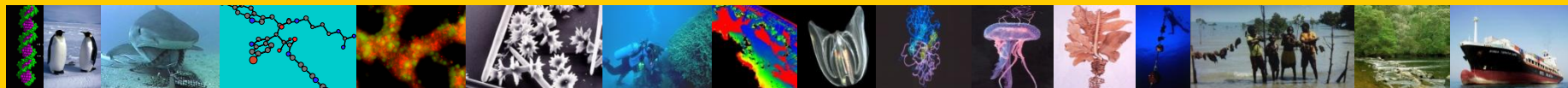




THE UNIVERSITY OF
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Te Whare Wānanga o Waikato

Aquaculture: The Wider Picture and Potential for the Bay of Plenty

Chris Battershill
March 2012

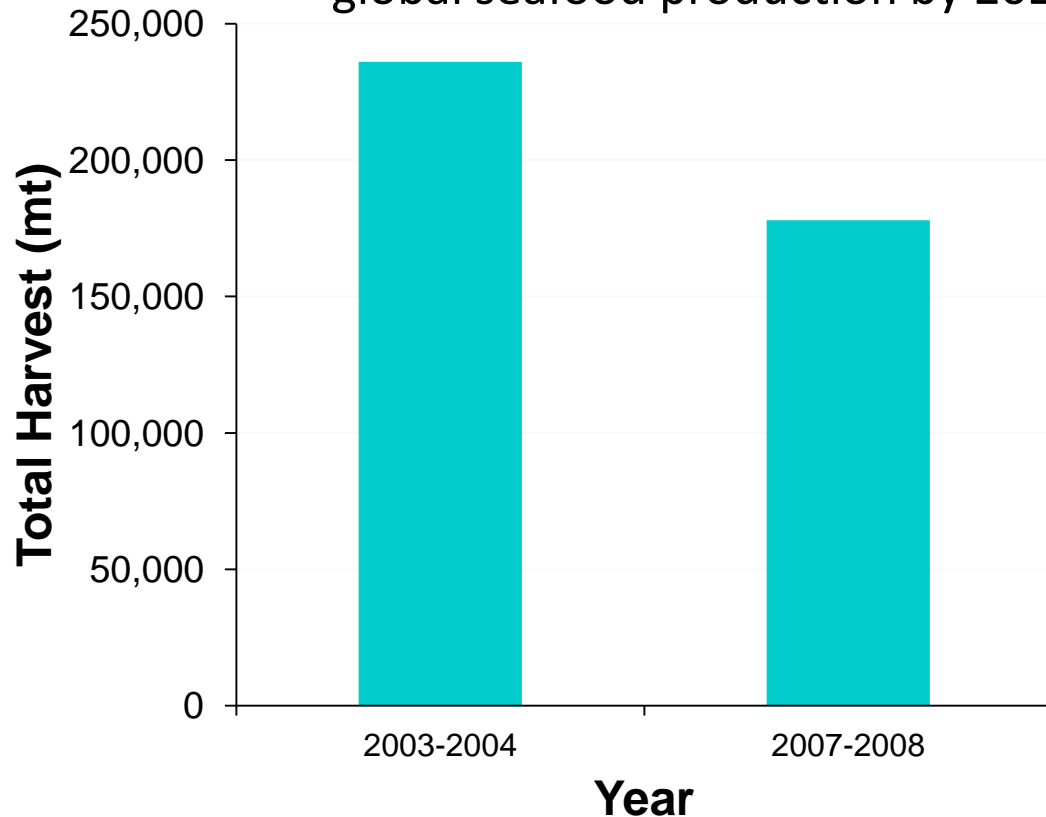


Sustainable Food Aquaculture

Developing Marine Crisis:

35% decrease in seafood harvest in 5 years.

- The Food & Agriculture Organisation (FAO) predicts that global consumer demand for seafood will almost double from 45 to 85 million tonnes by 2015.
- It is estimated that aquaculture will increase from 42% to 58% of global seafood production by 2020.

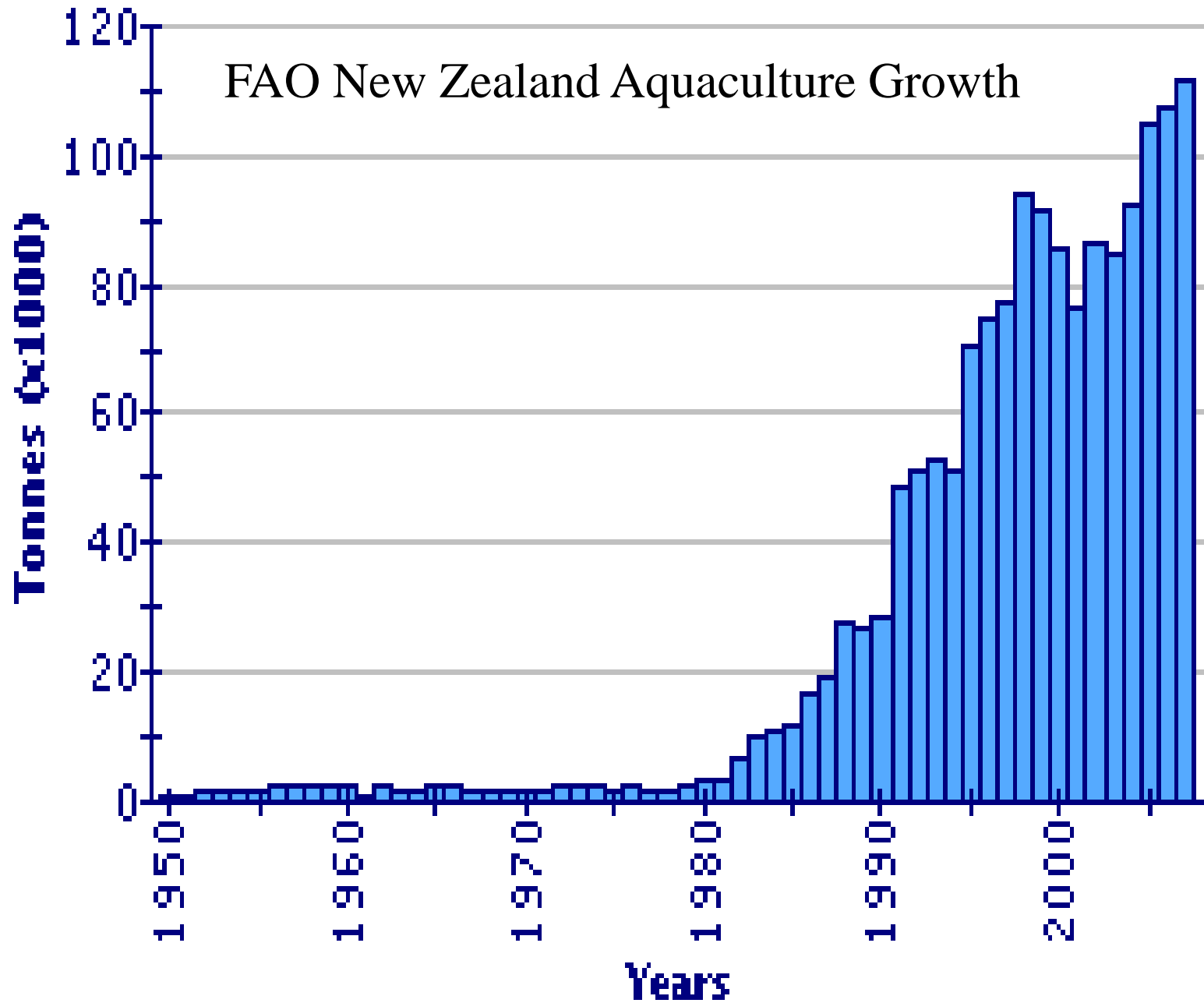


(ABARE 2010)

Fishery Yields Declining

MPA's do not address supply issue

FAO New Zealand Aquaculture Growth



New Targets for Marine Protein Production

New
Targets
For
Aquaculture



32,000 species of fish globally, <10 domesticated



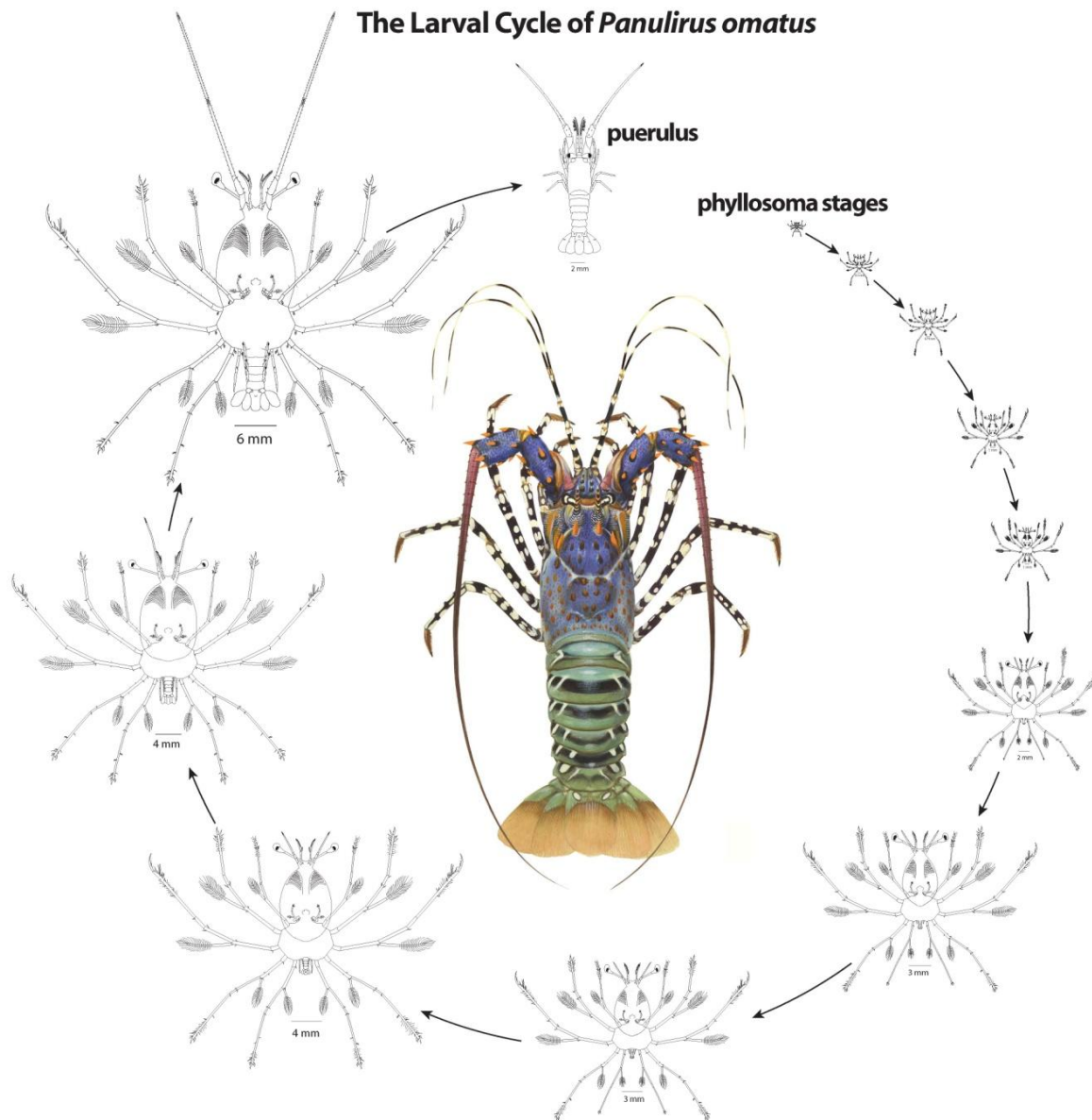
New Aquaculture Species Tropical



4-6 months



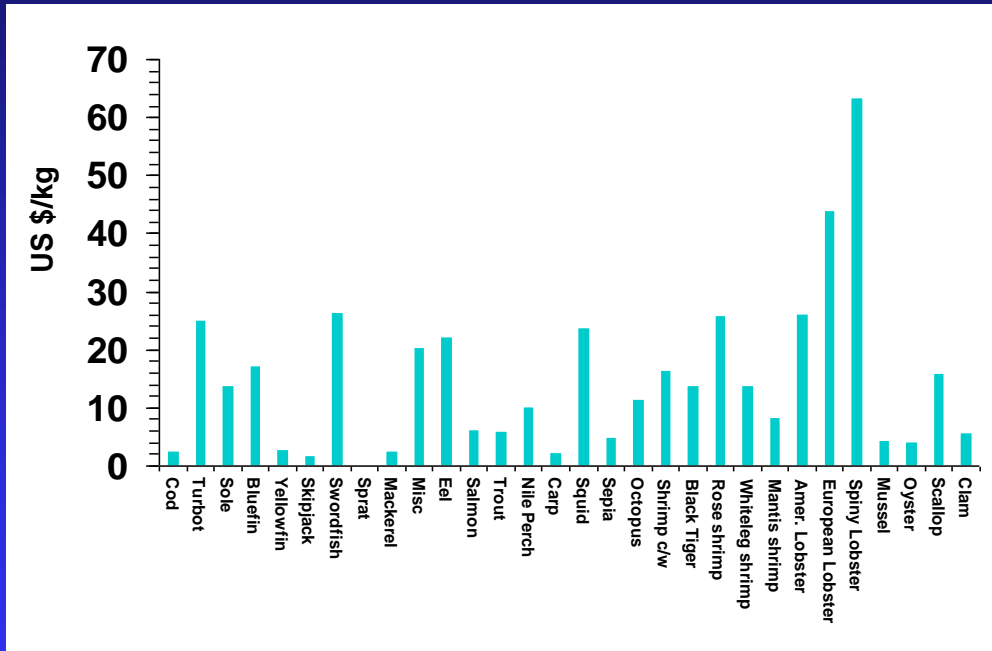
AUSTRALIAN INSTITUTE
OF MARINE SCIENCE



years

Possible new targets:

High value, 'domesticatable', fast economic growout



Sustainable Fuel Aquaculture

Future: Marine Biofuels



- Theory: 280 tonnes dry biomass/ha/yr
- Lipid content of 40%, therefore 115,000 L/ha/yr.
- Now only 20,000L/ha/yr of oil
- Compare Palm oil 6000L/ha/yr

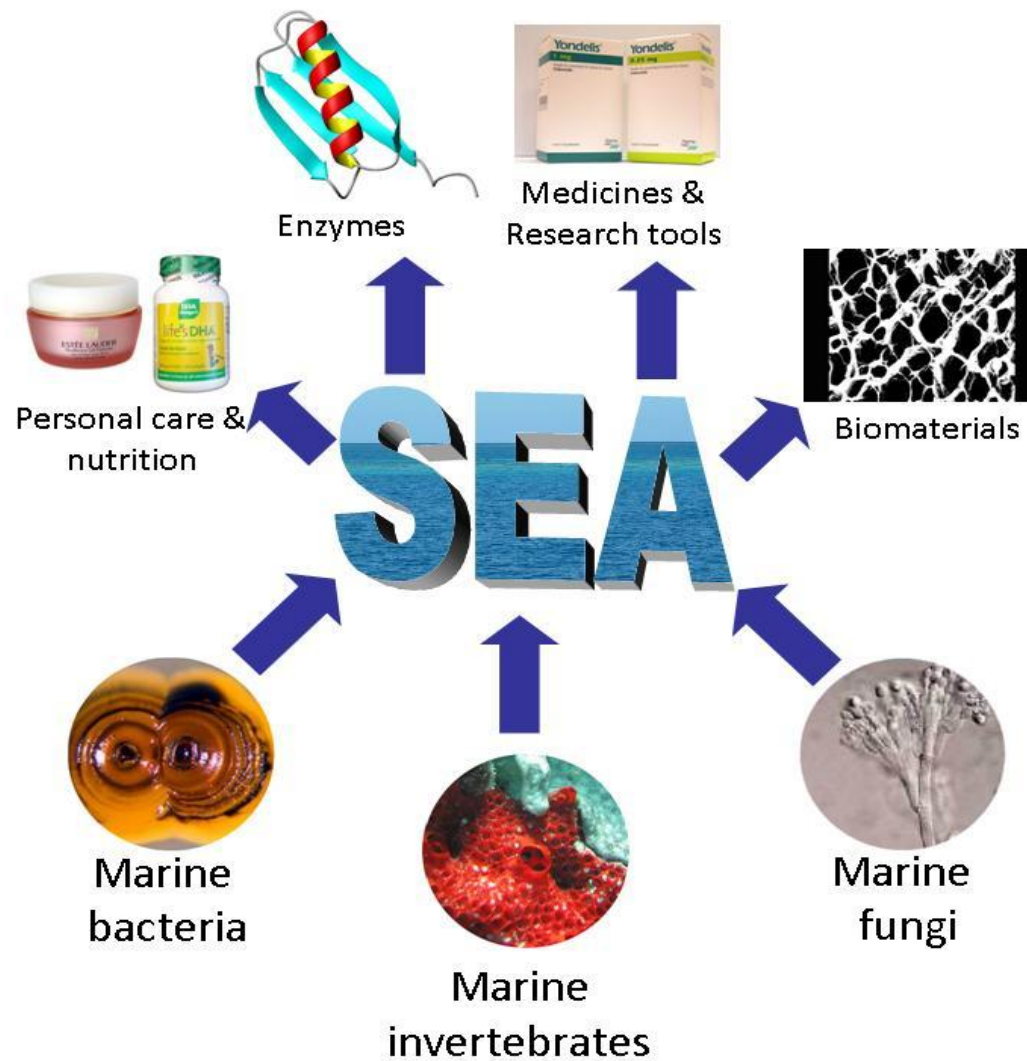
Wijffels RH 2008



- ◆ Macro Algae have the highest potential as a feedstock for biodiesel with up to 24X more oil per acre than palm
- ◆ Use of algae for high value products (eg ω 3 PUFAs, carotenoids for aquaculture and human health)

MACRO ALGAE!!

Marine Bioproducts of the Future

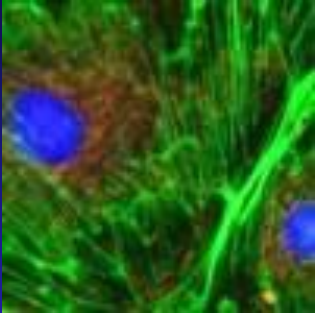


The natural non-drugs

- Functional foods eg fatty acids, carotenoids (\$US5b+/yr)
- Food additives eg algal polysaccharides (\$US6b+/yr)
- Cosmetic ingredients eg anti-inflammatory, sunscreens (\$US7b+/yr)
- Research tools and lab reagents
- REGULATORY HURDLES ARE LOWER (cf drugs)



Research Tools/Lab reagents



Aequorin – a bioluminescent dye from jelly fish
Aequora victoria.

SigmaAldrich: 1mg \$220



Calyculin A – a polyketide from sponge
Discodermia.

Used as molecular probe (selective
inhibitor of protein phosphatase 1)

SigmaAldrich: 10ug \$259

Agriculture Applications of Marine Products

International By-Products Conference 187
April 1990, Anchorage, Alaska

Sponge metabolites insecticidal against Lepidopteran pests:

- upto 95% growth inhibition of fifth instar larvae

Another reason for writing this paper is to increase our awareness of ecology. Ecology is the study of organisms in relation to their environment. More generally, it's a study of relationships in nature. As Americans, we have been slow to recognize some basic relationships about living on the earth. A good example of our ignorance is the increase of CO₂ we have allowed in our atmosphere. The increase in CO₂ may accelerate global warming, possibly causing droughts and crop failure.

Forestry and agriculture producers are in trouble with environmentalists because resource harvesters are reducing the carrying capacity of the land, while population requirements for food and fiber keep going up. In California soil erosion rapidly fills our bays, estuaries, and rivers with sediment, some of which was once soil sustaining the redwood forests of the north coast and a rich agricultural valley. Among other causes, soil erosion may have killed a run of chinook salmon once native to the San Joaquin River system.

Authors' addresses: B. Wyatt, University of California Cooperative Extension, 2604 Ventura Ave., Rm. 100P, Santa Rosa, CA 95403-2894; G. McGourty, County Court House, Agricultural Center, Ukiah, CA 95482.

to be an effective biopesticides against lepidopteran pests and larvae of *C. quinquefasciatus*.

Key words: Marine sponge, *Culex quinquefasciatus*

INTRODUCTION

Increasing use of synthetics leads to serious problems: environmental pollution long term persistence, high insect resistance to insecticides. In recent years there has been increasing information on the use of alternative methods (Blunt *et al.*, 2005). The marine environment is an exceptional reservoir of bioactive natural products which produce several novel structures with unique biological properties that may not be found in terrestrial products (Thakur and Muller, 2004; Venkateswararao, 2008). The present investigations were aimed at identifying newer drugs and other pharmaceuticals from marine sponges whereas comparatively little attention has been paid to the discovery of pesticide molecules (Li *et al.*, 2006; Kim *et al.*, 2006). Again Venkateswararao *et al.* (2008) suggested that the secondary metabolites isolated from the marine sponges may be an alternative source for control agents to replace the existing and highly synthetic insecticides and will play an important role in future insecticide development programme. Prev. Bradford *et al.* (1992) described the marine potential products to serve as insect control agents via mechanism of toxicity, interference with moulting of metamorphosis and feeding deterrence. Again Donia and Hamann *et al.* (2005); Haefner (2005); Venkateswararao (2008) demonstrated that the sponge consists of sesquiterpenes and diterpenes - secondary metabolites

© JBiopest. 192

Marine Natural Products with herbicidal and fungicidal activities:

- Novel chemistry
- Biodegradable
- No resistance to marine compounds

2246 J. Agric. Food Chem. 2003, 51, 2246-2252

JOURNAL OF
AGRICULTURAL AND
FOOD CHEMISTRY

Marine Natural Products as Prototype Agrochemical Agents

JIANGNAN PENG, XIAOYU SHEN,[†] KHALID A. EL SAYED,[‡] D. CHARLES DUNBAR,
TONY L. PERRY,[§] SCOTT P. WILKINS,[¶] AND MARK T. HAMANN*

Department of Pharmacognosy and National Center for the Development of Natural Products,
School of Pharmacy, The University of Mississippi, University, Mississippi 38677

STEVE BOBZIN,[‡] JOSEPH HUESING, AND ROBIN CAMP

Monsanto Company, 700 Chesterfield North Parkway, St. Louis, Missouri 63198

* Author to whom correspondence should be addressed [fax (662) 915-7076; e-mail mhamann@olemiss.edu].

[†] Present address: Novascene Biosciences Corp., 7170 Stadium Dr., Hanover, MD.

[‡] Present address: Department of Pharmacy, North East Louisiana State University at Monroe, LA.

[§] Present address: University of the Virgin Islands.

[¶] Present address: Astra-Zeneca Pharmaceuticals, Boston, MA.

[‡] Present address: Galileo Laboratories, 5301 Patrick Henry Dr., Santa Clara, CA.

of food, soil, and water. The ocean is the source of many natural products, and agrochemical agents being used as insecticides in some parts of the world (10).

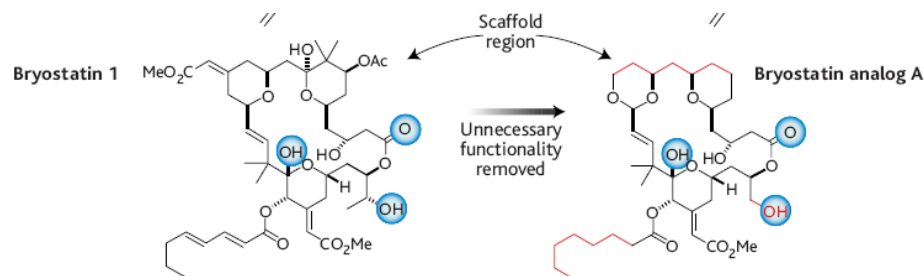
Marine Natural Products as Insecticides, Herbicides, and Fungicides: An Update. In our previous paper (11), the insecticidal compounds of marine origin and their activities were reviewed. In addition to developments summarized in our earlier paper, a new sesquiterpene, hydroxycoloroneone (6), was isolated from the soft coral *Nephthea chabrolti*, which showed strong



Marine Biotechnology: Agricultural and Industrial Applications

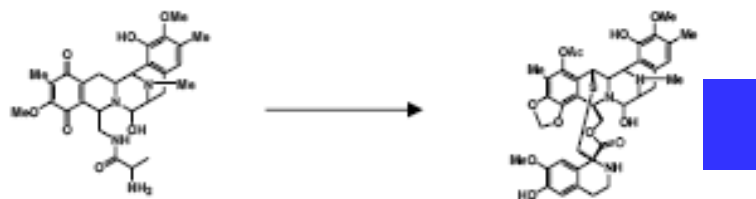


Aquaculture of drug leads



Taken from Paterson and Anderson, Science 21 October 2005

Bryostatin Analogue A Total Synthesis



Safracin B, produced by
Pseudomonas fluorescens

ET-743 (Yondelis)

Phar ma Mar
Soft Tissue Carcinoma active
Licensed Europe, September 2007

Yondelis (ET-743)
Hemi-Synthesis

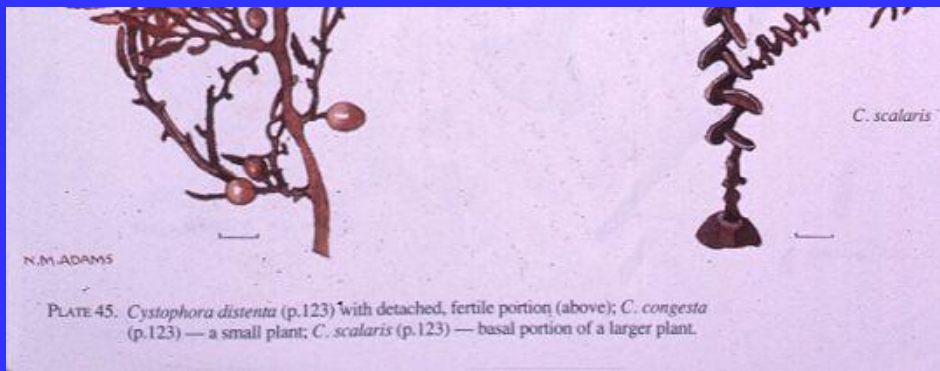


Total world seaweed production 8.5 million tonnes

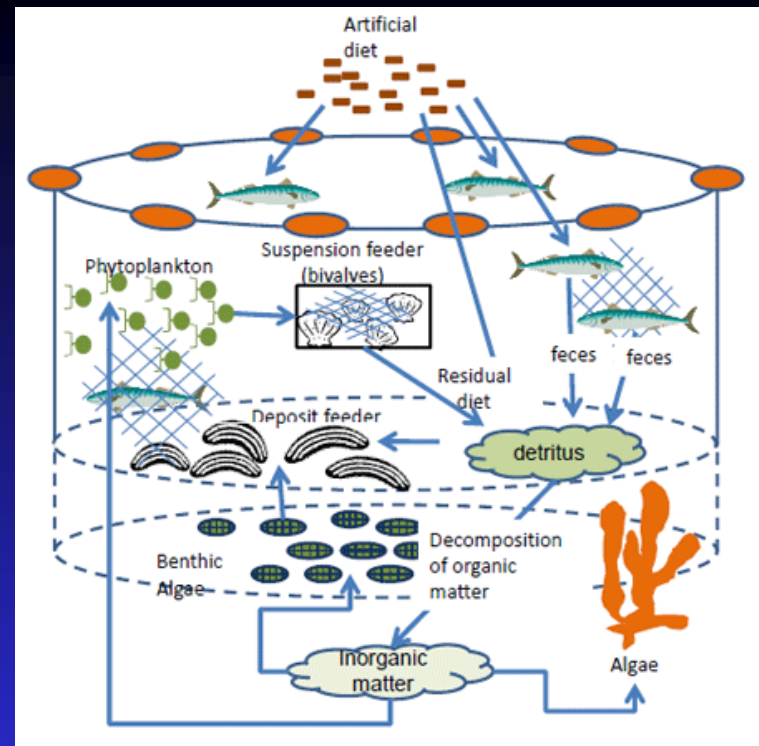
Sea Weed Industry uses 7.5-8 mill mt of wet sea weed /yr (\$US5-6b FAO 2004).

3 Important Phycocolloides:

- **Alginates \$US213m/yr, only *Laminaria japonica* grown in China.**
- **Carrageenan production depends on wild *Chondrus crispus*.**
- **Agar-Agar from *Gelidium* \$US132m/yr.**



Integrated Multi-Trophic Aquaculture (IMTA)



» INTEGRATED MULTI-TROPHIC AQUACULTURE (IMTA)

WiseSource salmon uses an IMTA system in which the byproducts (wastes) of one crop (finfish, such as salmon) are converted into fertilizer, food and energy for other crops (seaweed and shellfish), which can be sold on the market.

SUSPENSION EXTRACTIVE AQUACULTURE – ORGANIC (MUSSELS)

Rafts of mussels are strategically anchored where they can absorb, small, polluting particulate matter, such as fish feces and uneaten fish feed, carried by the tides.

FED AQUACULTURE (SALMON)

Salmon farming operations are notorious for using large quantities of wild fish to produce feed. Today, grains and waste from fish processing plants have drastically reduced the amount of wild fish needed to feed farmed salmon. Farming other fish, such as carp or tilapia, requires far fewer inputs, and is therefore considered more sustainable than salmon.

SUSPENSION EXTRACTIVE AQUACULTURE – INORGANIC (SEAWEEDS)

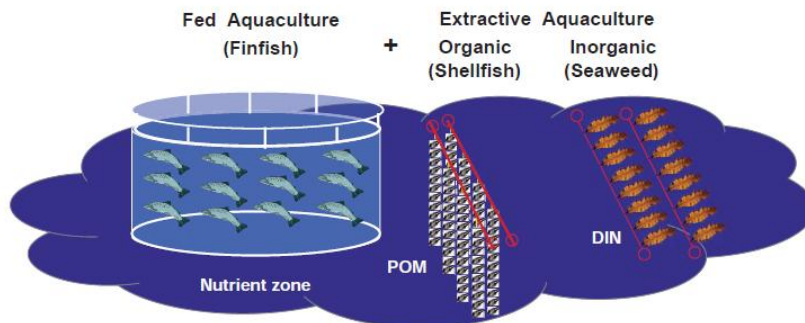
Long lines of seaweed extract inorganic nutrients, such as nitrogen and phosphorus, from the water and fish waste products. The seaweed can be harvested for food and cosmetic products. Researchers are exploring whether the protein from seaweed can be used for fish feed, closing the loop in the farm ecosystem.

FIGURE 1
Salmon (left), mussels (right foreground) and seaweeds (right background) integrated multi-trophic aquaculture (IMTA) in the Bay of Fundy, Canada



FIGURE 2
Conceptual diagram of an integrated multi-trophic aquaculture (IMTA) operation combining fed aquaculture (finfish) with organic extractive aquaculture (shellfish), taking advantage of the enrichment in particulate organic matter (POM), and inorganic extractive aquaculture (seaweeds), taking advantage of the enrichment in dissolved inorganic nutrients (DIN)

Integrated Multi-Trophic Aquaculture (IMTA)



Source: Chopin (2006).

Bay of Fundy IMTA





Benefits:

- Enhanced growth of all species
- Lower Environmental Impact
- Better use of 'sunk' costs
- Diversity of Industry Targets
- Diversity of Value add potential

Risks:

- Introduction of fouling species
- Parasite/pathogen cross contamination



Integrated aquaculture

Selecting the

Species selection criteria for tank cultivation



Seabream (*Sparus aurata*)



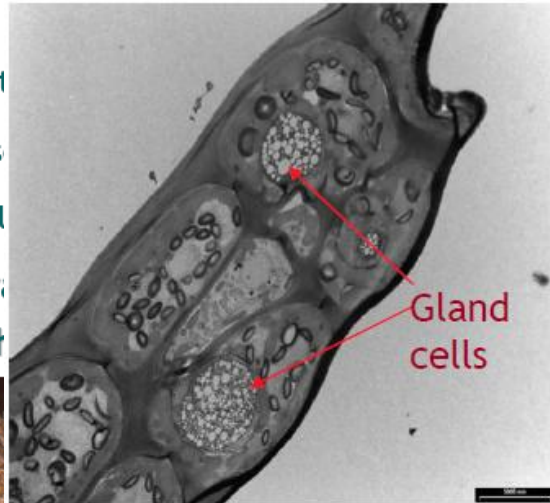
Seabass (*Dicentrarchus labrax*)

- High rate
- Low sus
- Morphol
- High v
- establish

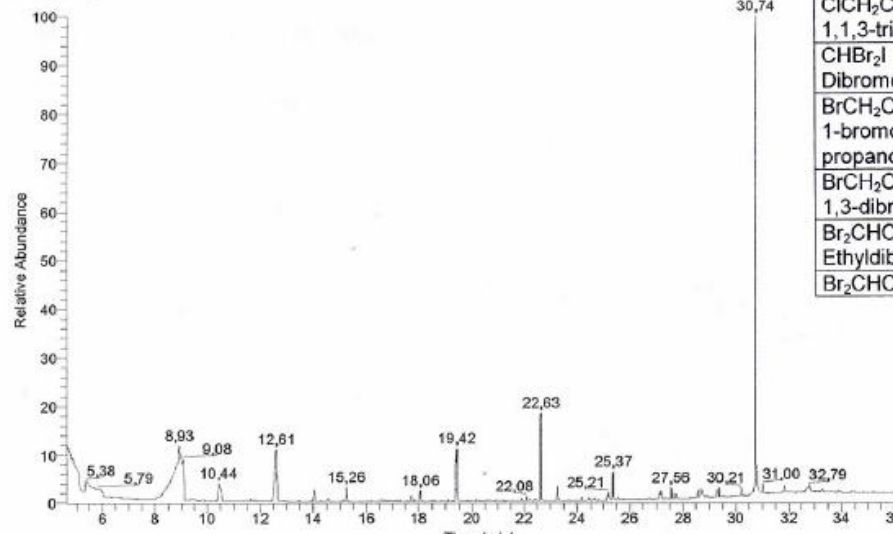
Water

Leon

Asparagopsis



Extracto CH_2Cl_2 FALK 1 (21/01/2005)
RT: 4,60 - 36,00

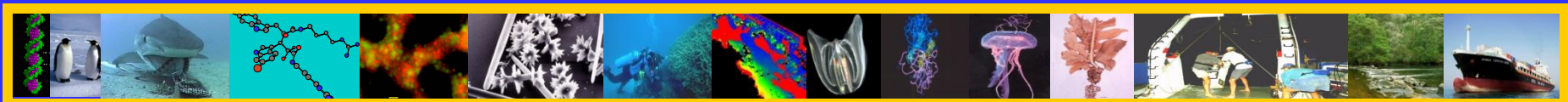


Halogenated compounds

Composés	Temps de Rétention en mn	Indice de similitude
CH_2BrCl Bromochlorométhane	3 : 13	680
BrCH_2CHO 2-bromoéthanal	4 : 62	-
CH_2ICl Chloriodométhane	6 : 56	-
$\text{BrCH}_2\text{COCH}_3$ 1-bromo-propanone	10 : 26	802
Br_2CHCHO 2,2-dibromoéthanal	12 : 42	-
Br_3CH Bromoforme	15 : 15	677
$\text{Br}_2\text{CHCOCH}_3$ 1,1-dibromo-propanone	15 : 66	-
$\text{ClCH}_2\text{COCHCl}_2$ 1,1,3-trichloro-2-propanone	17 : 19	558
CHBr_2I Dibromoiodométhane	18 : 79	-
$\text{BrCH}_2\text{COCHCl}_2$ 1-bromo-3,3-dichloro-2-propanone	18 : 90	-
$\text{BrCH}_2\text{COCH}_2\text{Br}$ 1,3-dibromo-2-propanone	19 : 02	559
$\text{Br}_2\text{CHCOOC}_2\text{H}_5$ Ethyl dibromoacétate	19 : 18	407
$\text{Br}_2\text{CHCH}(\text{OH})\text{CHBr}_2$	26 : 53	-

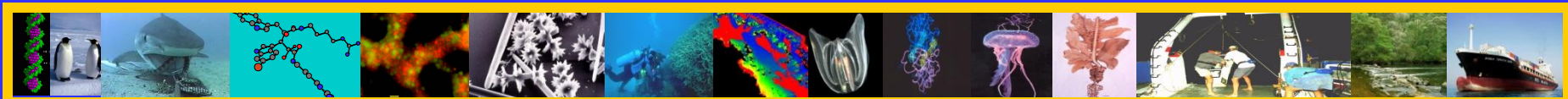
- More than 100 halogenated compounds were identified for *Asparagopsis*

Thank you

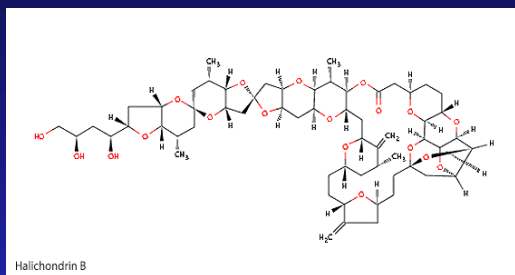


Acknowledgments

- Bay of Plenty Regional Council
- Priority One
- Tauranga Port Authority
- Bay of Plenty Polytechnic
- Awanuiarangi



Relative Economics



	Harvest	In Sea	exSitu	Synth
Avarol	\$.30/mg	\$.45/mg	\$.60/mg	\$.50/mg*
Hali B#	No	\$100/mg	\$300/mg	\$1,000+/mg
Hali B spiked (100x)		\$1/mg		

(Sipkema et al 2005, Battershill and Page 1996, Munro et al 1998)

- Estimated
- # 80 farms natural yield, 8 farms enhanced yield (10 longlines/farm inside existing!)