floor
5. Tidal Pump
6. Water Outlet
7. Hydrothermal Separation Chamber
8. Heat
9. Oil
10. Gas
11. Fertilizer
12. CO2 return to algae

- Industrial Scale
- Negative Carbon Emissions
- Clean Hydrothermal Technology
- Closed Loop System



THANK YOU!

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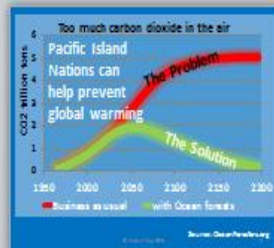
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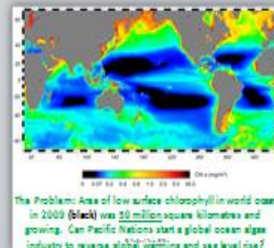
Abstract/Summary: Ocean Forest (CO2) is a very strong (Wetland) Provenance Production System

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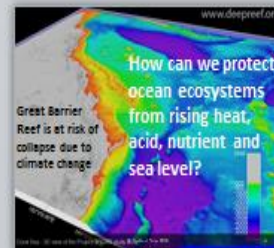
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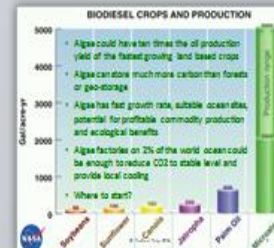
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Aim to Replace all fossil fuels

2 billion tons/yr of food

OceanForesters.org

Ocean Seaweed Algae Forests

19 billion tons/yr of food

USP

6

APPLIED RESEARCH AGENDA

Microbiology and Technology: Robert.Tulip@dfat.gov.au

- Can gas from seaweed system be utilized as a power source for the Pacific?
- What methods and techniques improve the yield and productivity of ocean forests in the warming environment?

Biology:

- How will the presence of the algae change local water quality, food, water availability and production?
- How do algae change affect the morphology and stability of coastal features like reefs and coral?
- How does seaweed affect the support of mangroves?
- How does nutrient reduction affect the productivity, biodiversity and sustainability?
- What proportion of the biomass and products can be used for the maximum production of energy and food?

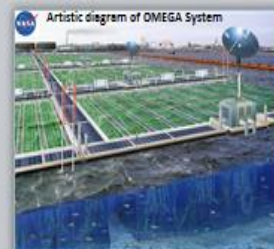
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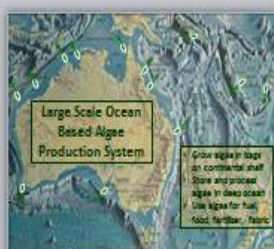
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CONCEPT RESEARCH AGENDA

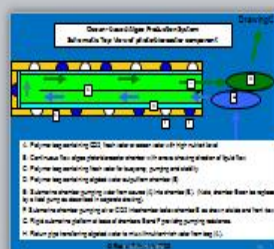
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 - desalinate algae
 - hydrothermal oil and gas production
- Tidal pumping and wave pumping using waterbags
- Move from sheltered locations to open ocean

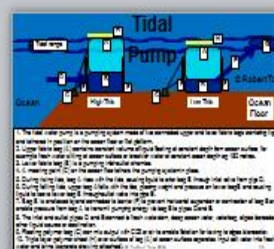
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THANK YOU

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