UNIVERSIDAD DE LOS LAGOS

Unwrapping the ecological relevance of microscopic stages of annual *Macrocystis pyrifera* population dynamic processes in southern Chile

Alejandro H. Buschmann

Centro i-mar, CeBiB, MASH
Universidad de Los Lagos
Puerto Montt · Chile

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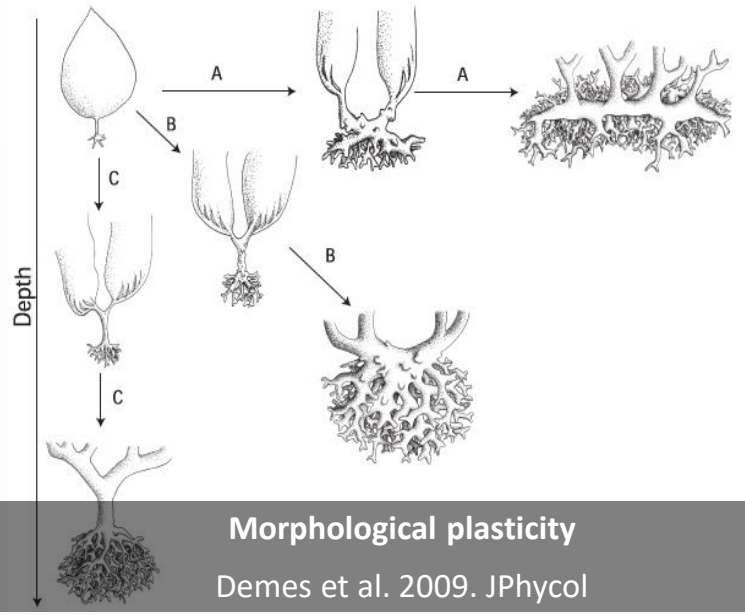
www.i-mar.cl
www.cebib.cl
abuschma@ulagos.cl

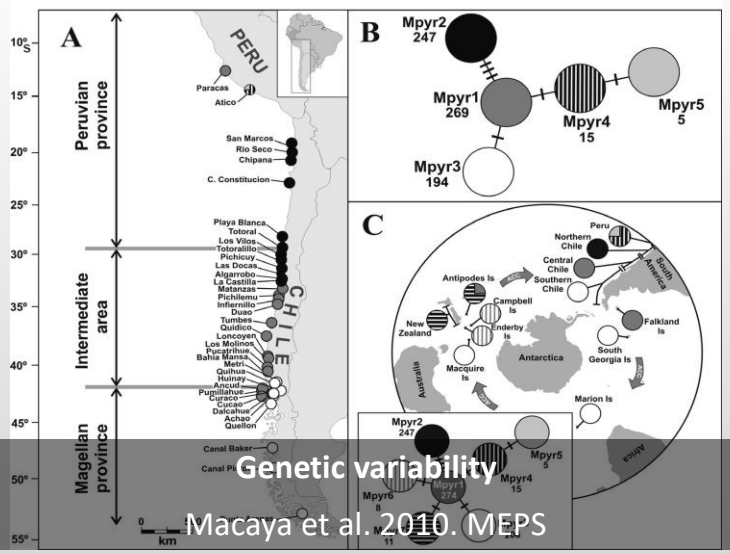
Laminareales
1. Kelps are not equal

- High Morphological Diversity
- Different Reproduction Strategies
- Different Population Dynamics
- Present in Different Habitats



Morphological plasticity

Demes et al. 2009. JPhycol



Genetic variability

Macaya et al. 2010. MEPS

Laminareales

1. Intraespecific Variability

Laminariales
3. Complex Life History

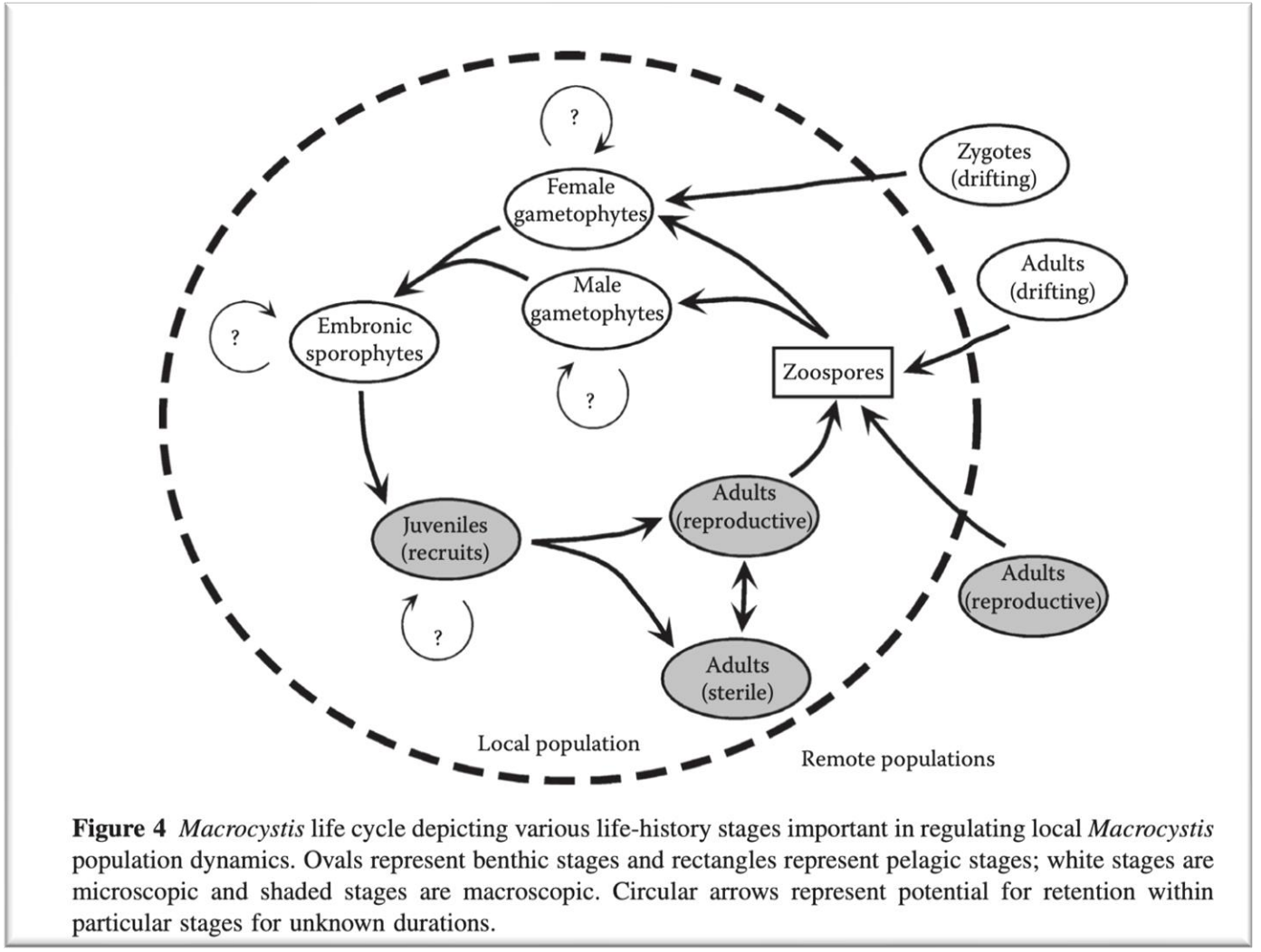


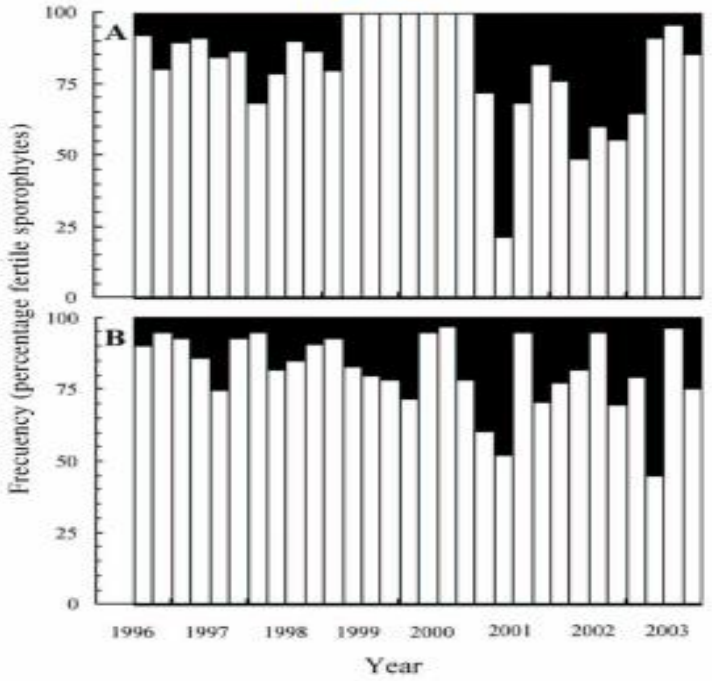
Figure 4 *Macrocystis* life cycle depicting various life-history stages important in regulating local *Macrocystis* population dynamics. Ovals represent benthic stages and rectangles represent pelagic stages; white stages are microscopic and shaded stages are macroscopic. Circular arrows represent potential for retention within particular stages for unknown durations.

- ✓ Sexual reproduction success
- ✓ Parthenogenesis
- ✓ Interfertility
- ✓ Etc.

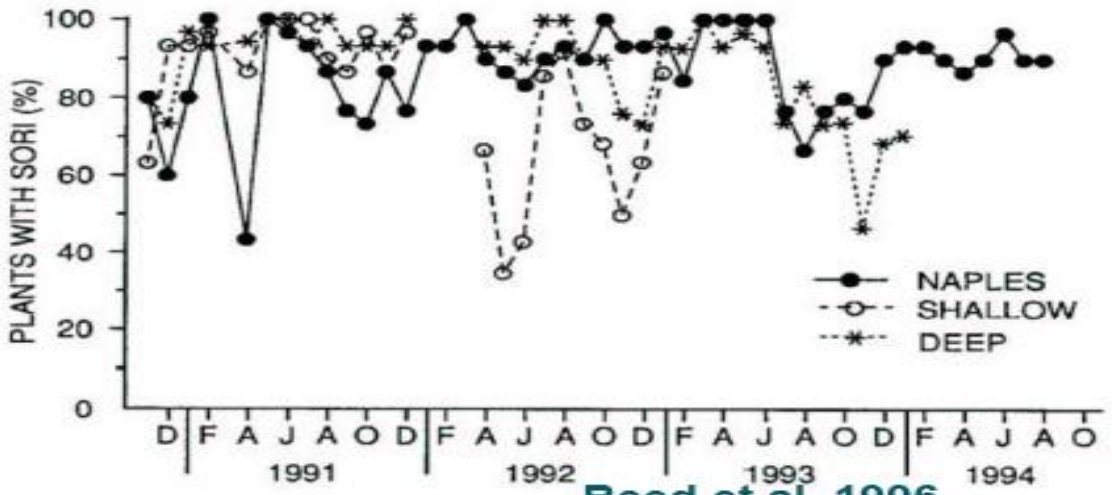
Macrocystis Population Dynamic

FIG. 3. Monthly variation in the percentage of adult *Macrocystis pyrifera* with fertile sori at Naples Reef, Shallow Goleta Bay, and Deep Goleta Bay

Chile

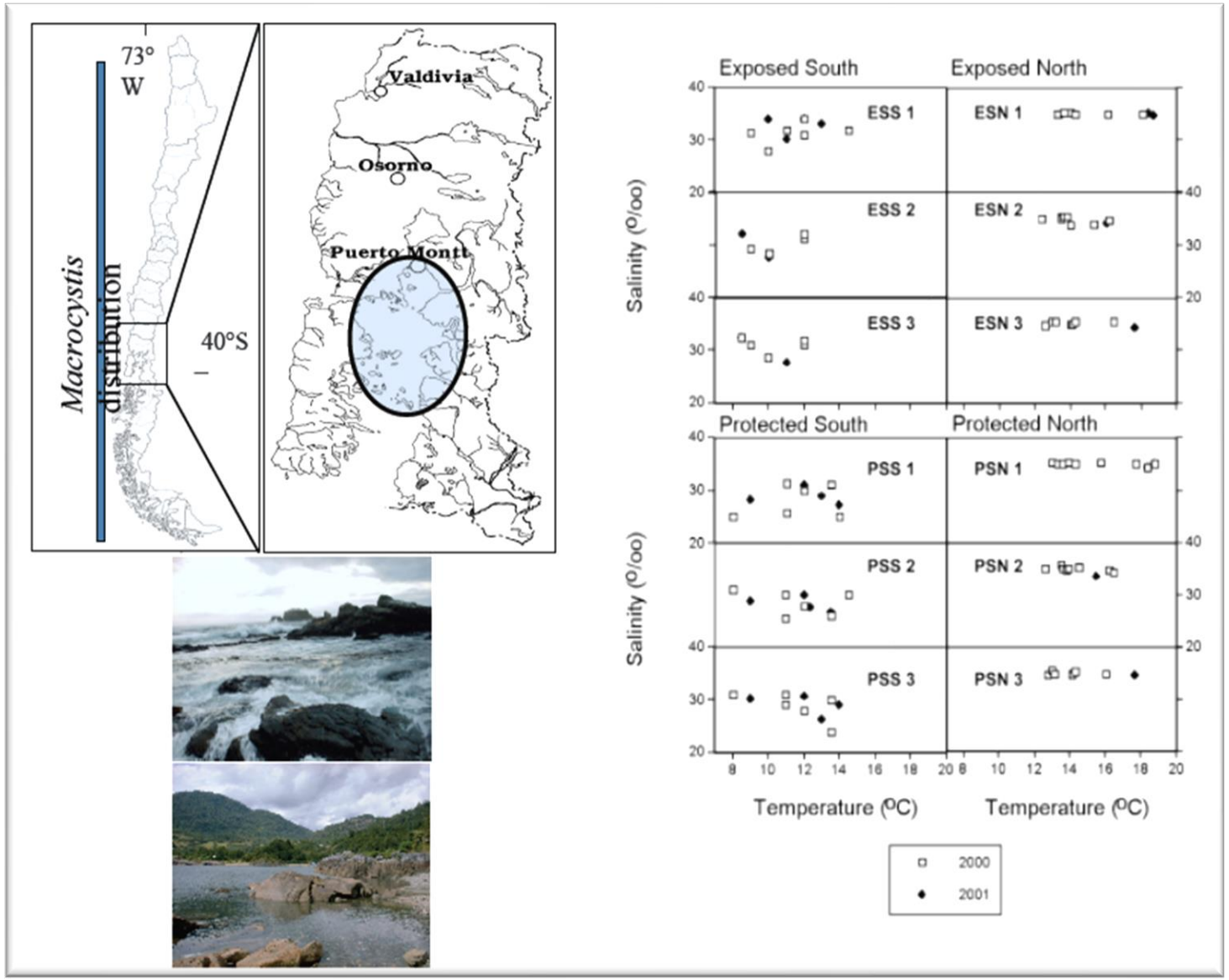


Macrocystis California



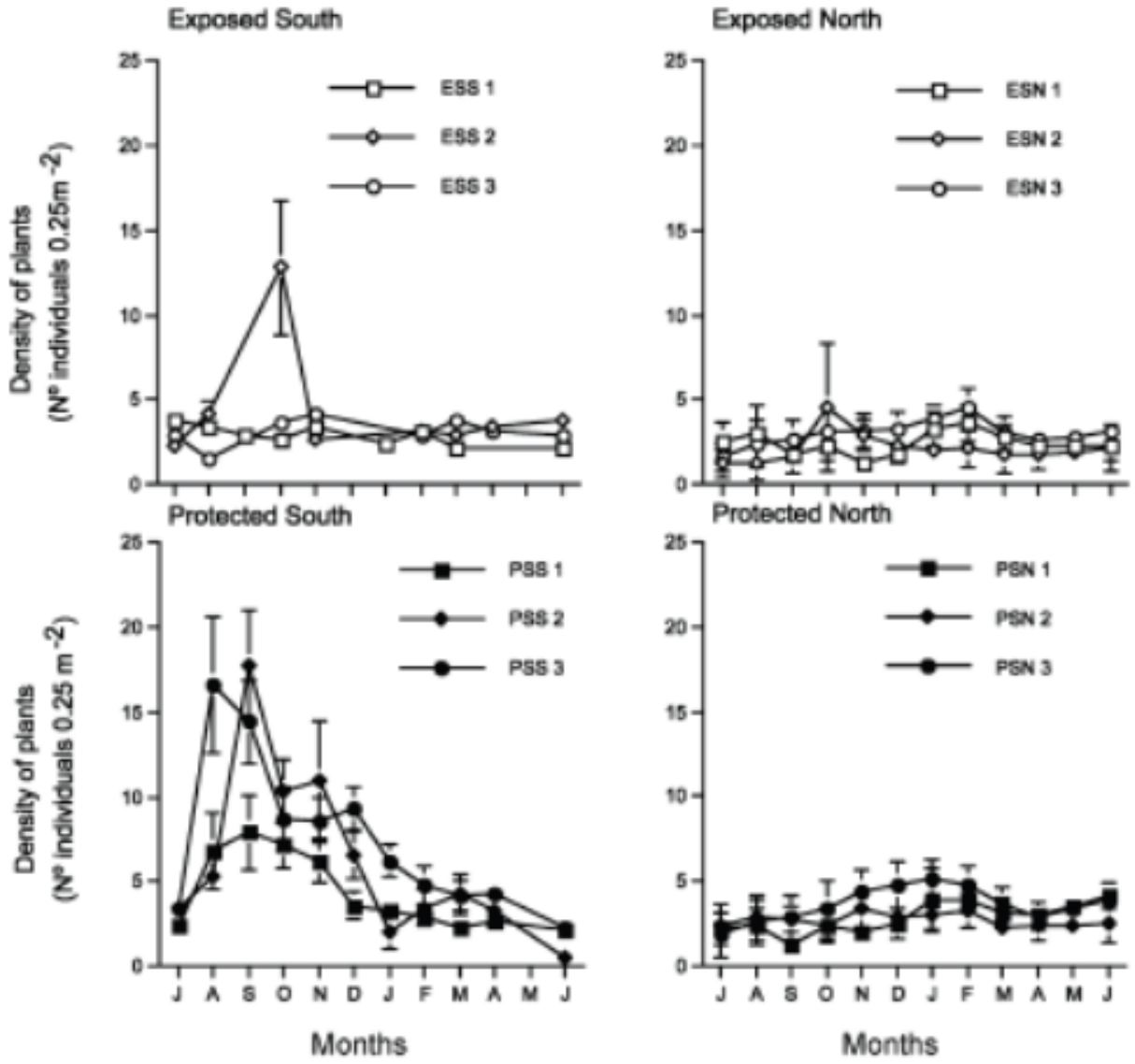
Reed et al. 1996.

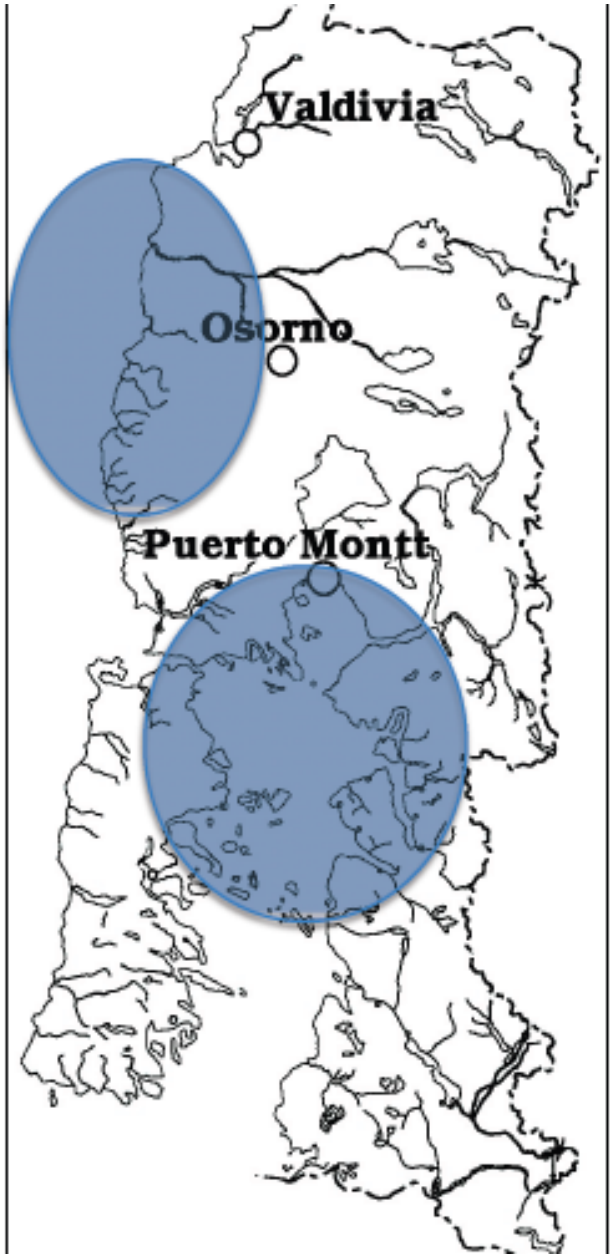
Vega, Vásquez & Buschmann 2005. Rev. Chil. Hist. Nat.



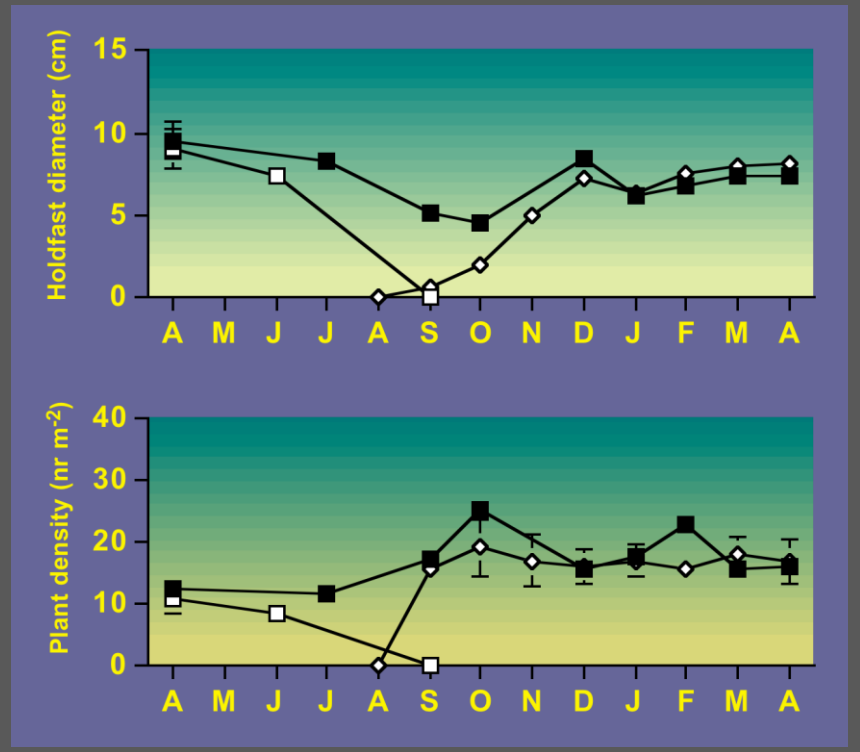
WHAT ABOUT INTRAESPECIFIC VARIATION IN POPULATION STRATEGIES?

Buschmann et al. Mar. Biol. (2004)

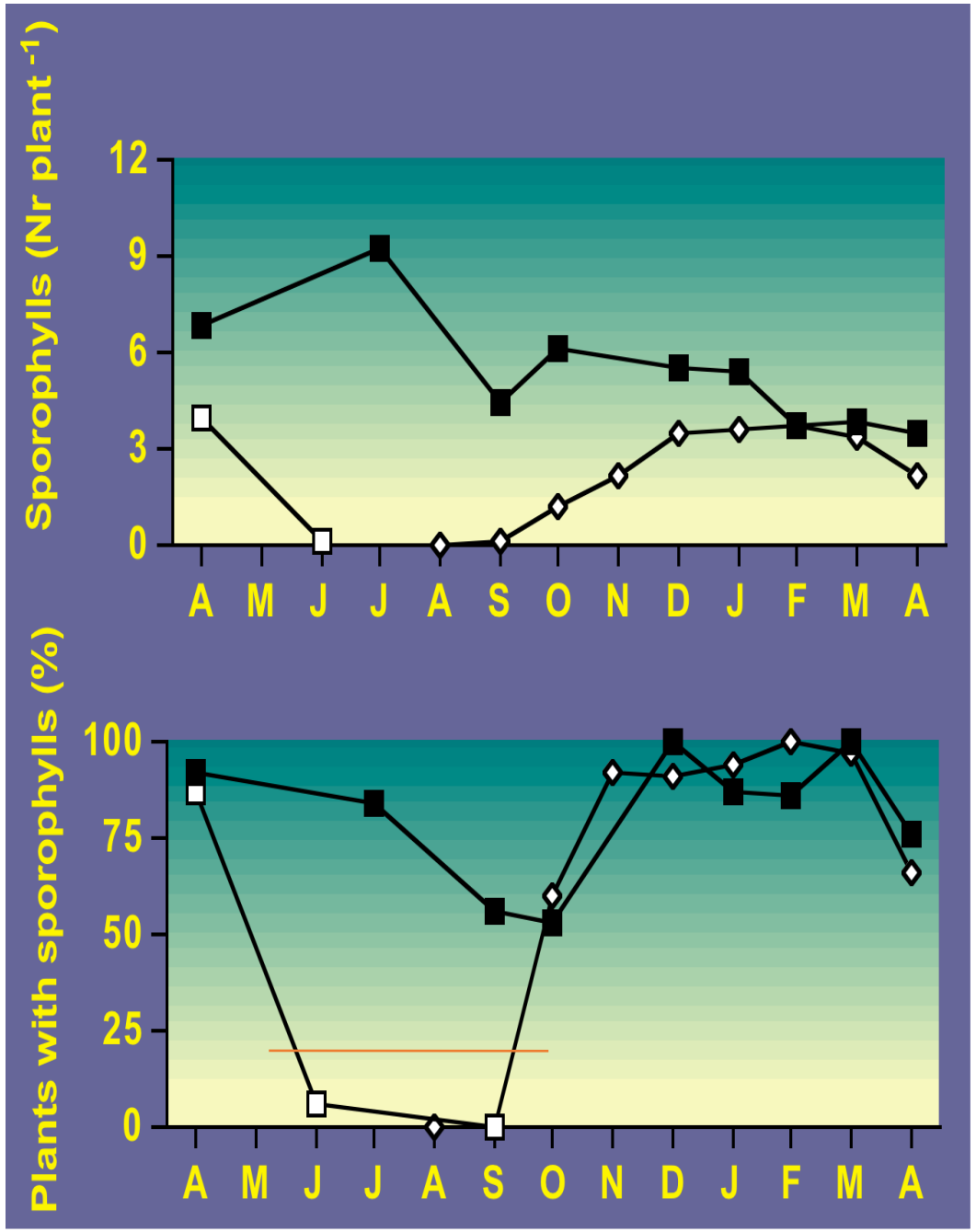




Buschmann et al. Mar. Biol. (2004)



- Buschmann et al. 2006. JAPH


Sporophylls (Nr plant -1)
12
9
6
3
0
A M J J A S O N D J F M A
Plants with sporophylls (%)
100
75
50
25
0
A M J J A S O N D J F M A

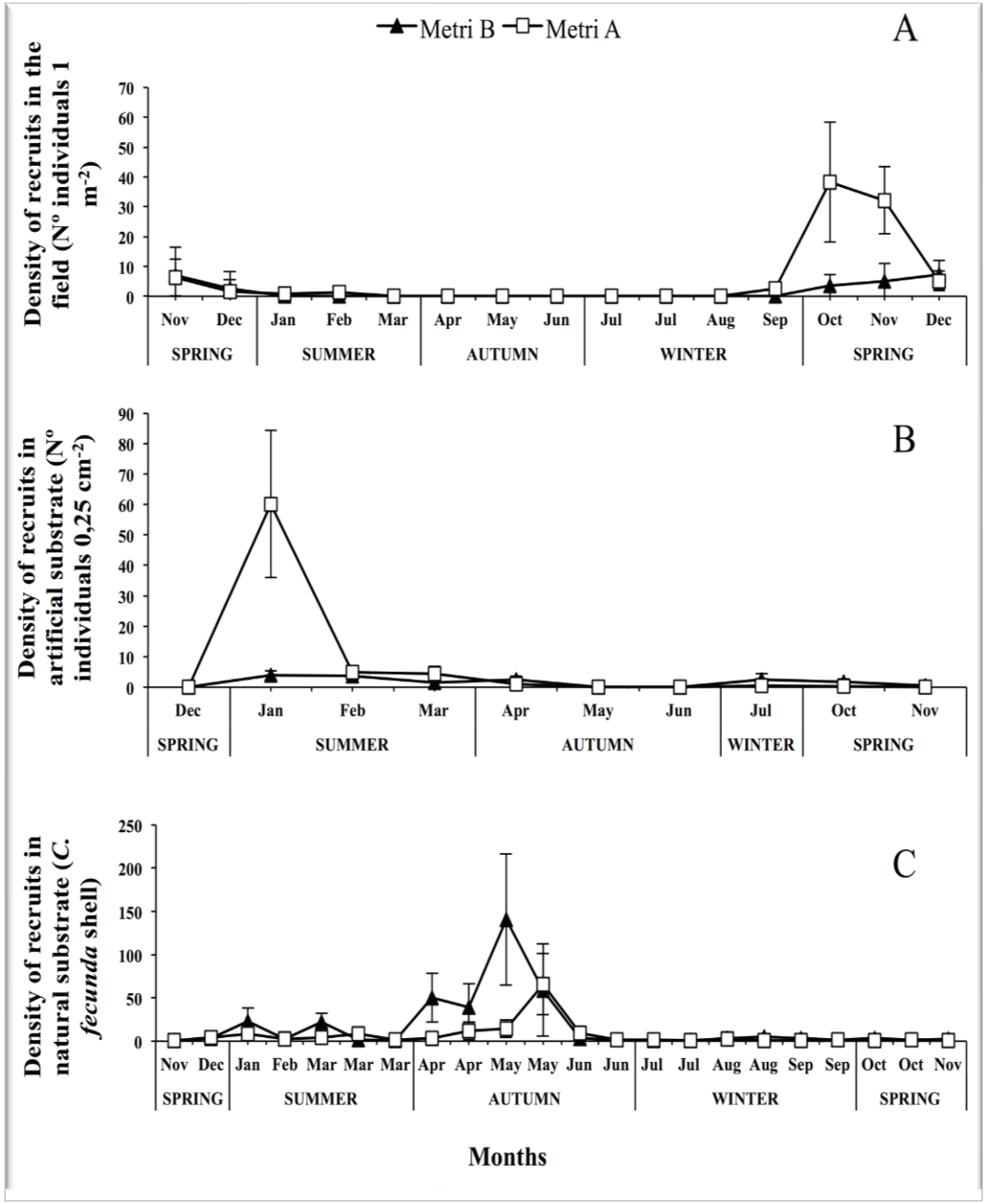
Reproduction

Henríquez-Tejo et al. unpublished

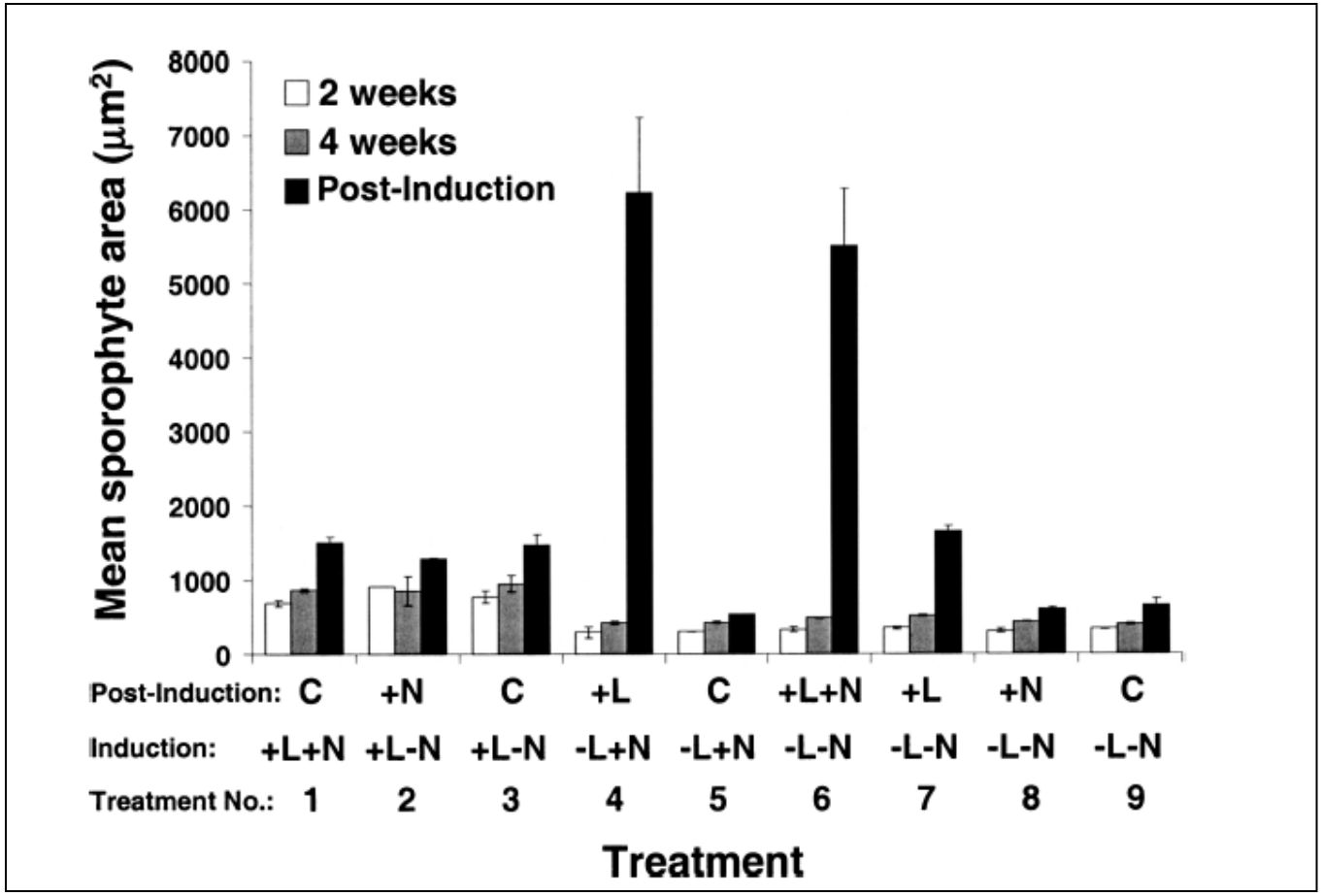
Season	Metri A			Metri B		
	Nr. Sporophyll	**% Reproductive Sporophytes m^{-2}**	**Nr. Released Spore cm^{-2}**	**Nr. Sporophyll**	**% Reproductive Sporophytes m^{-2}**	**Nr. Released Spores cm^{-2}**
Spring	0.64 (±1.79)[a]	19.3 (±28)	0	0.24 (±1.03)	6.94 (±16.6)	0
Summer	2.58 (±2.80)[b]	61.1 (±34)	$2{,}24 \times 10^6$ ($\pm 8.48 \times 10^6$)	2.48 (±5.03)	43.05 (±27.9)	$1{,}59 \times 10^6$ ($\pm 5.25 \times 10^5$)
Autumn	1.36 (±2.27)[a.b]	36.5 (±29.3)	$3{,}12 \times 10^6$ ($\pm 1.79 \times 10^6$)	1.72 (±3.1)	41.27 (±38.5)	1.84×10^6 ($\pm 5.29 \times 10^5$)

Sporophyte Recruitment

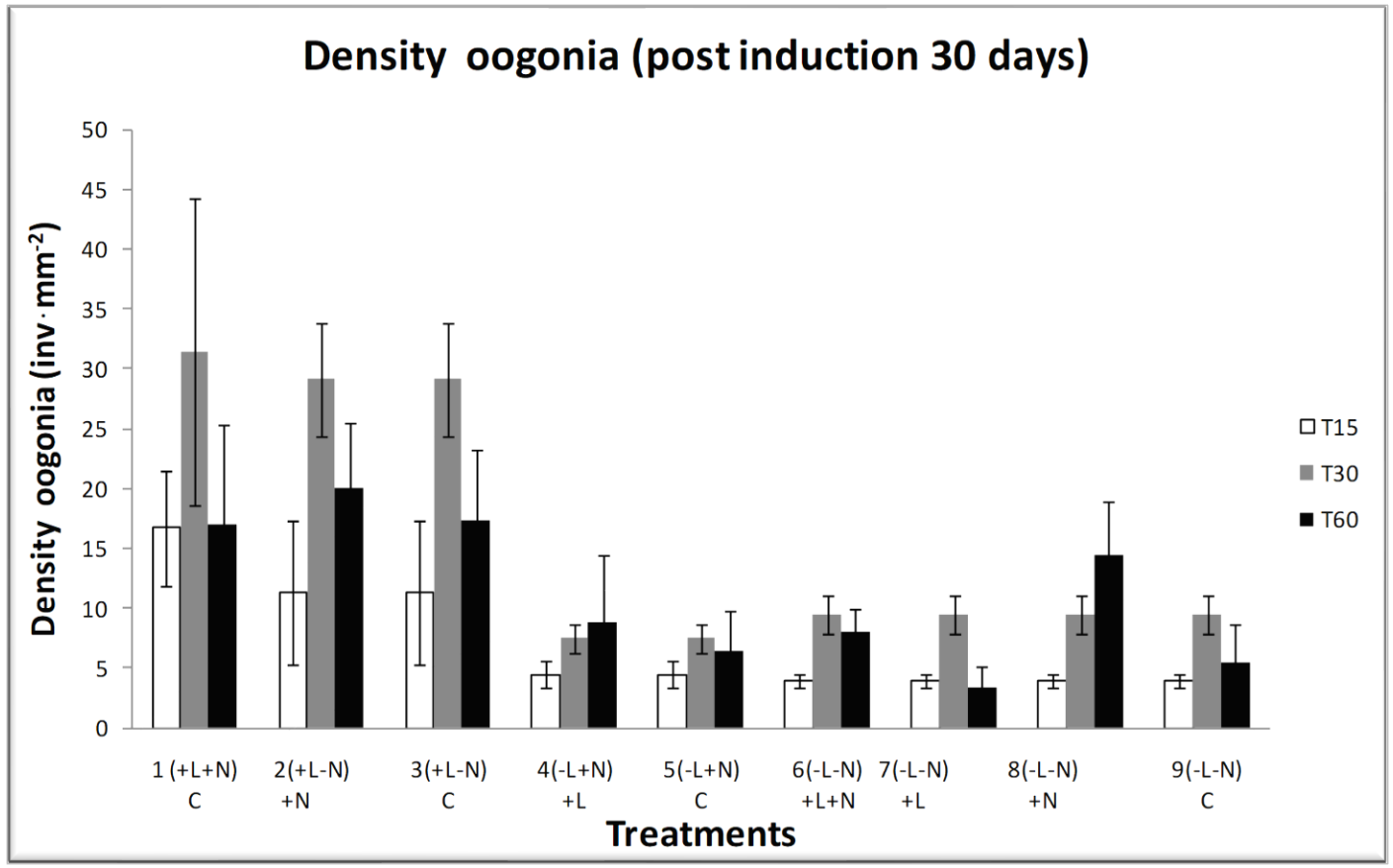
- FIELD COUNTS
- UNSEEDED ARTIFICIAL PLATES
- NATURALLY SEEDED SUBSTRATE (LABORATORY COUNTS)



ARRESTED DEVELOPMENT OF MICROSCOPIC STAGES

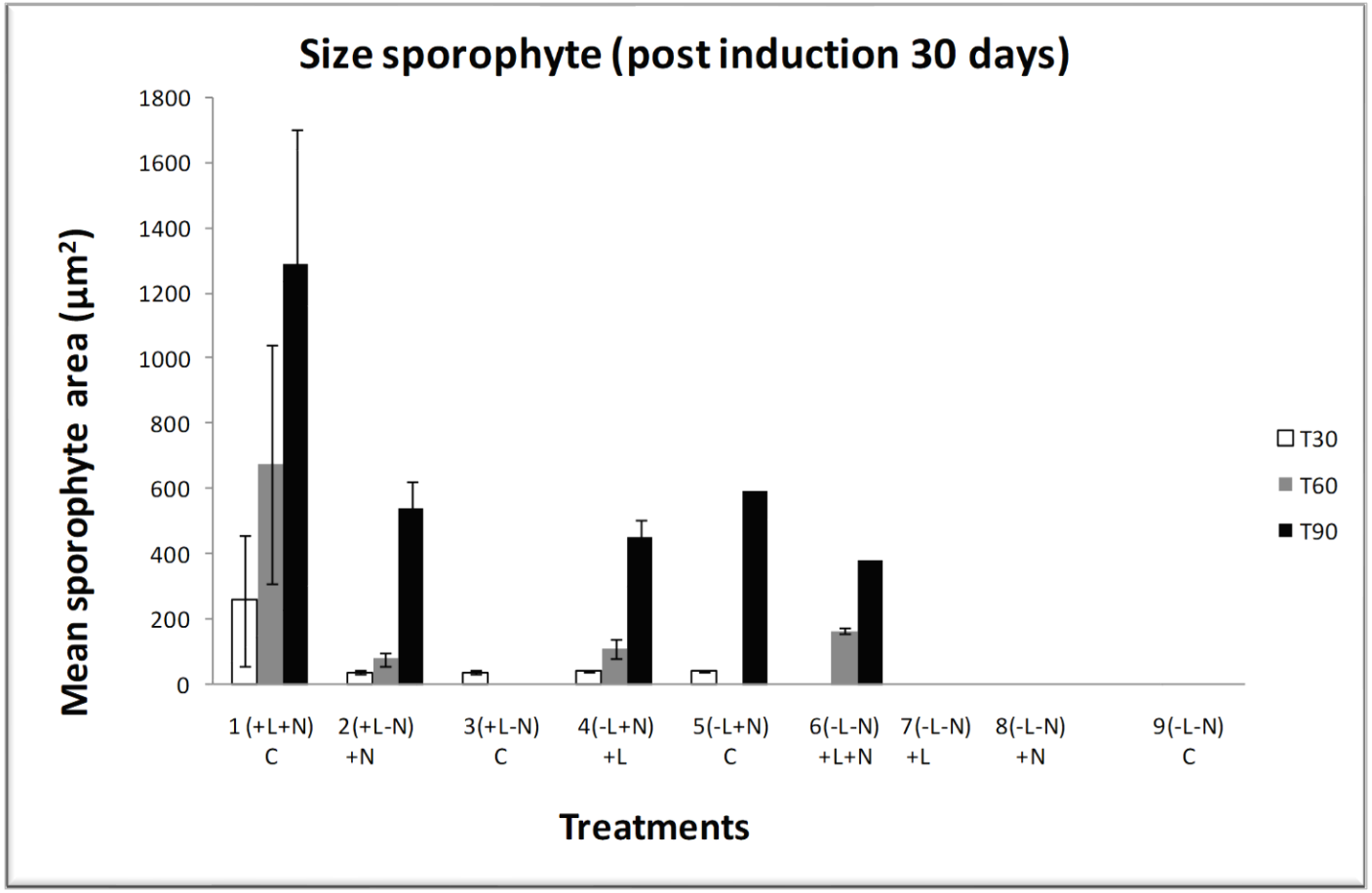


Kinlan et al. 2003, J. Phycol.



ARRESTED STAGES

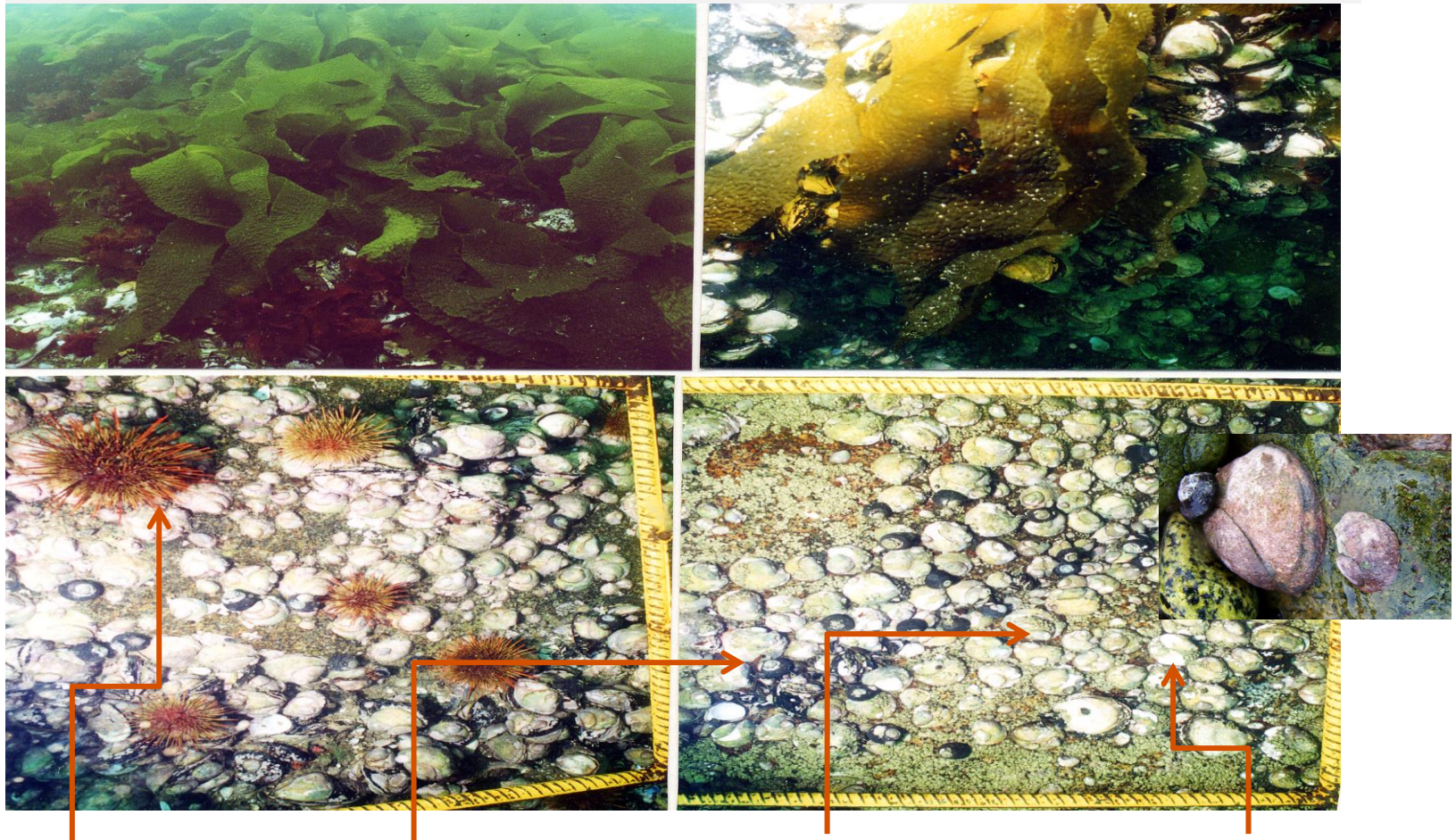
González, K. 2011 undergrad seminar.



ARRESTED STAGES

González, K. 2011 undergrad seminar.

How generations of *Macrocystis* are coupled?
How is the recruitment success explained?



Experimental Design

R = Naked rock with total exclusion

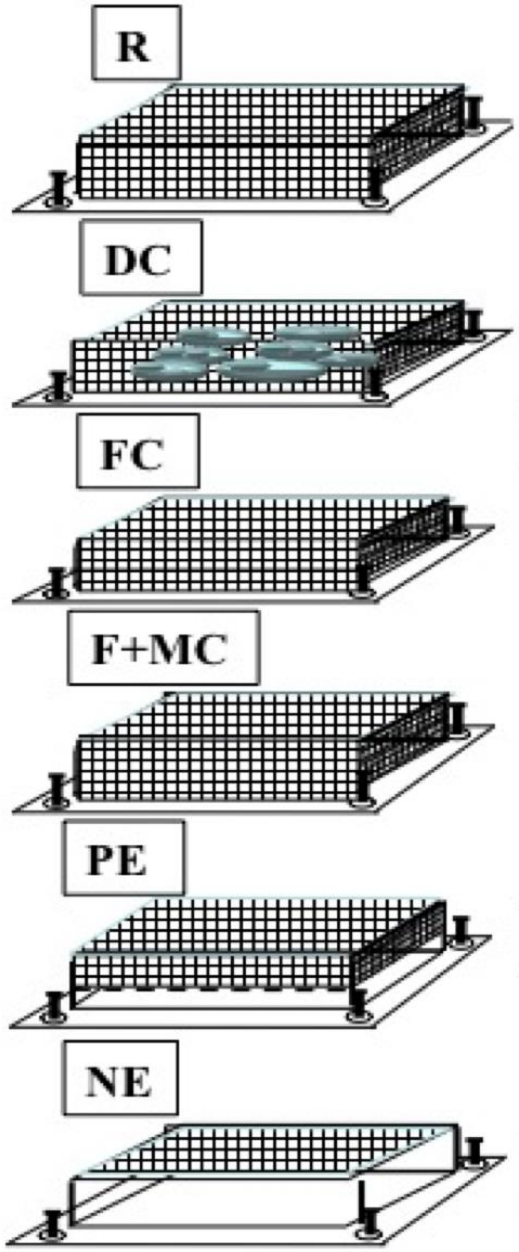
DC = Artificial substrate built with dead Crepipatella shells and total exclusion

FC = Substrate with females Crepipatella and total exclusion

F+MC = Substrate with females plus males Crepipatella and total exclusion

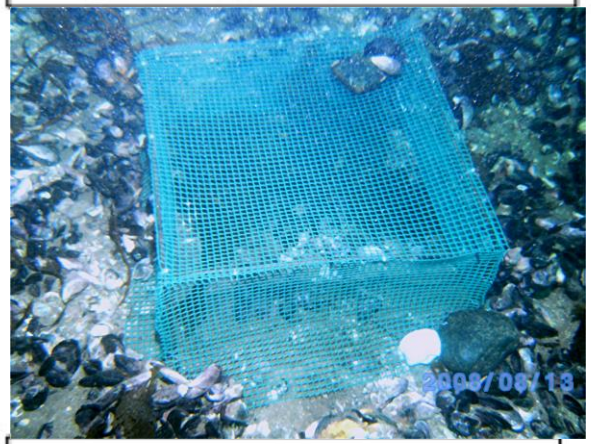
PE = Natural substrate with females plus males Crepipatella and a cage with partial exclusion

NE = Natural substrate with females plus males Crepipatella and a cage only with the roof (no exclusion)



Two study sites: (Metri e Ilque)
N= 5

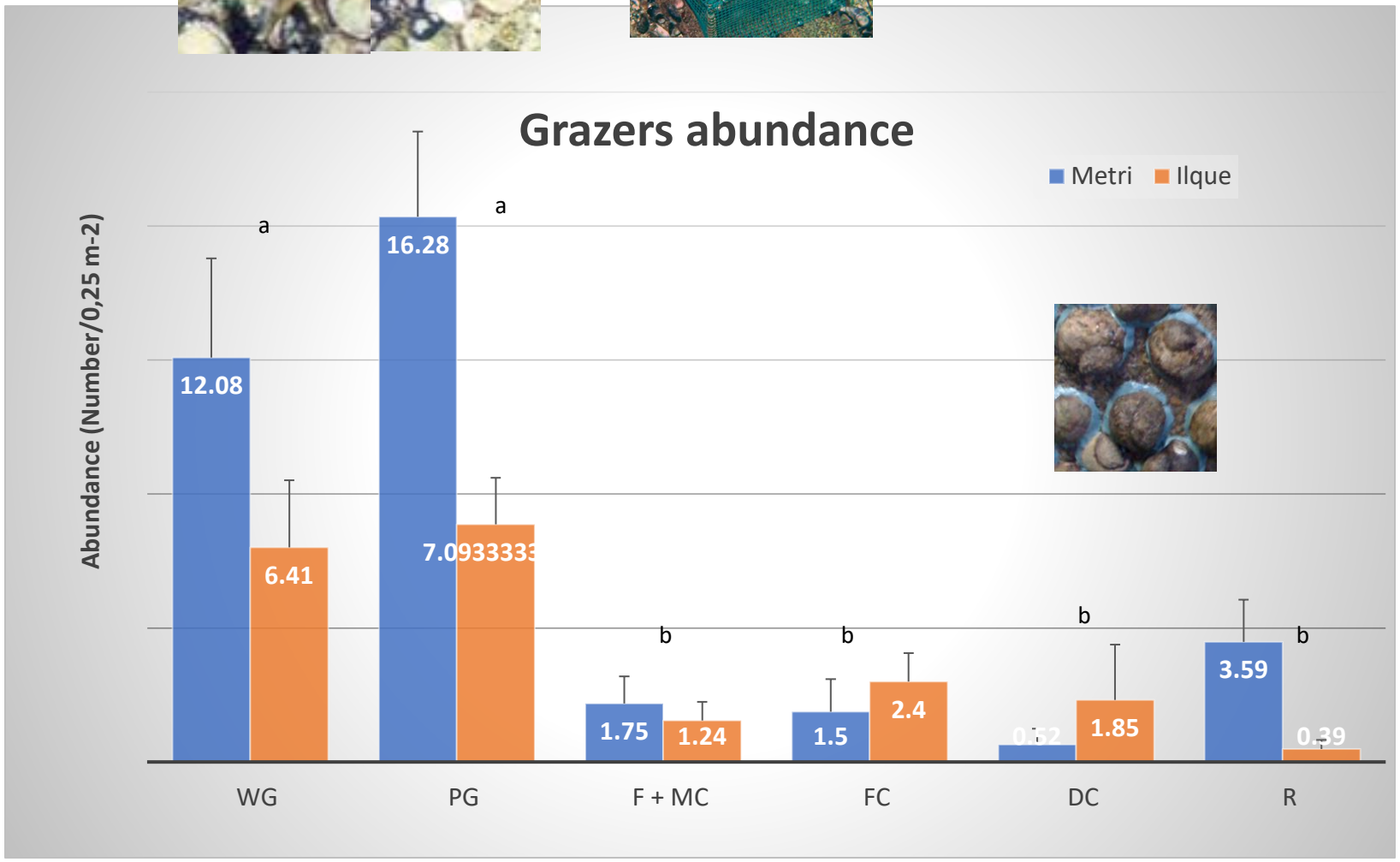
– *Tegula – Loxechinus – Arbacia*

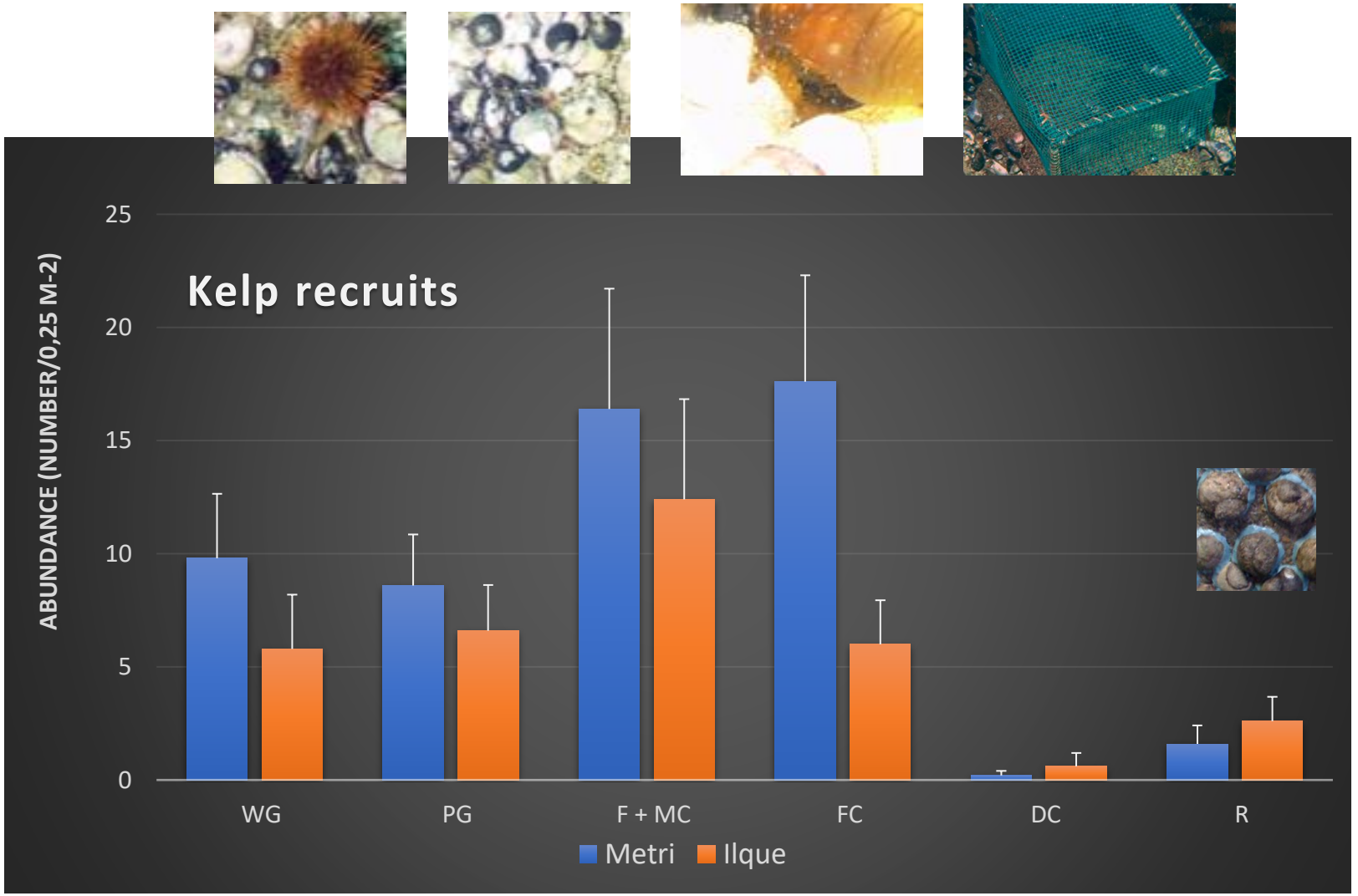


+*Tegula – Loxechinus – Arbacia*

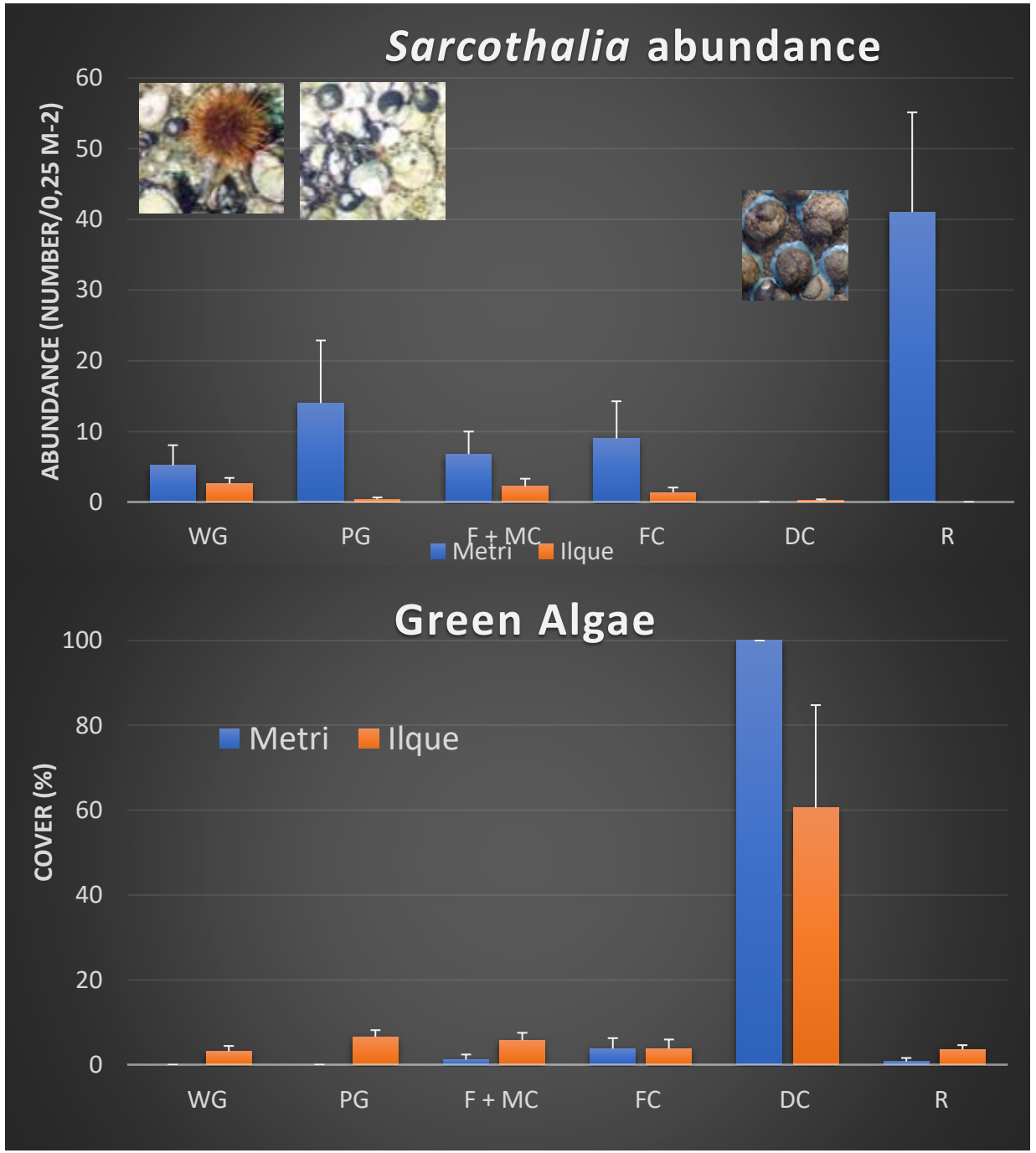
+*Tegula + Loxechinus + Arbacia*

Henríquez et al. 2011 JPhycol

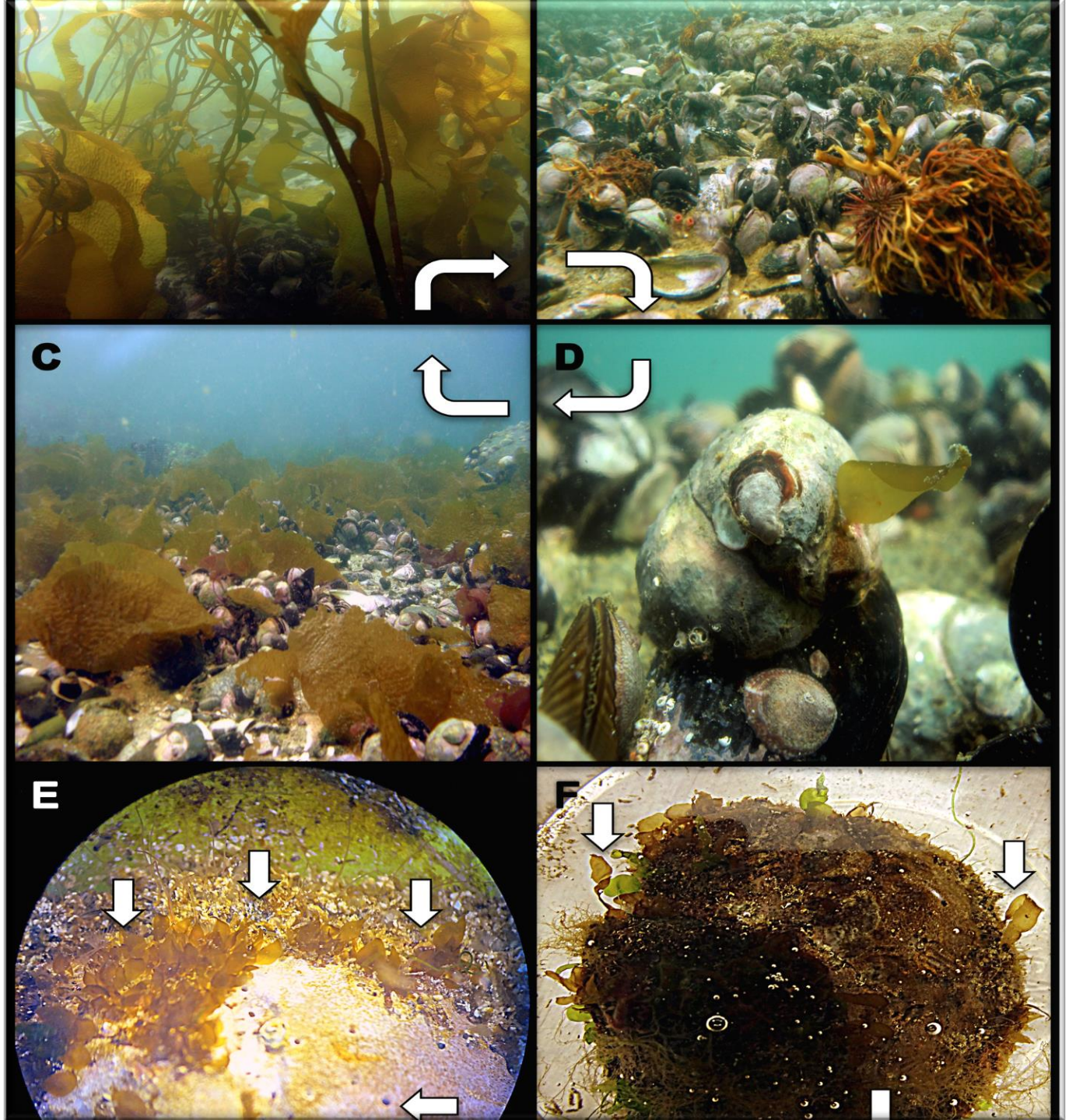

Grazers abundance
Metri
Ilque
Abundance (Number/0,25 m-2)
a
a
b
b
b
b
12.08
6.41
16.28
7.0933333
1.75
1.24
1.5
2.4
1.85
3.59
0.39
WG
PG
F + MC
FC
DC
R



Henríquez et al. 2011 JPhycol



Henríquez et al. 2011 JPhycol



Giant kelp Annual population Dynamic

✓ Other Mortality Factors?

Muth et al. 2016 Austral Ecology

- Sedimentation

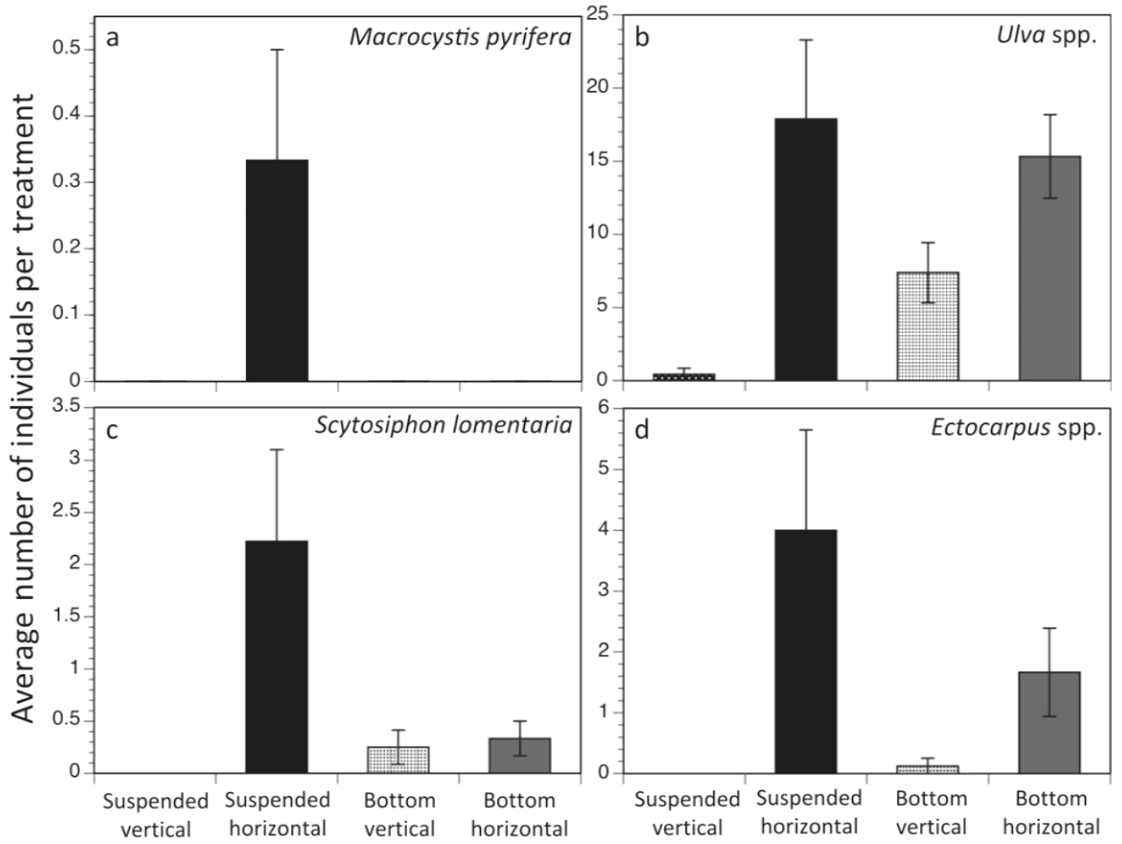
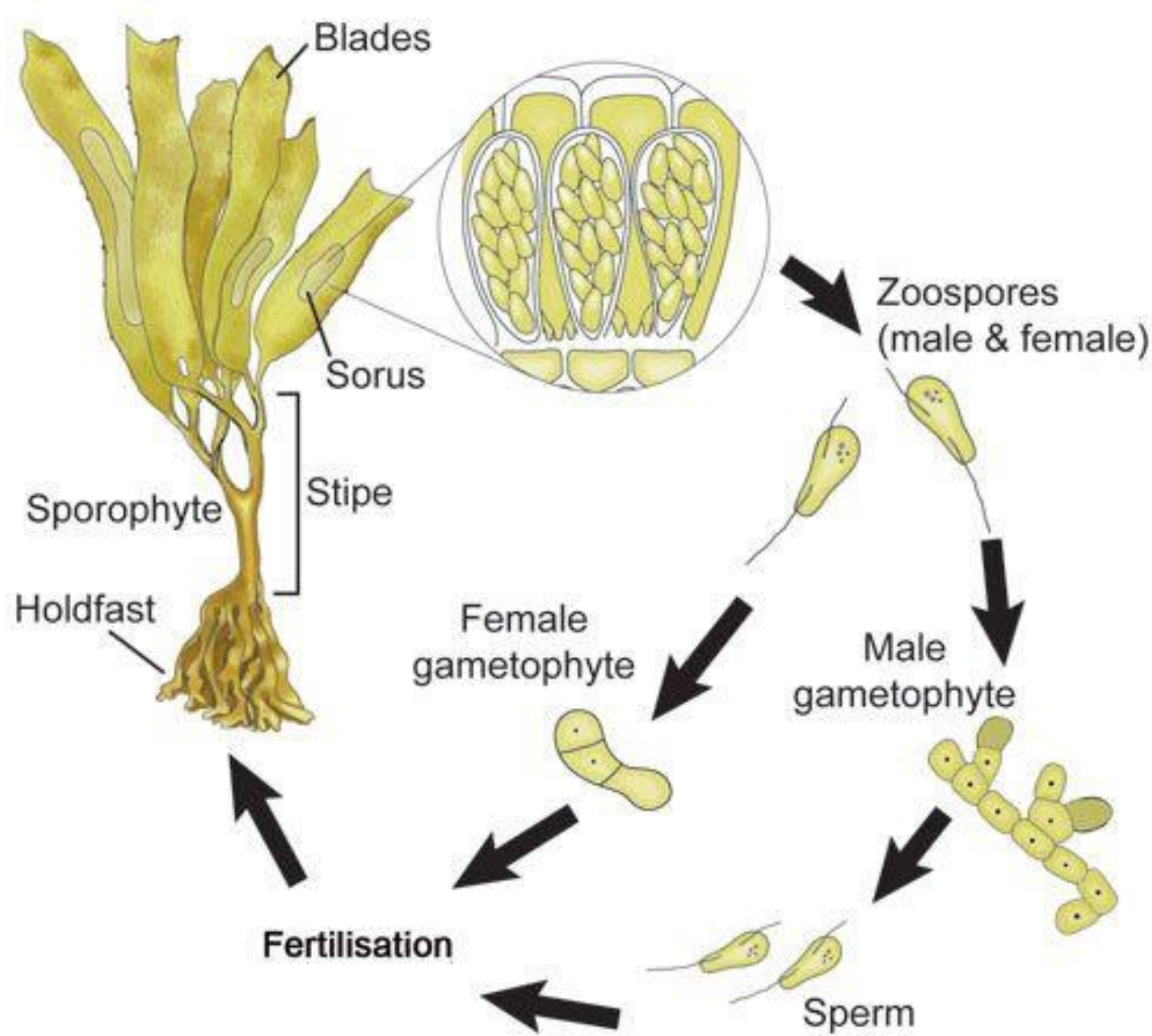
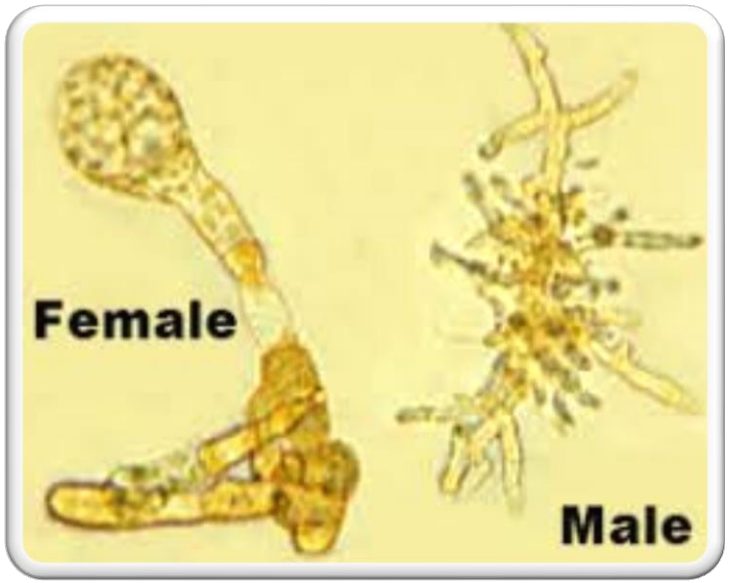


Fig. 1. Average recruitment of (a) *Macrocystis pyrifera*, (b) *Ulva* spp., (c) *Scytosiphon lomentaria*, and (d) *Ectocarpus* spp., per treatment (suspended vertical, suspended horizontal, bottom vertical and bottom horizontal). Error bars represent SE.

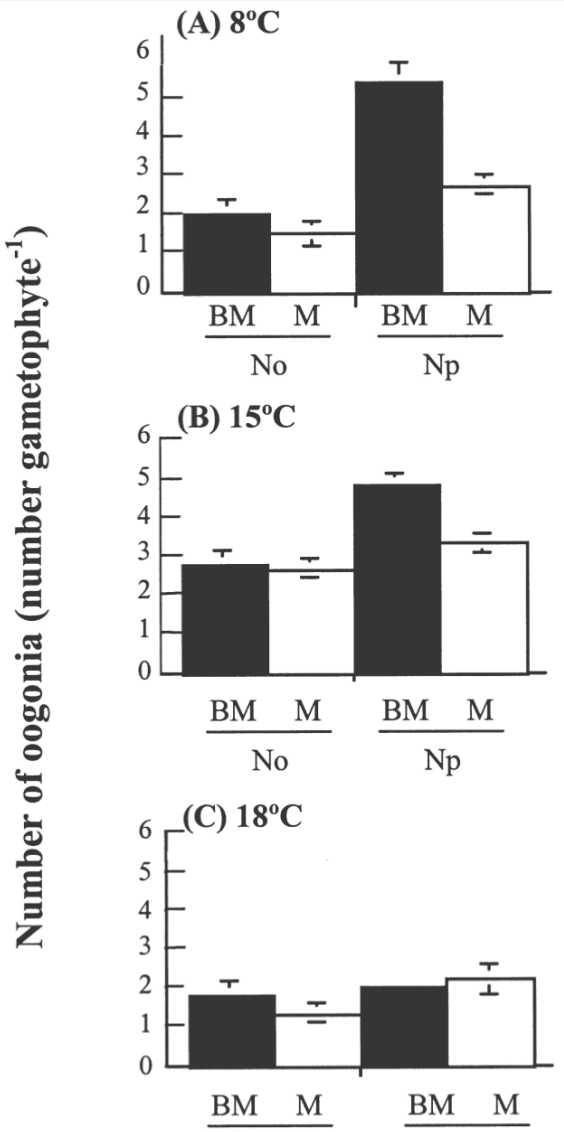
Kelp Life Cycle

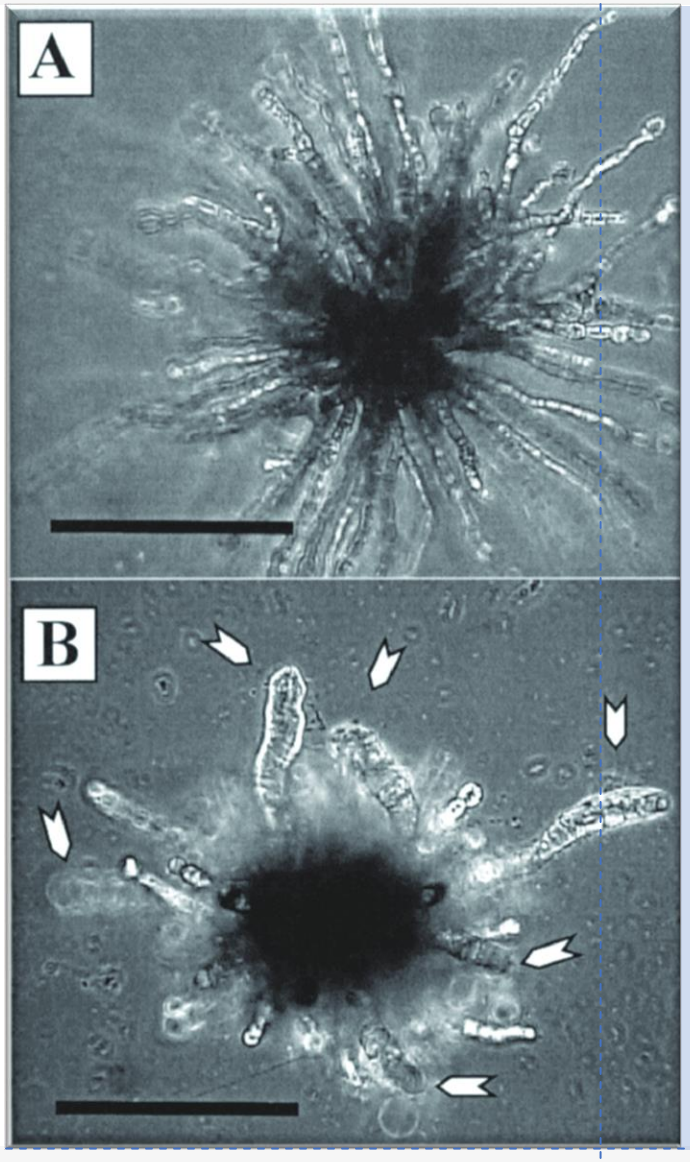




Multiple Oogonia

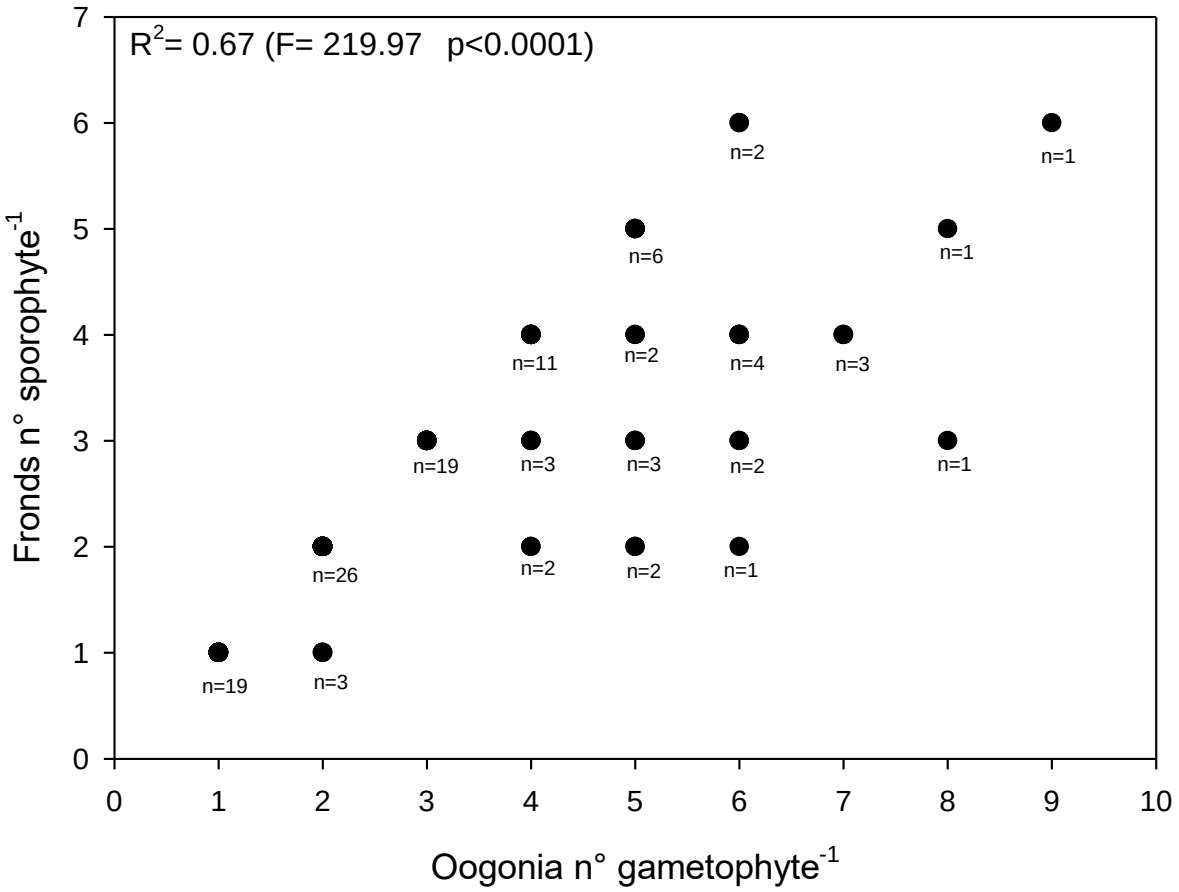
Effect of Temperature and Nutrients

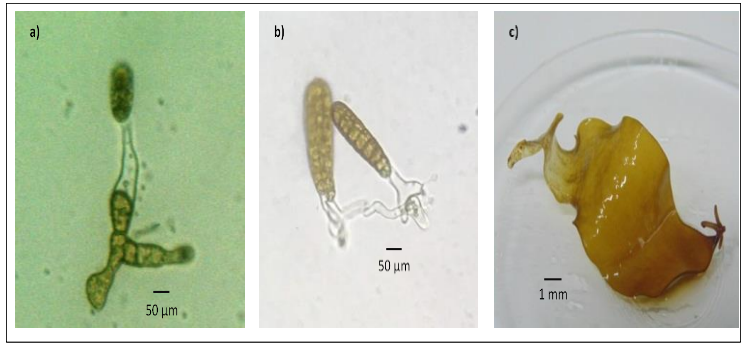


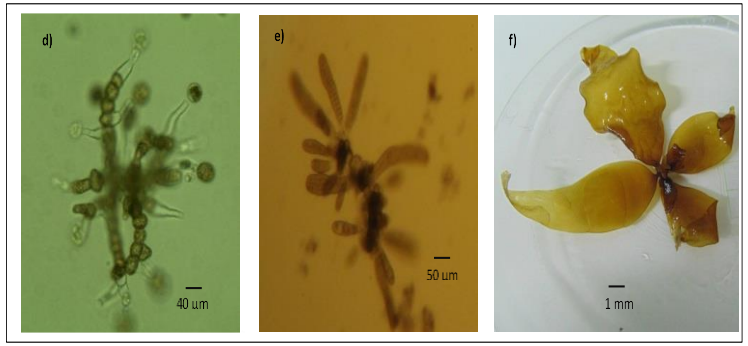


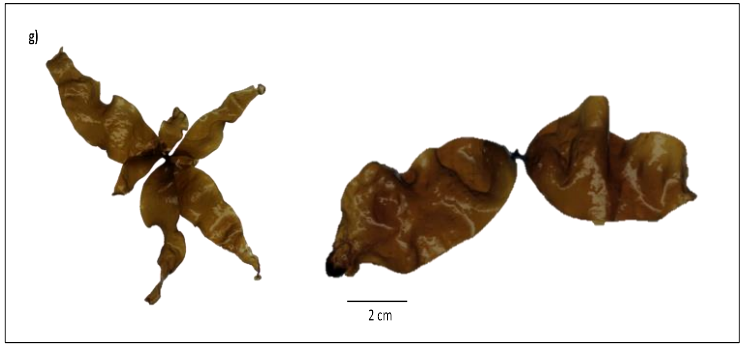
Muñoz et al., 2004. Rev. Chil. Hist. Nat.

Multiple frond Sporophytes









GENETICS

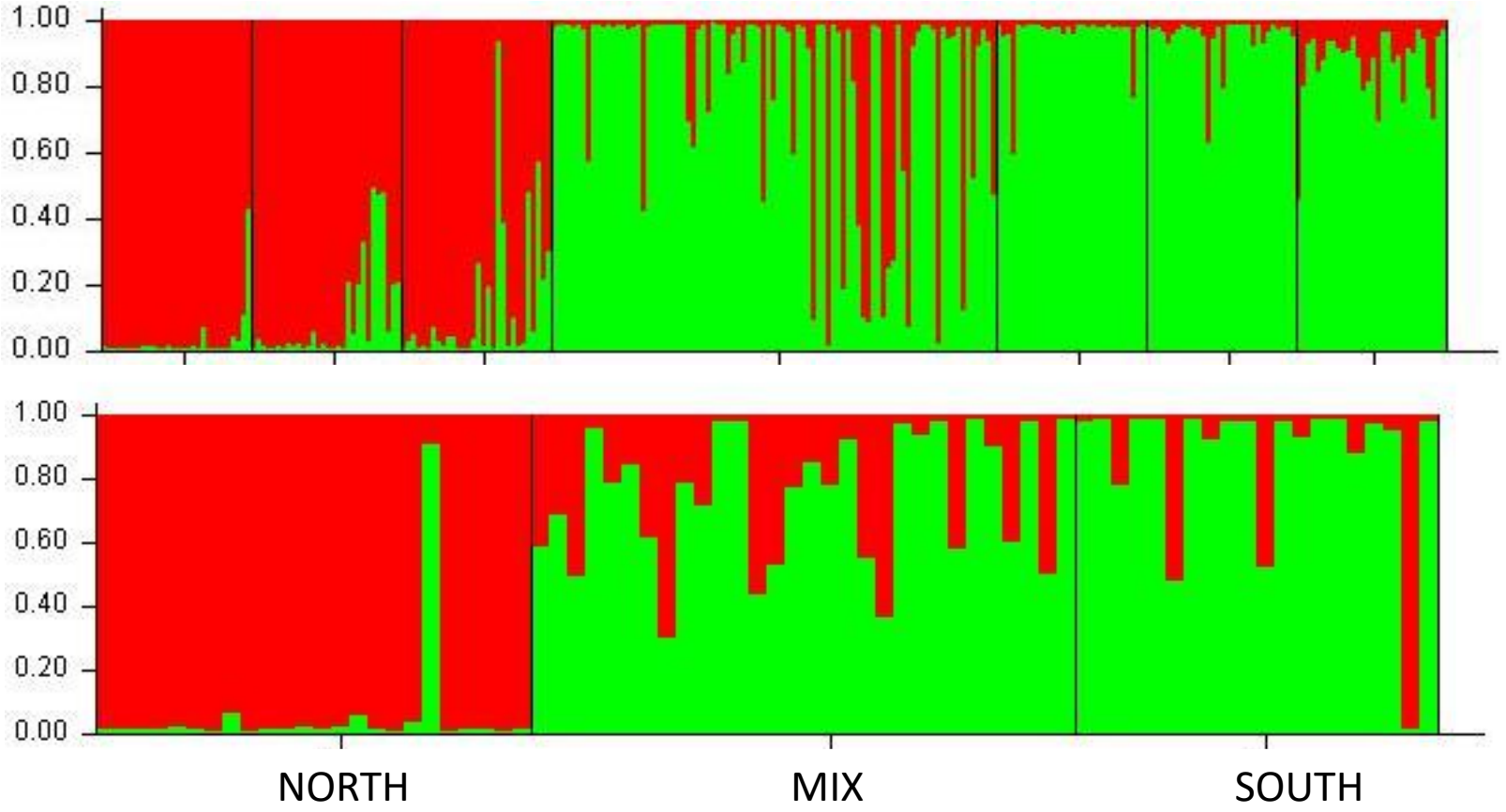
- All fronds of 12 sporophytes with multiple fronds were genotyped using ten microsatellites loci (Mp-BC-13, Mpy-11, Mpy-9, Mpy-14, Mpy-19, Mp-BC-25, Mp-BC-19, Mpy-7, Mp-BC-18, Mpy-17) available for *Macrocystis pyrifera* following Alberto et al.

Individual label	Number of sporophytes	Number of MLGs
1	3	3
2	4	4
3	5	5

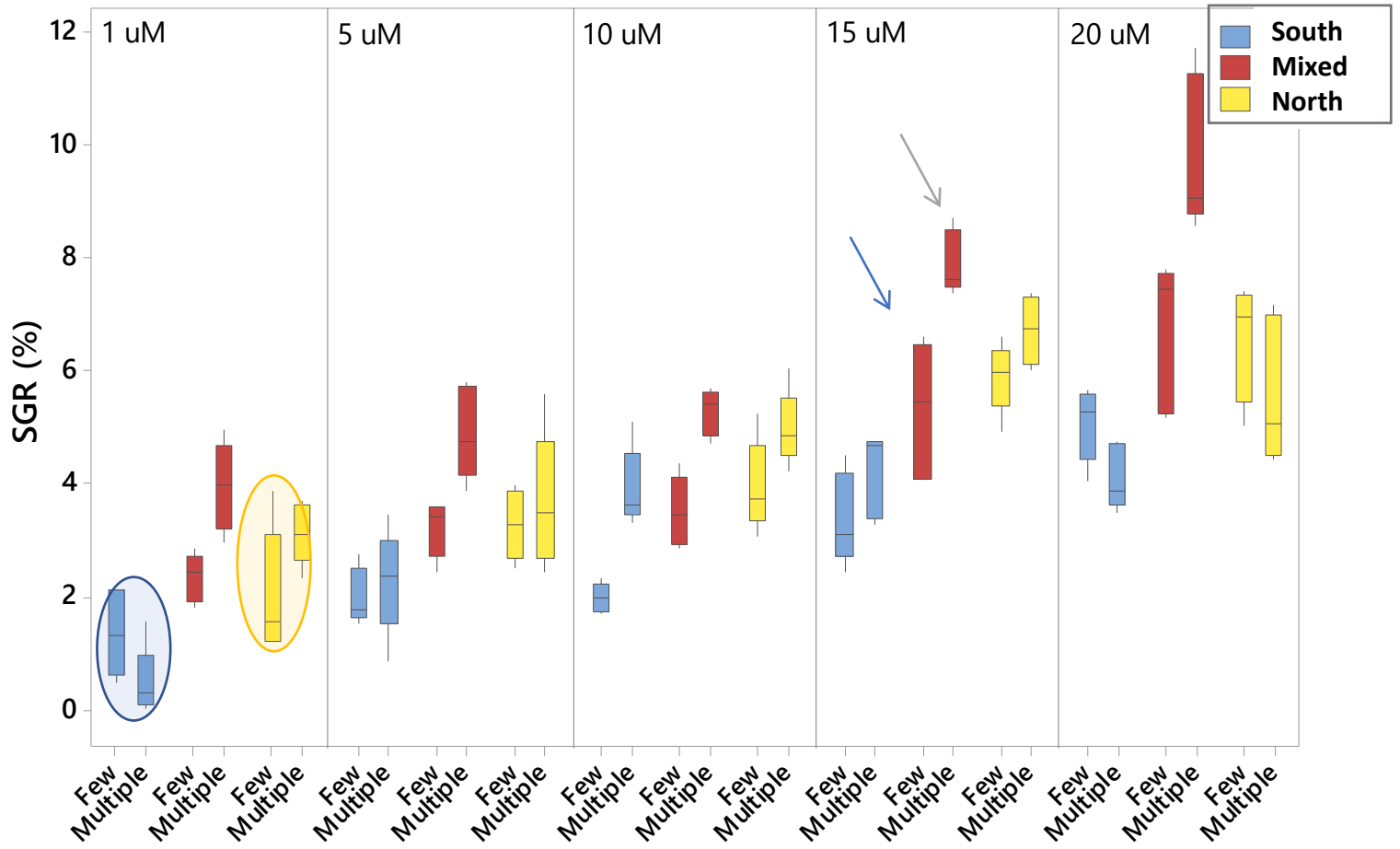
Buschmann et al. 2020. Algal Research

Giant Kelp Populations Interfertility

- Unpublished data



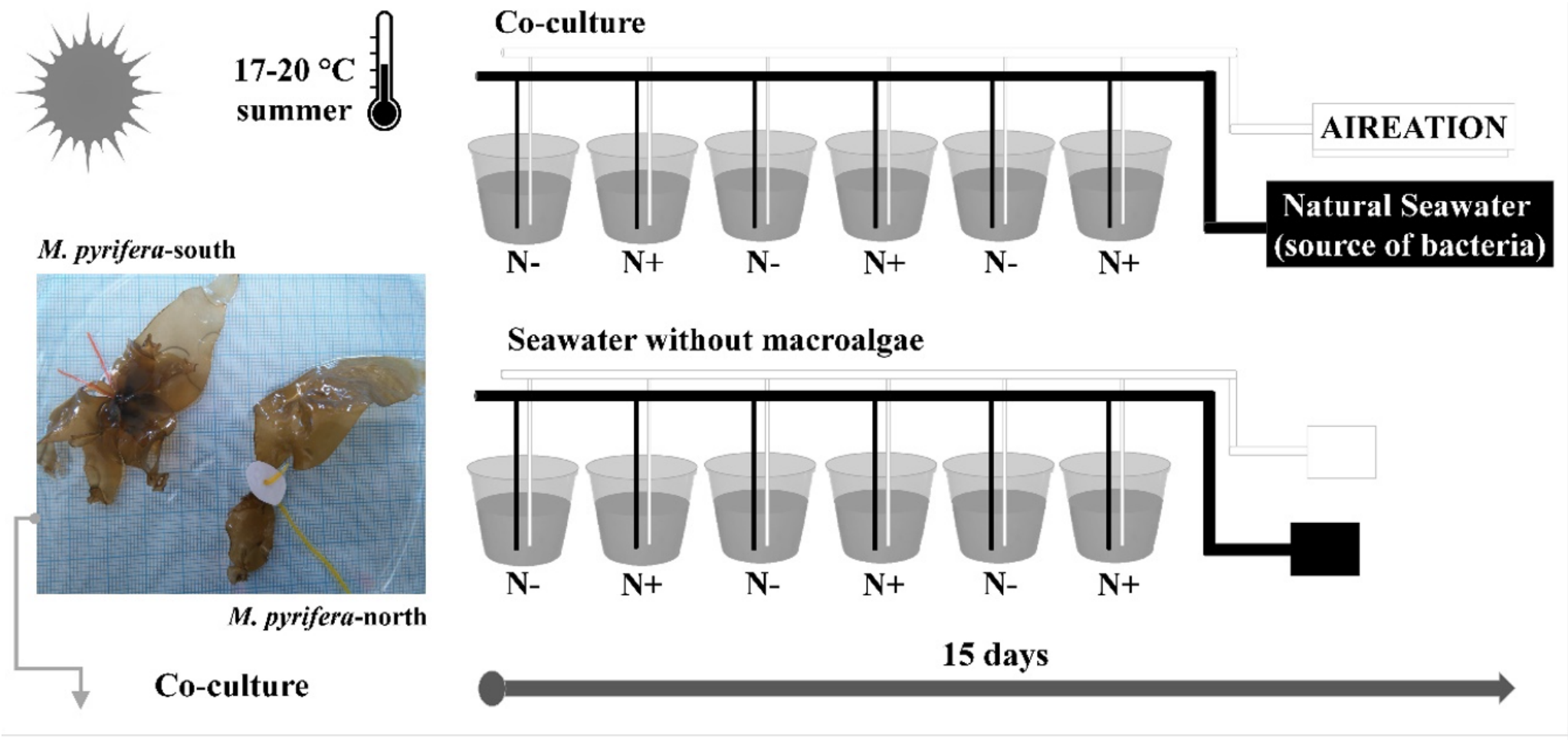
NITROGEN - LIMITATION



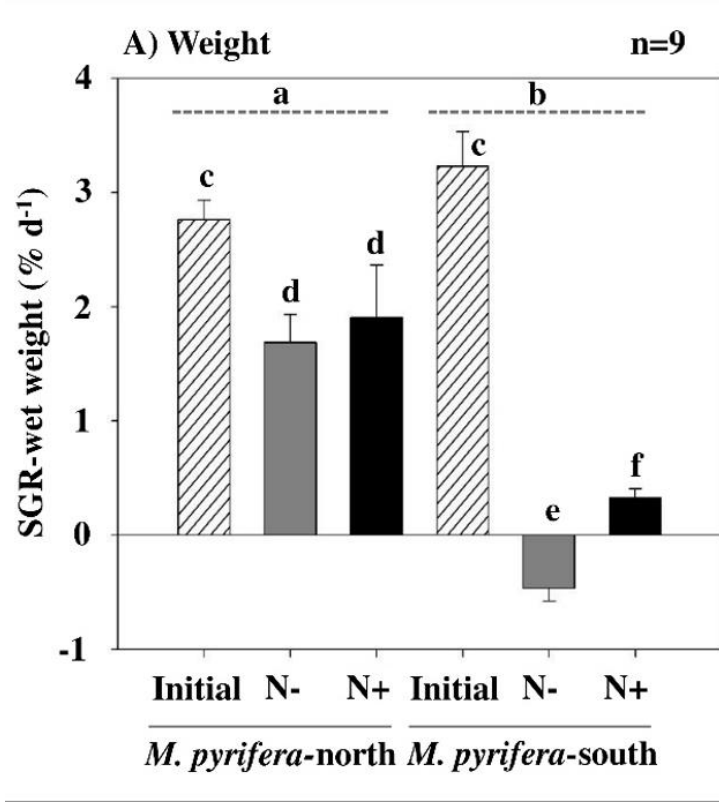
Source	DF	Adj SS	Adj MS	F-Value	P-Value
NO_3* Population* morphotype	**8**	**18,423**	**2,3028**	**3,45**	**0,001**

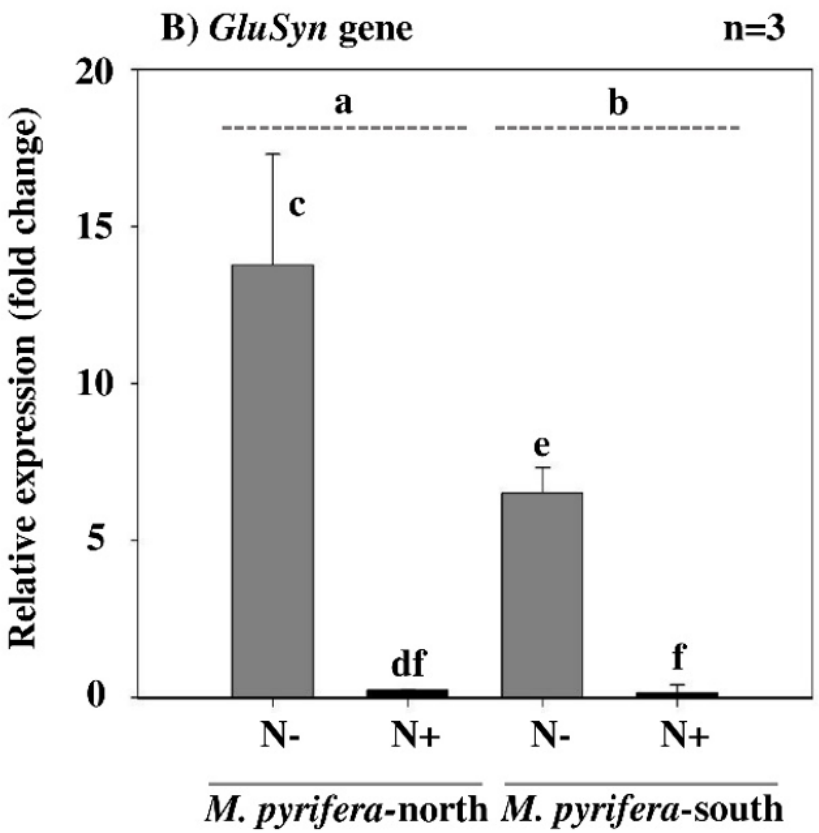
Kelp –bacteria interaction

- Florez et al. J. Phycol (2021)

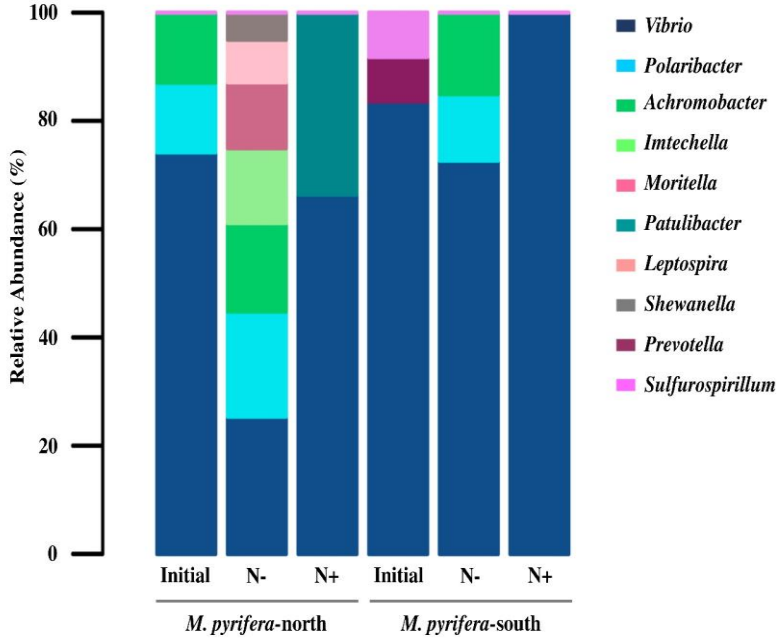


Kelp –bacteria interaction





C) Relative abundance of *nrfA* bacterial genera



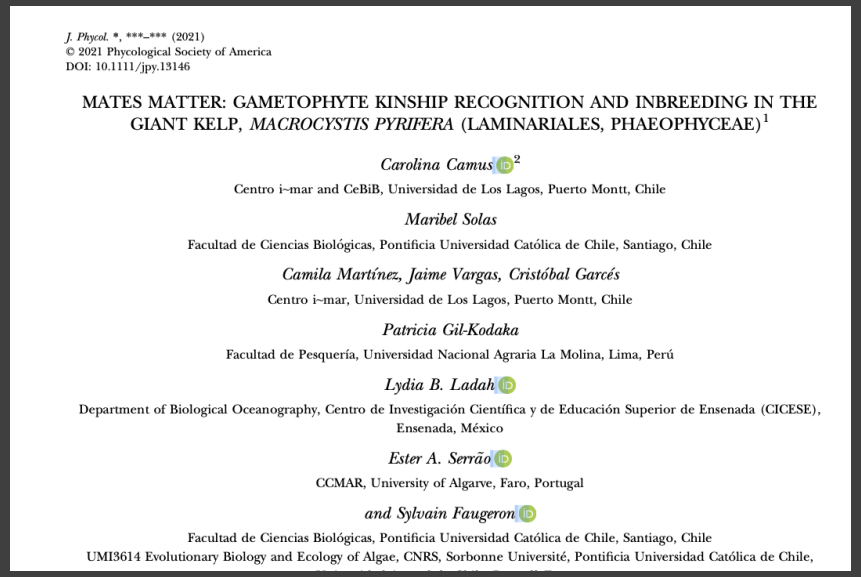
Florez et al. J. Phycol (2021)

Other Relevant Traits: Mates Matter

THE INCREASED FECUNDITY COMPENSATED FOR THE REDUCED FERTILITY, LEADING TO A STABLE OVERALL REPRODUCTIVE OUTPUT.

INBREEDING ALSO AFFECTED MORPHOLOGICAL TRAITS OF JUVENILE SPOROPHYTES, BUT NOT THEIR THERMAL TOLERANCE.

THE MALE–FEMALE KINSHIP EFFECT WAS STRONGER IN HIGH-LATITUDE POPULATIONS, SUGGESTING THAT FEMALES FROM LOW-LATITUDE MARGINAL POPULATIONS MIGHT HAVE EVOLVED TO MATE WITH ANY MALE GAMETE TO GUARANTEE REPRODUCTIVE SUCCESS



J. Phycol. *, ***–*** (2021)

DOI: 10.1111/jpy.13146

MATES MATTER: GAMETOPHYTE KINSHIP RECOGNITION AND INBREEDING IN THE GIANT KELP, *MACROCYSTIS PYRIFERA* (LAMINARIALES, PHAEOPHYCEAE)[1]

Carolina Camus[2]

Centro i~mar and CeBiB, Universidad de Los Lagos, Puerto Montt, Chile

Maribel Solas

Facultad de Ciencias Biológicas, Pontificia Universidad Católica de Chile, Santiago, Chile

Camila Martínez, Jaime Vargas, Cristóbal Garcés

Centro i~mar, Universidad de Los Lagos, Puerto Montt, Chile

Patricia Gil-Kodaka

Facultad de Pesquería, Universidad Nacional Agraria La Molina, Lima, Perú

Lydia B. Ladah

Department of Biological Oceanography, Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE), Ensenada, México

Ester A. Serrão

CCMAR, University of Algarve, Faro, Portugal

and Sylvain Faugeron

Facultad de Ciencias Biológicas, Pontificia Universidad Católica de Chile, Santiago, Chile
UMI3614 Evolutionary Biology and Ecology of Algae, CNRS, Sorbonne Université, Pontificia Universidad Católica de Chile,

Unwrapping the ecological relevance of microscopic stages

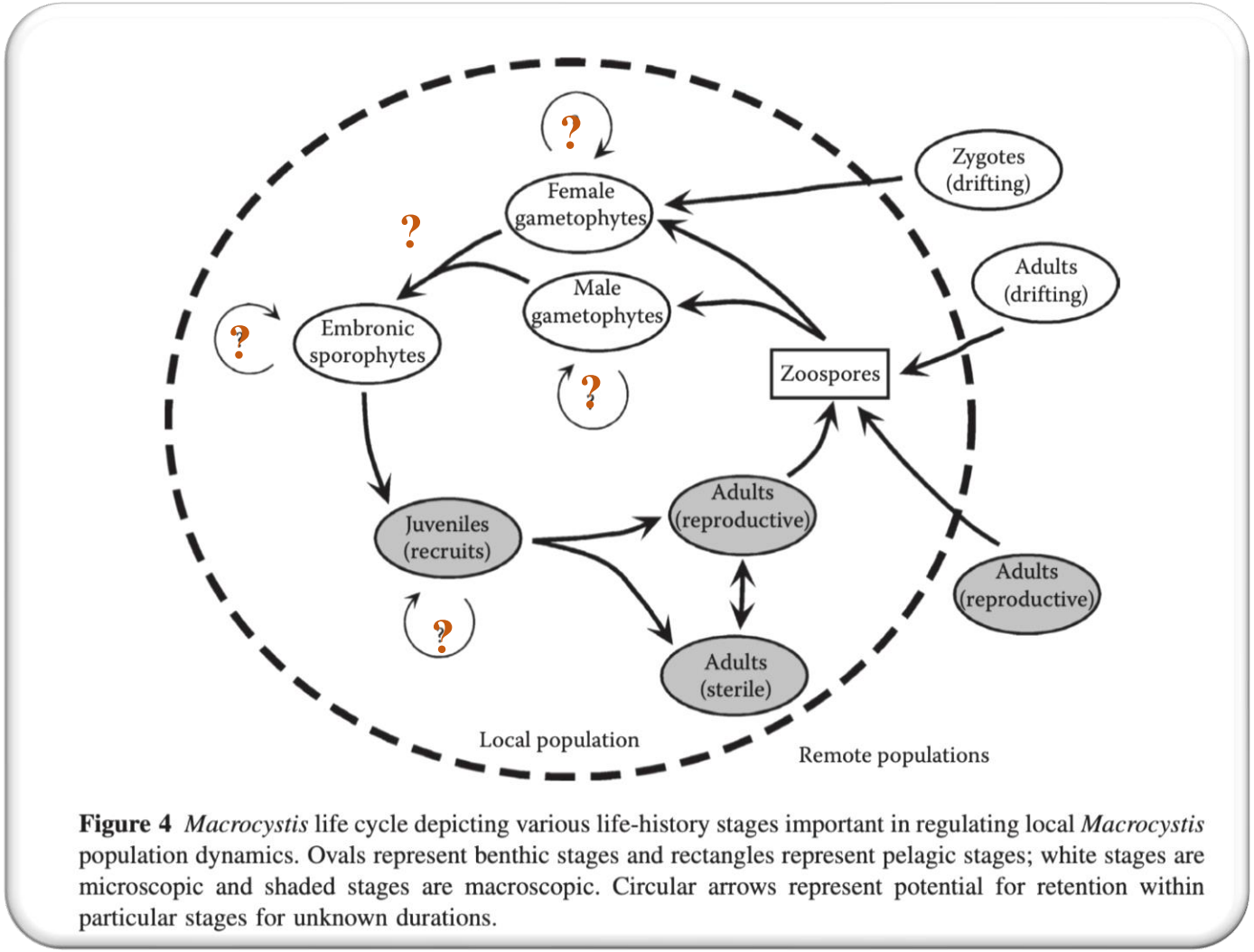
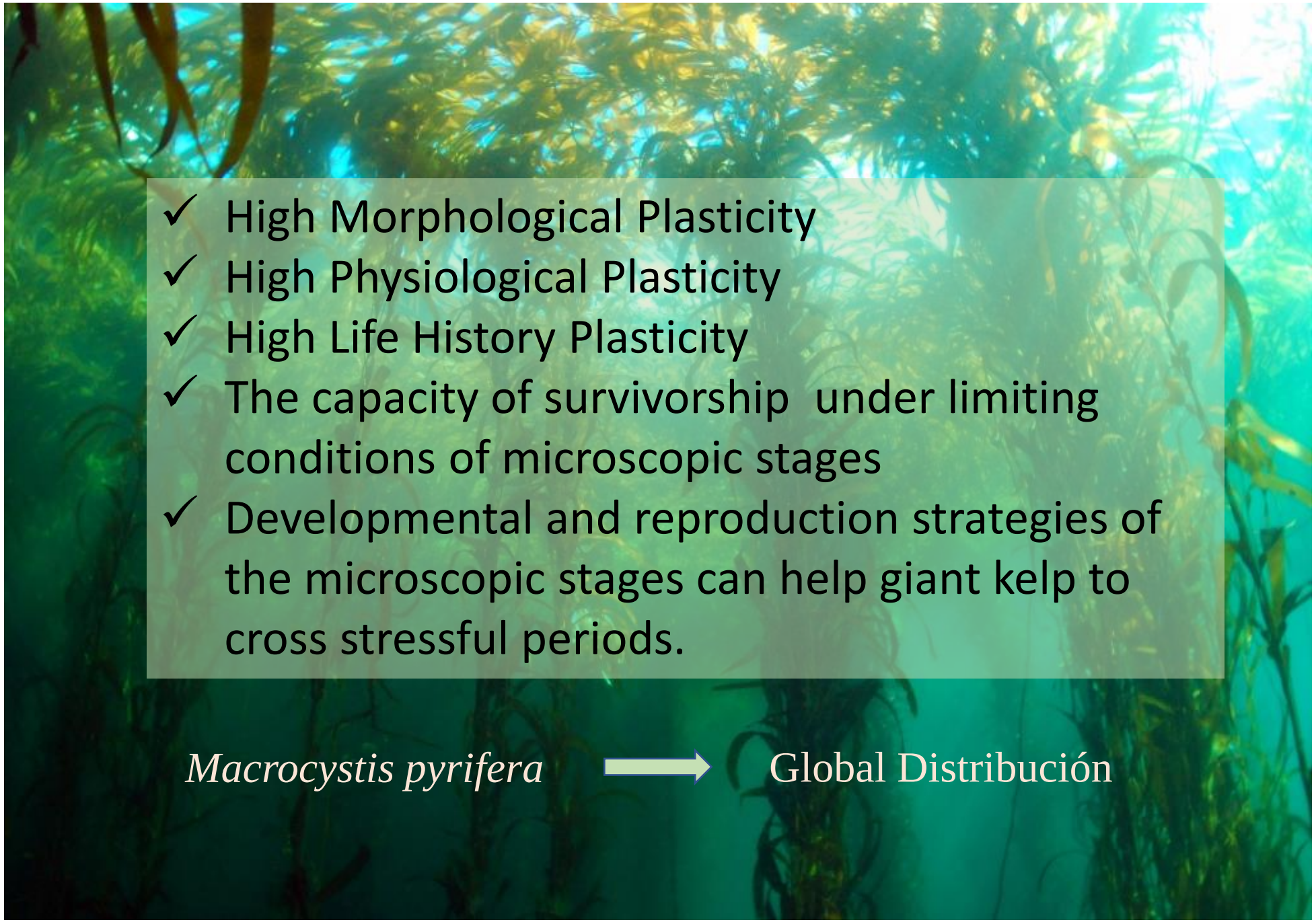


Figure 4 *Macrocystis* life cycle depicting various life-history stages important in regulating local *Macrocystis* population dynamics. Ovals represent benthic stages and rectangles represent pelagic stages; white stages are microscopic and shaded stages are macroscopic. Circular arrows represent potential for retention within particular stages for unknown durations.

Graham, Vásquez & Buschmann 2017 OMBAR


✓ High Morphological Plasticity
✓ High Physiological Plasticity
✓ High Life History Plasticity
✓ The capacity of survivorship under limiting conditions of microscopic stages
✓ Developmental and reproduction strategies of the microscopic stages can help giant kelp to cross stressful periods.
Macrocystis pyrifera
Global Distribución

- CONCLUSION -

Understanding developmental strategies of microscopic stages of kelp populations are critical for their conservation, especially under variable environmental scenarios

1

Long-term (months) survival of microscopic stages in the field, allows to couple time-separated sporophytic cohorts in annual kelp populations

2

Microscopic stages and early sporophyte recruits can be affected by herbivores and algal competitors

3

Microscopic stages can have complex fertilization strategies, allowing to respond to environmental stress conditions

Thank You!

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- Karina Villegas
- Robinson Altamirano
- José Luis Kappes
- July Florez

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