cellana™

algae-based products
for a sustainable future℠

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Our Focus

To develop the most productive plants on earth – **microalgae** – to produce biofuels, nutritional oils, aquaculture and animal feeds while simultaneously reducing industrial emissions of CO_2.

Cellana Timeline

HR BioPetroleum Founding

ALDUO™ Patent Filed

Commercial Facility MOU

Kona Demo Facility Operational

HRBP Acquires Cellana

Cellana JV Formed

ALDUO™ patent issued

1997 // 2003 • 2004 • 2005 • 2006 • 2007 • 2008 • 2009 • 2010 • 2011

Pilot Facility Production (NELHA)

Demo Facility Production

DARPA (DoD) funds

Shell Petroleum JV Funding ($80M)

Leveraging >$80MM investment in technology platform

Validated operating platform at Kona Demonstration Facility

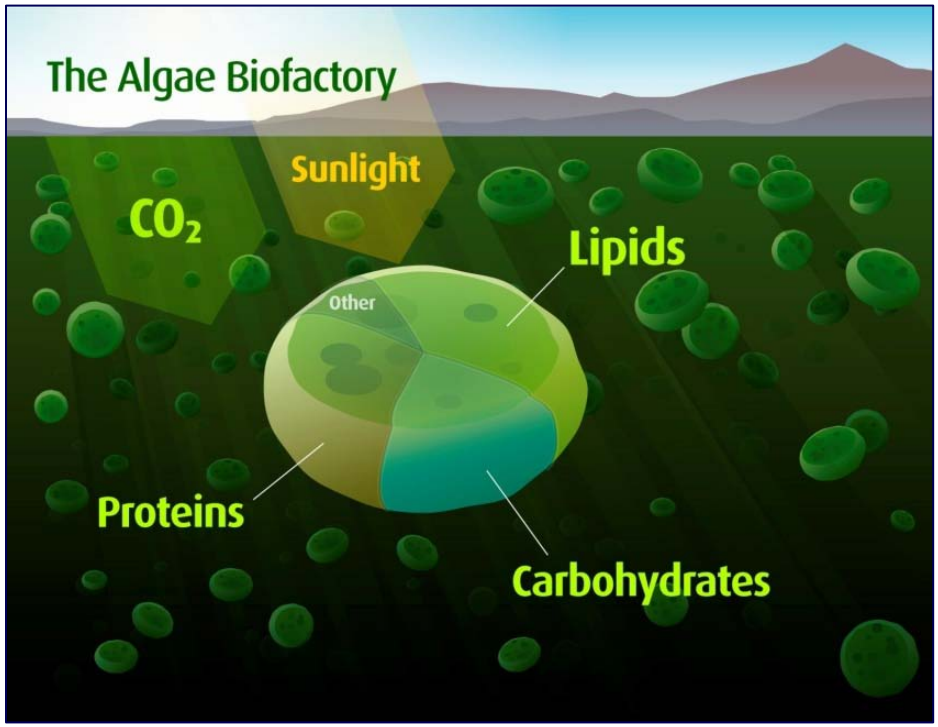
Team member in a $44M DoE grant: National Alliance for Advanced Biofuels & Bioproducts

Leading $9M DOE Funded

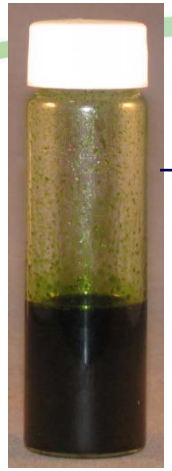
$5.5M Grant

Why Microalgae?

- Microbes that grow like plants
- Use carbon dioxide, water, nutrients and light for photosynthetic biomass production
- Produce proteins, carbohydrates, lipid-oils and wide range of metabolites
- Under stressed environment
  → alter lipid metabolism

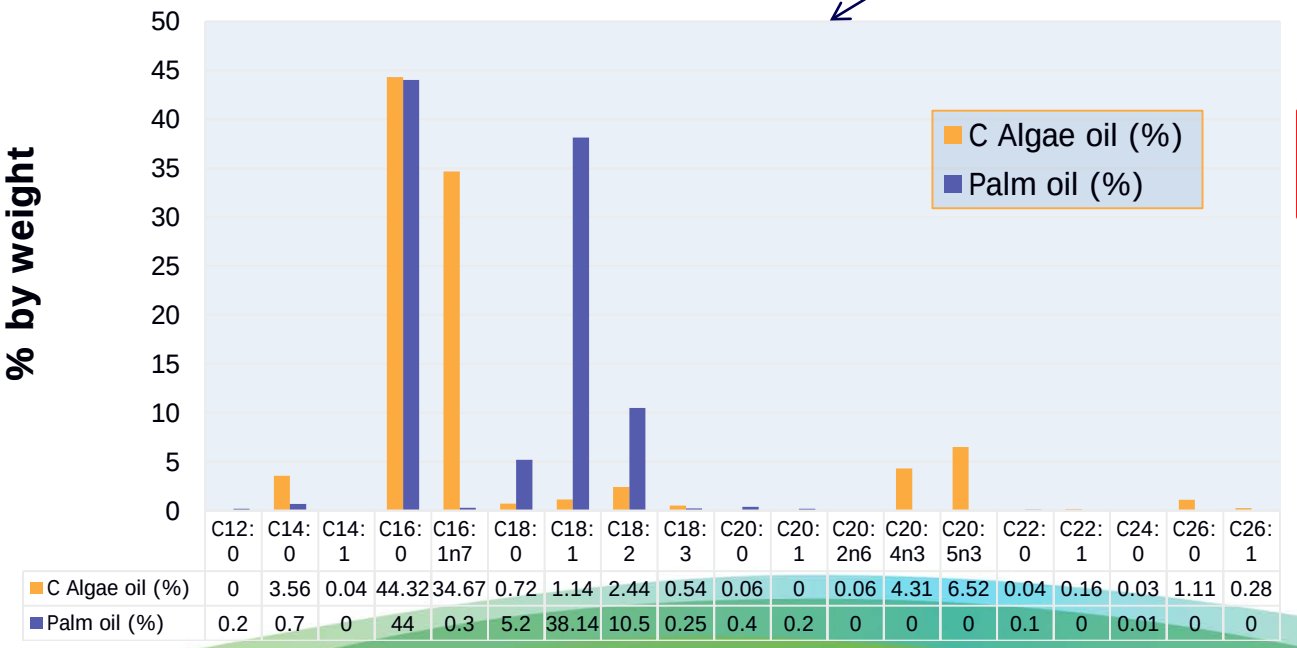


The right kind of Oil



Group	%
Glycerides and Fatty Acids	79
Phospholipids	1
Sterols	2
Carotenes	1.5
Chlorophyll	0.30
Others	16.2

	% By Weight
C12:0	0.00
C14:0	3.56
C14:1	0.04
C16:0	44.32
C16:1n7	34.67
C18:0	0.72
C18:1	1.14
C18:2	2.44
C18:3	0.54
C20:0	0.06
C20:1	0.00
C20:2n6	0.06
C20:4n3	4.31
C20:5n3	6.52
C22:0	0.04
C22:1	0.16
C24:0	0.03
C26:0	1.11
C26:1	0.28



	C12:0	C14:0	C14:1	C16:0	C16:1n7	C18:0	C18:1	C18:2	C18:3	C20:0	C20:1	C20:2n6	C20:4n3	C20:5n3	C22:0	C22:1	C24:0	C26:0	C26:1
C Algae oil (%)	0	3.56	0.04	44.32	34.67	0.72	1.14	2.44	0.54	0.06	0	0.06	4.31	6.52	0.04	0.16	0.03	1.11	0.28
Palm oil (%)	0.2	0.7	0	44	0.3	5.2	38.14	10.5	0.25	0.4	0.2	0	0	0	0.1	0	0.01	0	0

PUFAs

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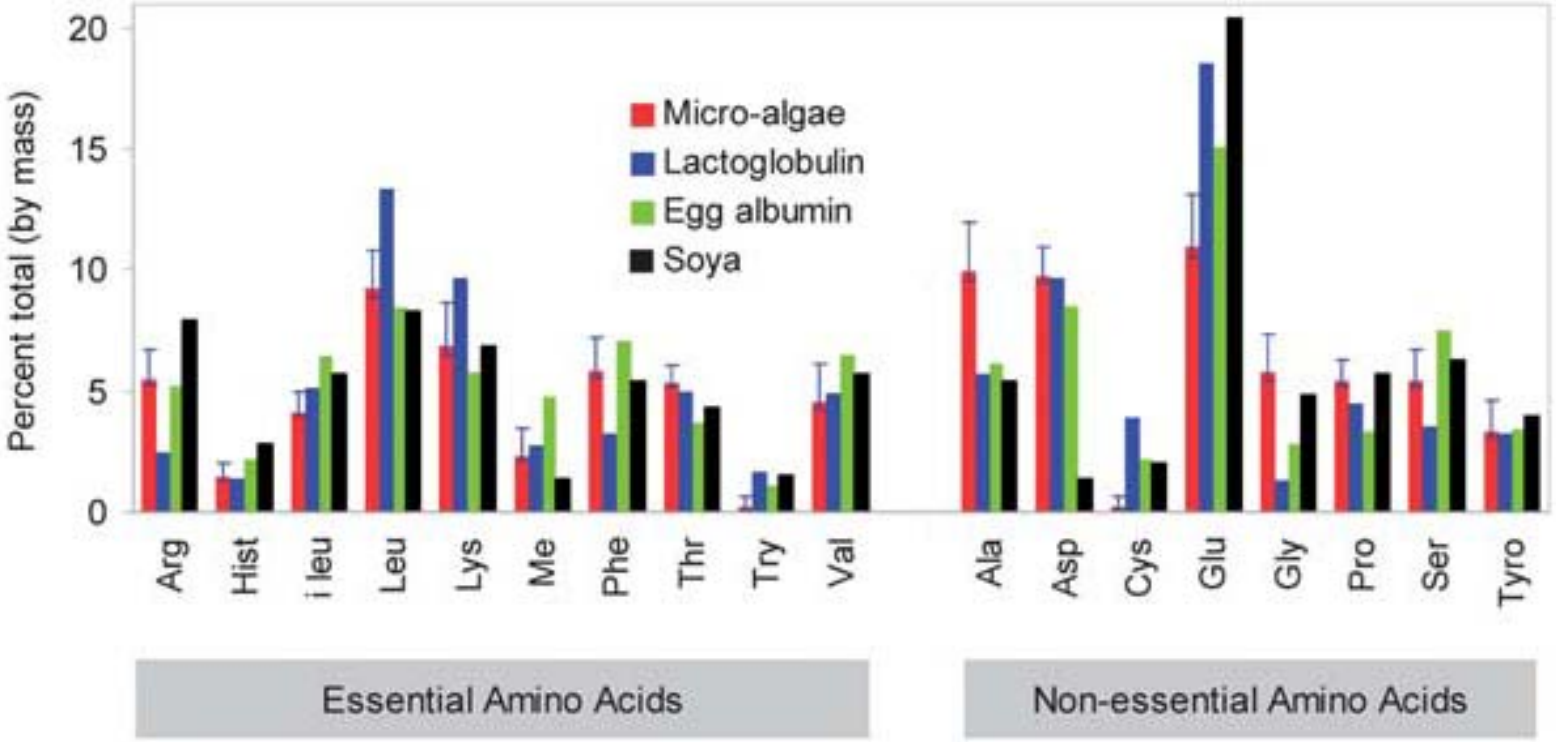
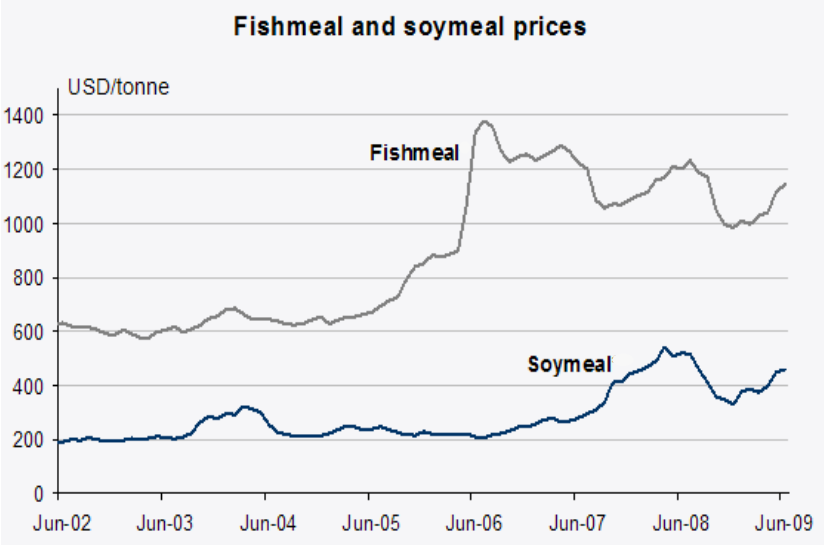
The right kinds of Proteins



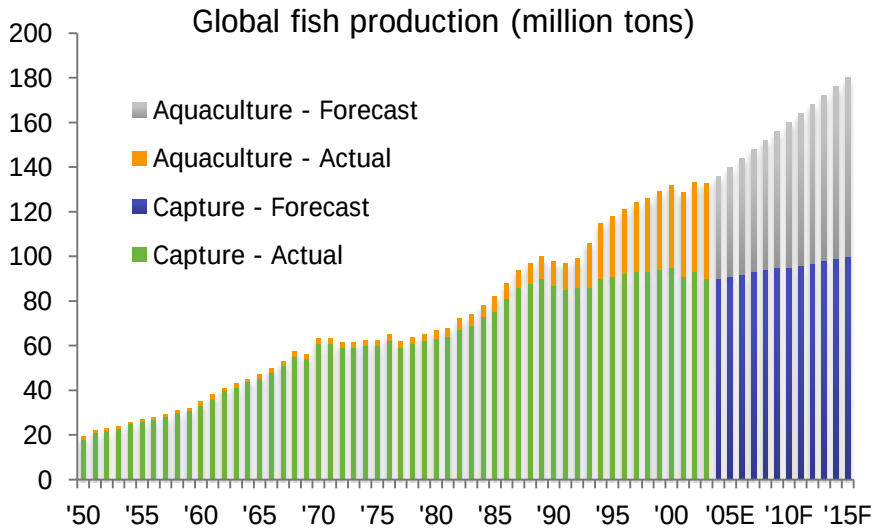
Amino acid distribution is comparable to high-value feed proteins

Opportunity for Algal Protein to Replace Fishmeal in Aquafeeds

Fishmeal supply declining
and prices expected to increase
(current price >$1,500/MT)



Aquaculture growing rapidly
and in need of protein



Market Opportunities: Animal Feed/Aquaculture

Current and Future Need for Feed Supply is Great

Large opportunity for algal-based feeds to replace fishmeal in aquafeeds and supplement livestock feed

- Demand increasing
  - World population growth is driving meat consumption, more meat means more rising animal feed demand
  - Market
    - $9B+ fishmeal: 6-7 million MT/yr @ $1500+/MT
    - $300B+ livestock feed: 1 billion MT/ yr @ $300+/MT
  - Need for non-fish sourced protein
- Feed types
  - High value: Whole biomass
  - Good value: Proteins/Carbohydrates (oil extracted)

*UN Food and Agriculture Organization (FAO)

Cellana's Technology Pathway: Kona Demonstration Facility (KDF)

2.5 ha/ 1.5 ha

ALDUO™ Hybrid Cultivation Technology

Step 1:
Photobioreactors (PBRs):
Continuous, contamination-free biomass production (*nutrient replete*)

Step 2:
Open production ponds:
Efficient, large-scale batch production of lipid-enhanced algae (*nutrient deplete*)

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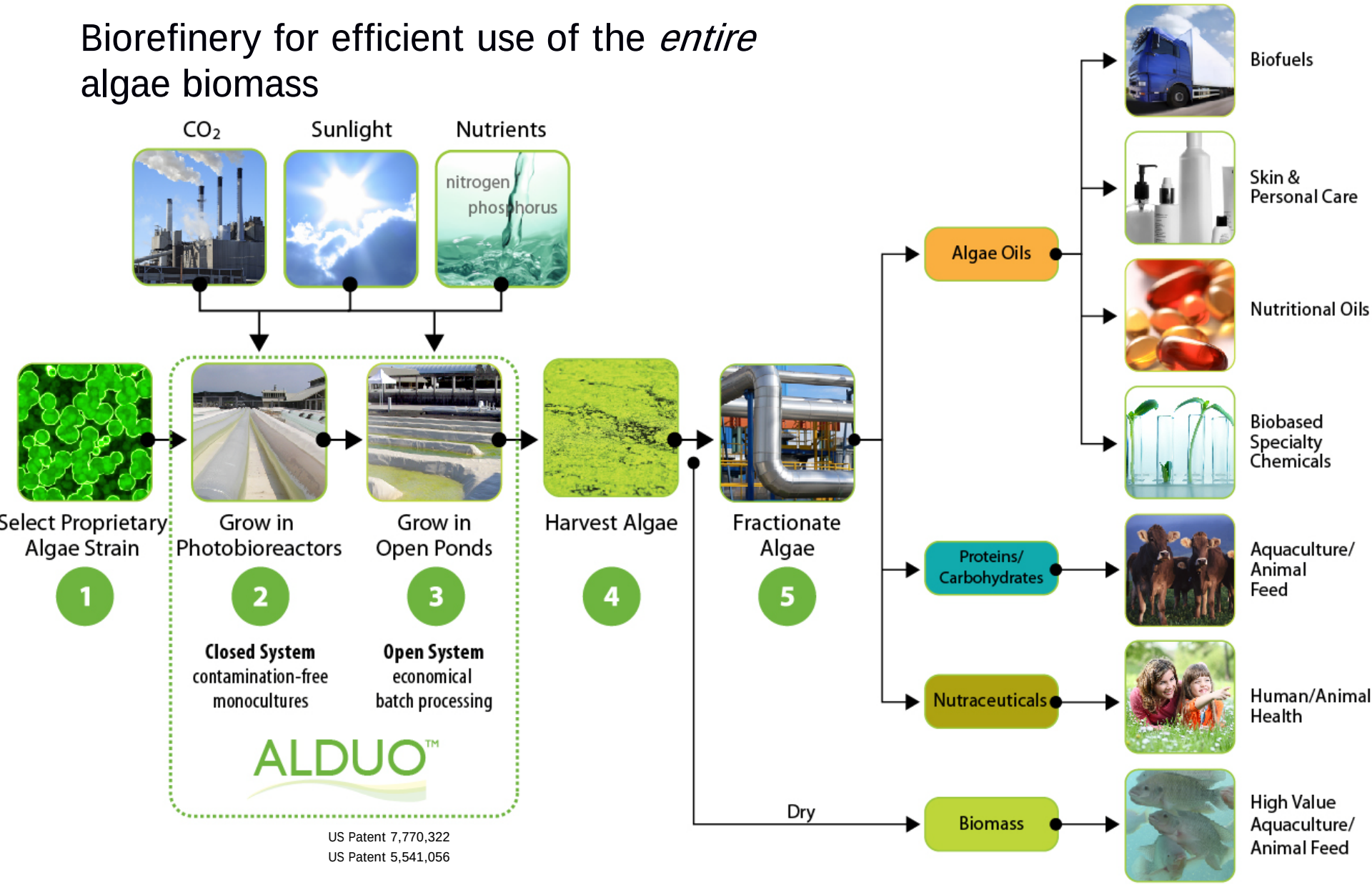
Biorefinery Model

Biorefinery for efficient use of the *entire* algae biomass



US Patent 7,770,322
US Patent 5,541,056

We use only native marine microalgae

1. Identify, isolate and characterize naturally occurring strains of **marine microalgae**. No conflict with freshwater.

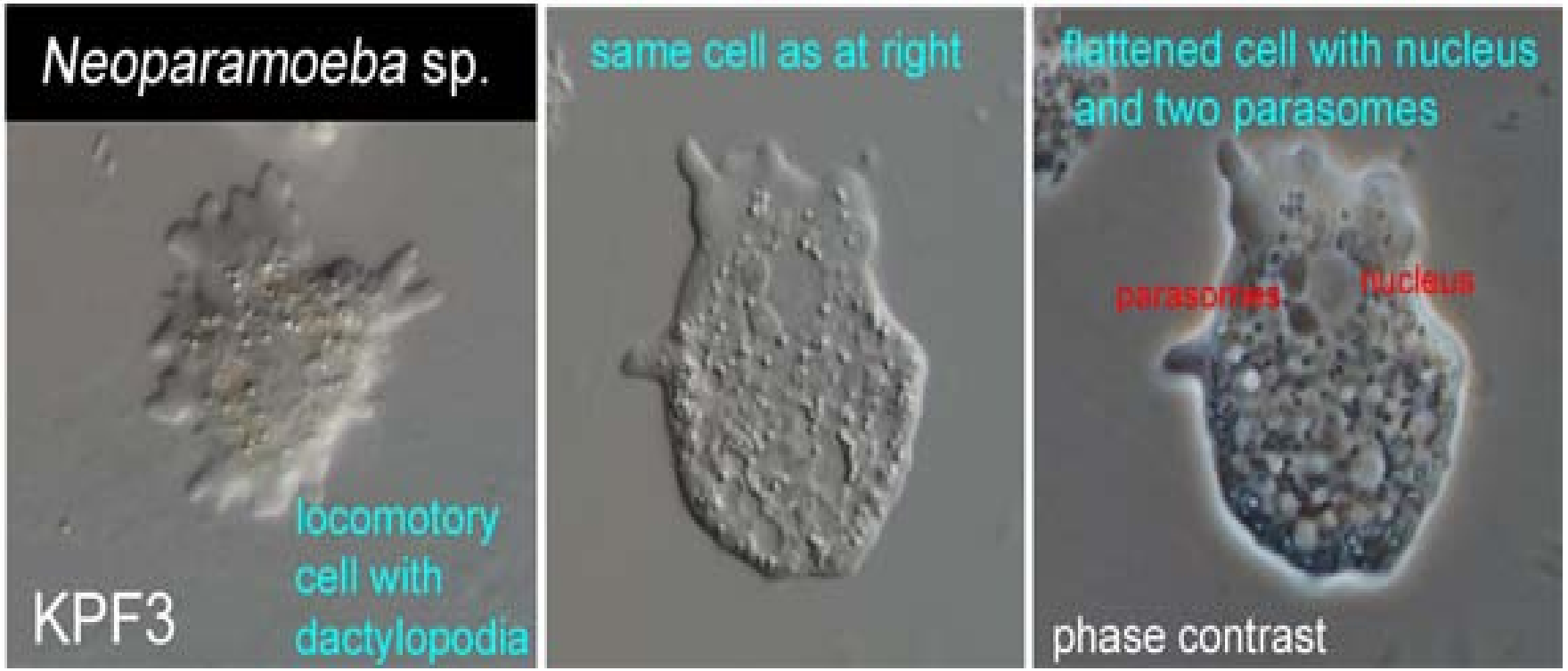
2. At the facility we grow **non-genetically modified** marine microalgae indigenous to Hawaii.

We select the best strains

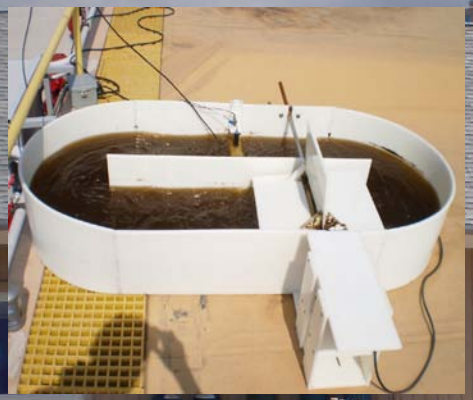
1. Microalgae strains subject to biological & biochemical screening program.

2. Trials conducted at bench-top (20L) to mid-scale (200L), to large outdoor cultivation (750,000 L).

Biological Contaminant Control



We optimize the best strains



1. Mid-Scale System comprises 12 x PBRS & Ponds (x 200 L)

2. Up to 4 x strains tested **simultaneously** under **outdoor** conditions (triplicate randomized design) to prepare strains for large scale **ALDUO ™** System

Patented hybrid ALDUO™ system – photobioreactors (PBRs) and…

1. Microalgae are cultivated in hybrid ALDUO system, using a combination of 25,0000L photobioreactors (PBRs) and 60,000 L raceway ponds

2. PBRs ensure <u>continuous</u> production of biomass with maximum cell division and low contamination risk (**nutrient replete**)

…Open Raceway Ponds

1. Biomass from PBRs used to inoculate to open raceway ponds for generation of intracellular lipids over a 3-4 day pond cycle (**nutrient deplete**)

Harvesting and Dewatering

1. Harvested biomass undergoes **gravitational settlement** (5-8% solids) prior to **centrifugation** (15-20% solids) and **drying** (95% solids)

Microalgae Oil versus Palm Oil Production

Oil yield	Min	Max	Unit	Source
KDF oil yield	5.5	8	$g/m^2/d$	KDF data
	22306	32444	L/hectare/yr	
Palm oil yield	5960	5960	L/hectare/yr	Demirbas and Demirbas, 2011
KDF vs. palm oil	3.7	5.4		

Source: Bemirbas A and Demirbas MF, 2011, Importance of algae oil as a source of biodiesel. Energy conversion and management 52: 163-170

1. Left and background - dried microalgae biomass (defatted)
2. Center - Algal biodiesel and biocrude oil
3. Right – co-product omega-3 oils and carotenoids

US Department of Energy

Large Scale Production of Fuels and Feeds from Marine Microalgae

$15M Grant: Sept. 2010 to February 2013

Objectives

1. **Product Development**:
   Algal lipids (fuel) and defatted biomass (aquaculture feed);

2. **Pilot Production**:
   Bulk biomass production at Kona Demonstration Facility (KDF)

3. **Mid-Scale Screening**:
   Test strains in 200L photobioreactor and mini-pond system;

4. **Laboratory Scale Studies**:
   5L studies to improve strain characteristics (lipid; growth rates)

5. **Analytical Method Development** –
   Tools to measure algal biochemistry; physiology; genetic profiles;

US Dept of Agriculture

Developing a New Generation of Animal feed Protein Supplements: Co-Products from Marine Algae Biofuel Production

$5.5M Grant; May 2011- April 2013

Objectives:

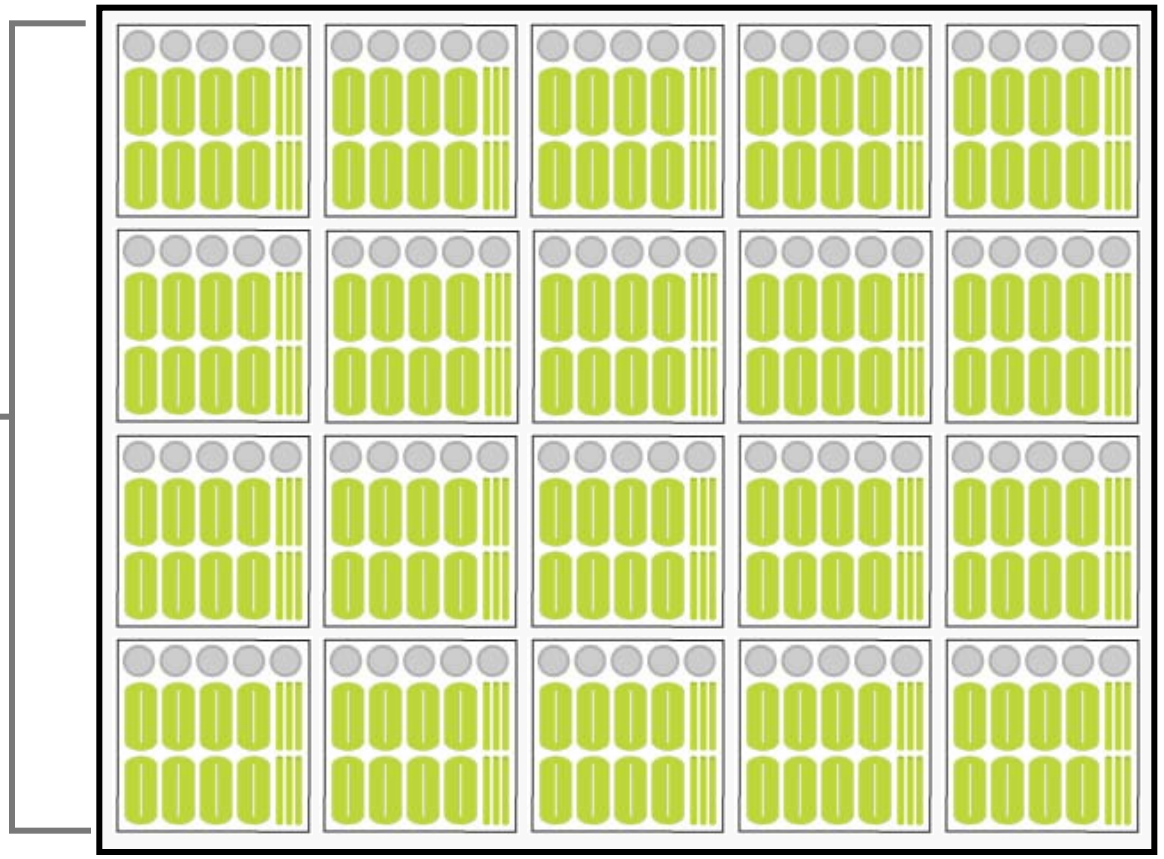
1. **Feedstock Development**: strain development; cultivation; harvesting/dewatering & processing.
2. **Bio-based Product Development**: Feed formulation; feed trials; feed optimization
3. **Biofuels Development Analysis**: Energy, environment (LCA); strategic guidance.



Modular, Scale-Up Enables Facility Expansion

X

1.5 ha Kona Demonstration Facility (KDF) "Module"



Commercial Algae Facility Example
(20 "Modules" = 30 ha)

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Cellana's First Commercial Plant: Maalaea, Maui: 2014-2015

8 modules x 11 ha = 88 ha production
Production: 12,000 – 15,000 MT/year

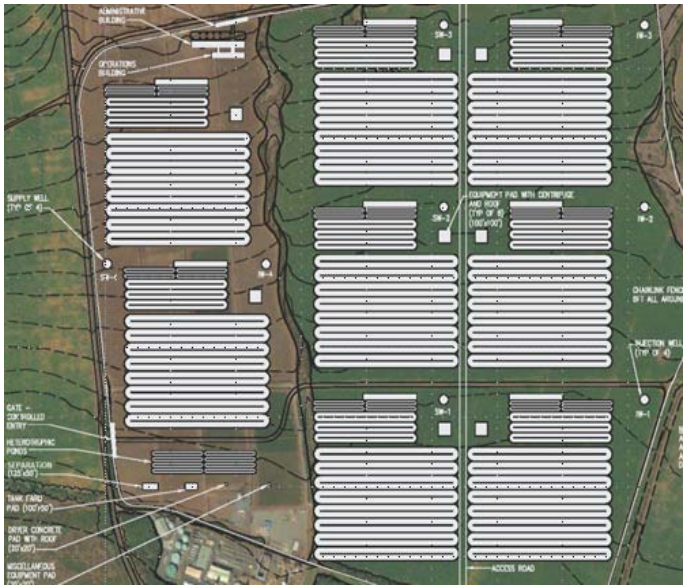
Techno-Economic Assessment

- Technical and economic assessment **(TEA)** for construction and operation of microalgae production facilities

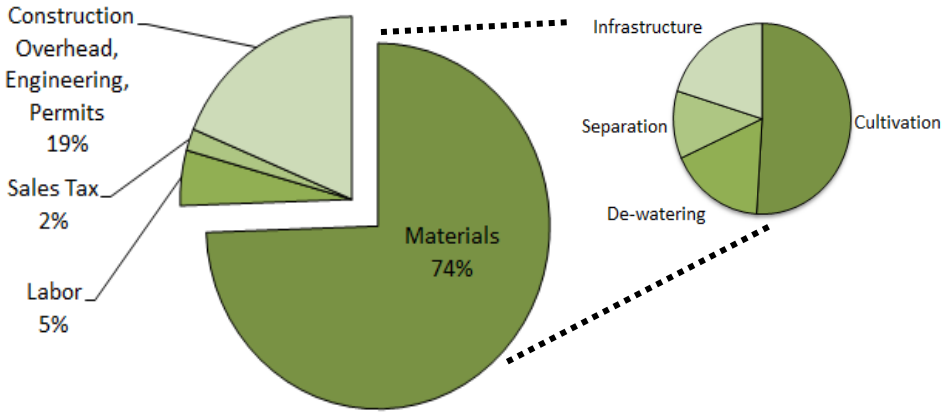
- TEA starts with estimates of production, nutrient usage, and carbon dioxide requirements for specific microalgae strains in a geographic location.

TEA of a site-specific facility

Site-specific information combined with a modular design allow for accurate cost estimates.



Example Biorefinery
$ 58.1 M
88 -ha facility



tem Number	Item Description	Item Detail	Material, Labor, Tax, Overhead	Depr Term	Equipment Cost Total facility	Equipment Cost Total facility
3	Pond construction			20	88-ha	200-ha
		Excavation	Labor		$ 689,040	$ 1,550,340
		Embankment	Labor		$ 415,800	$ 935,550
		Fine Grade	Labor		$ 216,809	$ 487,821
		Liner	Material	20	$ 5,238,149	$ 11,785,835
		Liner Install	Labor		$ 448,984	$ 1,010,215
		Tax	Tax		$ 209,526	$ 471,433
		Subtotal			$ 7,218,308	$ 16,241,194
		Contractor				

(Above-Right) Cost breakdown for an example facility.

(Right) Cost breakdown for an individual sub-category of the model, applying local material, labor, and tax rates to the model.

Profitable Production of Algae Bioproducts

High value products expected to generate attractive economic yield

Projected algae yields with current product pricing will yield ~$4.2K per ton of processed algae

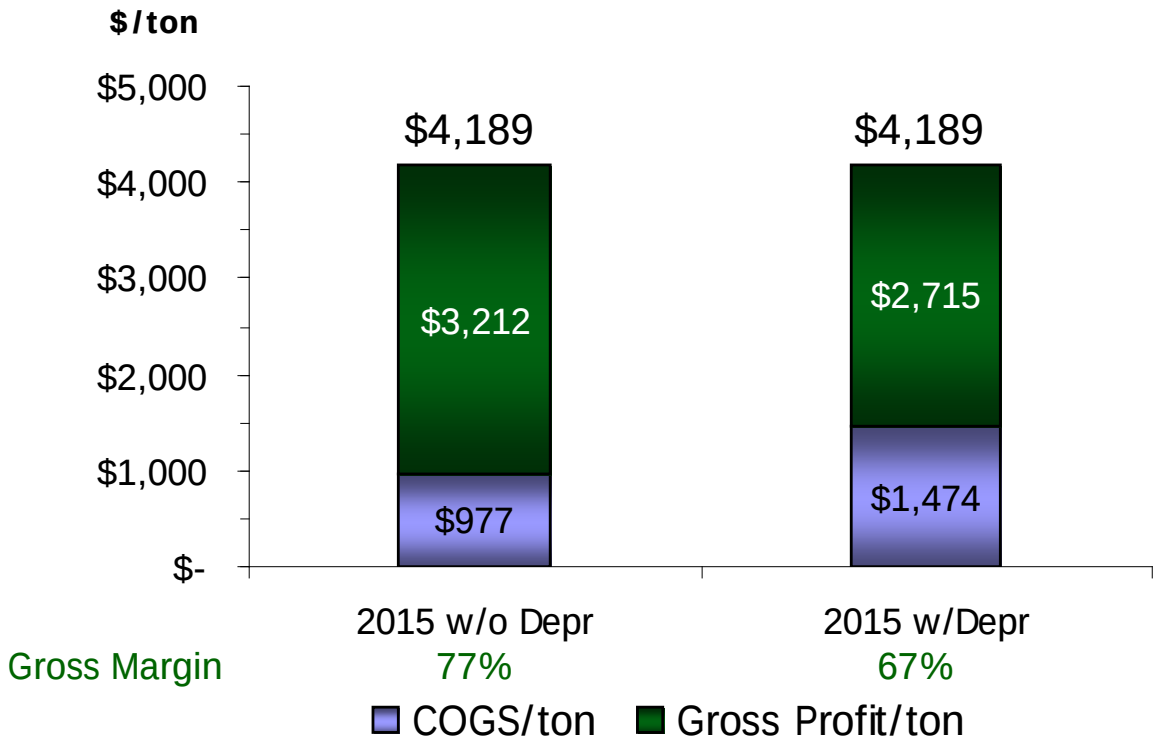
Biomass Fraction	% of Algae Biomass	US$ per kg*	US$ per MT DW*
Omega-3 Fatty Acids (PUFAs)	3.0%	$102.00	$3,373
Protein and Carbohydrate	59.0%	$1.06	$626
Lipid	28.0%	$0.68	$190
Ash + other by-products	10.0%	$0	$0
Total	**100.0%**		**$4,189**

* Based on 2015 forecasted biomass prices and algal yields

Profitable Production of Algae Bioproducts

Estimated Maui Commercial Facility Production Economics

With expected economies of scale, projected production costs of approximately $977/ton will result in significant profitability with gross margins of approximately 67%



Life-Cycle Assessment, Energy and Carbon Balance

Energy and carbon budget is completed for a specific site

PRODUCTION PROCESS ELECTRICAL POWER CONSUMPTION

KWH= 0.110 $

ITEM	EQUIPMENT NAME	QTY	ELECTRICAL LOAD		DAILY OPS HOURS	DAILY KWH	DAILY ENERGY COST $	ANNUAL ENERGY COST $
			H.P.	KW				
15	Injection Well Pump (P-2)	0.5	100	74.60	14	522.20	57.44	20105
16	Water Treatment Unit	1	5.9	4.40	8	35.21	3.87	1356
17	CIP system generators	0.5	104	77.58	8	310.34	34.14	11948
18	CO2 Delivery Blower	1	5	12.70	12	152.40	16.76	5867
	Cultivation Subtotal							97479
	De-watering Subtotal							26308
	Total for one Module			**373**		**3,215**	**354**	**123787**

(Above) Power consumption for part of the technology line-up.
Electrical rates can be applied for various locations

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Mahalo

For further information please visit
www.cellana.com

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