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Centro UNESCO Gran Canaria
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El cultivo de Macro- y Microalgas para el desarrollo de nuevas aplicaciones ecológicas y energéticas

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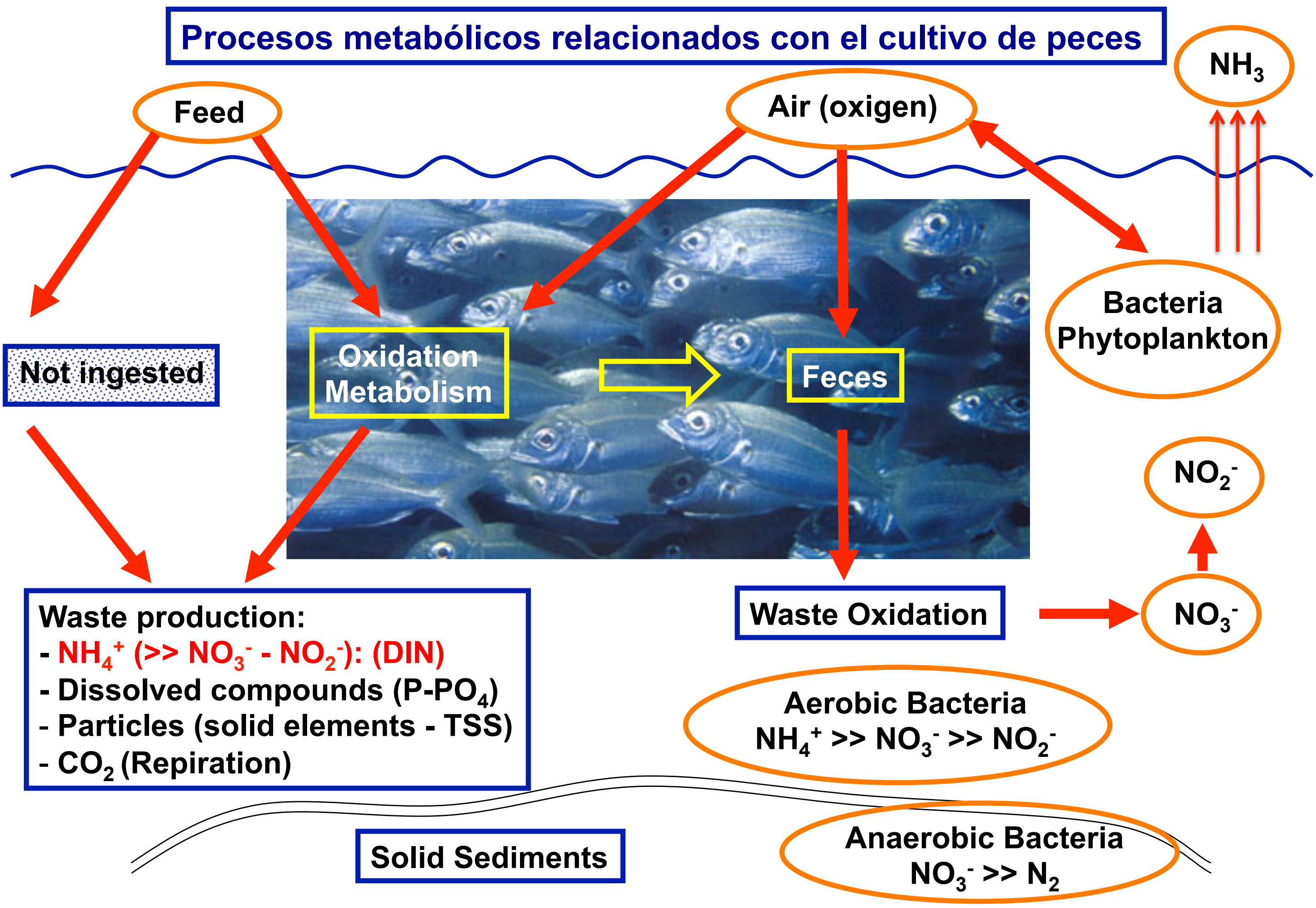
Soluciones SOSTENIBLES (con ALGAS) que ayuden a minimizar el aumento de los problemas medioambientales y energéticos del planeta:

1.- Sistemas Integrados en Acuicultura

2.- Biotecnología de Microalgas para la obtención de Biocombustibles



Average annual water quality in effluents of fish farms located on French Atlantic coastal wetlands, according to intensification level, sampled after a settling treatment for Farms 4 and 5

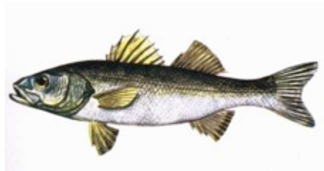
Parameter	Unit	Farm 1 EX-Unit	Farm 2 SI-Unit (sea bass)	Farm 3 SI-Unit (sea bream)	Farm 4 IO-Unit (sea bass)	Farm 5 IO-Unit (turbot)	Farm 6 IH-Unit (sea bream)
Daily renewal	% per day	1.6[a]	33	30–50	600	900	3000 m^3/day
Water/kg_{fish}[b]	m^3	n.d.[c]	44	n.d.[c]	55	65	n.d.[c]
TSS	mg/l	32	22.9	108	12	22	7.8
Chl *a*	μg/l	17	28	9.5	9	2	n.d.
DIN (TAN + NO_2 + NO_3)	μM	4	19	62.3	150	84	244
$P\text{-}PO_4$	μM	4.9	17.5	1.05	11	4.5	10.5
$Si\text{-}SiO_2$	μM	25	12.7	27.6	25	36	12.3
N/Si/P	mol/mol	0.8:5.1:1	1.1:0.7:1	59.5:26.3:1	13.6:2.3:1	18.7:8:1	23.3:1.2:1
Si/N	mol/mol	6.4	0.6	0.4	0.2	0.4	0.05
Limiting element		N	N	P	Si	balanced	Si

All analyses were carried out according to standard methods (Aminot and Chaussepied, 1983; Koroleff and Grasshoff, 1983) in our research laboratory (Hussenot, 1998; Hussenot et al., 1998) for Farms 1 to 5; unpublished data for Farm 6).

[a] Only one exchange day (50% of total volume) each month, i.e., an equivalent per day of 1.6%.

[b] Water used per kg of fish produced in the unit.

[c] n.d. = not determined.



Hussenot (2003), Aquaculture 226:113-128

Nutrient excretion and retention rates (as percentages of the constituent present in the feed consumed)

Retained		In feces (particulate)		Excreted (dissolved)		Type of fish	Reference
N	P	N	P	N	P		
49	36	14	55	37	9	*A. salmon*	Johnsen et al., 1993; Bergheim and Åsgård, 1996
	17–19		48–54		28–34	*A. salmon*	Holby and Hall, 1991
11	32					Carp	Avnimelech and Lacher, 1979
27	30					Channel catfish	Boyd, 1985
10	40	35	15	55	45	Sea bass	Lemarié et al., 1998
30		10		60		Sea bream	Porter et al., 1987
19–26						Sea bream	Krom et al., 1995
30		13		57		Rainbow trout	Beveridge et al., 1991
25	30	15	70	60	0	Rainbow trout	Håkanson, 1988; Pillay, 1992
21–22	18.8	3.6–5.4	19–22	59–72	60–62	Tilapia hybrid	Siddiqui and Al-Harbi, 1999

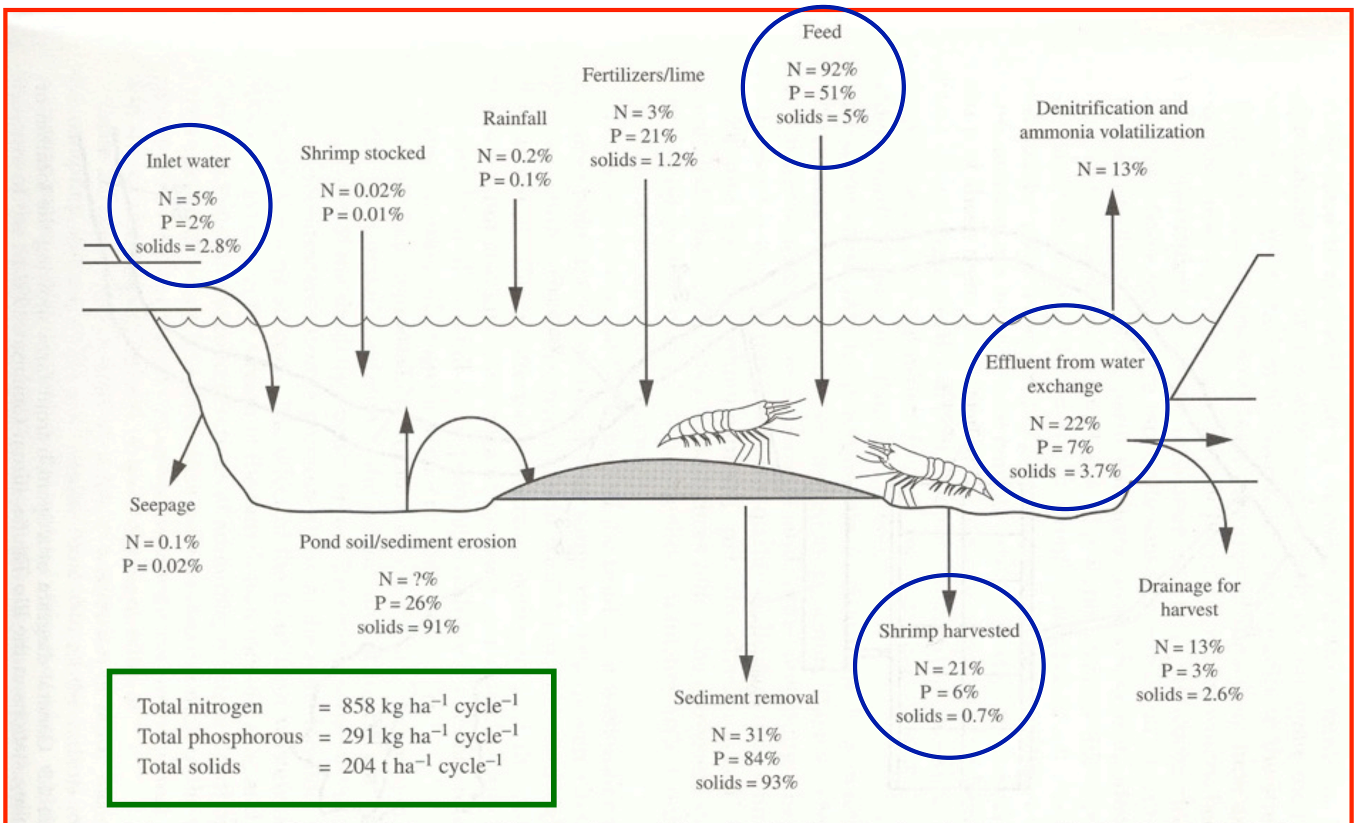
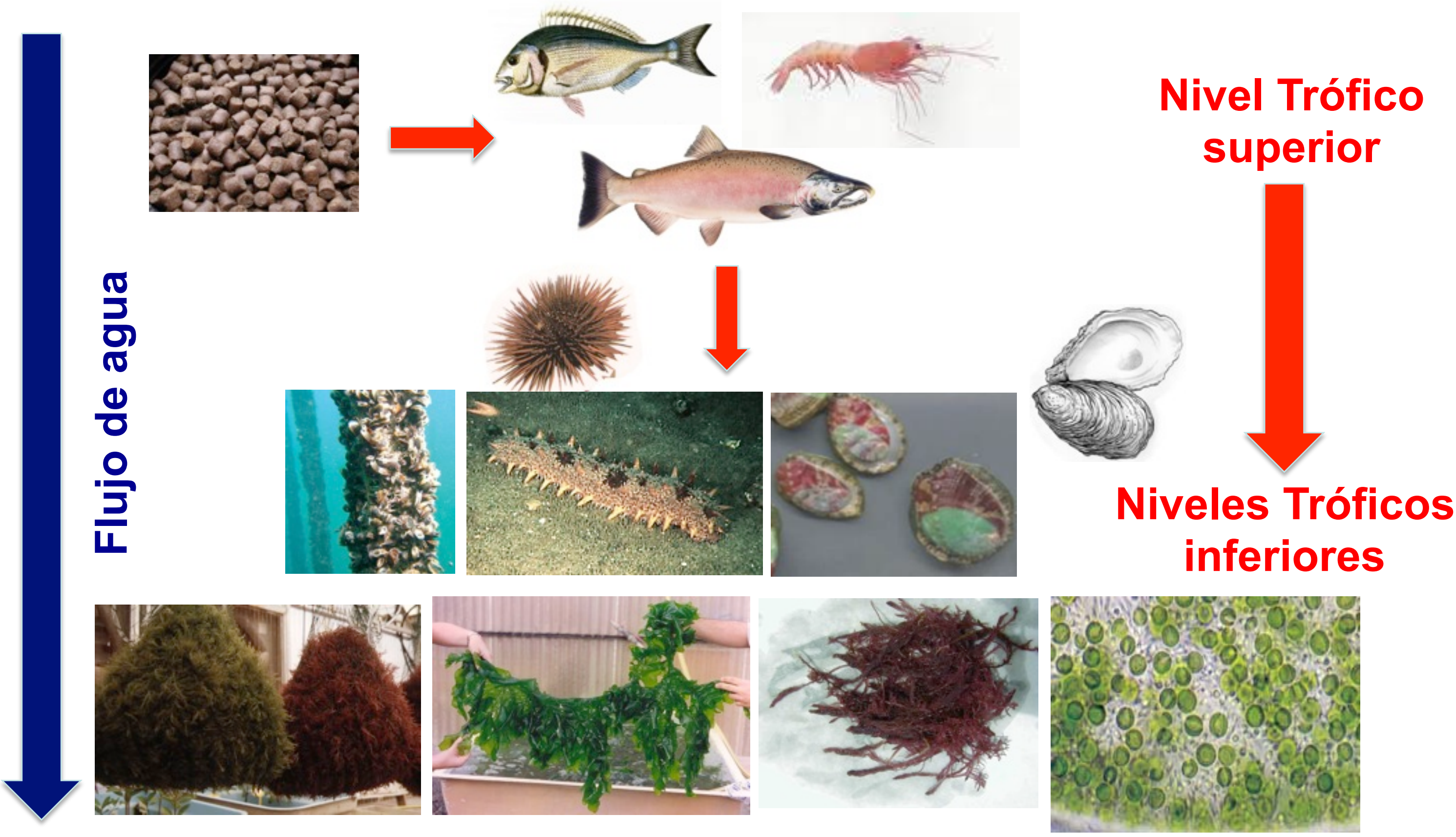


Figure 2.4 The sources and sinks of nitrogen (N), phosphorus (P) and solids in intensive shrimp ponds. Numbers refer to the percentage of the total either introduced to or exported from the pond, as indicated by the direction of the arrow. (From Briggs and Funge-Smith, 1994.)

Acuicultura Multi-Trófica Integrada (IMTA)
Sistemas de Policultivo Integrado



Acuicultura Multi-Trófica Integrada (IMTA)

Principios básicos:

(1) Conversión en lugar de dilución
(*ecológico*)

(2) Diversificación de especies
(*cultivo y producción de nuevas especies*)

(3) Aumento de los Ingresos
(*económico*)

Biofiltración con macroalgas: concepto

1790 kg feed
132 kg N (100%)
25 kg P (100%)

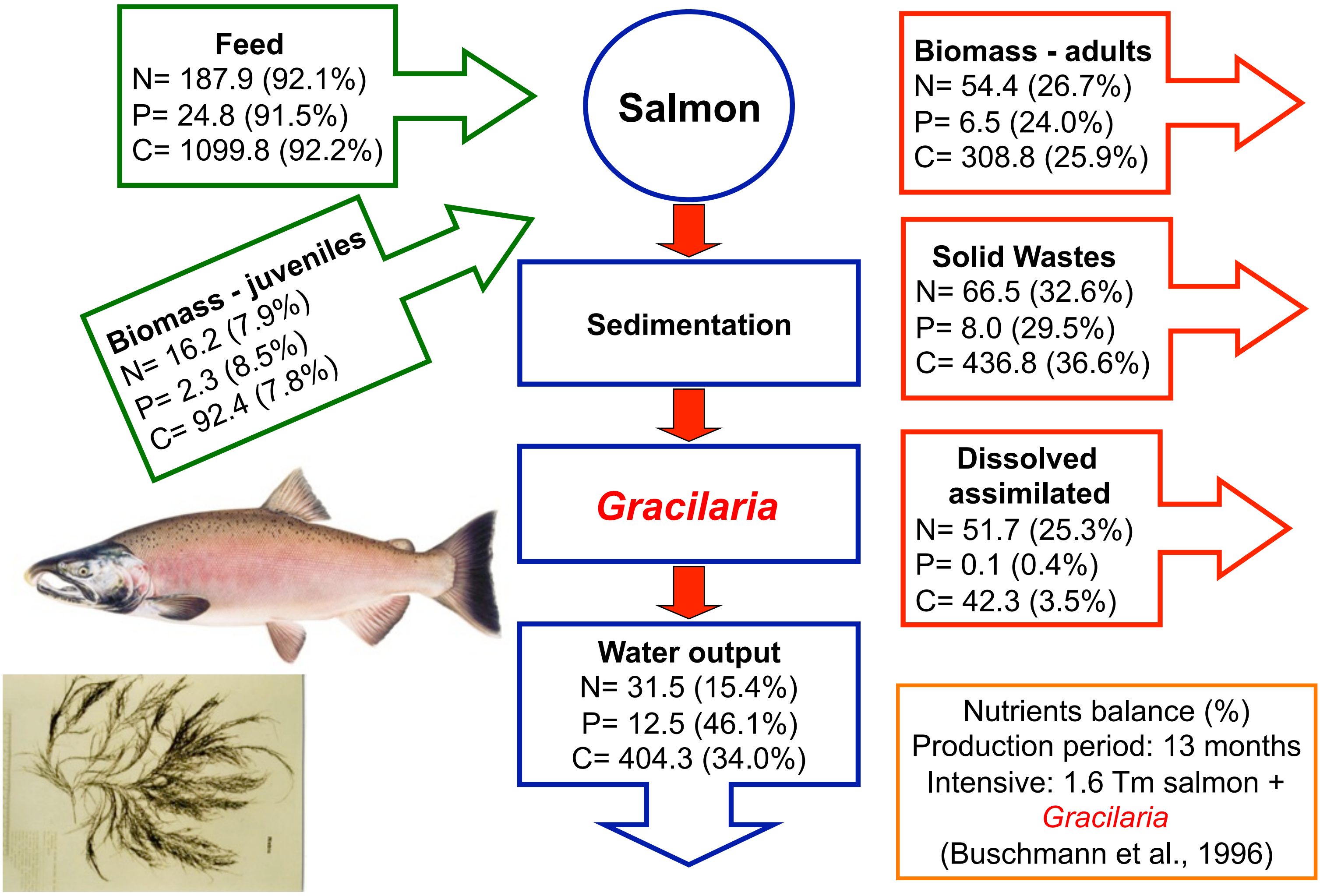
Fish retained
28.5 kg N (22%)
7.2 kg P (29%)

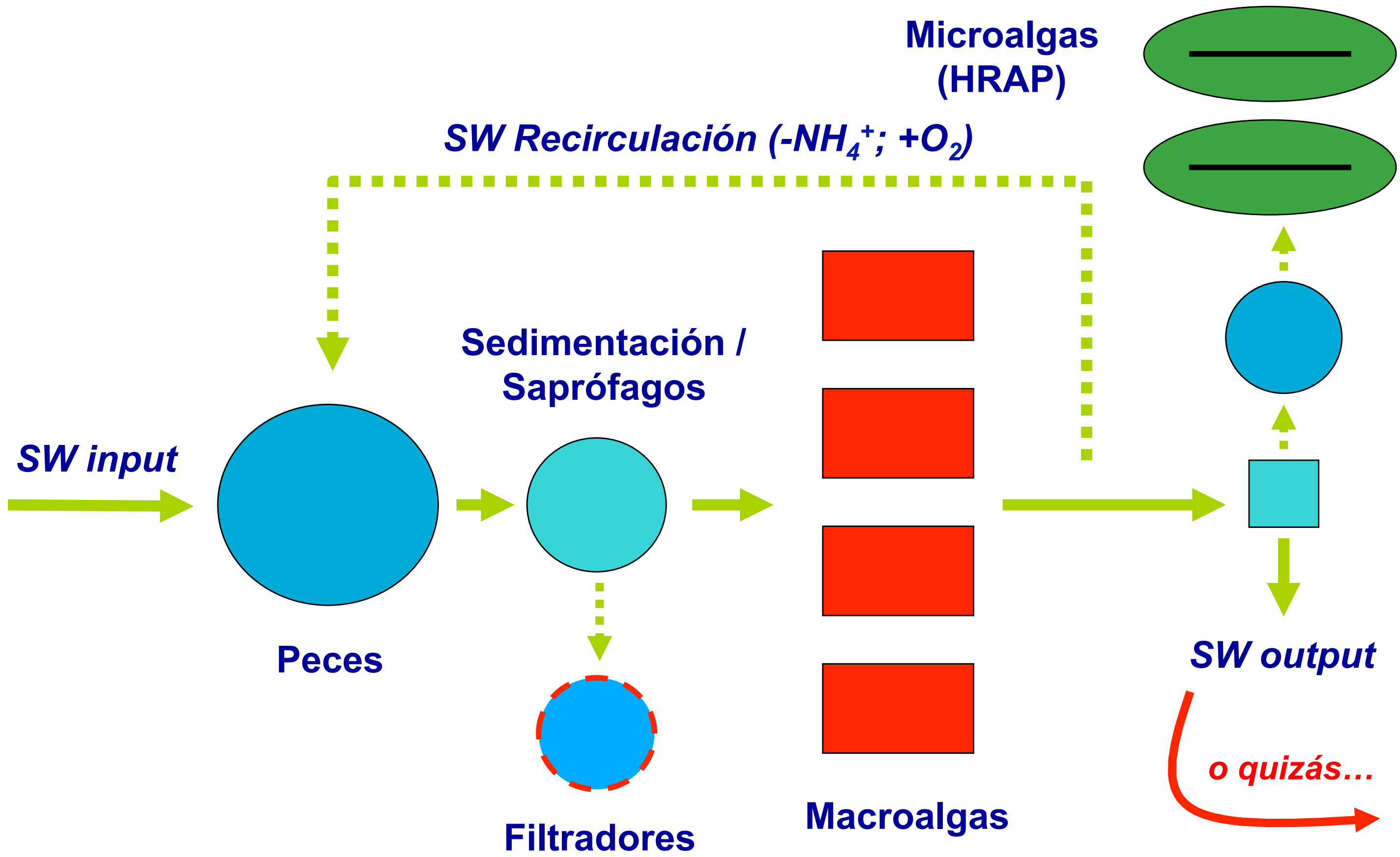
Excretions
80.5 kg N (61%)
4.8 kg P (19%)

Soluble feces
9.2 kg N (7%)
2.0 kg P (8%)

Particulates feces
13.2 kg N (10%)
11.0 kg P (44%)

Nutrients balance from a seabream cultivation unit in kg Tm^{-1} produced to 400 g (relative percentages expressed as a function of feed input)





Esquema de un sistema indicando los flujos de agua entre compartimentos

¡ Halófitas o Manglares !

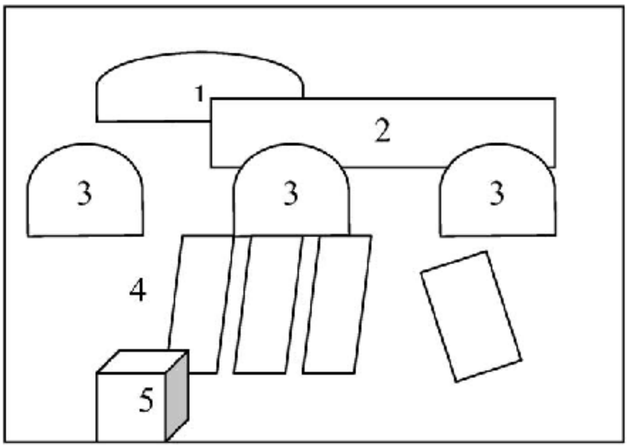
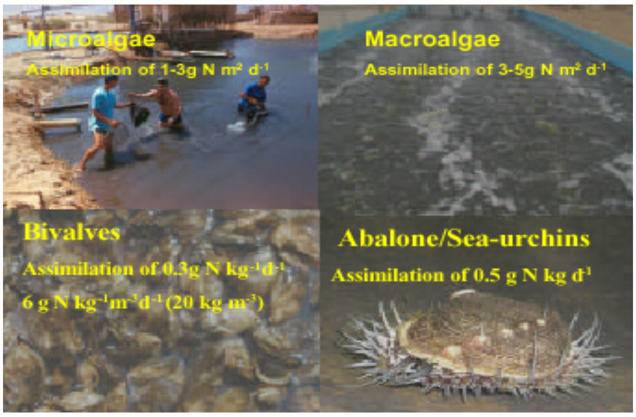
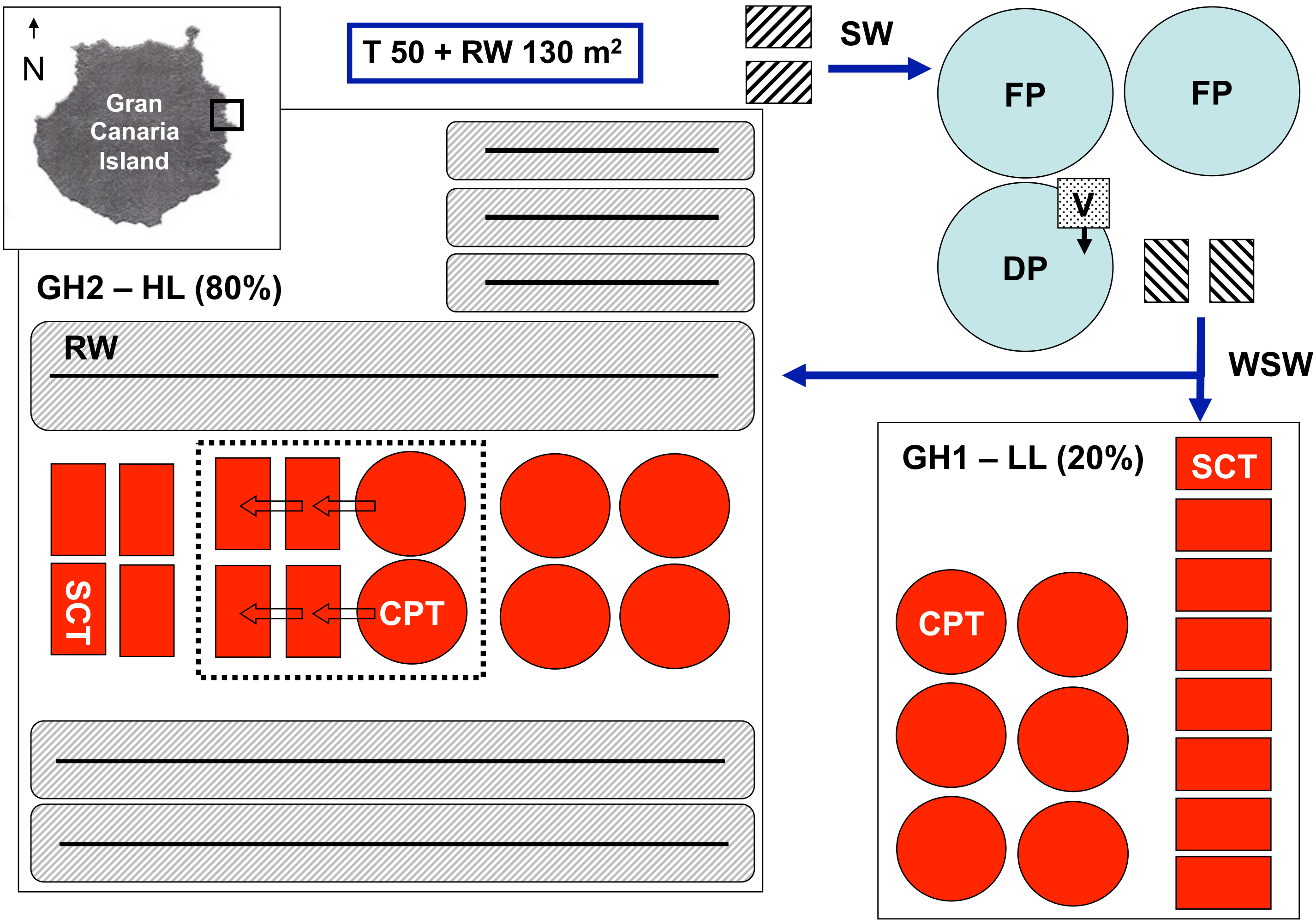


Fig. 1. The SeaOr Marine Enterprises integrated mariculture farm in Mikhmoret, on the Mediterranean coast of Israel. From back to front (numbers in line diagram): (1) water reservoir, (2) abalone culture facility, (3) fishponds, (4) seaweed ponds and (5) effluent sump and seaweed harvesting facility.

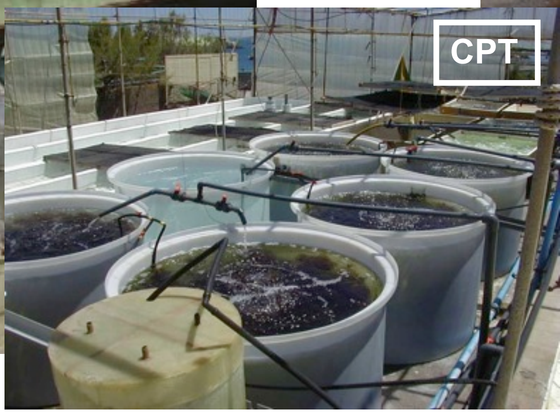


At the Haga Haga Farm, 70 kilometers from East London on South Africa's southeast coast, effluent from covered tanks containing the mollusk abalone (Haliotis midae) *(left) flows into shallow seaweed* (Ulva lactuca, U. rigida, *and* U. fasciata) *raceways, serving as source water.*

Neori et al. (2007) Environment

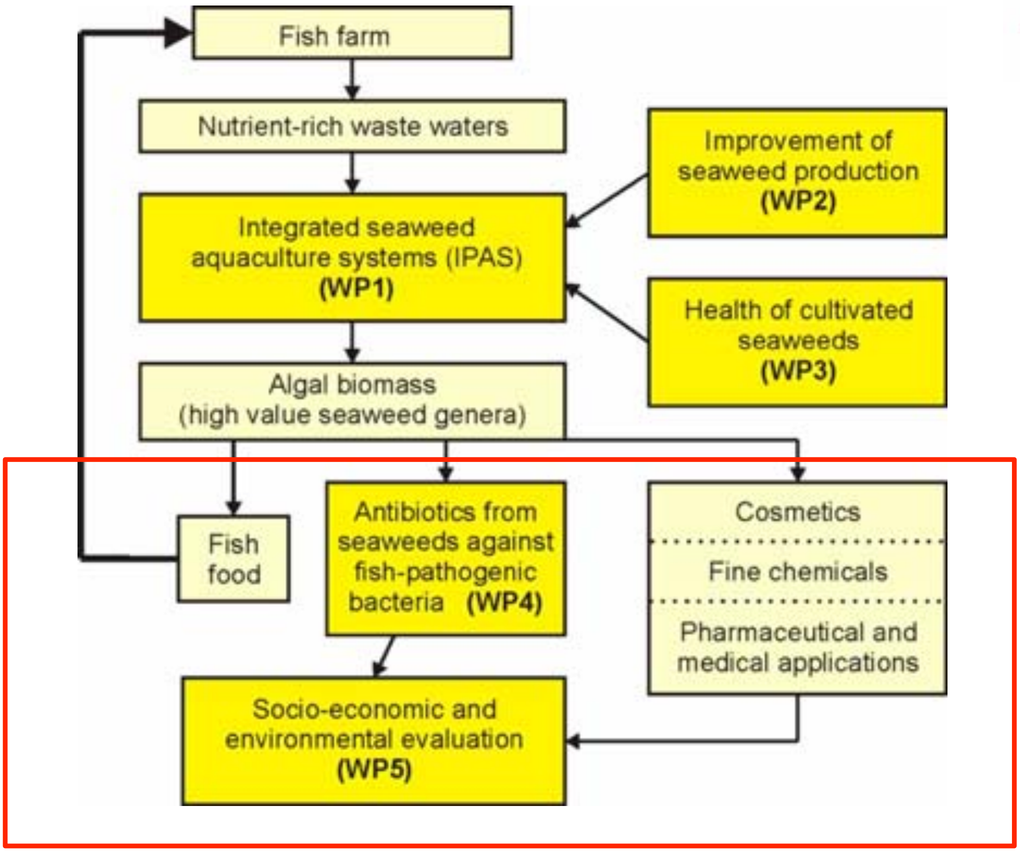






SCT: 1.8 m² – 750 L
CPT: 1.5 m² – 1500 L
RWS: 8 m² (3x)
RWM: 30 m² (2x)
RWB: 50 m² (1x)

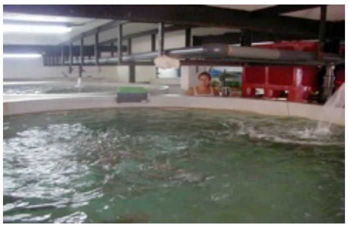


Growth performance of seaweed species with potential commercial significance in integrated poly-aquaculture systems

Gracilaria cornea
G. cornea var. green
G. verrucosa
G. gracilis
G. bursa-pastoris
Hypnea spinella
H. musciformis
Halopytis incurva
Grateloupia dichotoma
G. doryphora
Laurencia chondrioides
Asparagopsis taxiformis
Drachiella minuta
Corallina elongata
Codium taylorii
Valonia utricularis
Ulva rigida

BIOFILTRACIÓN DE EFLUENTES DE PISCIFACTORÍAS CON ALGAS Y USO DE LA BIOMASA: SUSTANCIAS DE INTERÉS AGRONÓMICO, PISCÍCOLA Y BIOMÉDICO-FARMACOLÓGICO



PISCIFACTORÍA

Efluentes ricos en nutrientes

MACROALGAS BIOFILTRADORAS

Efluente depurado

BIOMASA DE ALGAS

UNIVERSIDAD DE LAS PALMAS DE GRAN CANARIA

UMA (MICROBIOLOGÍA)

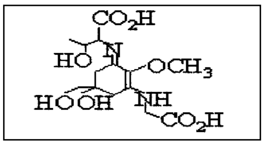
USO PISCÍCOLA
Inmunoestimuladores
Alimento

USO AGRONÓMICO
Bioestimuladores
Compost

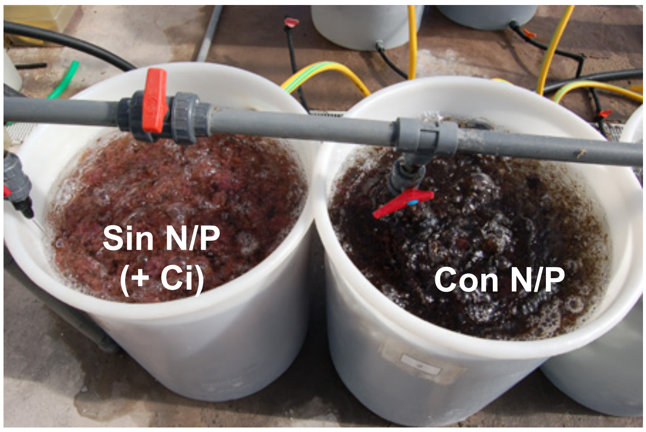
UMA (FOTOBIOLOGÍA)

USO BIOMÉDICO-FARMACOLÓGICO
Fotoprotectores
Antioxidantes
Inmunoestimuladores

UNIVERSIDAD DE MÁLAGA



Proyecto DEPUSIAL AGL2001-1888-C03
Proyecto SEAPURA QLRT-1999-31334



N and **P** production per Tm produced of sea bream and sea bass in pens (in The Canary Islands):
120.0 kg N (78.4% soluble)
16.8 kg P (69.1% particulated)

Per every 100 kg of **N** and **P** consumed (7.3% N and 0.9% P):

Sea bream yields:	64.59 kg N dissolved
	14.85 kg N particulated
	22.96 kg P dissolved
	47.24 kg P particulated
Sea bass yields:	60.90 kg N dissolved
	19.80 kg N particulated
	19.56 kg P dissolved
	47.64 kg P particulated

Vergara et al. (2005)

Nova Scotia (Canada): ***Laminaria***
Maine (USA): ***Porphyra***
Chile: ***Macrocystis***

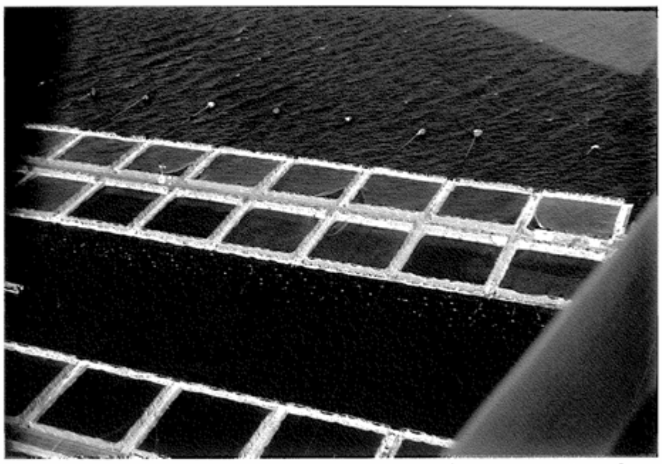
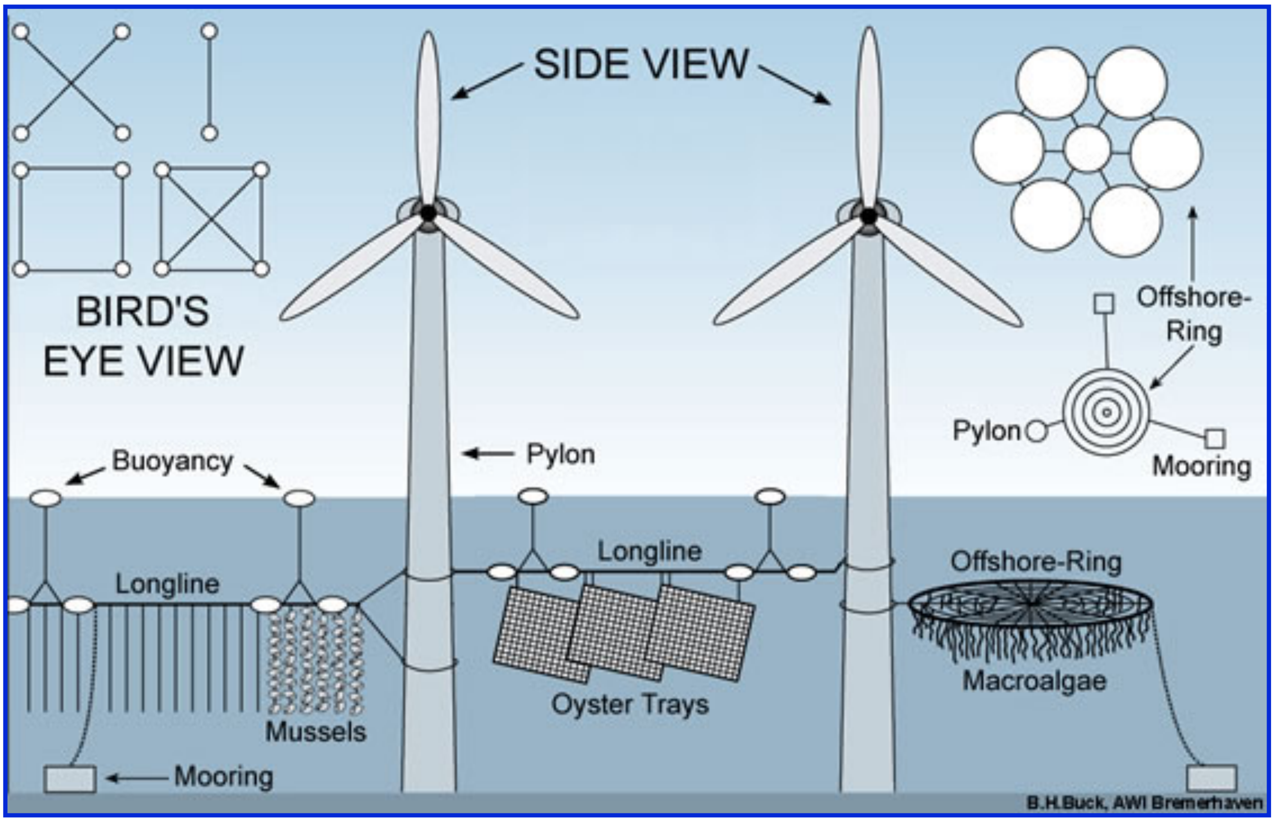


Figure 4. Nets of Porphyra yezoensis *(nori) around salmon cages at Deep Cove, Cobscook Bay, Maine, USA. (Photograph courtesy of I. Levine, Coastal Plantations International, Inc.)*



AWI Bremerhaven (Germany): ***Laminaria***


Correio da Manhã | Quinta-feira, 27 Novembro 2003 9
ALGARVE

CIÊNCIA ■ UNIVERSIDADE DO ALGARVE

▲ Experiência realizada numa exploração da Ria Formosa foi coroada de êxito

Algas 'limpam' pisciculturas

INVESTIGAÇÃO CIENTÍFICA

Algarve descobre alga para limpar as águas

PAG. 9

Cientistas do Algarve transformam dejectos de peixes em produtos anticaspa

Investigação europeia já deu origem a pedido de patente

Investigadores da Universidade do Algarve desenvolveram uma alga que pode transformar dejectos de peixes das pisciculturas em compostos antivirais e antibacterianos, para serem usados em cosméticos de combate à caspa e ao acne.

"Trata-se de criar condições que permitam a produção de biomassa com valor acrescentado a partir dos efluentes das pisciculturas e aquários", explicou Rui Santos, do Centro de Ciências do Mar da Universidade do Algarve. Os estudos inserem-se no projecto europeu Seapura, que integra parceiros portugueses, espanhóis, irlandeses, alemães e franceses

Os dejectos dos animais servem de adubo para que a alga vermelha "Falkenbergia rufolanosa" se propague. A alga produz amónia, que tem actividade antiviral e antibacteriana, e pode ser colhida e transformada na indústria cosmética.

"Os nossos colegas franceses já começaram a aplicar esses compostos em produtos anticaspa e antiacne", disse o investigador. Mas o produto pode ter outras aplicações: por exemplo, a prevenção do desenvolvimento de bactérias e vírus em peixes criados em aquacultura e a integração em tintas, para evitar o desenvolvimento de fungos.

Os investigadores desenvolvem agora, com o parque zoológico Zoomarine, uma colaboração para potenciar o uso do sistema no recinto, utilizando as algas vermelhas em estudo na reciclagem das águas em que vivem os golfinhos, tubarões e focas, entre outros.

Os cientistas portugueses já pediram uma patente para o processo de produção e extracção da alga, que estudaram em profundidade, enquanto os parceiros franceses e alemães se dedicaram aos compostos que a alga produz ao retirar a amónia dos efluentes das pisciculturas. ■ LUSA

da cosmética, em produtos destinados ao combate da acne e da caspa.

Os testes levados a cabo por cientistas portugueses do grupo ALGAE - Ecologia de Plantas Marinhas, do Centro de Ciências do Mar da Universidade do Algarve foram conclusivos e a alga tem reconhecida utilidade na depuração dos efluentes das pisciculturas, área em que incidiu o trabalho realizado por uma equipa liderada por Rui Santos. "Actualmente não existe legislação levado a cabo na empresa Aquamarim (situada no Parque Natural da Ria Formosa)", esclarece Rui Santos.

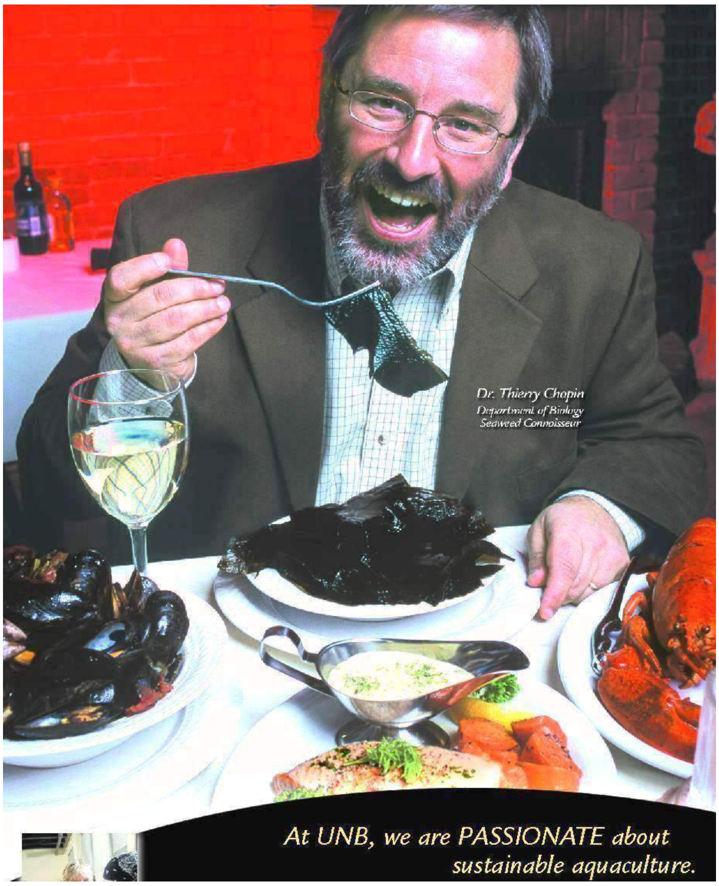
Em estudo está, agora, a utilização da alga num projecto inovador, a biofiltração dos sistemas de reciclagem dos tanques do parque Zoomarine, em Albufeira.

A investigação da Universidade do Algarve insere-se no projecto europeu SEAPURA, que envolve parceiros espanhóis, irlandeses,

caspa e acne

ses vão reunir-se a partir de hoje e até sábado na Universidade do Algarve, a fim de trocarem experiências e discutirem os resultados dos trabalhos levados a cabo, num workshop sobre purificação de efluentes.

O programa inclui uma visita à exploração Aquamarim (no último dia) e entre os oradores e participantes contam-se responsáveis do parque aquático Zoomarine e do Oceanário de Lisboa. ●



See the Integrated Aquaculture video at www.aquanet.ca

AquaNet

At UNB, we are PASSIONATE about sustainable aquaculture.

From your orange juice in the morning to your toothpaste in the evening, seaweeds are everywhere in your life! One of UNB's many passionate minds, Dr. Thierry Chopin is developing integrated aquaculture systems by combining fish, seaweeds and shellfish. His findings? Seaweeds and shellfish thrive on nutrients and food available in proximity to salmon farms. That means a biological and cost-effective way to improve water quality and marine crop diversification for this significant component of the agro-food sector. We support the innovative practices researched by Dr. Chopin and his inter-disciplinary team.

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MAKING A SIGNIFICANT DIFFERENCE

Soluciones SOSTENIBLES (con ALGAS) que ayuden a minimizar el aumento de los problemas medioambientales y energéticos del planeta:

1.- Sistemas Integrados en Acuicultura

2.- Biotecnología de Microalgas para la obtención de Biocombustibles

OCEANIC FARMS for energy production (methane, ethanol,…)
And recently … CO_2 absorption

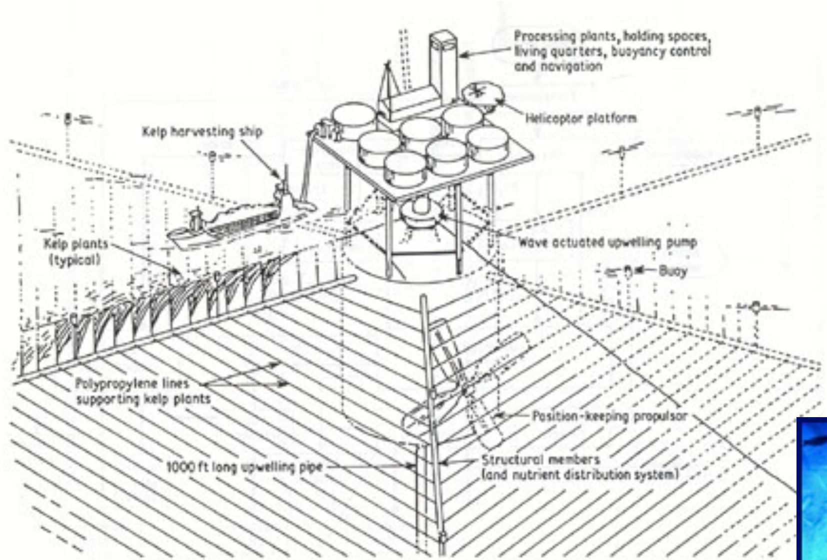
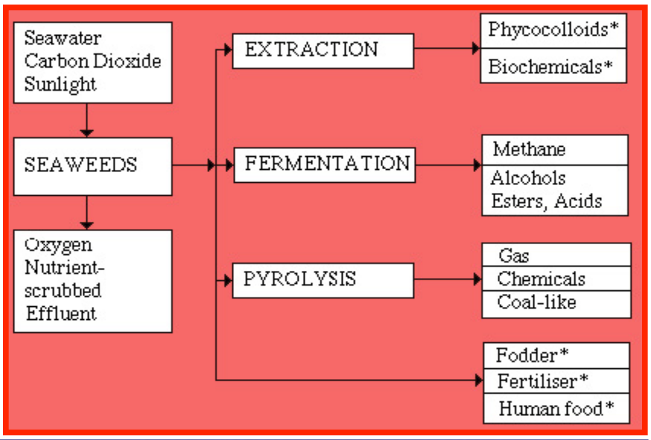
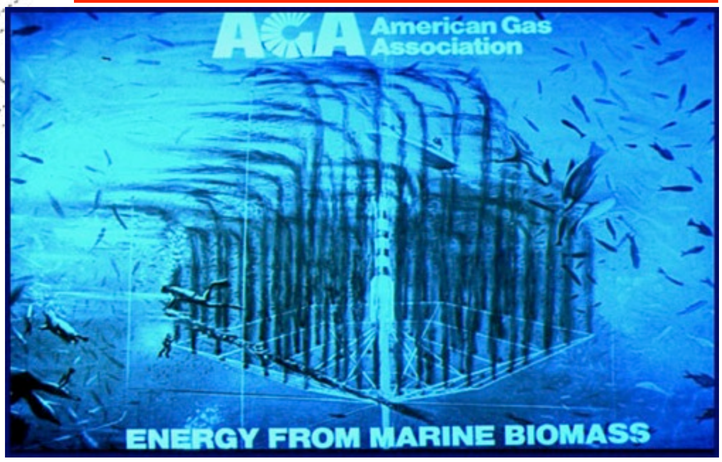


Fig. 2.5 Conceptual design 1000-acre ocean food and energy farm unit.

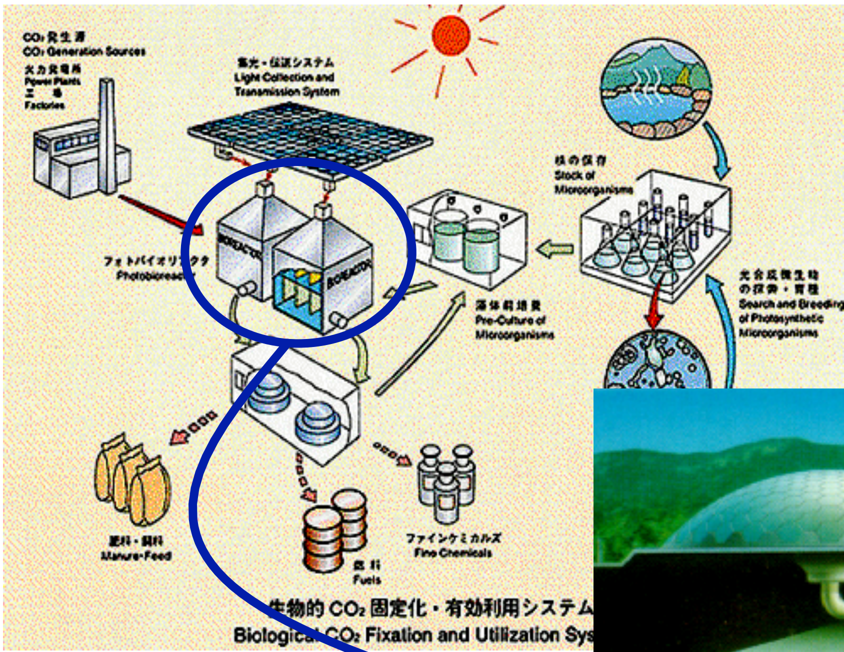




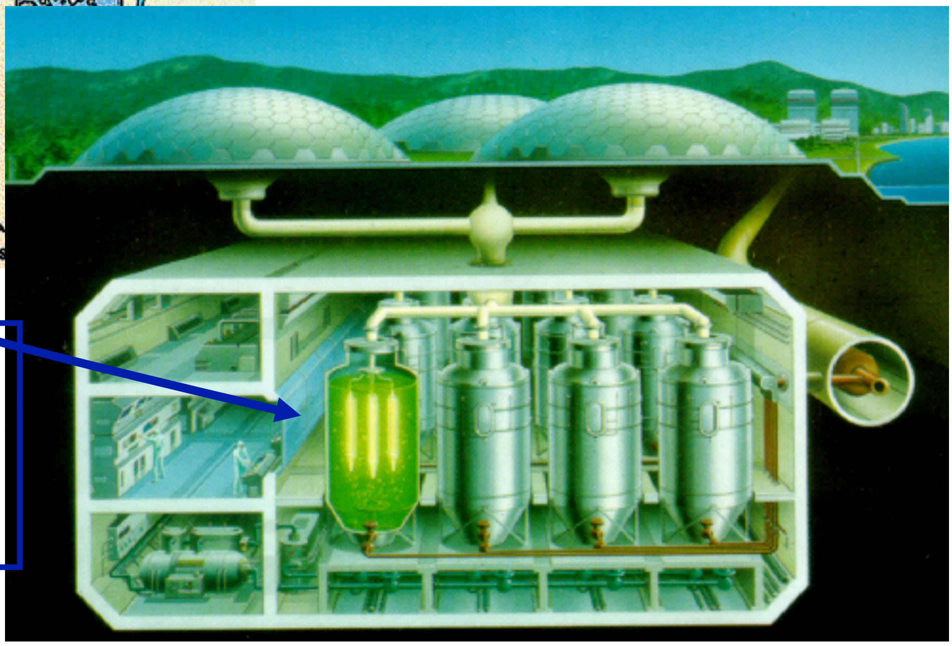
Energy production

Methane (biogas)
Hydrocarbons
Ethanol

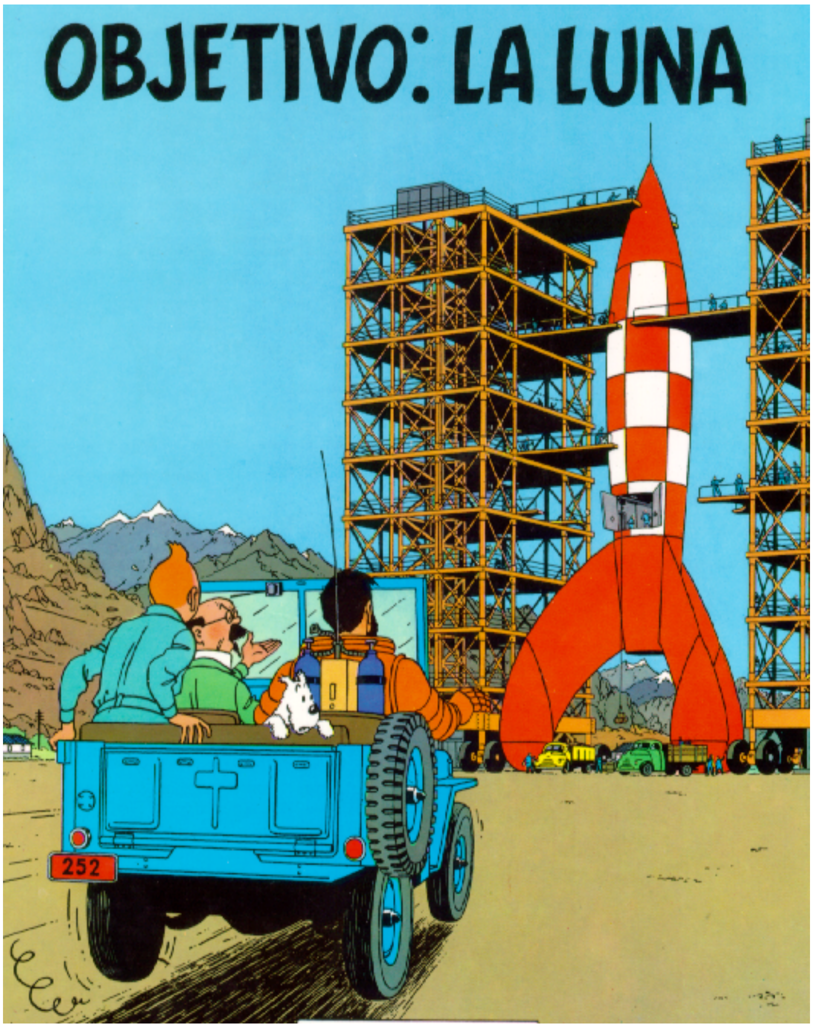
Wilcox and Sunrise Projects



Filtración de CO_2 por cultivo intensivo de microalgas *(FBR)*



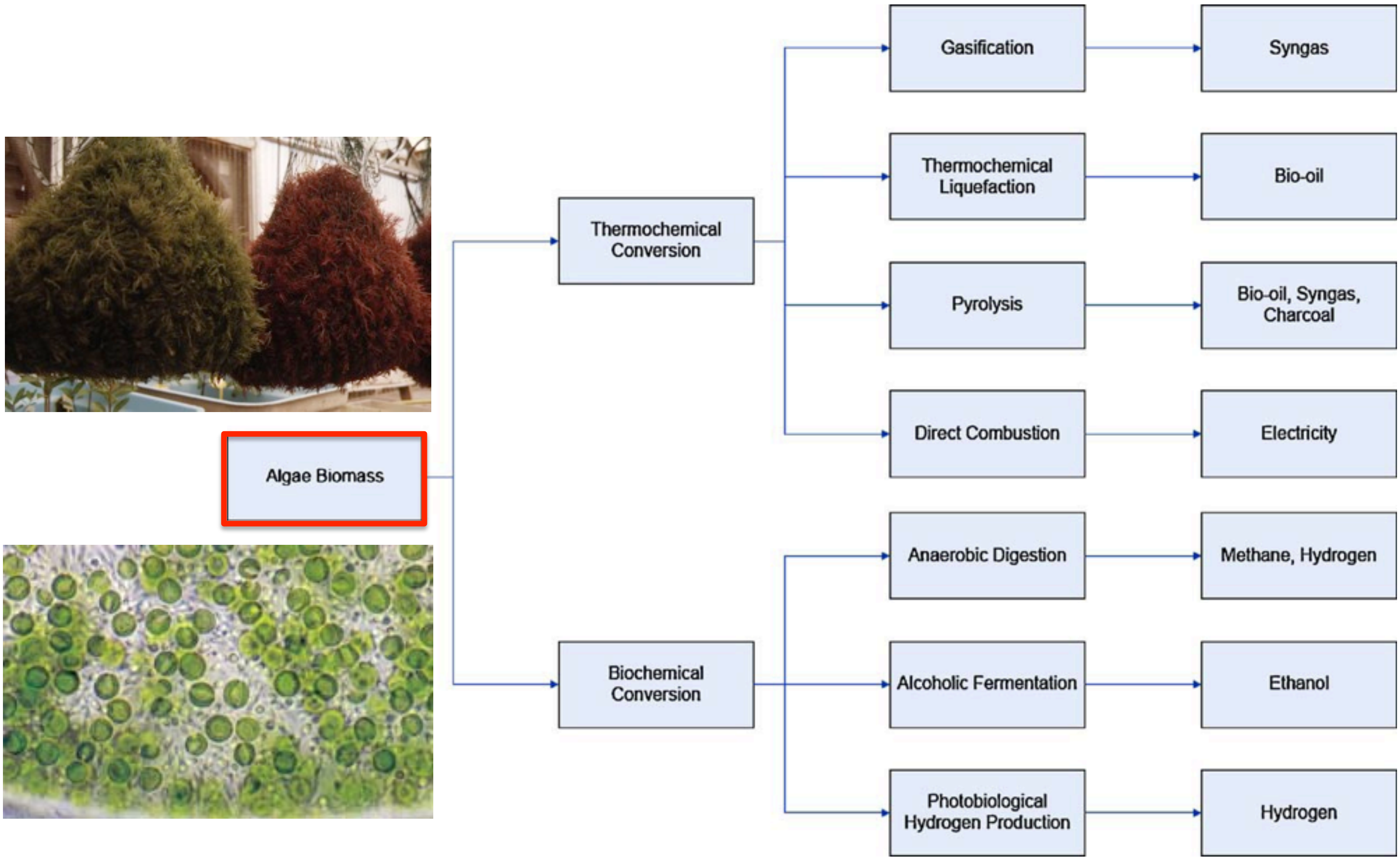
1 Tm biomasa algal:
- **fija 450 Kg CO_2**
- **produce 1.200 Kg O_2**



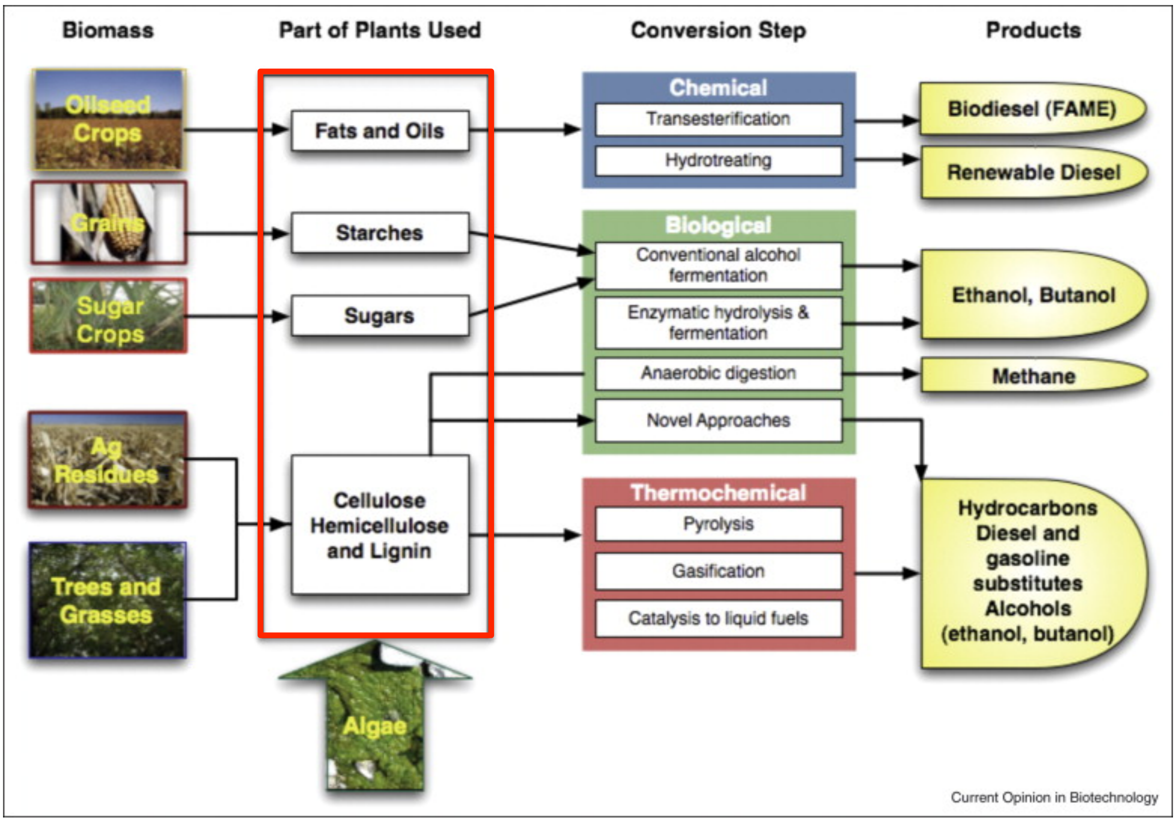
Algología Planetaria

→ ***Spirulina*** **o** ***Chlorella*** en el espacio:

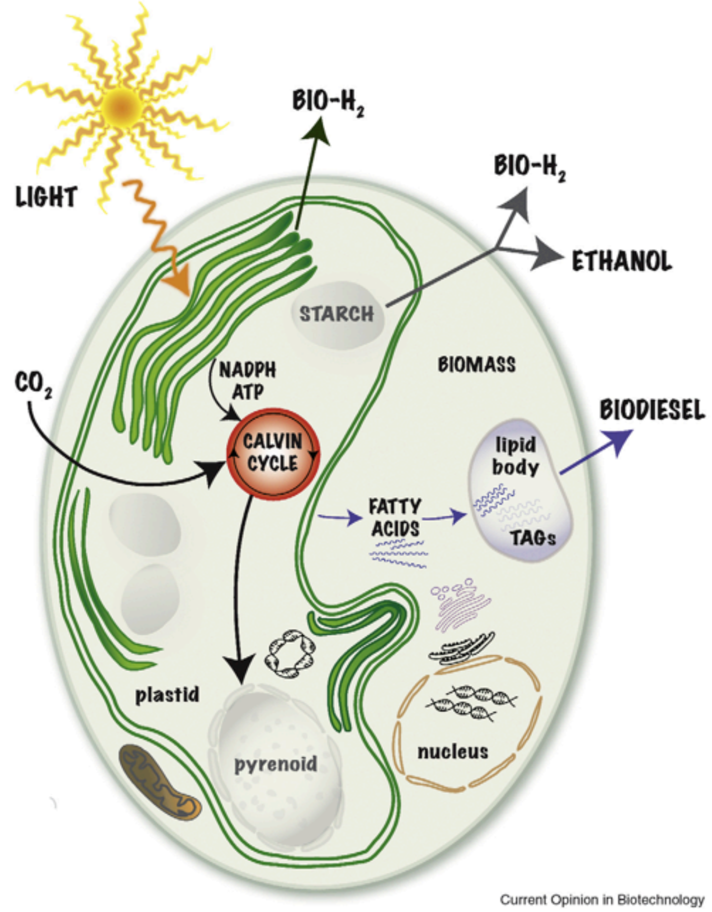
- Para transportar / generar O_2
- Para filtrar / eliminar CO_2
- Para eliminar/ regenerar residuos
- Para transportar/ generar calorías
- Para transportar/ gener. nutrientes



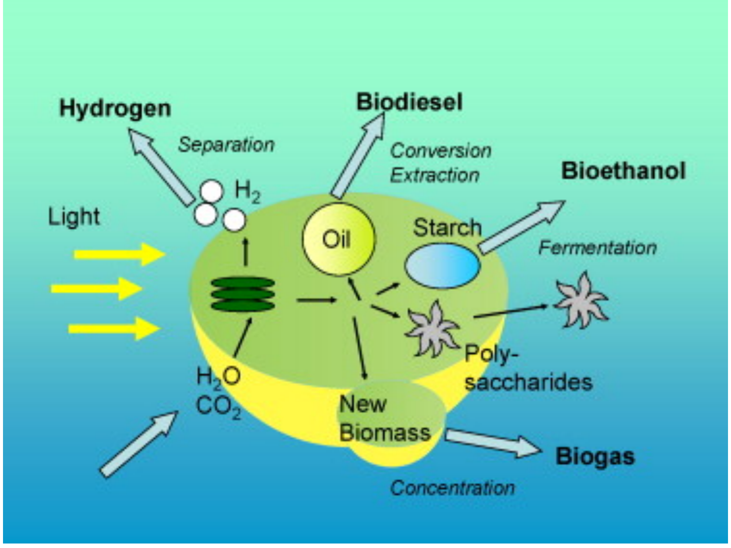
Brennan & Owende. 2010. Renewable and Sustainable Energy Reviews 14:557–577

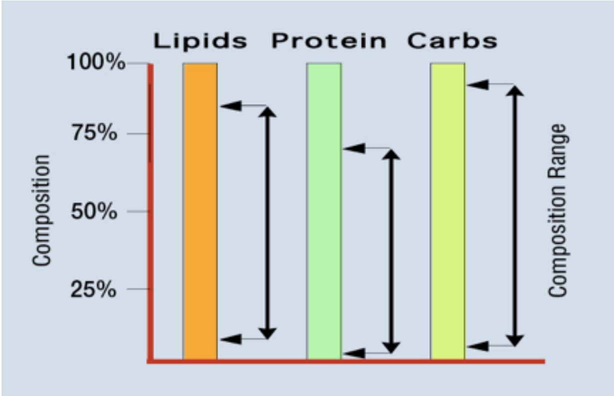


Sheehan (2009) Current Opinion in Biotechnology, 20:318–324



Beer et al. 2009. Current Opinion in Biotechnology, 20:264–271

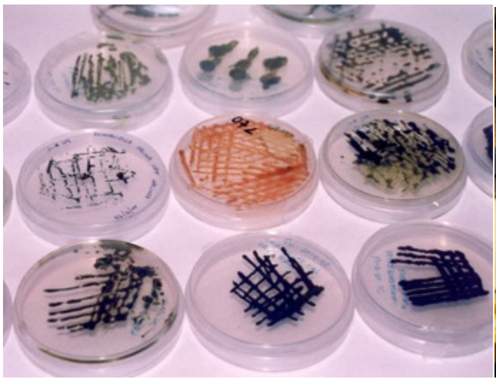




Selección de especies (cepas)

→ **Consideraciones importantes:**

- Composición: lípidos (tinción Rojo de Nilo), carbohidratos, proteínas
- Carácterísticas de crecimiento: altas producciones
- Posibilidades de cultivo a escala industrial
- Estadíos para la síntesis de metabolitos (una/dos fases; condiciones de estrés)
- Rendimientos: biomasa producida * concentración del “producto de interés”
- Disponibilidad: Colecciones de cultivo
- Mejora de especies: por selección o ingeniería genética



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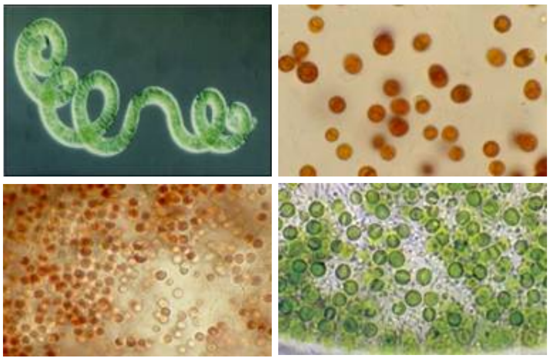
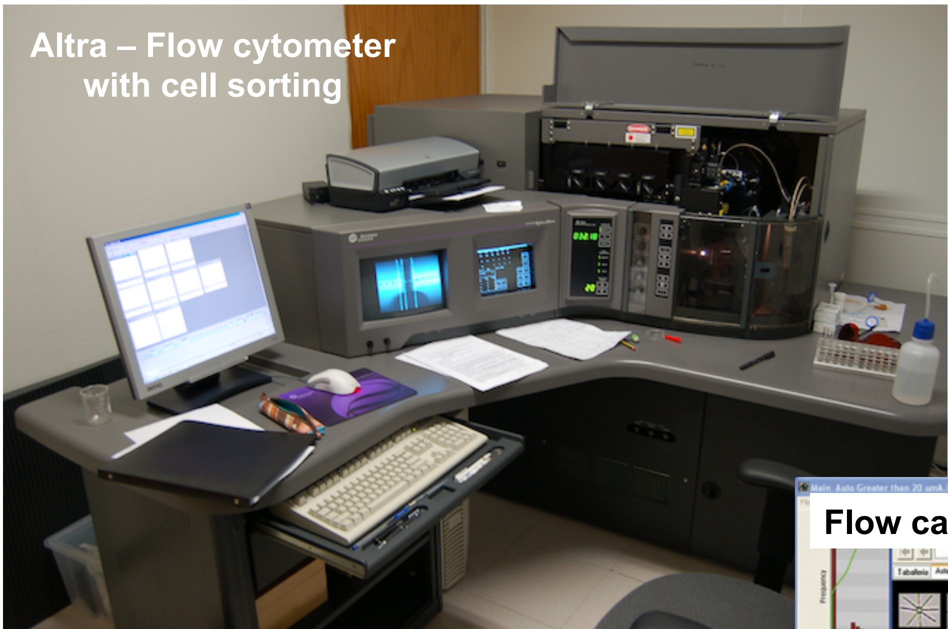
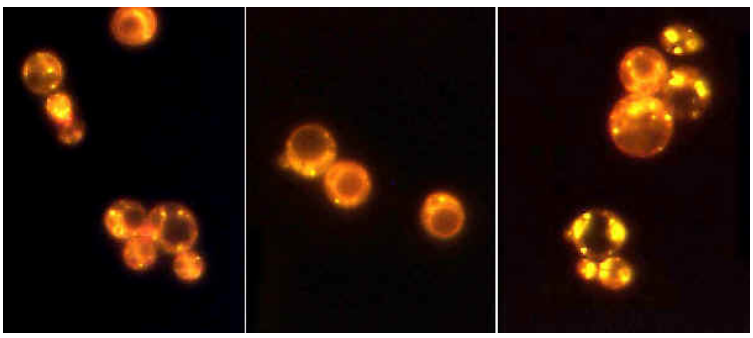
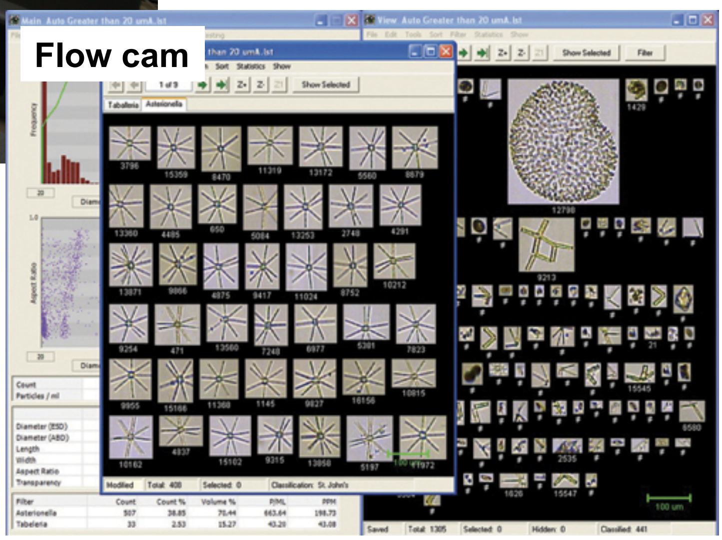
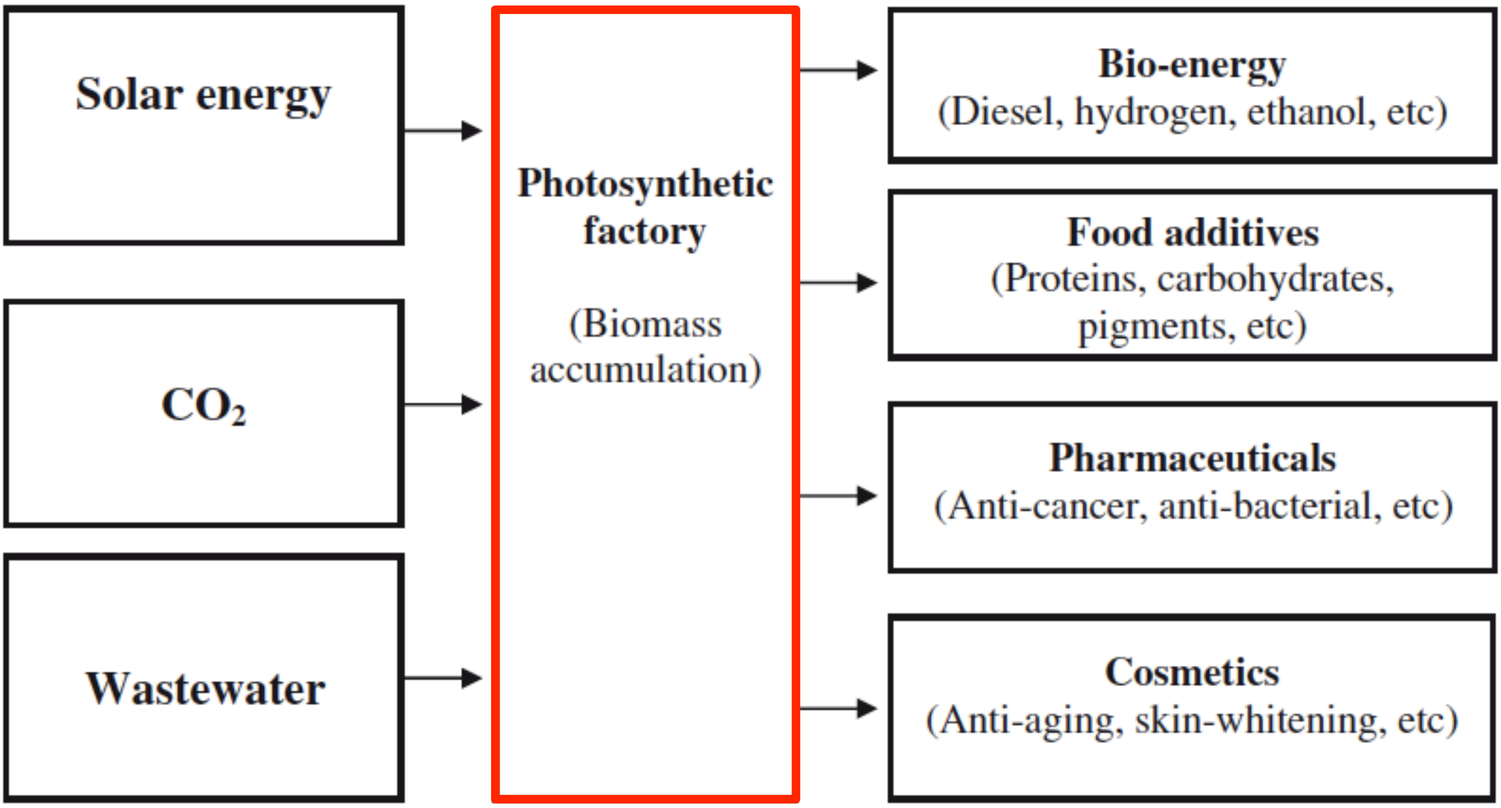


NATIONAL BANK OF ALGAE Culture Collection









Ho et al., Biotechnol. Adv. (2011)

Cultivo: crecimiento, eficiencia fotosintética y producción

Aplicaciones medioambientales (CO_2 y aguas residuales)

Greenhouse Gas Mitigation Project (Int. Univ. Bremen) www.irccm.de

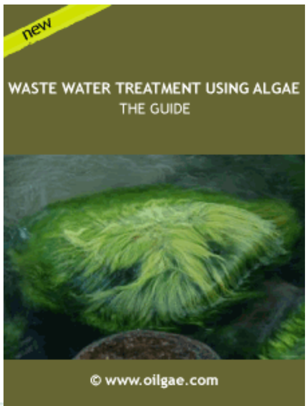
Micro-photobioreactors at the E.ON power plant

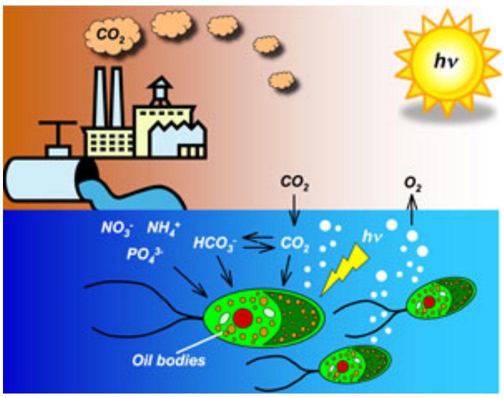
Table 1. Some characteristic microalgal strains mentioned in this paper.

Species	Unique properties	Reference
Acaryochloris marina Miyashita et al.	Possesses chlorophyll *d* as a major photosynthetic pigment	Miyashita et al. (1996, 1997) Hu et al. (1998b)
Chlorococcum littorale N. Chihara, T. Nakayama et I. Inouye	Grows at high CO_2	Kodama et al. (1993)
Porphyridium purpureum (Bory de Saint-Vincent) K. Drew et Ross	Possesses unique gene structure and novel catalytic site of CA	Mitsuhashi et al. (1996, 2000a, 2000b)
Stichococcus bacillaris Nägeli	Sensitive to high CO_2	Iwasaki et al. (1996, 1998)
Synechocystis aquatilis Sauvageau	Very short doubling time (2 h)	Zhang et al. (1999)

➔ **Tratamientos de aguas residuales**:

- Biofiltración de nutrientes inorgánicos de la Acuicultura
- Aguas residuales de actividades Agrícolas (p.e. purines)
- Aguas residuales Urbanas
- Aguas residuales de los procesos de producción de Biogas





Review

$BioCO_2$ – A multidisciplinary, biological approach using solar energy to capture CO_2 while producing H_2 and high value products

Kari Skjånes [a,b,*], Peter Lindblad [b], Jiri Muller [c]

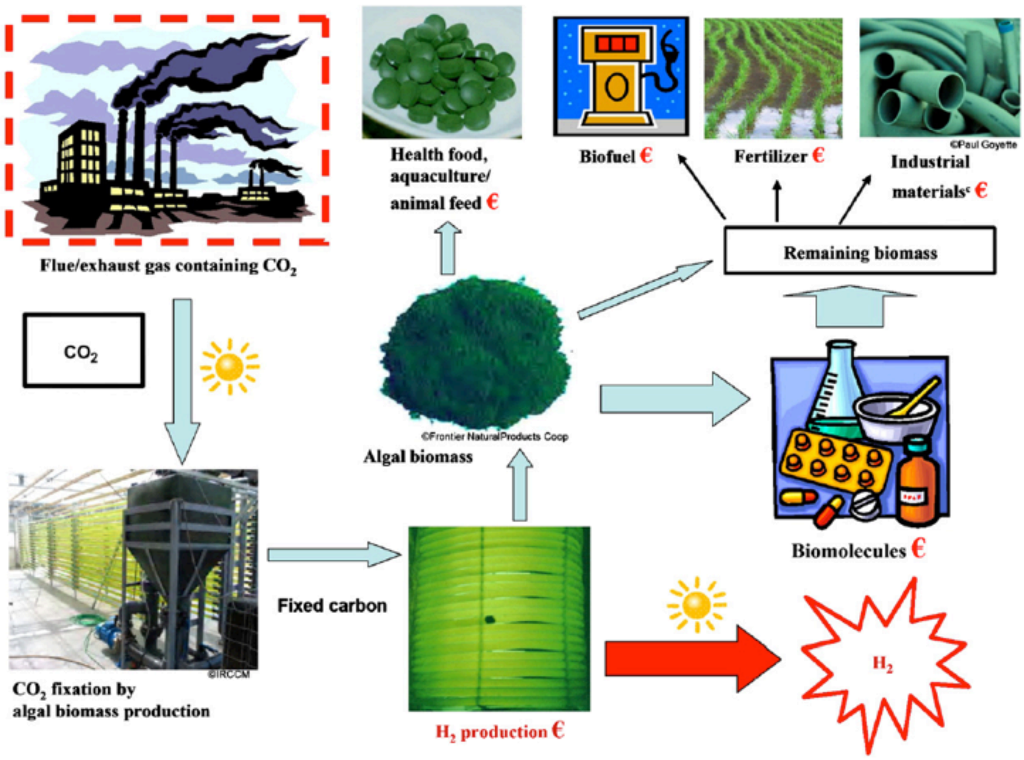
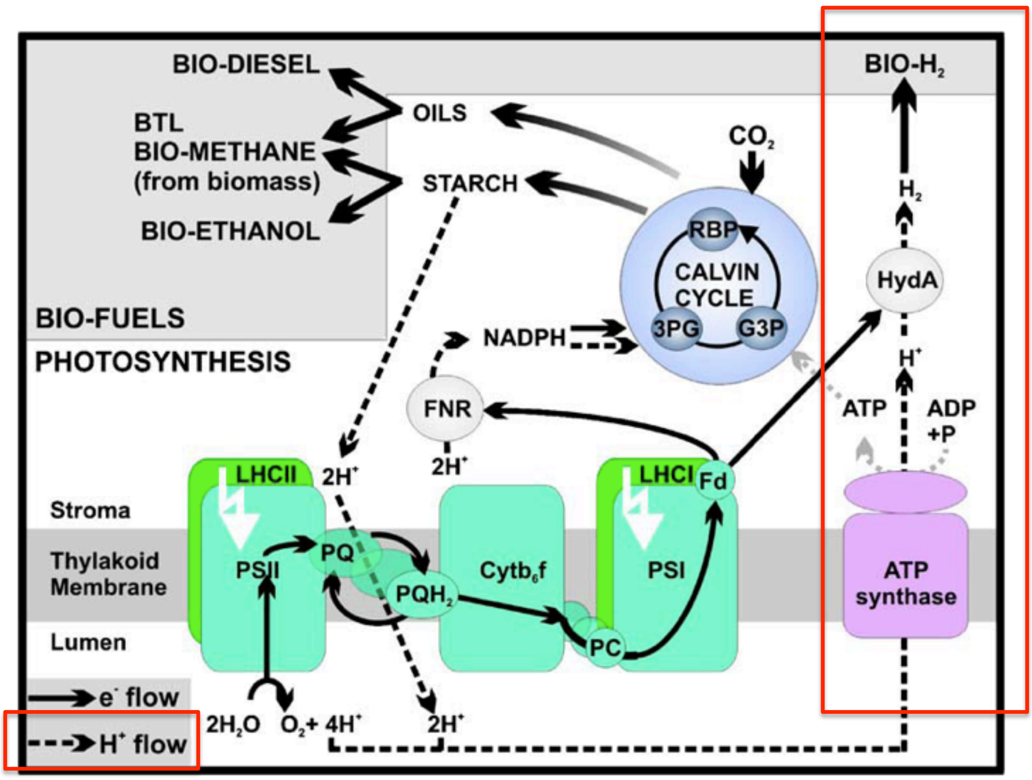


Fig. 1. The illustrated process captures CO_2 in photobioreactors, using microalgae to convert industrially produced CO_2 and solar energy into algal biomass by photosynthesis. The algae will then be transferred to a separate photobioreactor for H_2 production, where the algae will convert solar energy into H_2 gas using a biophotolytic process under sulfur deprivation. After the H_2 production phase the algal biomass will be collected and used for different purposes: the algae can be used directly as health food for human consumption, as animal feed or in aquaculture. After nutrient limitation algal biomass can contain large amounts of valuable biomolecules which will be extracted for pharmaceutical or industrial retail. However, these substances usually only comprise few percent of the biomass, leaving the majority of the fixed CO_2 in the remaining biomass. The residual algal biomass from different process stages can be used either as a fertilizer for agriculture in which case the fixed carbon will be retained for some years, or for storage of the fixed CO_2 by industrial applications like production of plastics. Residual biomass can also be used as an energy carrier by extraction of biodiesel or by direct conversion of the biomass to other energy carriers using biological or thermo-chemical methods.

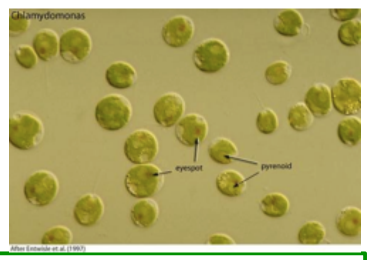
K. Skjånes et al. / Biomolecular Engineering 24 (2007) 405–413

Bio-Hydrogen



Schenk et al. 2008.
Bioenergy Research

Fig. 1 The process of photo-synthesis coverts solar energy into chemical energy and is key to all biofuel production systems in plants



- Hydrogenase (eukariotic algae): *Chlamydomonas, Scenedesmus* – light and anaerobic cond., or
- Nitrogenase (in Cyanobacteria): catalyze H_2 (gas) production in the absence of O_2 y N_2

Bio-Methane and Bio-Ethanol

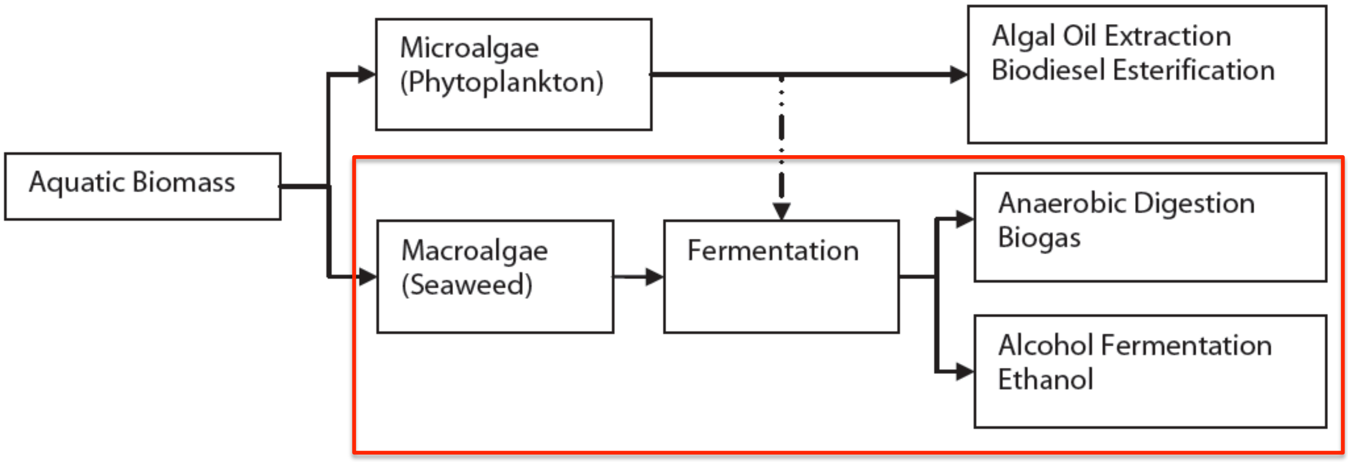
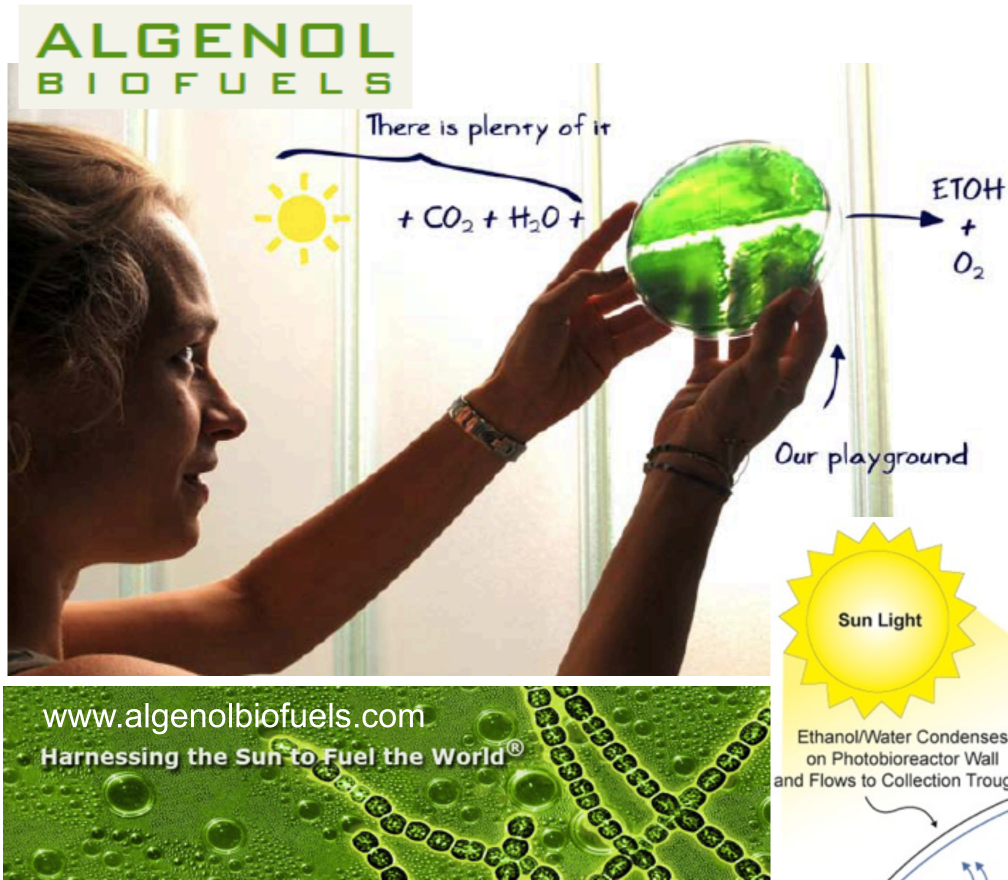


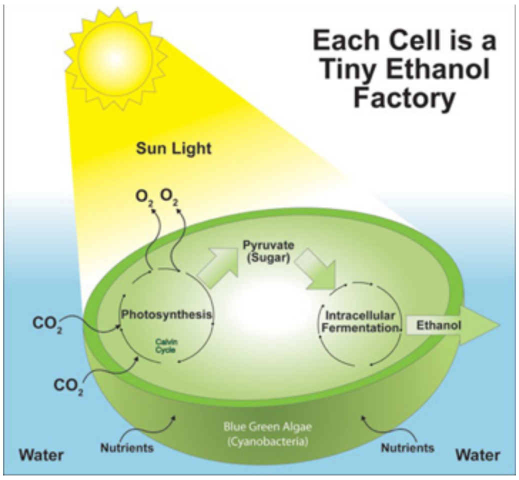
Figure 1: Principal Energy Processes Being Developed for Aquatic Biomass

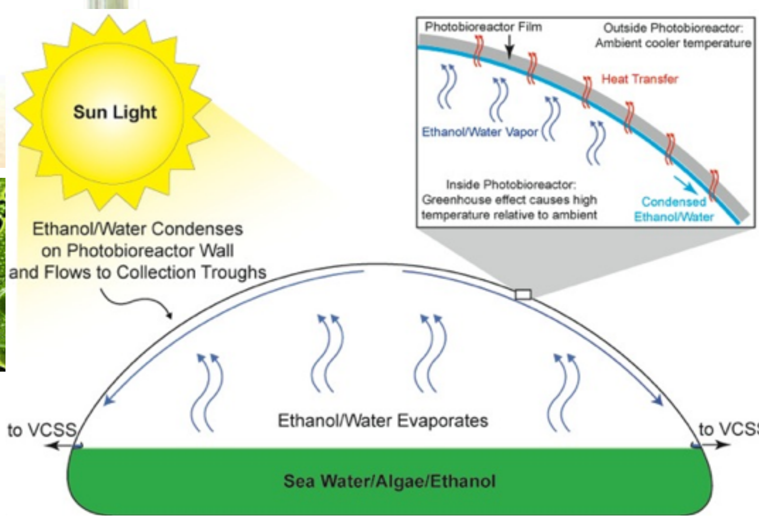
Table 7
Methane yield from the different algae strains.

Biomass	Methane yield ($m^3\,kg^{-1}$)
Laminaria sp.	0.26–0.28
Gracilaria sp.	0.28–0.4
Macrocystis	0.39–0.41
L. Digitata	0.5
Ulva sp.	0.2

A Review of the Potential of Marine Algae as a Source of Biofuel in Ireland (2009)







Biodiesel

Table 1
Typical oil yields from the various biomass sources in ascending order.

S.N.	Crop	Oil yield (l/ha)
1	Corn	172
2	Soybean	446
3	Peanut	1,059
4	Canola	1,190
5	Rapeseed	1,190
6	Jatropha	1,892
7	Karanj (*Pongamia pinnata*)	2,590
8	Coconut	2,689
9	Oil palm	5,950
10	Microalgae (70% oil by wt.)	136,900
11	Microalgae (30% oil by wt.)	58,700

Data sources: Chisti [3]; Lele [4]; http://journeytoforever.org/biodiesel_yield.html.

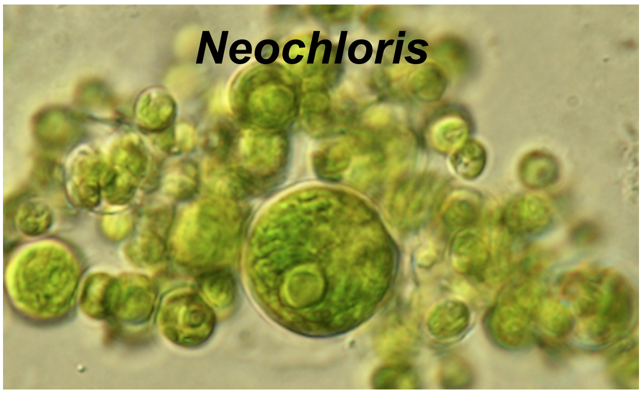
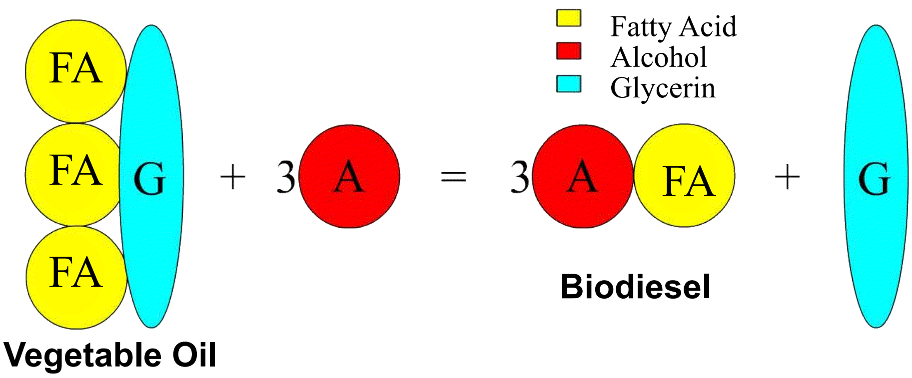


Table 5
Oil contents of microalgae.

Microalgae	Oil content (% dwt)
Botryococcus braunii	25–75
Chlorella sp.	28–32
Crypthecodinium cohnii	20
Cylindrotheca sp.	16–37
Dunaliella primolecta	23
Isochrysis sp.	25–33
Monallanthus salina	>20
Nannochloris sp.	20–35
Nannochloropsis sp.	31–68
Neochloris oleoabundans	35–54
Nitzschia sp.	45–47
Phaeodactylum tricornutum	20–30
Schizochytrium sp.	50–77
Tetraselmis suecica	15–23
B. braunii	25–75

Adapted from: Chisti [3].

Singh & Gu. 2010. Renewable and Sustainable Energy Reviews (in press)



Biodiesel production

Parent oil used in making biodiesel consists of triglycerides (Fig. B1) in which three fatty acid molecules are esterified with a molecule of glycerol. In making biodiesel, triglycerides are reacted with methanol in a reaction known as transesterification or alcoholysis. Transestrification produces methyl esters of fatty acids, that are biodiesel, and glycerol (Fig. B1). The reaction occurs stepwise: triglycerides are first converted to diglycerides, then to monoglycerides and finally to glycerol.

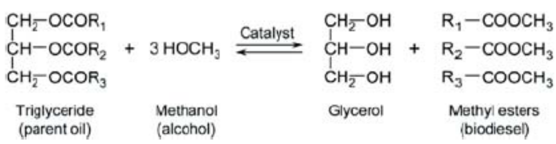
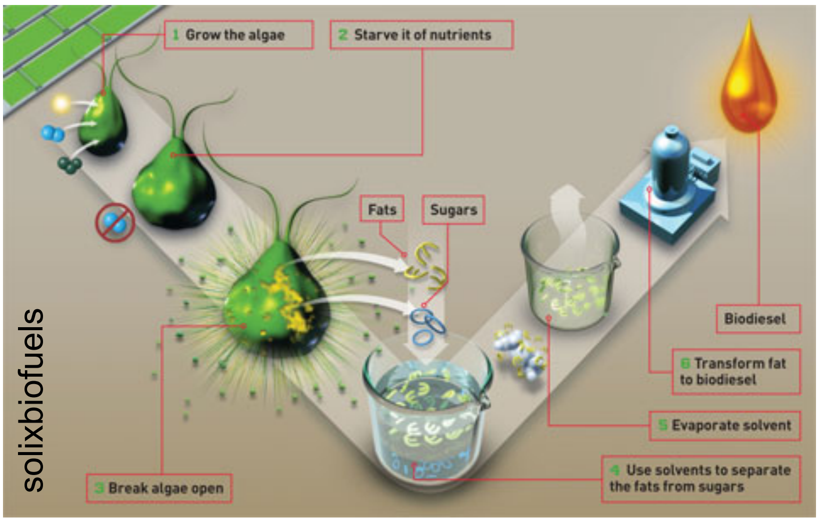
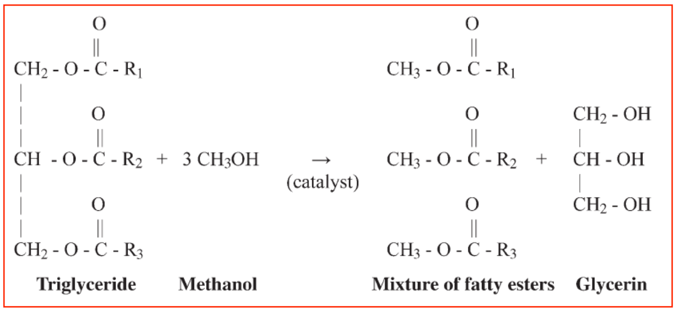


Fig. B1. Transesterification of oil to biodiesel. R_{1-3} are hydrocarbon groups.

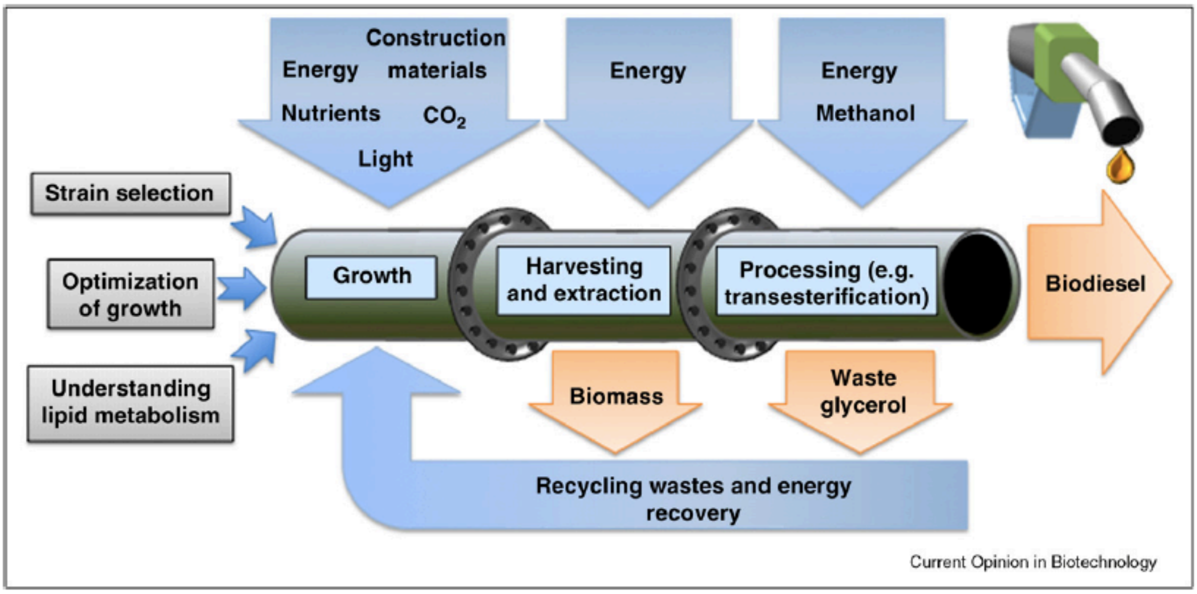
Chisti, Y. (2007). Biotechnol. Adv. 25:294





MICROALGAL CULTIVATION FOR CO_2 BIOFILTRATION AND BIODIESEL PRODUCTION

¿ Bio-combustibles CO_2-neutros ?



Algal biofuel pipeline, showing the major stages in the process, together with the inputs and outputs that must be taken into consideration by life-cycle analysis.

Scott et al. Current Opinion in Biotechnology 2010, 21:1–10

Biorefinery Concept

J. Singh, S. Gu / Renewable and Sustainable Energy Reviews xxx (2010) xxx–xxx

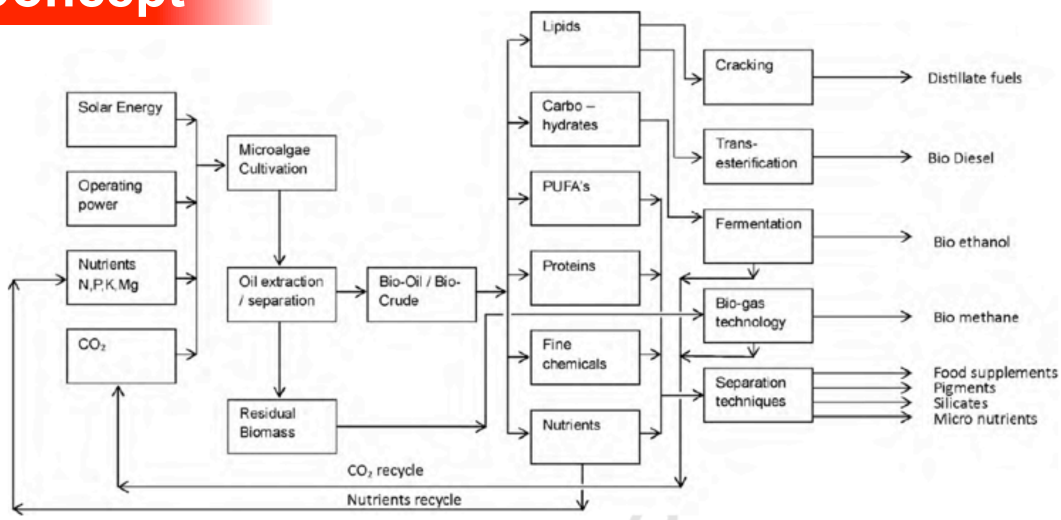


Fig. 4. Proposed schematic flow sheet for a microalgae biorefinery.

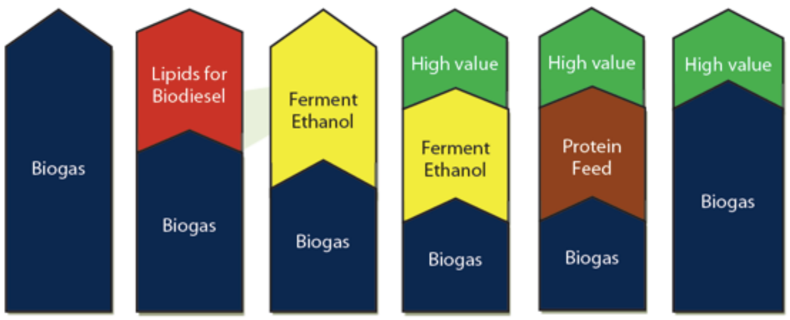
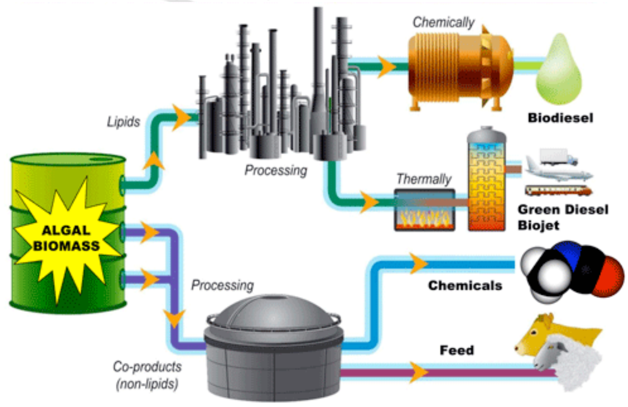
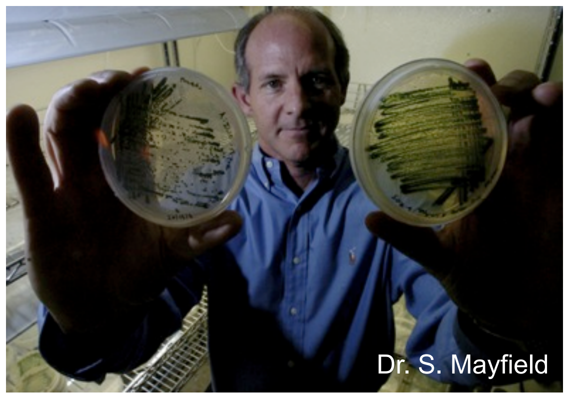


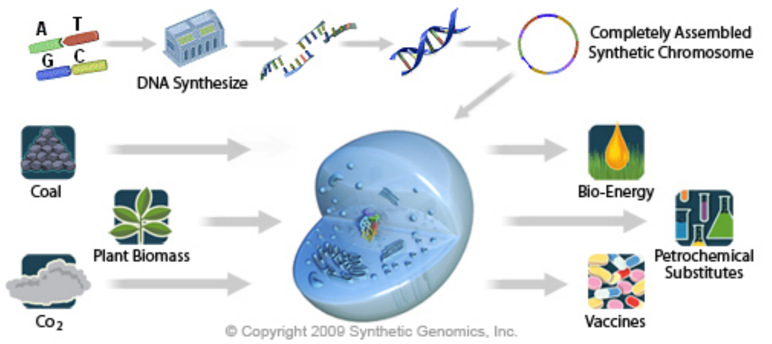
Figure 20: Biorefinery Concepts for Algae



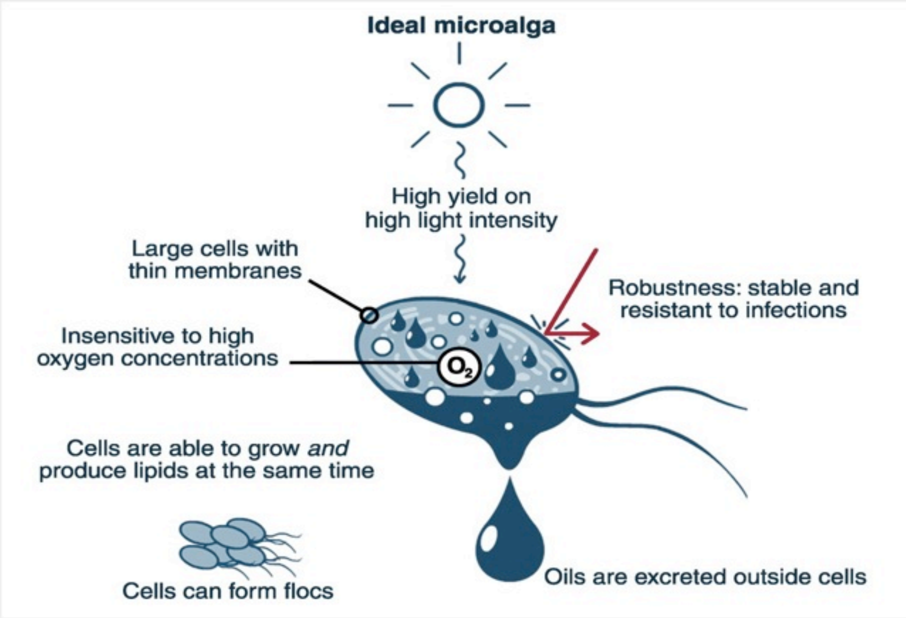
Tendencias y Desafíos

Selection from an extensive culture collection, along with metabolic manipulation and genetic engineering, were ways NREL researchers developed strains of microalgae producing high levels of lipids for biofuel production. PIX 03987





The ideal photosynthetic cell factory for production of biofuels



R. H. Wijffels et al., Science 329, 796-799 (2010)

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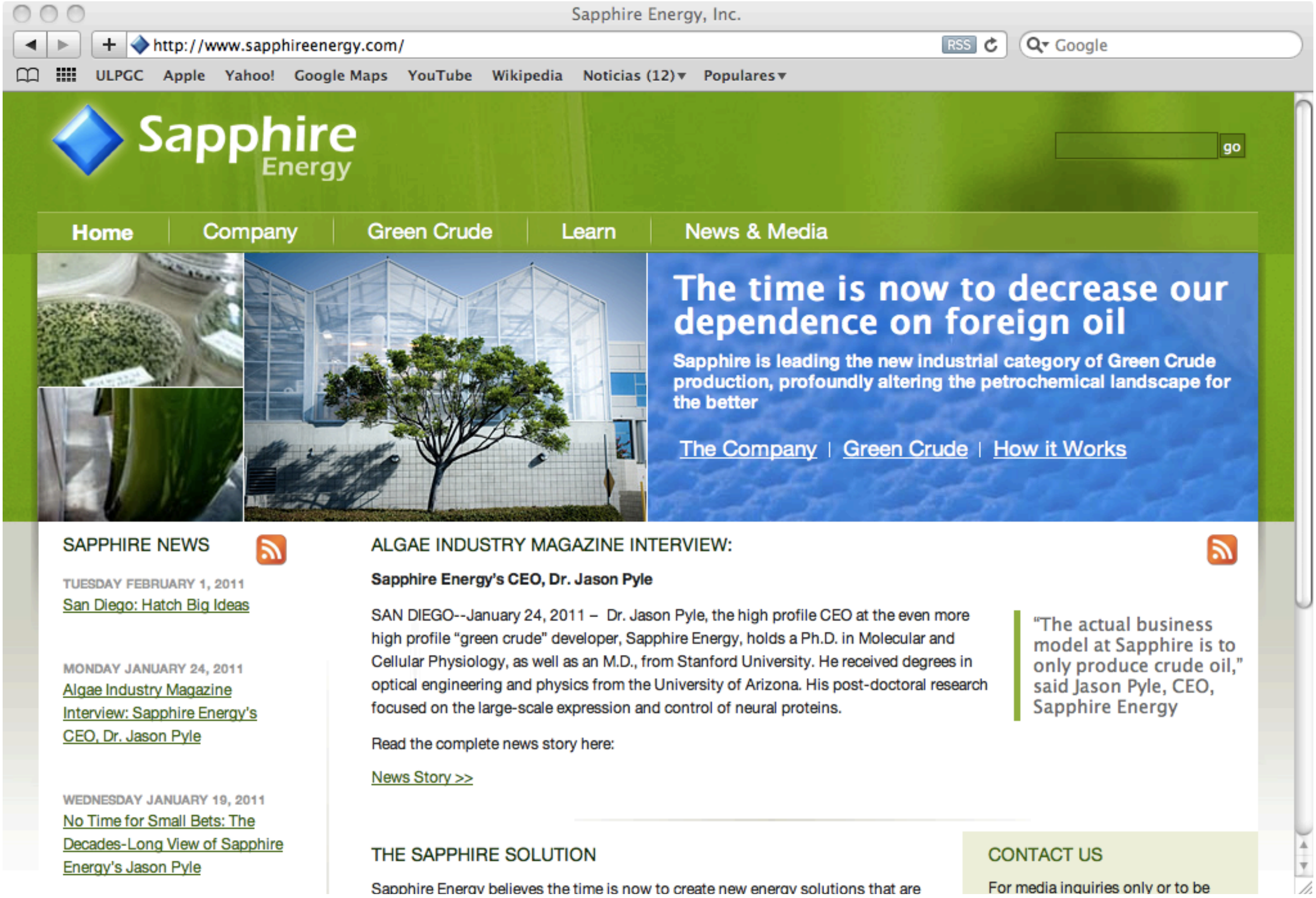
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Sapphire Energy's CEO, Dr. Jason Pyle
SAN DIEGO--January 24, 2011 – Dr. Jason Pyle, the high profile CEO at the even more high profile "green crude" developer, Sapphire Energy, holds a Ph.D. in Molecular and Cellular Physiology, as well as an M.D., from Stanford University. He received degrees in optical engineering and physics from the University of Arizona. His post-doctoral research focused on the large-scale expression and control of neural proteins.
Read the complete news story here:
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"The actual business model at Sapphire is to only produce crude oil," said Jason Pyle, CEO, Sapphire Energy
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World's First Flight Powered by 100% Algae Biofuels Completed

by Matthew McDermott, New York, NY on 07.22.10

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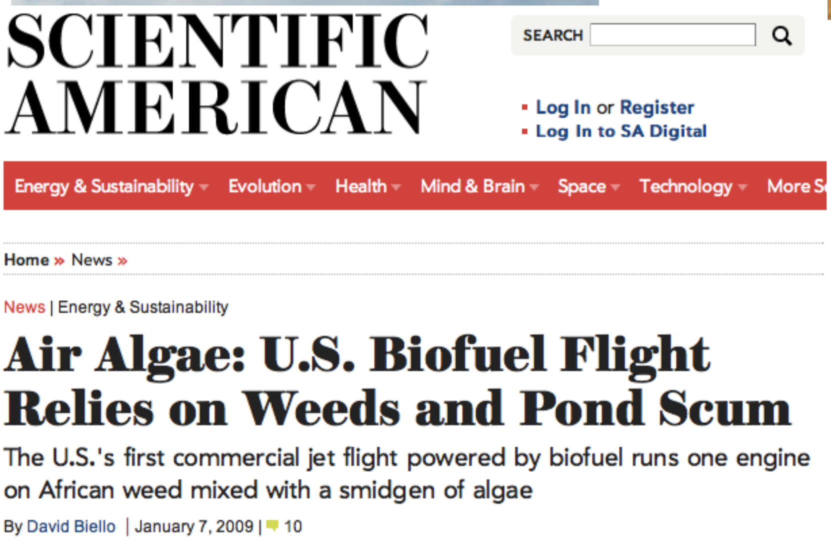

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Air Algae: U.S. Biofuel Flight Relies on Weeds and Pond Scum

The U.S.'s first commercial jet flight powered by biofuel runs one engine on African weed mixed with a smidgen of algae

By David Biello | January 7, 2009 | 10

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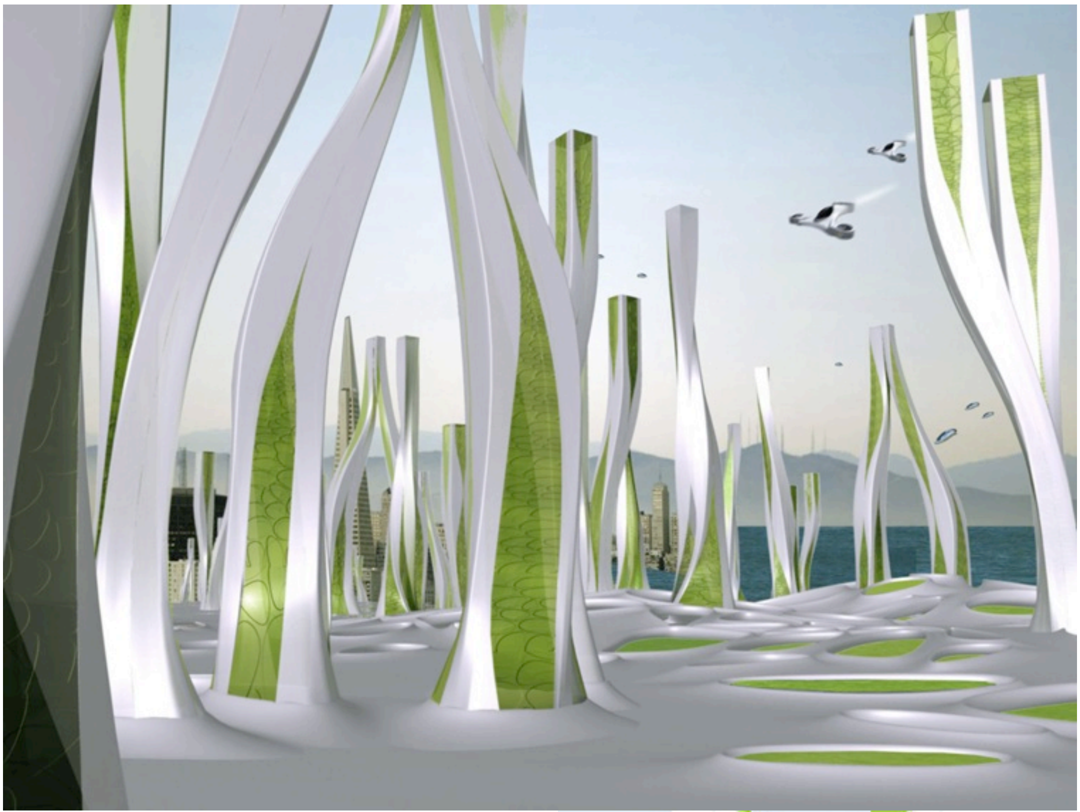

Muchas Gracias por su atención

ALGAE→H_2

-Predictions estimate sea level rise of 2 to 5 meters in San Francisco by 2108

-Innundated baylands are reoccupied as hybrid aquaculture/urbanism zone

-Algae aquaculture provides source for generating hydrogen fuel

←Hydro-Net generates and stores hydrogen energy made from new algae aquaculture network which reoccupies baylands flooded due to climate change

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