Seaweed Use to Mitigate Aquaculture Induced Eutrophication Processes in Chile

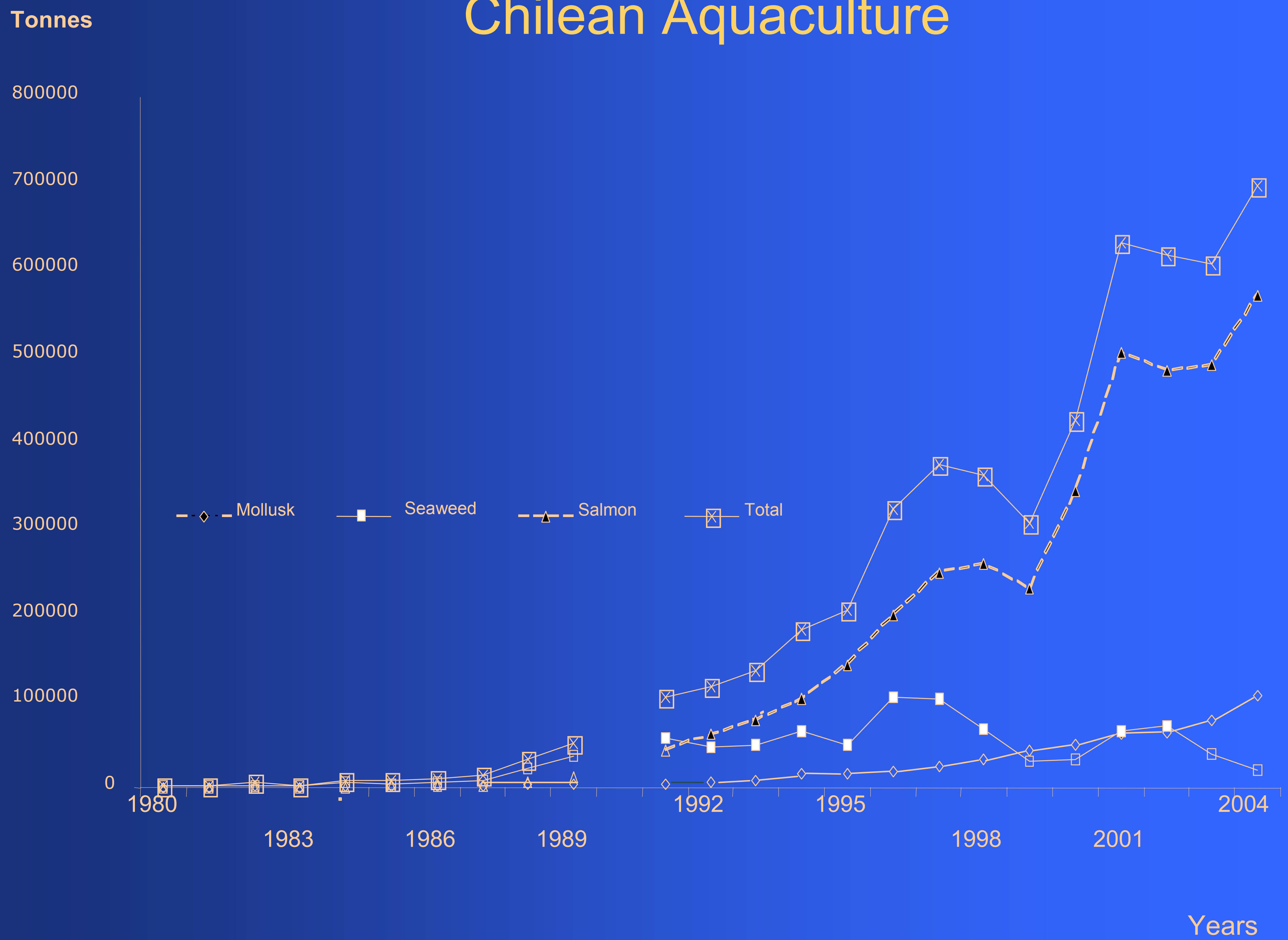
Alejandro H. Buschmann

International Workshop on Bioextractive Technologies for Nutrient Remediation
Stamford CT, December 3 2009

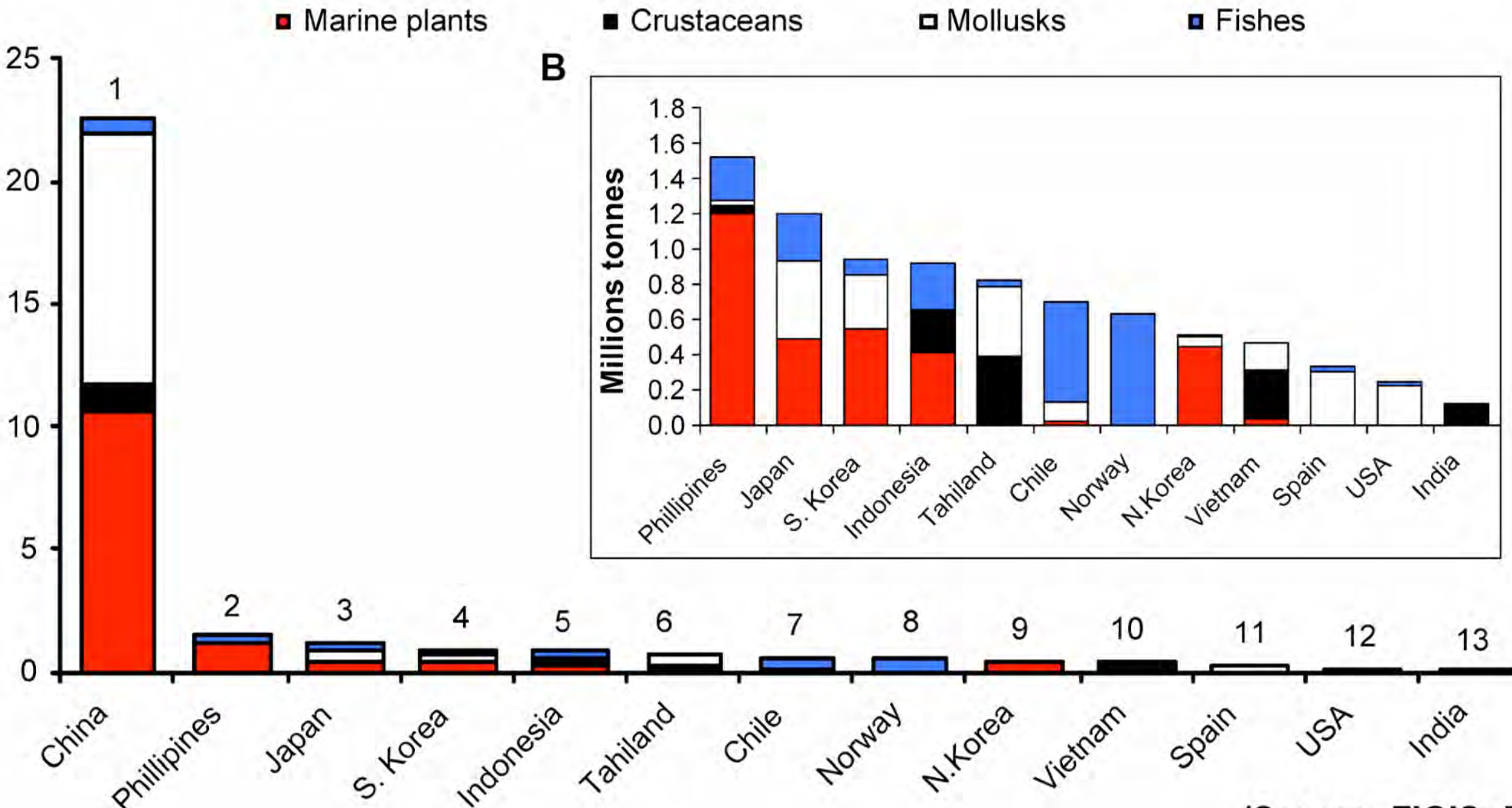
Exponential Growth of Aquaculture in Chile




Chilean Aquaculture



World Marine Aquaculture Production



(Source: FIGIS; F
2004)

Goals

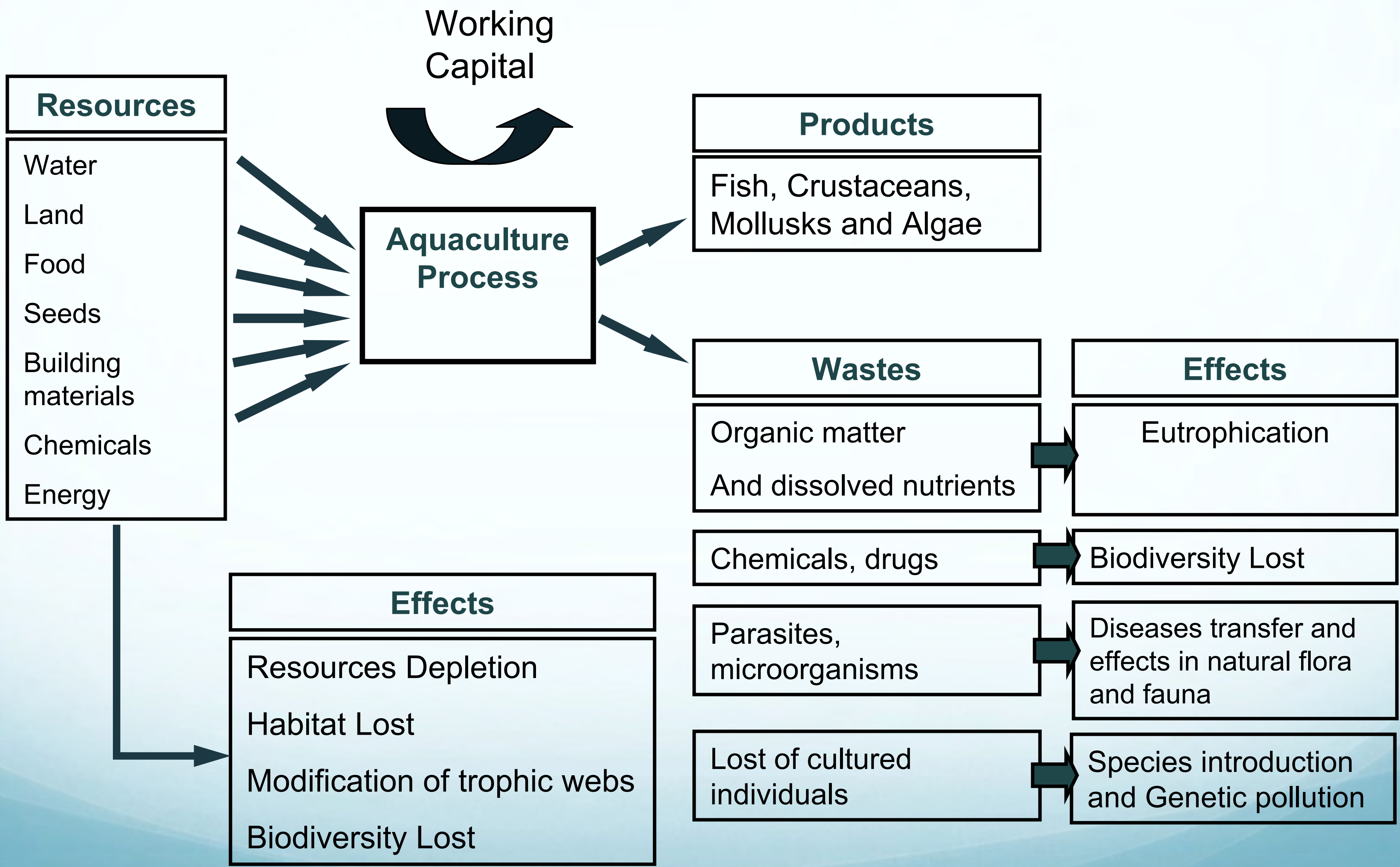
1. Determining Aquaculture Environmental Impacts: Eutrophication of Coastal Ecosystems

2. Ecological Engineering: IMTA

3. Discussion of Limitations and Challenges



Productive Process and Environment

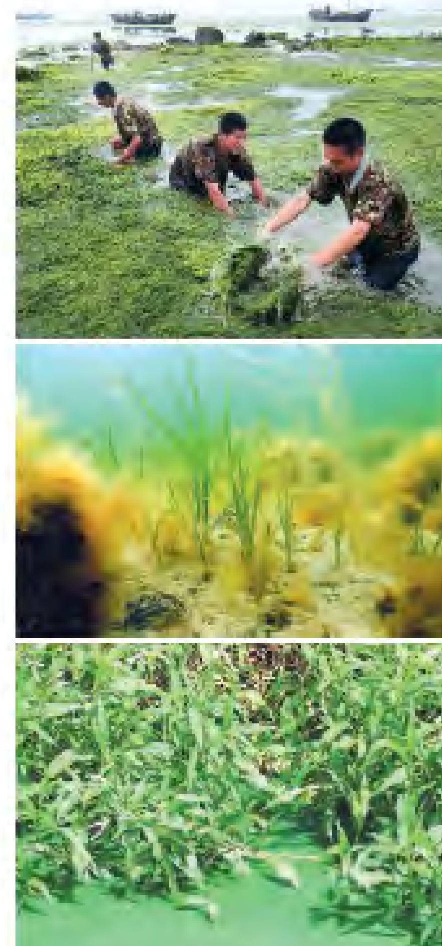


ECOLOGY 20 FEBRUARY 2009 VOL 323 SCIENCE www.sciencemag.org

Controlling Eutrophication: Nitrogen and Phosphorus

Daniel J. Conley,[1*] Hans W. Paerl,[2] Robert W. Howarth,[3] Donald F. Boesch,[4] Sybil P. Seitzinger,[5] Karl E. Havens,[6] Christiane Lancelot,[7] Gene E. Likens[8]

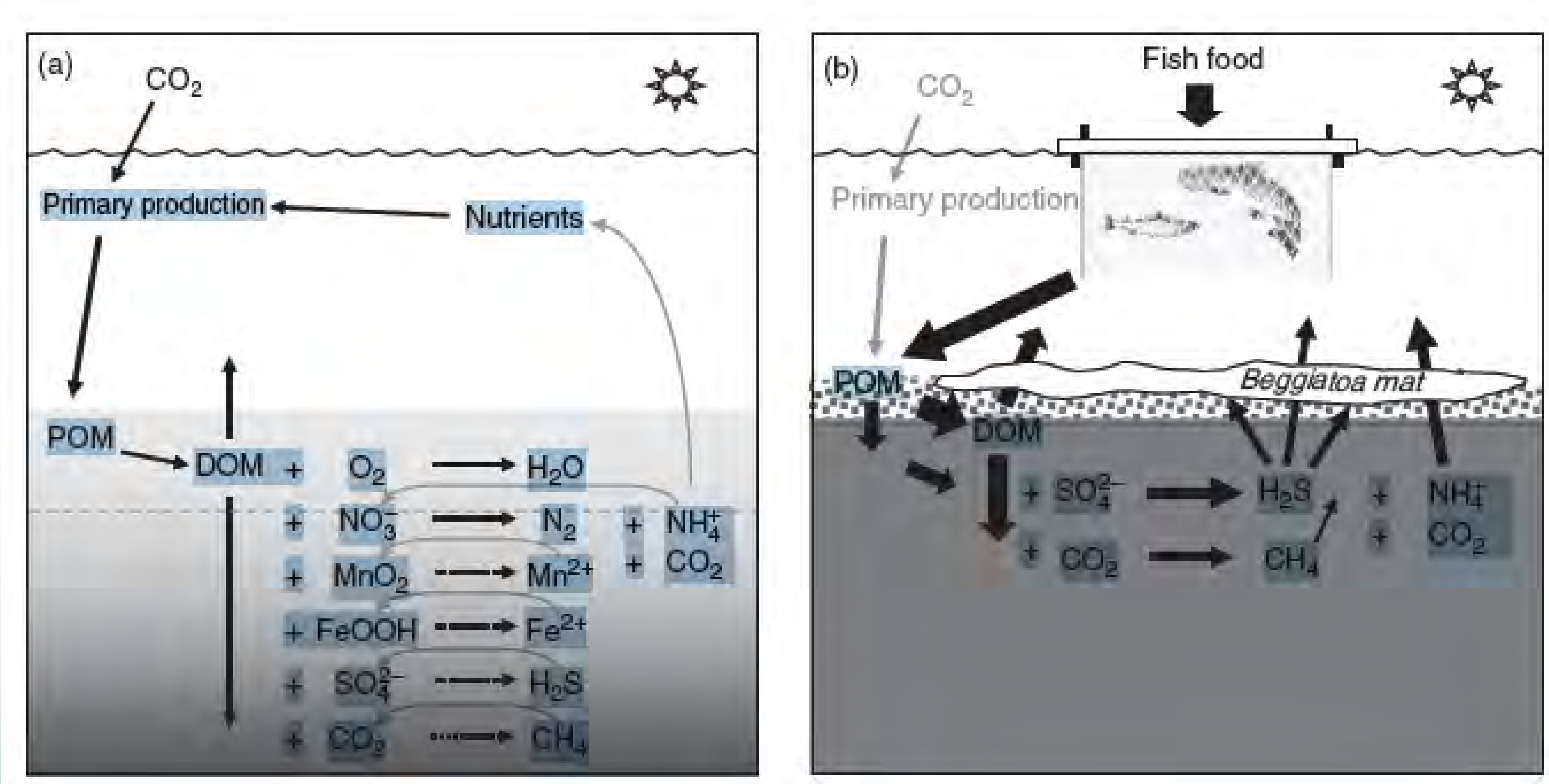
Improvements in the water quality of many freshwater and most coastal marine ecosystems requires reductions in both nitrogen and phosphorus inputs.



Too much algae. (Top) Removing macroalgal blooms at the Olympic Sailing venue, China. (Middle) Seagrasses covered with attached algae in a Danish estuary. (Bottom) Non–N2-fixing cyanobacteria blooms in Lake Okeechobee, Florida, U.S.A.

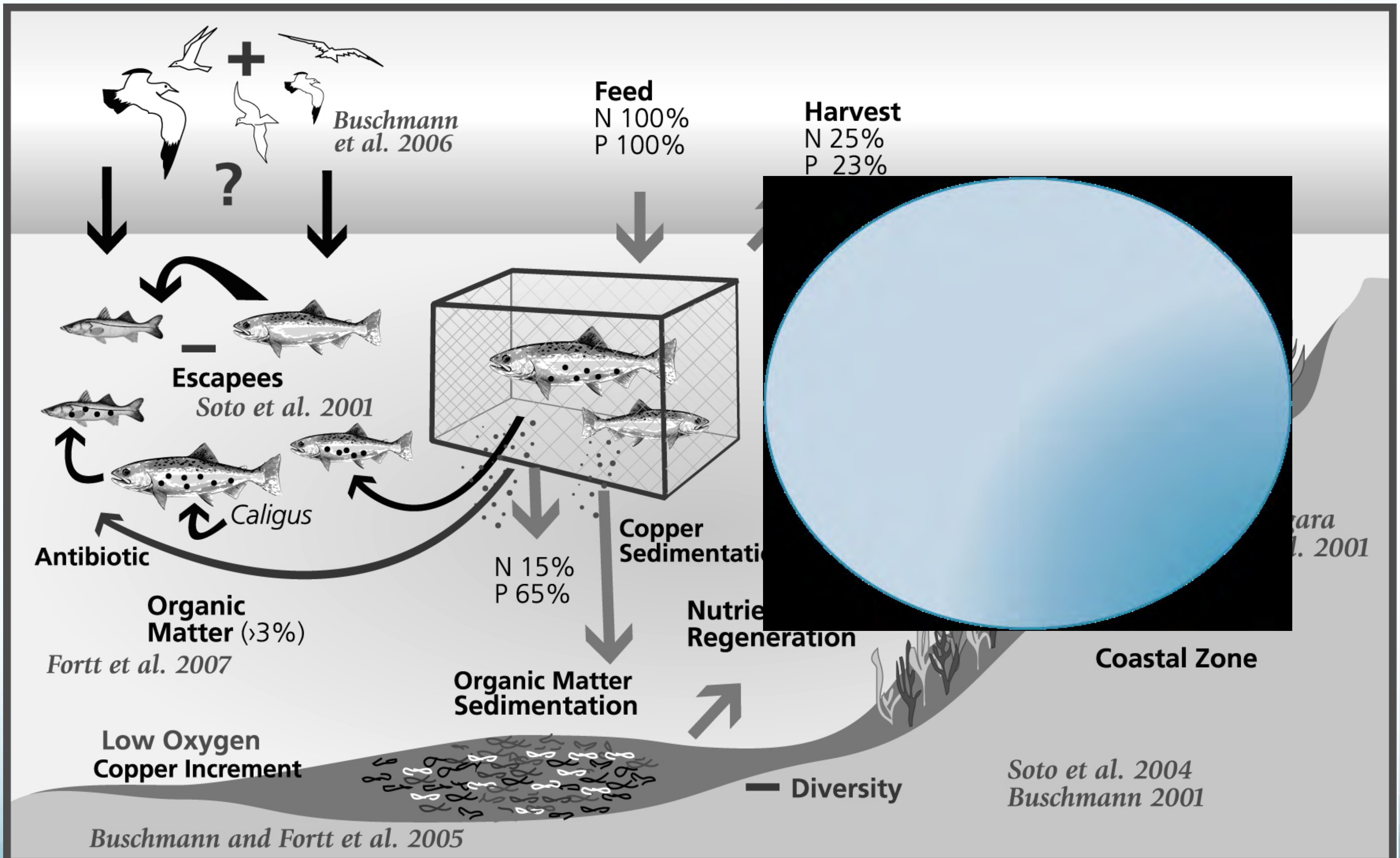
Ecological Engineering

"Ecological Engineering is an emerging field that uses ecological processes within natural or constructed systems to achieve environmental goals"



Buschmann, Hernández-González, Aranda, Chopin, Neori, Halling & Troell. Mariculture Waste Management. In Sven Erik Jørgensen and Brian D. Fath (Editor-in-Chief), Ecological Engineering. Vol. [3] of Encyclopedia of Ecology, 5 vols. pp [2211-2217] Oxford: Elsevier.

EUTROPHICATION



Buschmann 2007. Anales Academia Chilena de Ciencias
Buschmann et al. 2009. Ocean & Coastal Management

Goast Nutrients

Vol. 374: 1–6, 2009
doi: 10.3354/meps07763

MARINE ECOLOGY PROGRESS SERIES
Mar Ecol Prog Ser

Published January 13

OPEN ACCESS

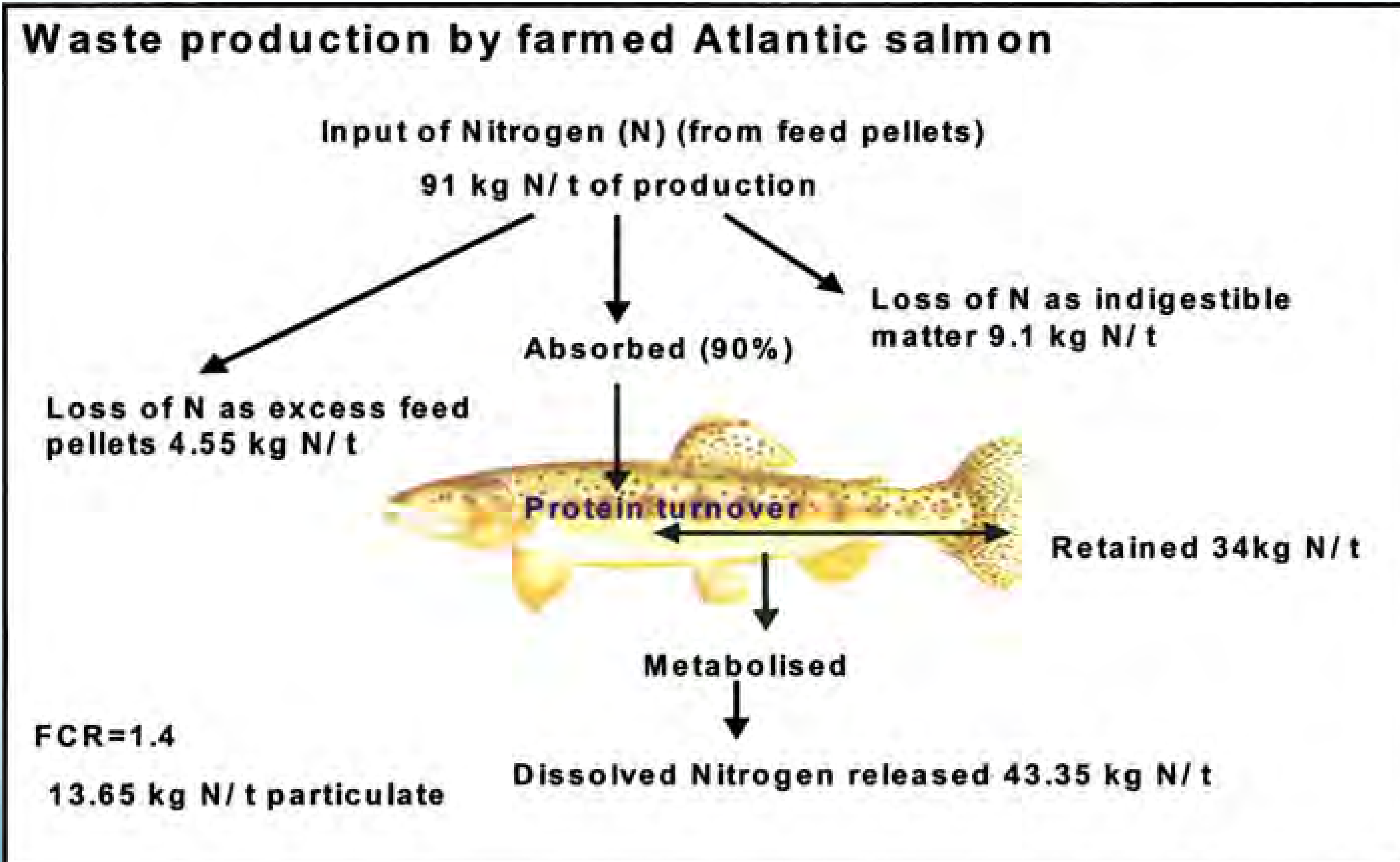
FEATURE ARTICLE

'Ghost nutrients' from fish farms are transferred up the food web by phytoplankton grazers

Paraskevi Pitta[1], Manolis Tsapakis[1], Eugenia T. Apostolaki[1], Tatiana Tsagaraki[1], Marianne Holmer[2], Ioannis Karakassis[3,*]

[1]Hellenic Centre for Marine Research, Institute of Oceanography, PO Box 2214, 71003 Heraklion, Crete, Greece
[2]Institute of Biology, SDU-Odense University, Campusvej 55, 5230 Odense M, Denmark
[3]Marine Ecology Laboratory, Department of Biology, University of Crete, PO Box 2208, 71409 Heraklion, Crete, Greece

N Budget

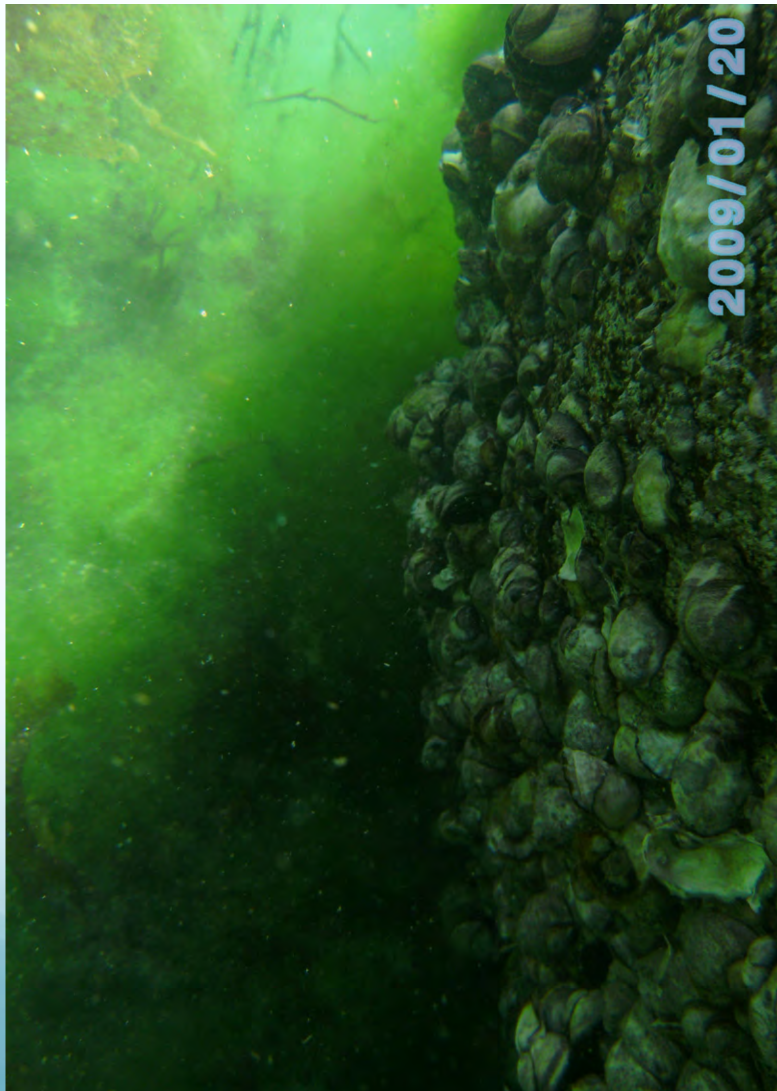


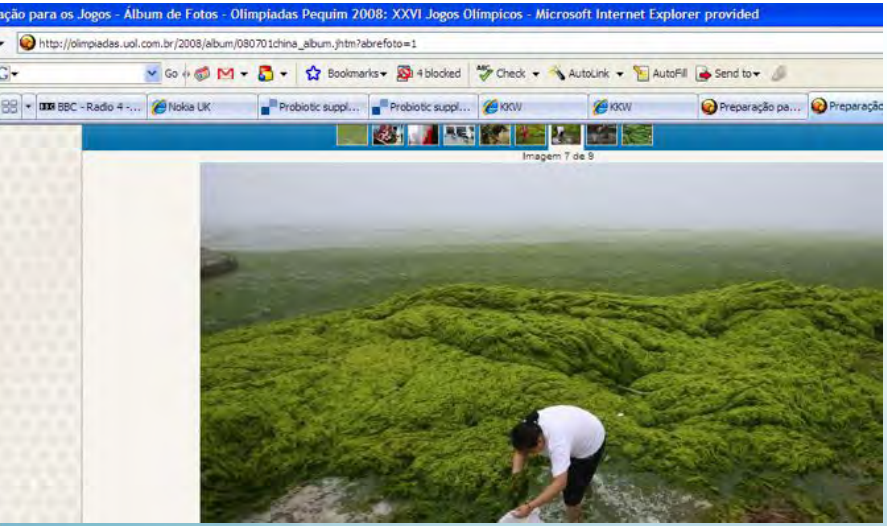
Mente et al. 2004. Aquaculture International

Nitrogen Loads: Tasmania

EUTROPHICATION IN SOUTHERN CHILE

(Green Tides)





Tracking the algal origin of the *Ulva bloom in the Yellow Sea by a combination of molecular, morphological and physiological analyses*

Pang et al. Marine Environment Research (in press)

Land-Based IMTA

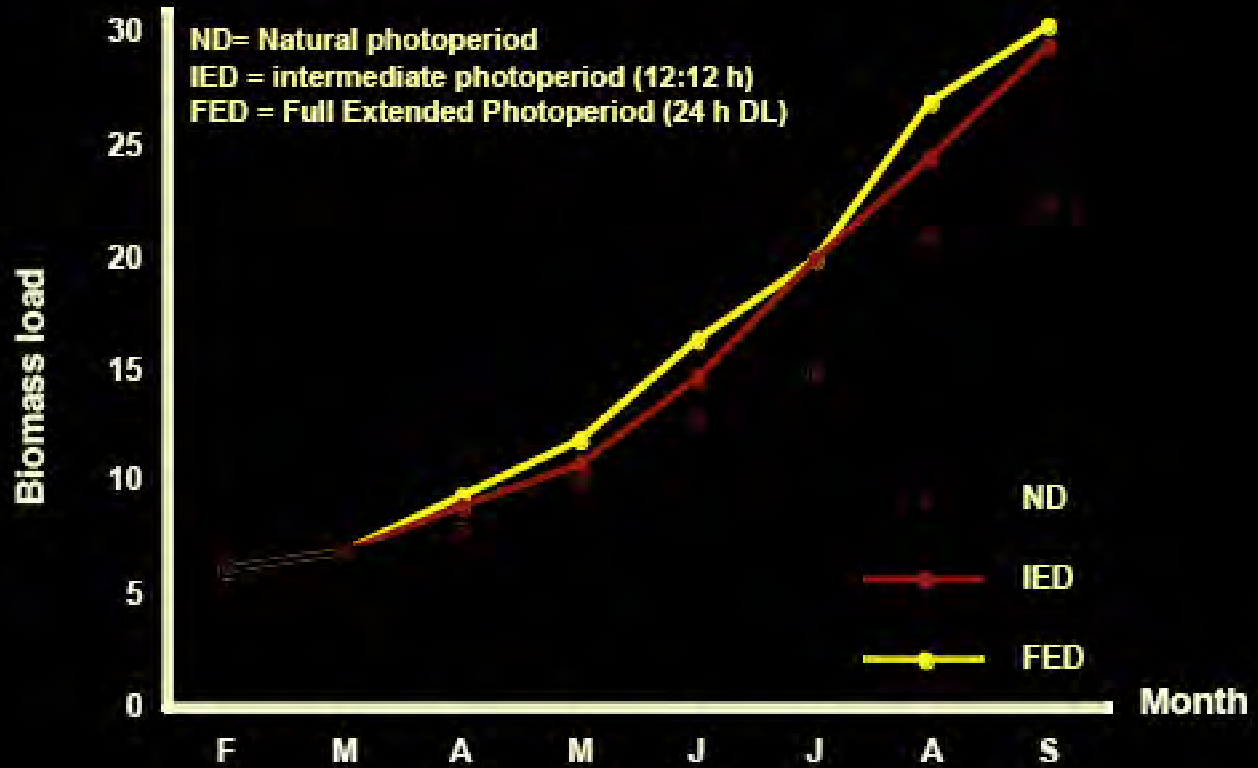
Integrated aquaculture on an abalone farm on the southeast coast of South Africa, with the abalone tanks under shade on the left. The paddle raceways grow the green seaweed *Ulva*, for feed, in abalone effluent. Photograph: R.J. Anderson.

Bolton J.J. 2006. South African Journal of Science 102:507- 508

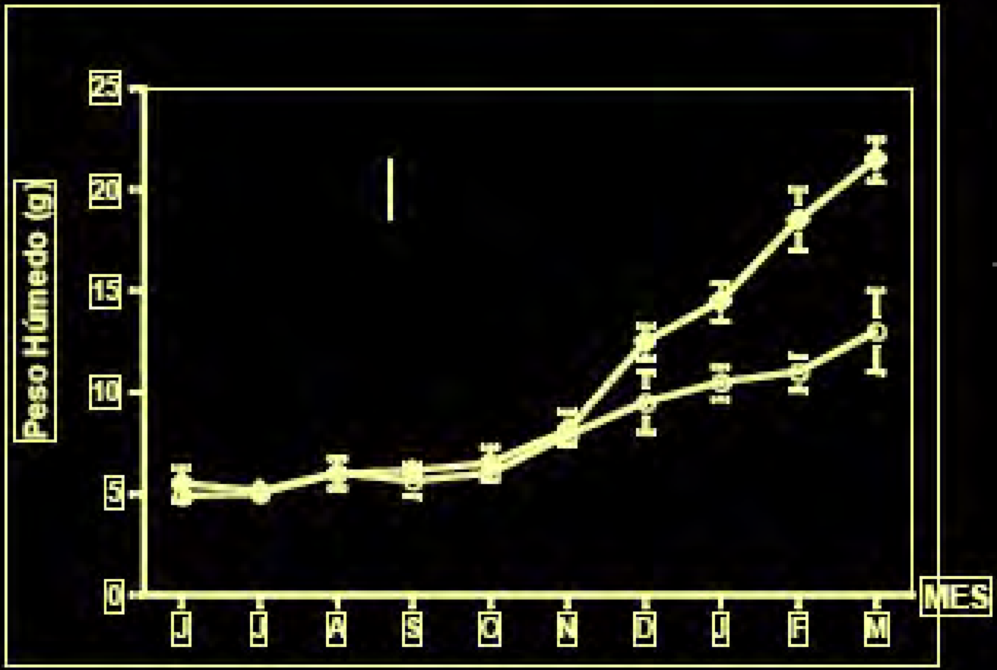
Buschmann et al 1994. Aquacultural Emngineering
Buschmann et al. 1996. Hydrobiologia

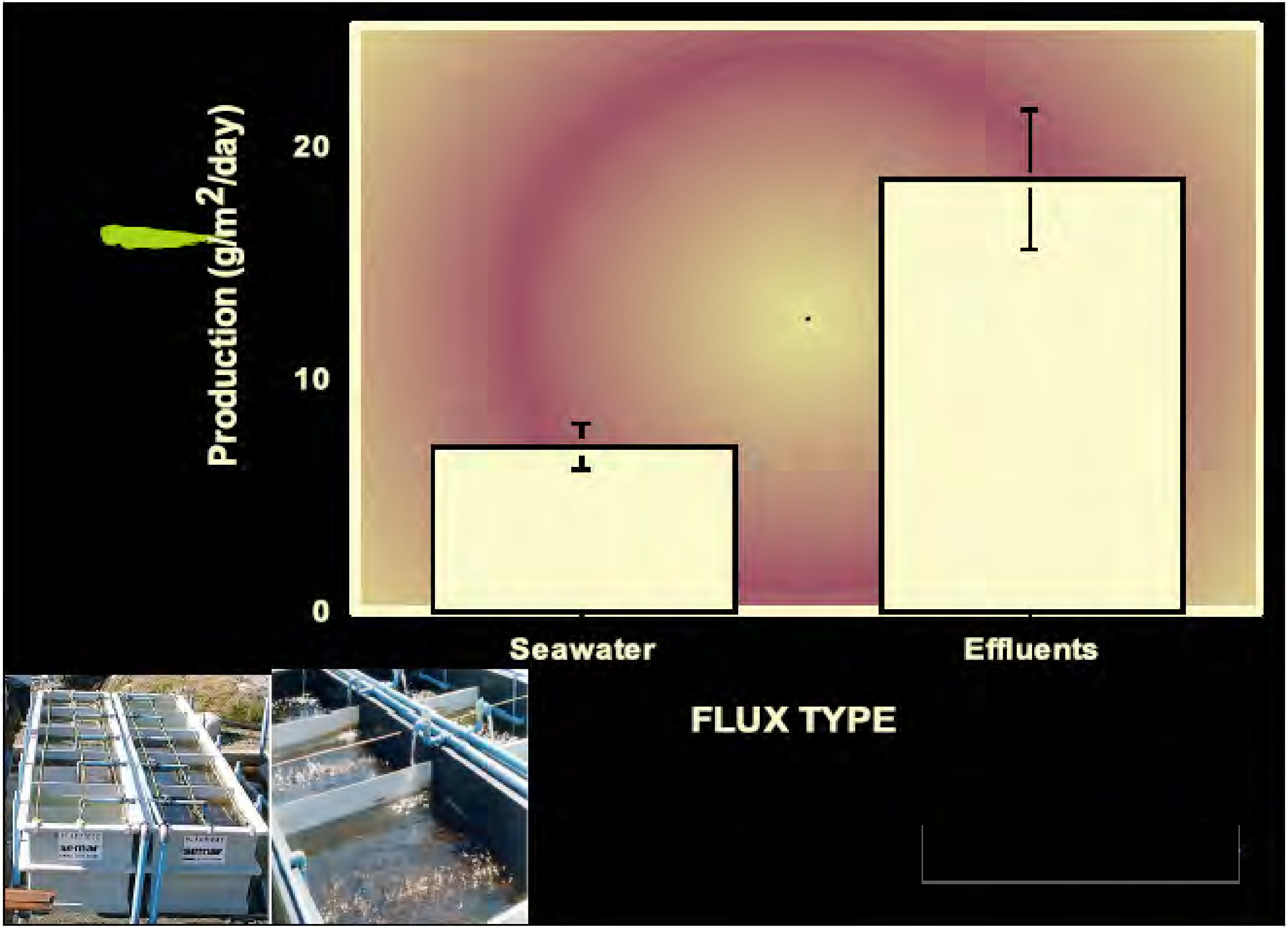
Figure 10 The SeaOr Marine Enterprises Ltd. IMTA farm in Mikhmoret, Israel. The abalones (*Haliotis discus hannai*) are grown in the white building in the background, the green-covered fishponds (*Sparus aurata*) are in the middle, and the elongated seaweed ponds (*Ulva* sp. and *Gracilaria* sp.) are in front. Photo by M. Shpigel and B. Scharfstein.

Neori, A., et al. 2004. Integrated aquaculture: rationale, evolution and state of the art emphasizing seaweed biofiltration in modern aquaculture. Aquaculture 231: 361-391.


ND= Natural photoperiod
IED = intermediate photoperiod (12:12 h)
FED = Full Extended Photoperiod (24 h DL)
Biomass load
30
25
20
15
10
5
0
ND
IED
FED
Month
F
M
A
M
J
J
A
S

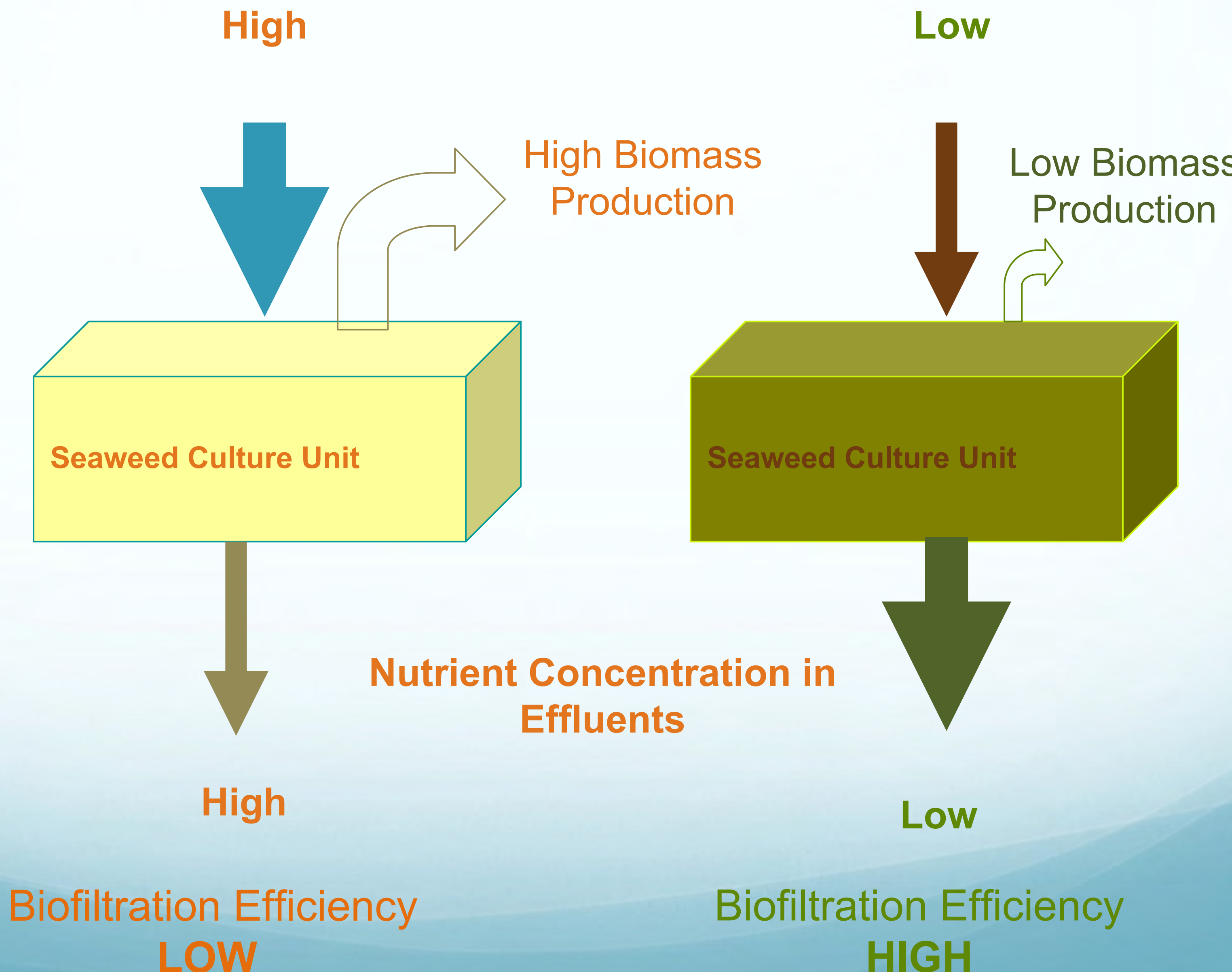

semar
semar


Peso Húmedo (g)
25
20
15
10
5
0
MES
J
J
A
S
O
N
D
J
F
M

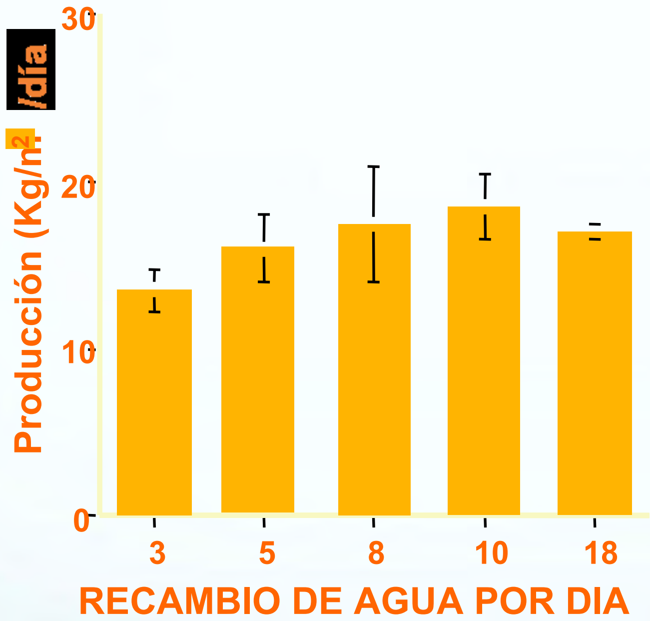


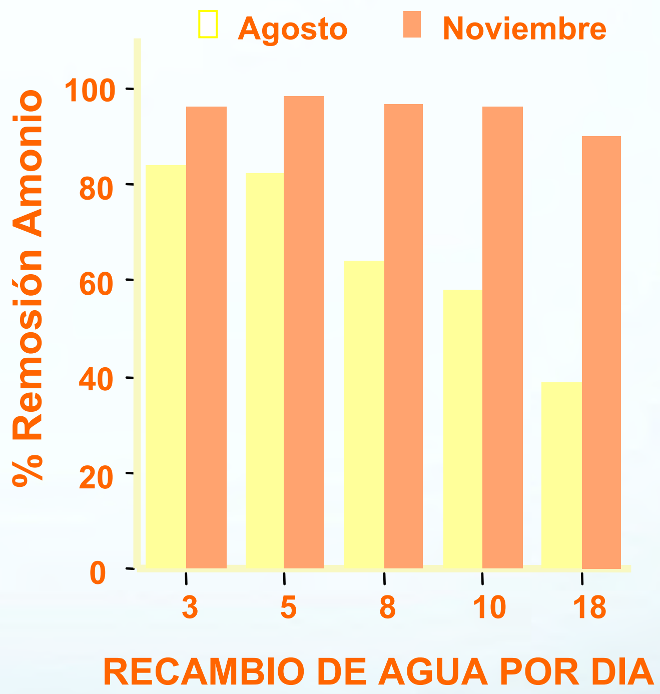
Buschmann et al. 1994. Aquacultural Engineering

WATER FLOW



High
Low
High Biomass Production
Low Biomass Production
Seaweed Culture Unit
Seaweed Culture Unit
Nutrient Concentration in Effluents
High
Low
Biofiltration Efficiency
LOW
Biofiltration Efficiency
HIGH


Producción (Kg/m2/día
30
20
10
0
3
5
8
10
18
RECAMBIO DE AGUA POR DIA


Agosto
Noviembre
% Remosión Amonio
100
80
60
40
20
0
3
5
8
10
18
RECAMBIO DE AGUA POR DIA

Buschmann et al. 1996 Hydrobiologia 326/327: 75-82

OPEN SYSTEMS IMTA

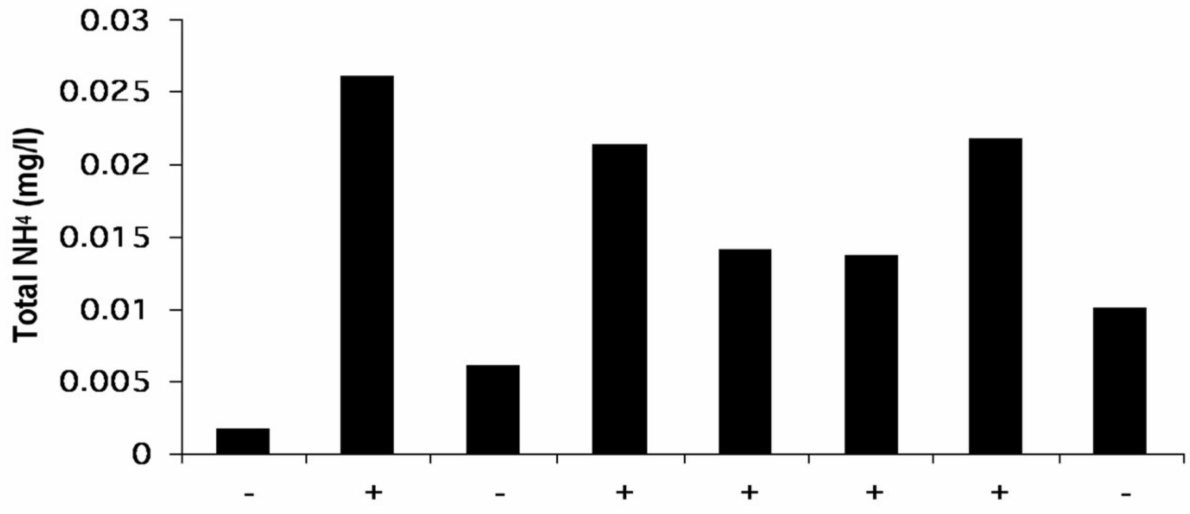
Canada

Chile

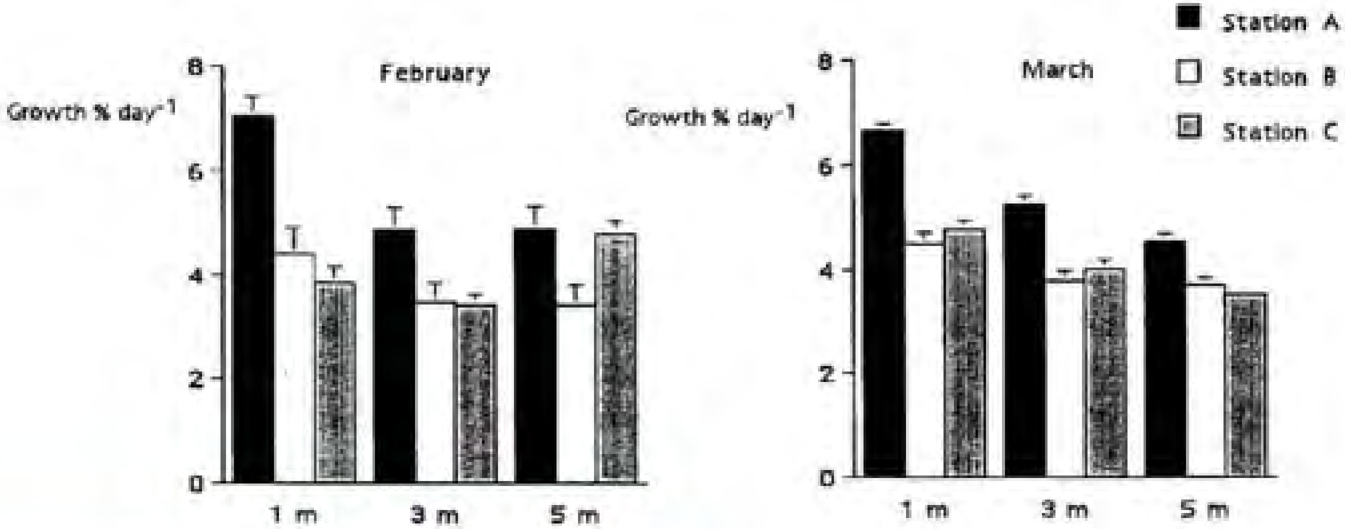
Chopin et al. 2008. Encyclopedia of Ecology, Elsevier. Vol.3, pp.2463-2475

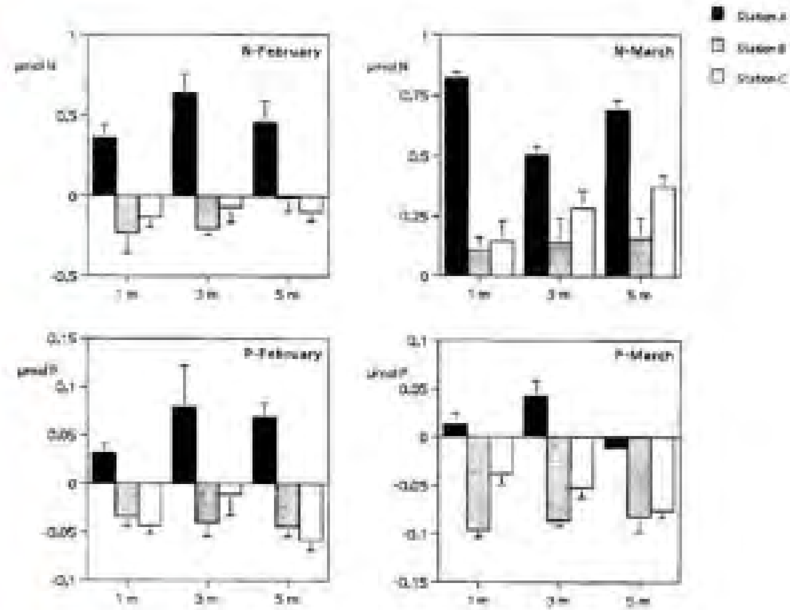
Troell et al. 1997 Aquaculture
Halling et al. 2005. Aquaculture International
Buschmann et al. 2008. J appl. Phycol
Abreu et al.2009. Aquacultue

OPEN SEA AQUACULTURE



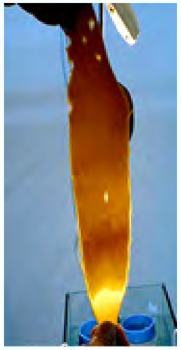
Buschmann et al., 2006. ICES Journal of Marine Science

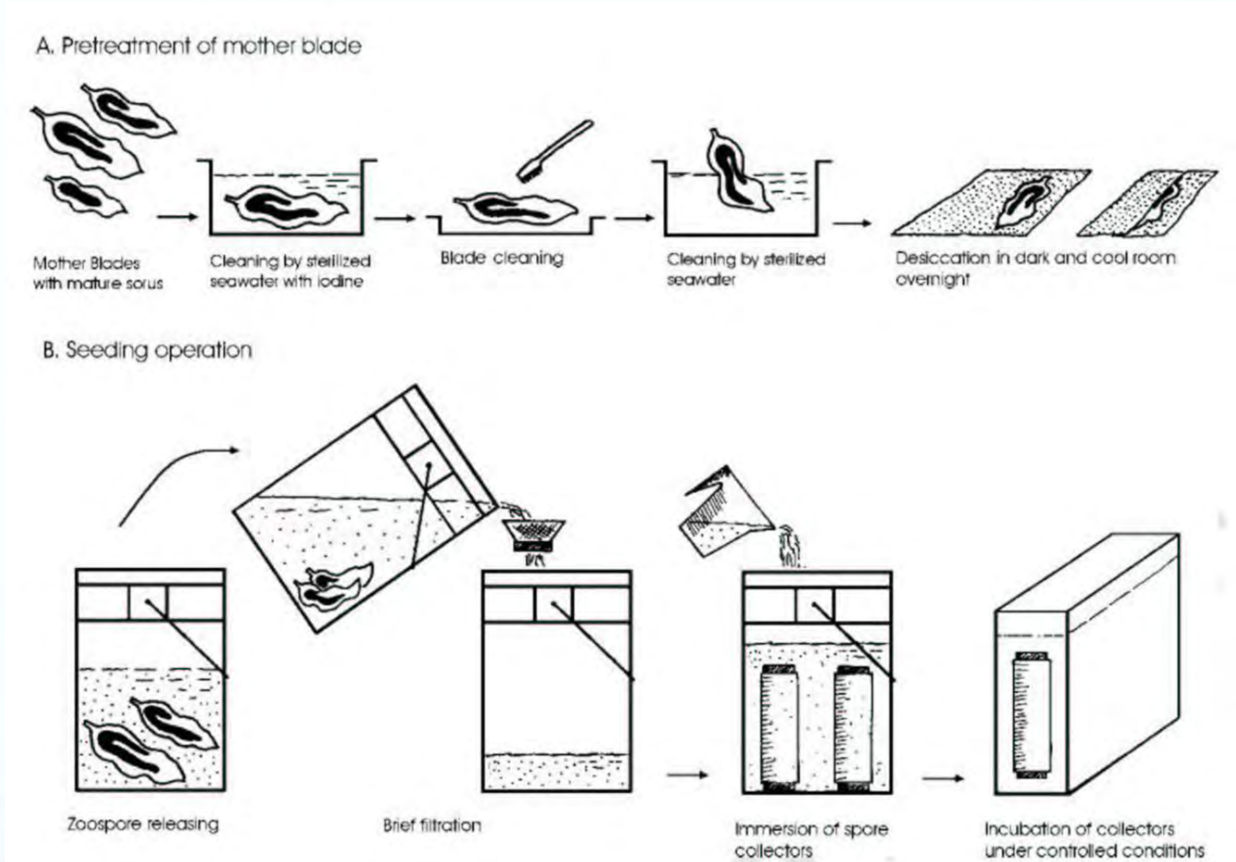


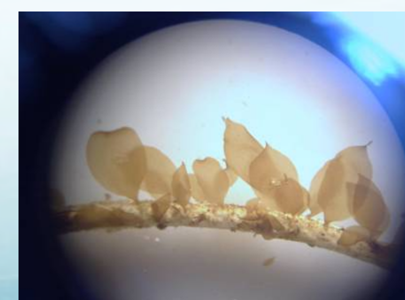


Troell et al. 1997. Aquaculture

Hatchery technology for *Macrocystis*



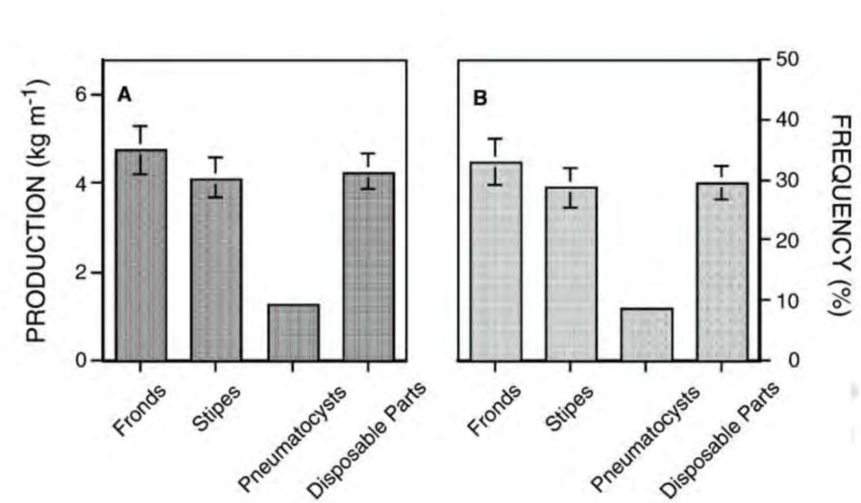


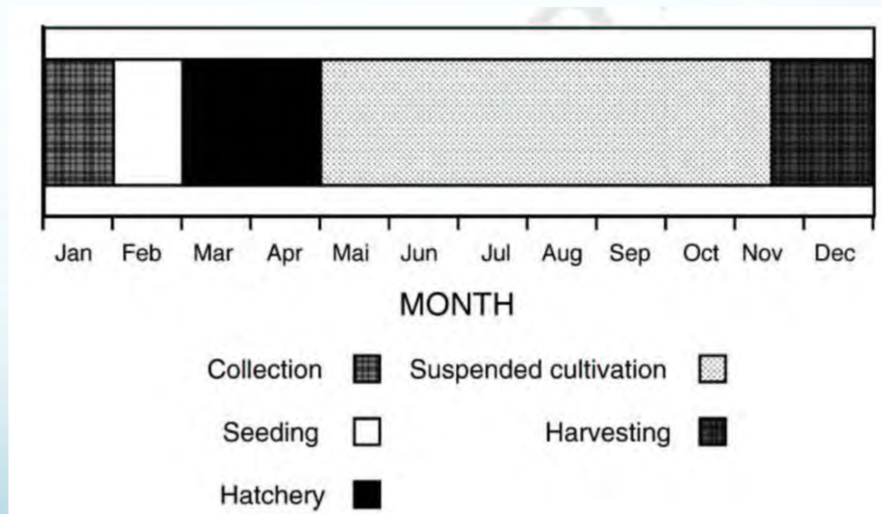


Gutierrez et al. JAP. 2006

Macrocystis Production Systems

14, 9 kg/m



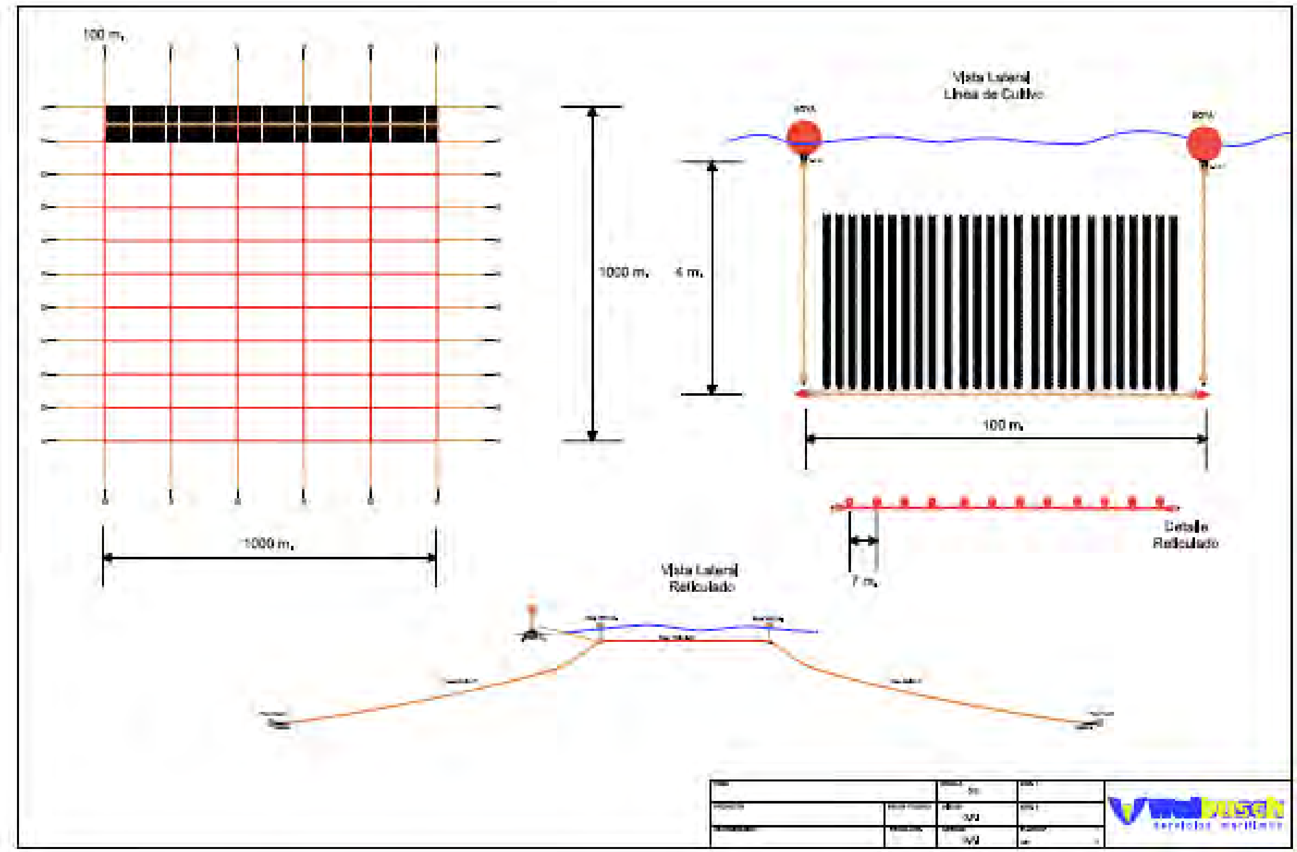


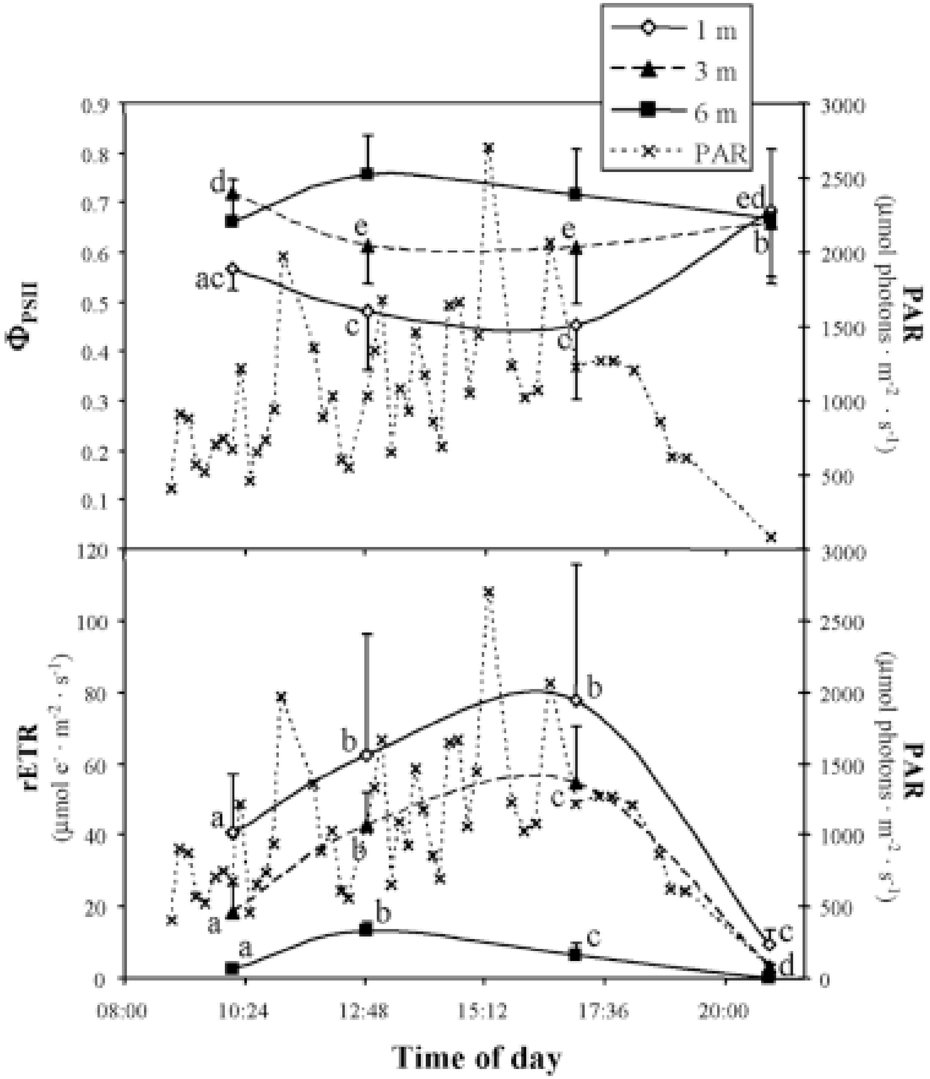
Gutierrez et al. 2006 JAP

Winter Production:

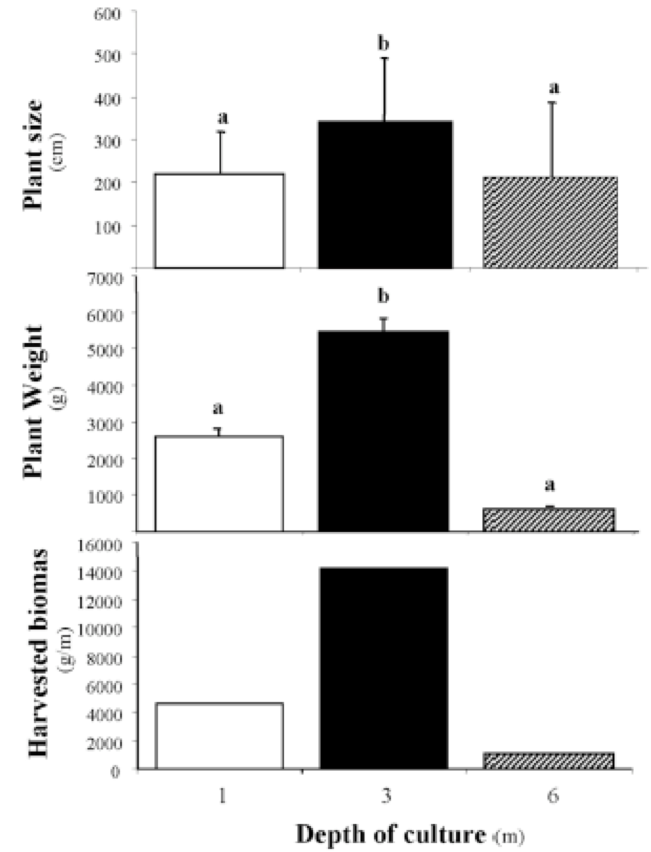
Additional 18-20 kg m^{-1}

Large-Scale Seaweed Aquaculture

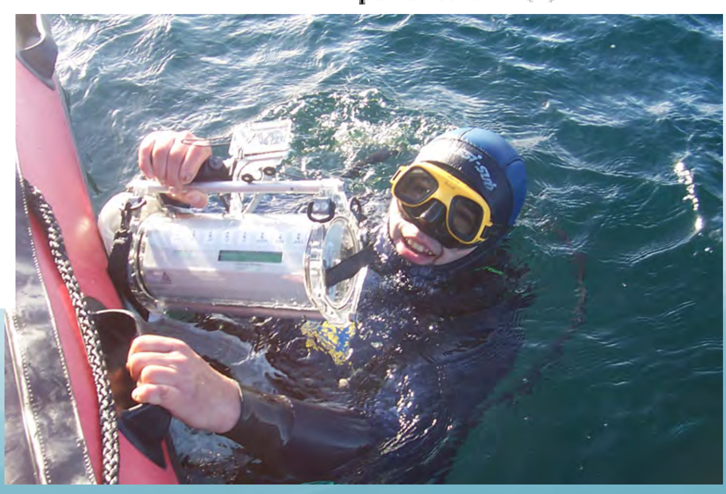


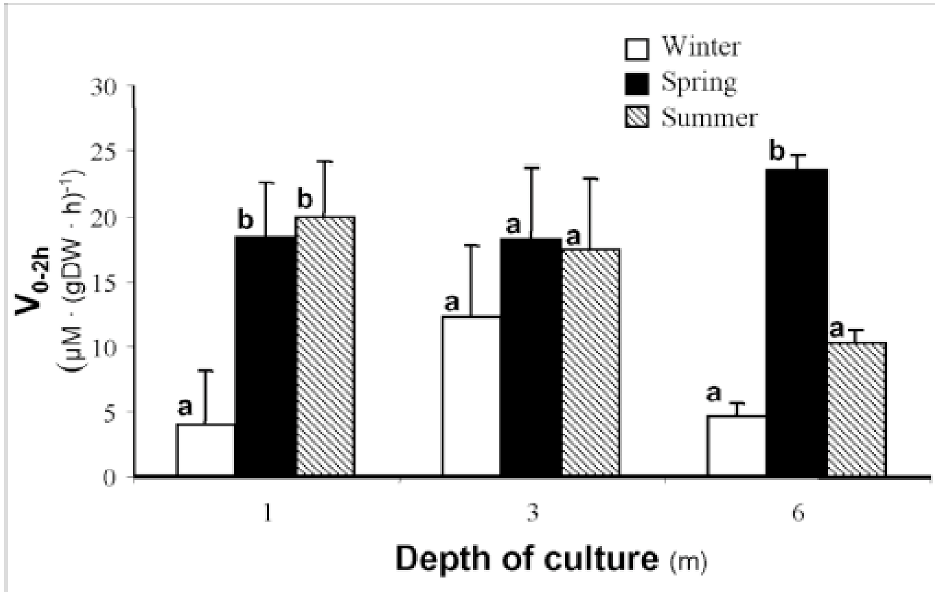


1 m
3 m
6 m
PAR
Φ_{PSII}
PAR (µmol photons · m^{-2} · s^{-1})
rETR (µmol e$^-$ · m^{-2} · s^{-1})
Time of day
08:00
10:24
12:48
15:12
17:36
20:00

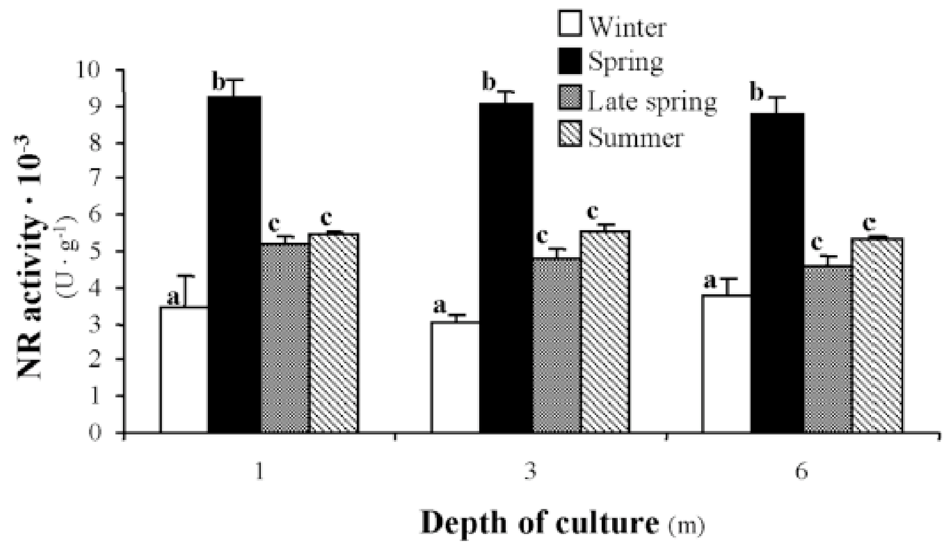


Plant size (cm)
Plant Weight (g)
Harvested biomas (g/m)
Depth of culture (m)
1
3
6





Nitrate uptake rate evaluated over (in) a 2 h period (V0-2h) in M. pyrifera plants cultivated at different depths. Different letters above mean significant differences at $p < 0.05$ (Tukey'HSD).



Nitrate reductase activity in M. pyrifera plants cultured at different depths. Different letters above mean significant differences at $p < 0.05$ (Tukey'HSD).