Zooplankton and biogeochemical cycles: Who is conducting the orchestra?

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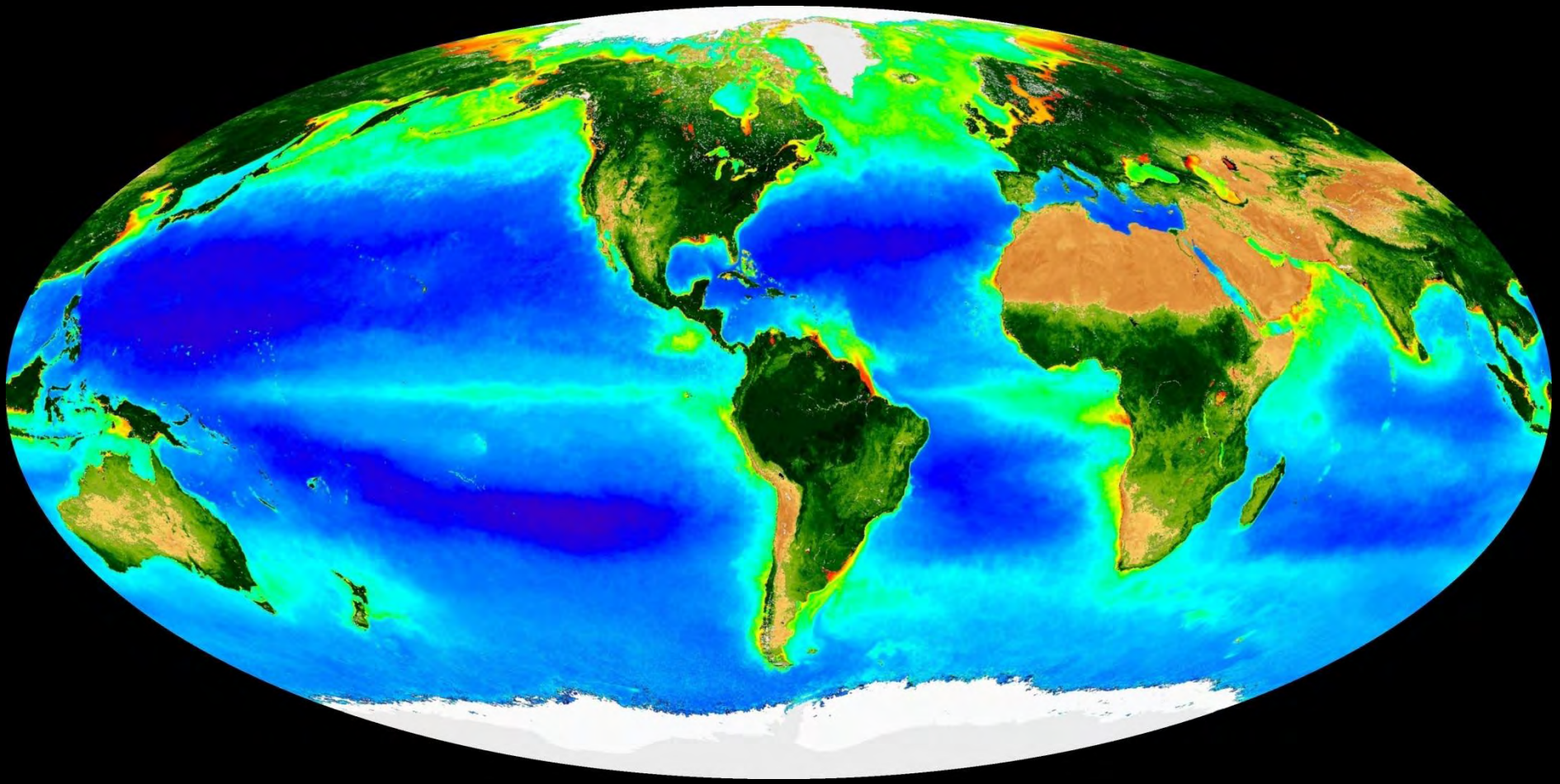
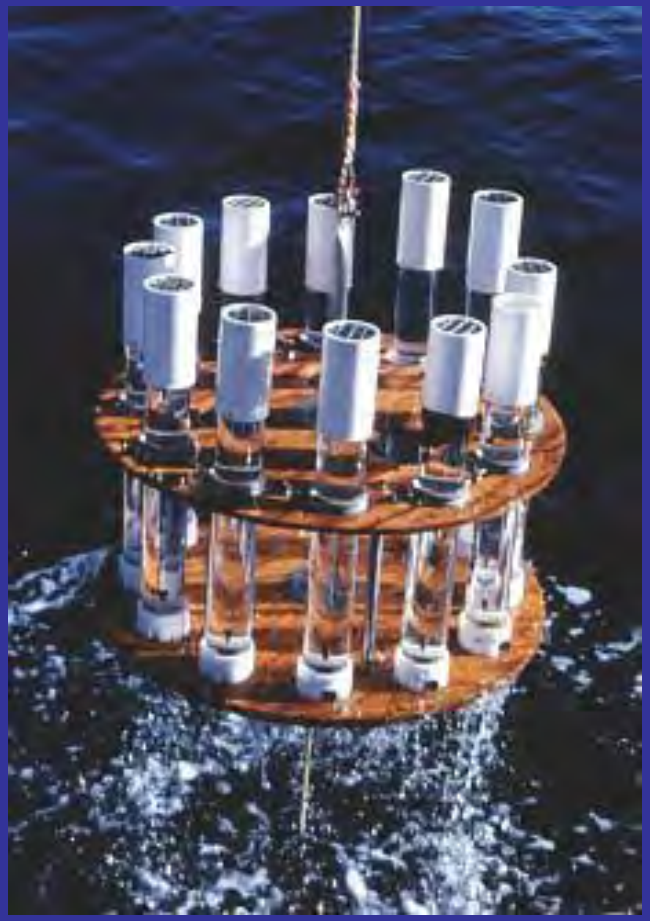
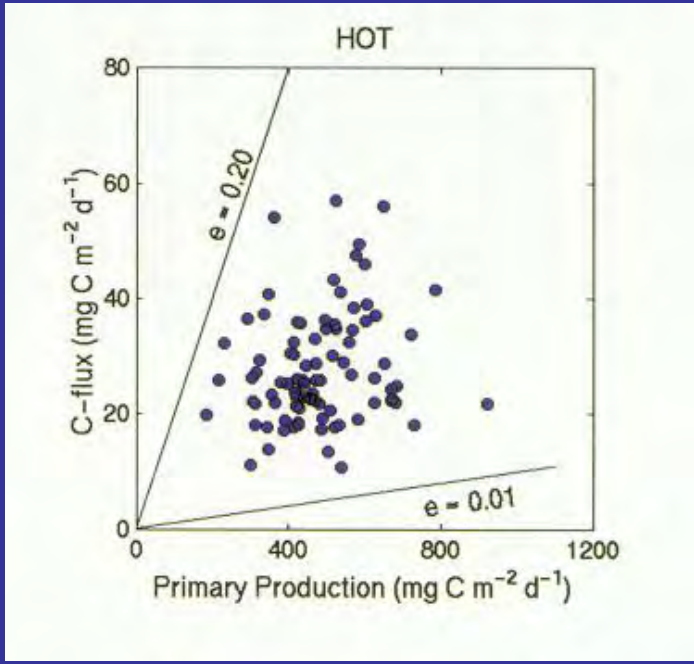
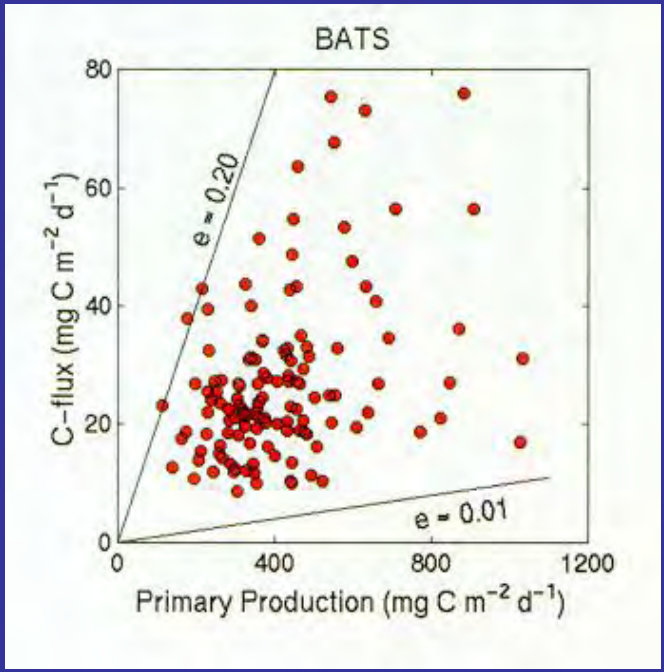
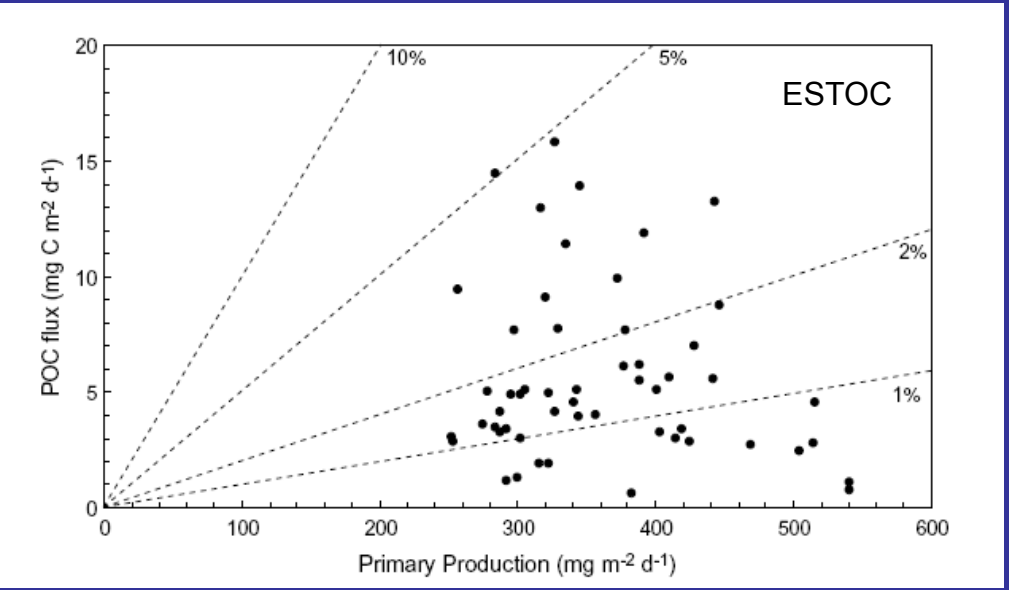


Gravitational Flux

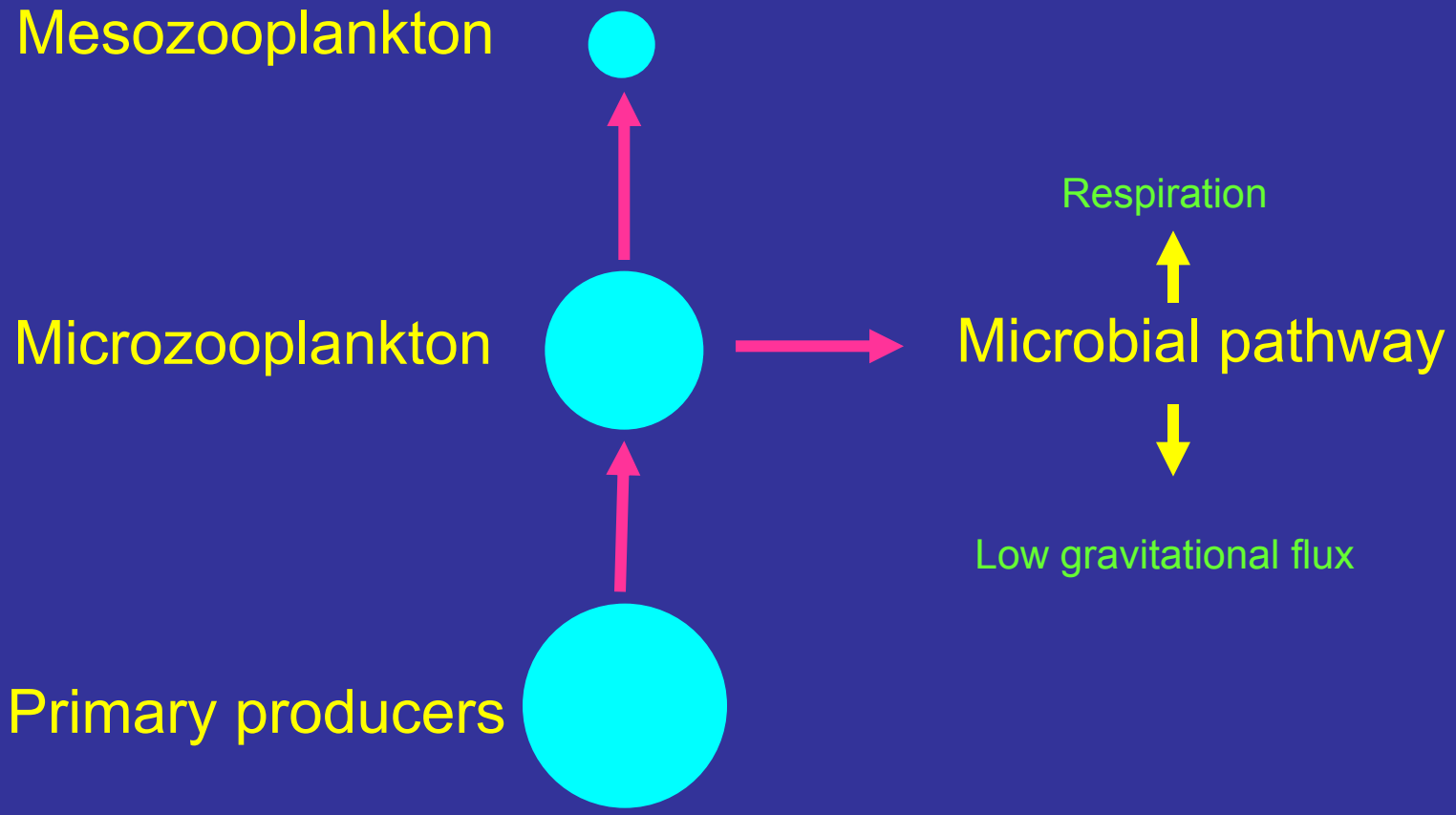




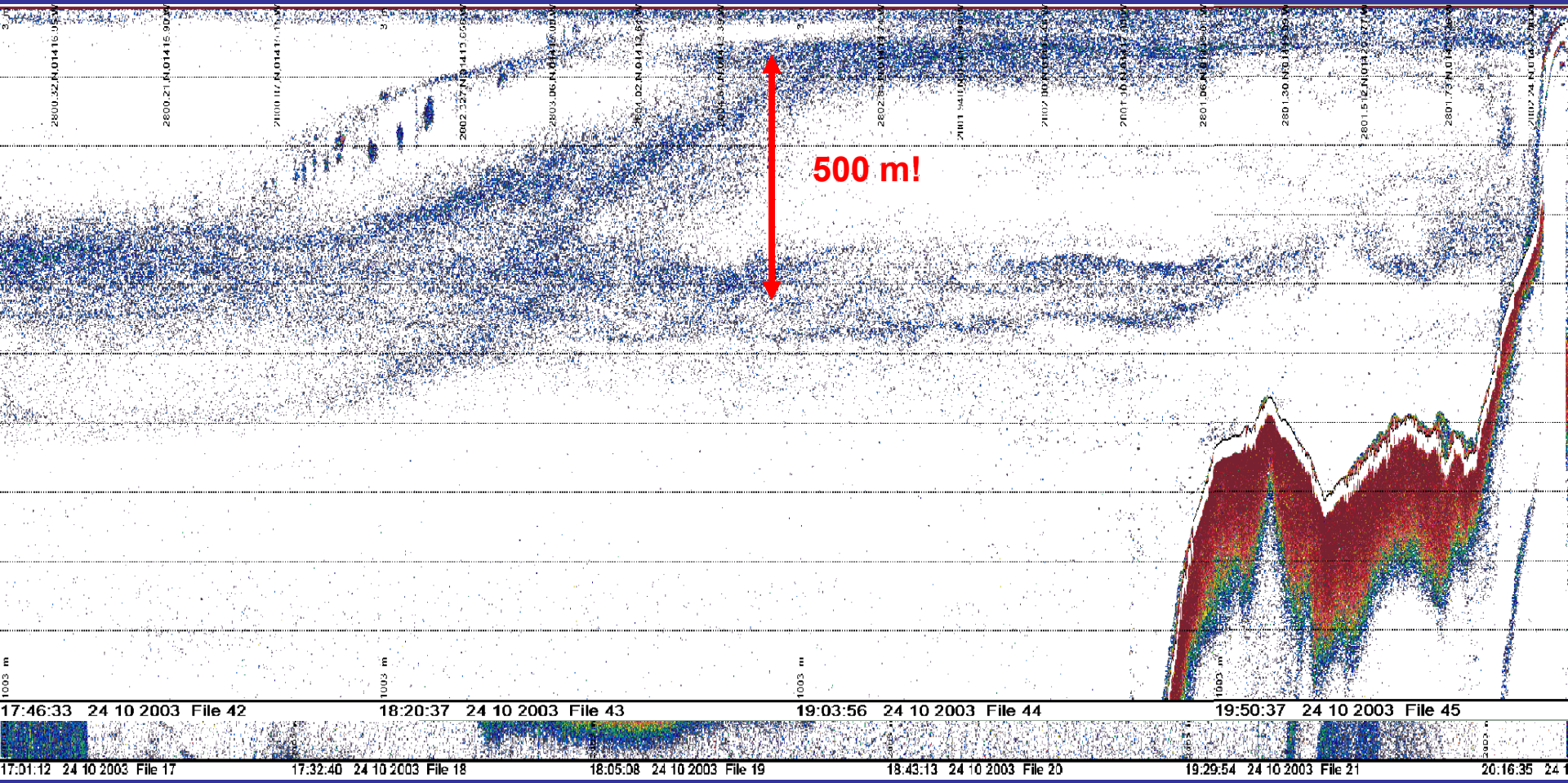




Neuer et al. (2007)

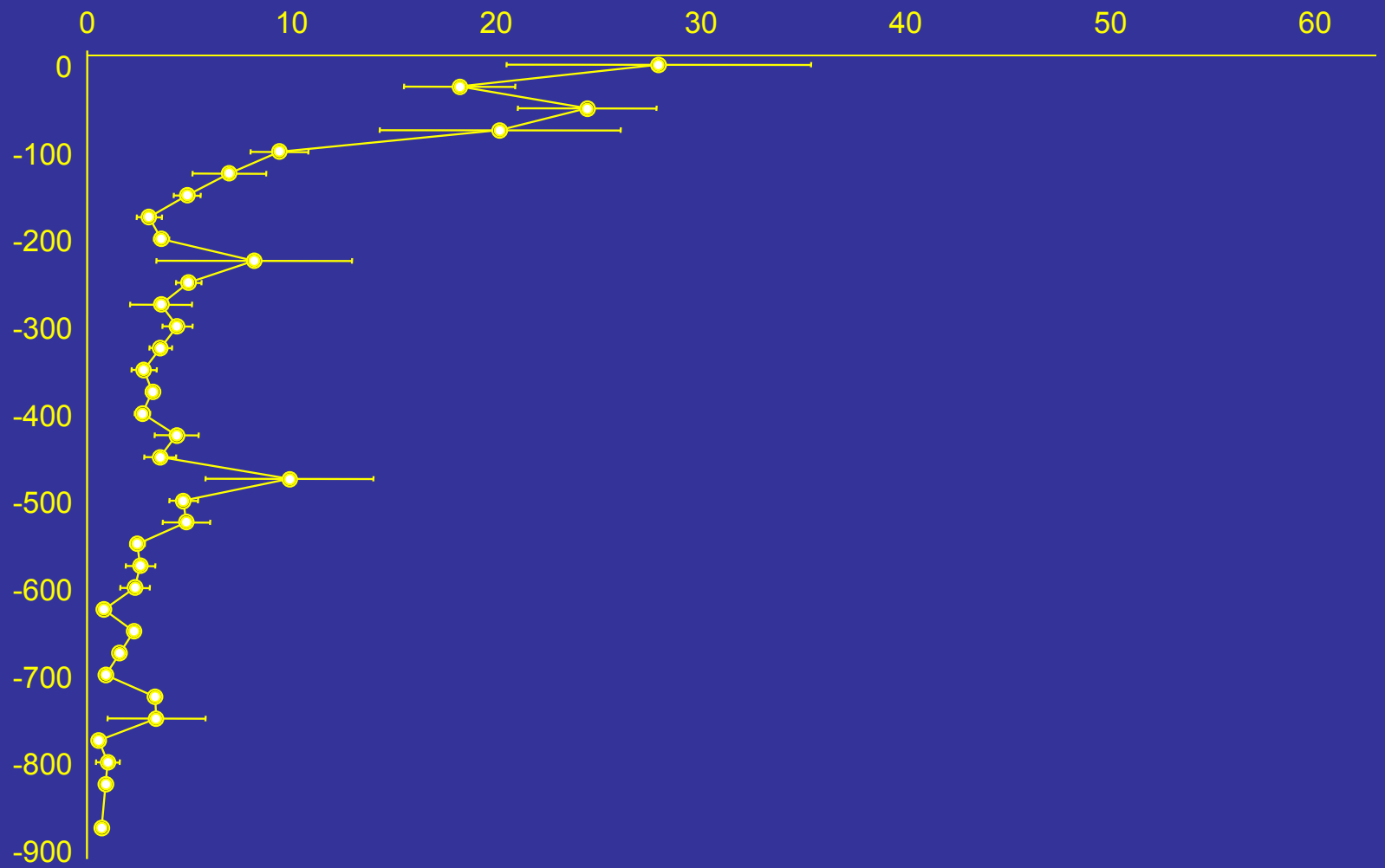

Mesozooplankton
Microzooplankton
Primary producers
Respiration
Microbial pathway
Low gravitational flux

Active Flux



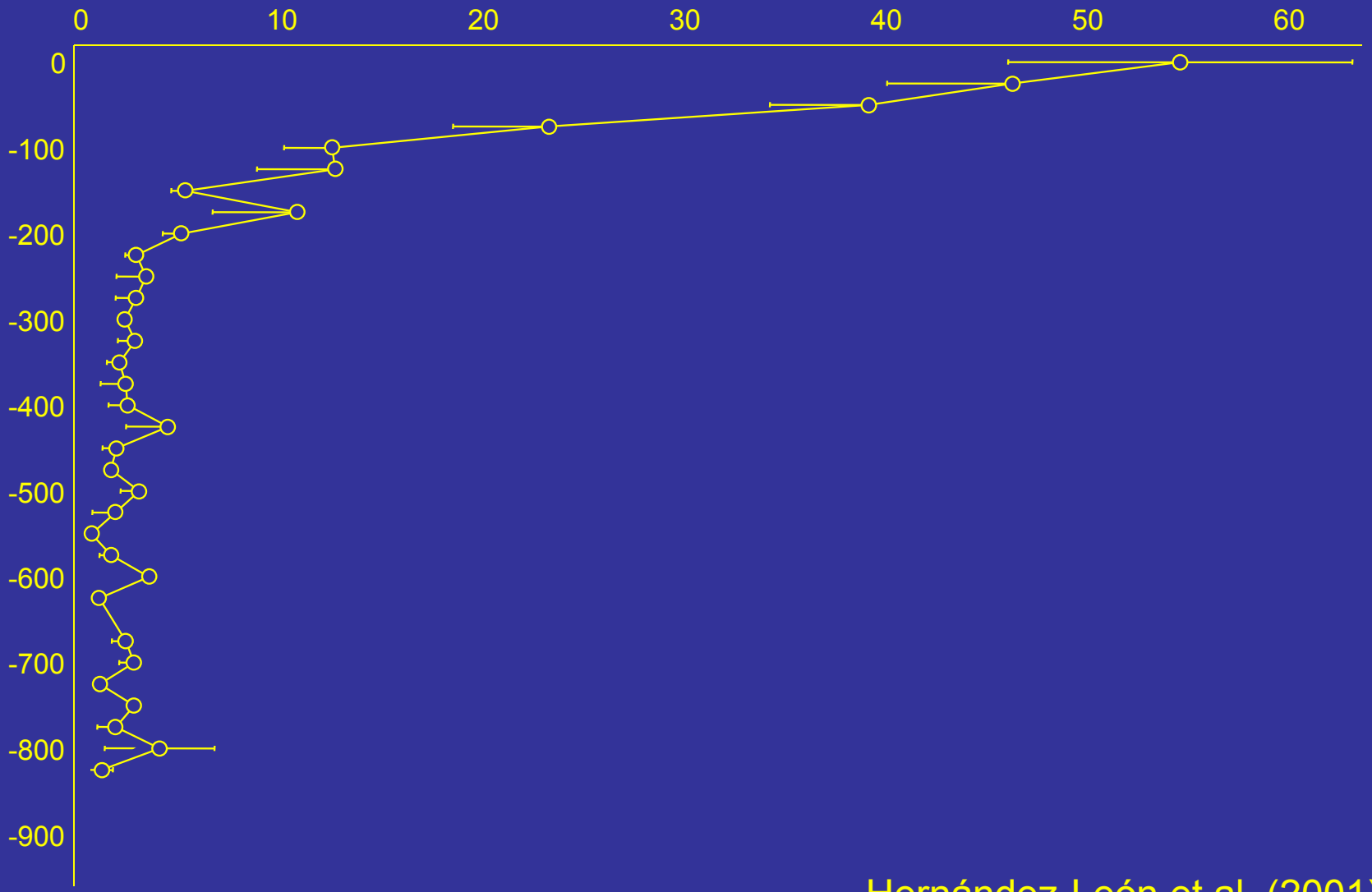
Bordes et al. (2010)

Respiration (day)

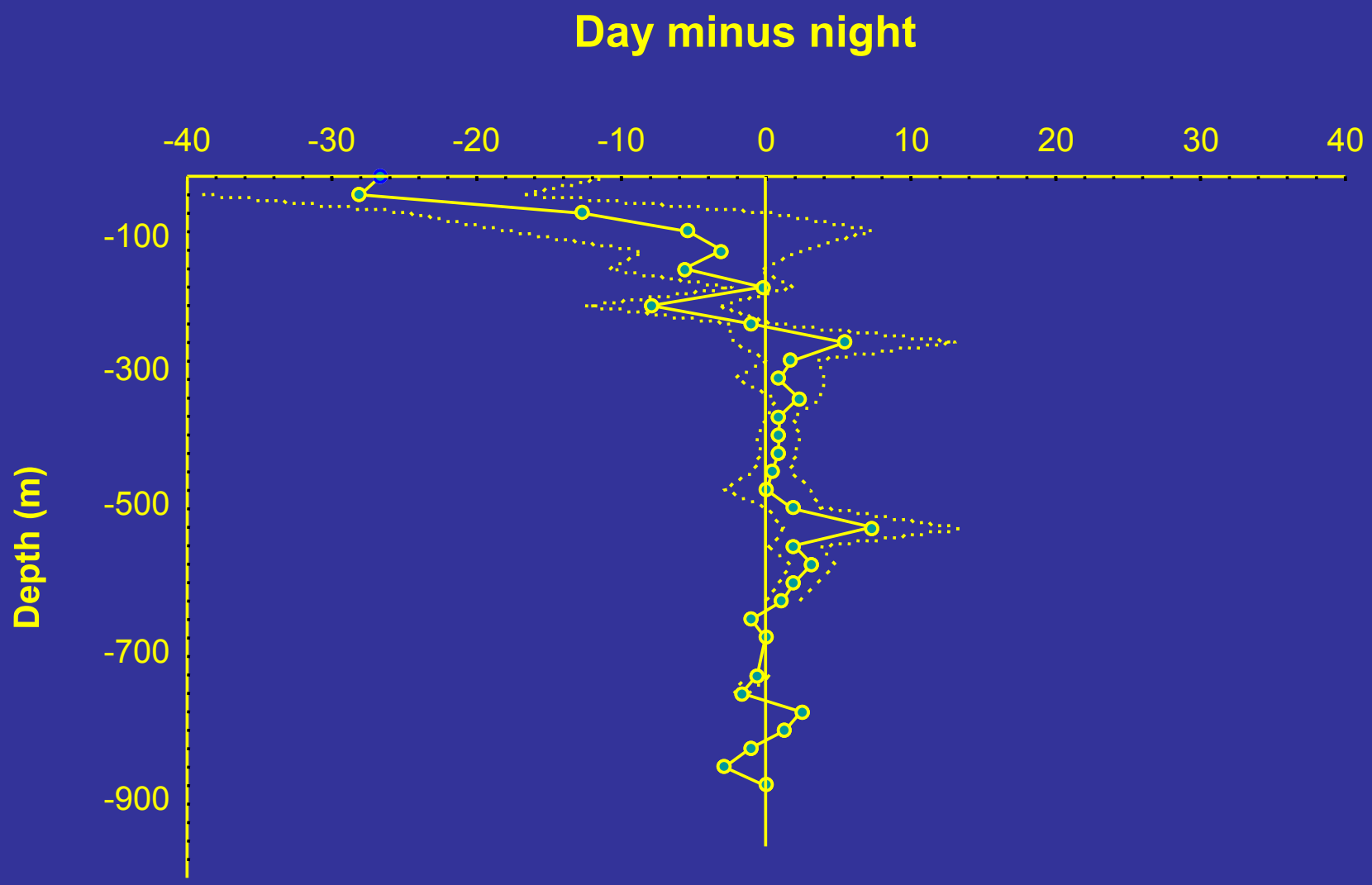


Hernández-León et al. (2001)

Respiration (night)



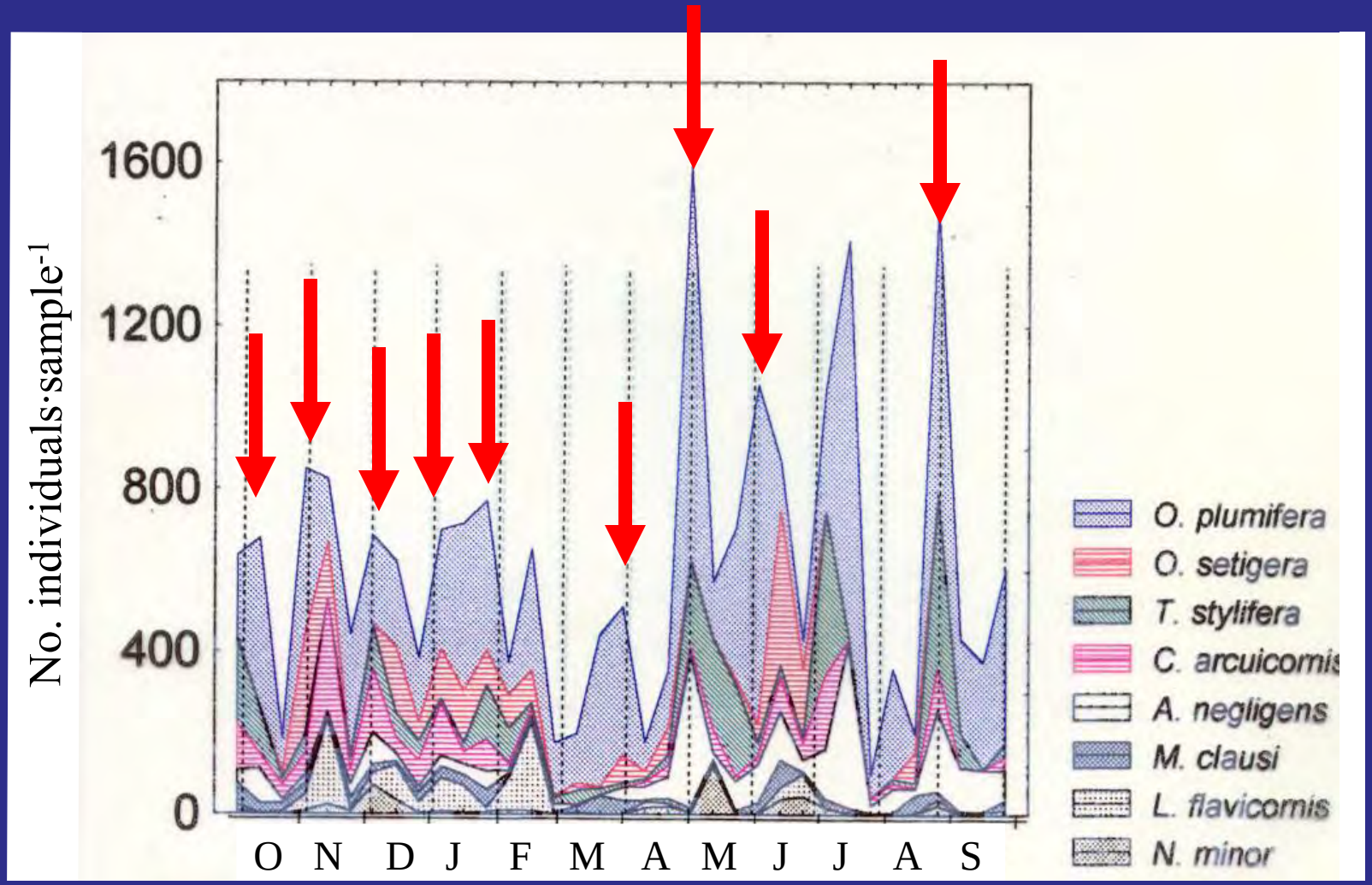
Hernández-León et al. (2001)



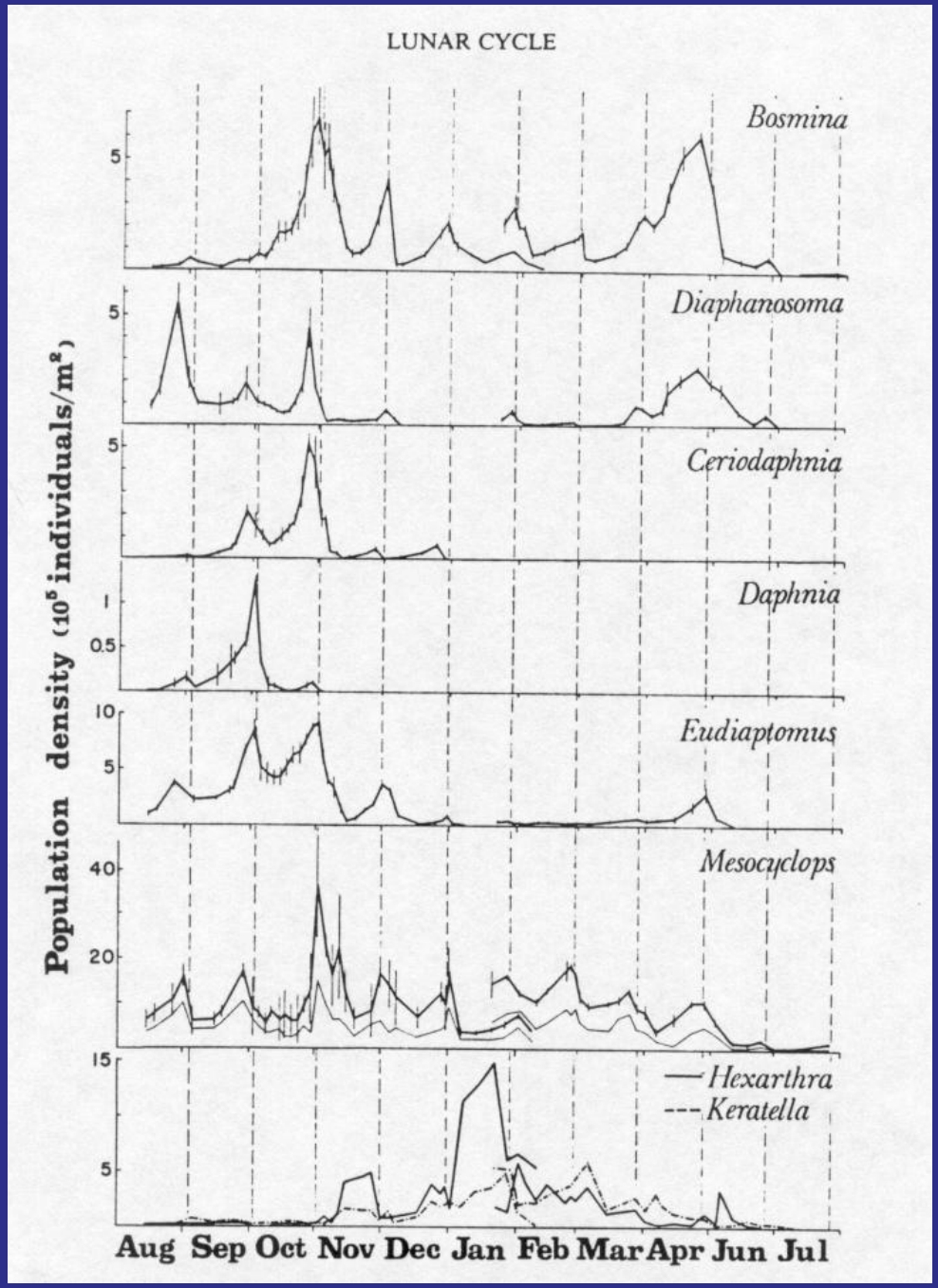
Hernández-León et al. (2001)

Location	Time of year	Migrant biomass ($mmolC \cdot m^{-2}$)	Respiratory flux ($mmolC \cdot m^{-2} \cdot d^{-1}$)	Gut flux ($mmolC \cdot m^{-2} \cdot d^{-1}$)	Mortality flux ($mmolC \cdot m^{-2} \cdot d^{-1}$)	% of POC flux*	References
Pacific Ocean							
Eastern Equator	March - April	8±2.1	0.35±0.10	-	0.24±0.07	18	Zhang and Dam (1997)
Eastern Equator	October	12.9±2.7	0.61±0.12	-	0.45±0.09	25	Zhang and Dam (1997)
Central Equator (HNLC)	October	4.41	0.50	-	-	4	Le Borgne and Rodier (1997)
Western Equator	October	3.91	0.25	-	-	6	Le Borgne and Rodier (1997)
Western Equator	February	25 (12-37)	1.10 (0.61-1.58)	-	0.29 (0.22-0.37)	24 (13-35)	Hidaka *et al.* (2001)
ALOHA	Year-round	13.5 (9-18)	0.30 (0.22-0.4)	-	-	15 (12-18)	Al-Mutairi and Landry (2001)
ALOHA	June - July	13.16	0.31	-	-	18	Steinberg *et al.* (2008)
Equator divergence		0.23-1.82	0.08-0.1	-	-	<1-2	Roman *et al.* (2002)
Oligotrophic area		2.52-2.82	0.11-0.14	-	-	4	Roman *et al.* (2002)
Atlantic Ocean					-		
NFLUX	September	2.42	0.16	-	-	3	Longhurst *et al.* (1989, 1990)
Oligotrophic (BATS)	March/April	16 (7–45)	1.21 (0.52-3.4)	-	-	34 (18-70)	Dam *et al.* (1995)
Oligotrophic (BATS)	year-round	4 (0-10)	0.17 (0-0.83)	-	-	8 (0-39)	Steinberg *et al.* (2000)
Oligotrophic (BATS)	year-round	0.05-39	-	0-0.37	-	0.03-21	Schnetzer and Steinberg (2002
North (coastal)	Oct-November	30 ± 5.8	2.5 ± 0.1	-	-	-	Isla and Anadón (2004)
North (poleward current)	Oct-November	22.5 ± 17	0.86 ± 0.5	-	-	-	Isla and Anadón (2004)
North (Oceanic)	Oct-November	2.5 ± 0.8	0.2 ± 0.02	-	-	-	Isla and Anadón (2004)
Canary Islands	August	15 (10-20)	0.26 (0.16-0.36)	0.11 (0.03-0.20)	-	30 (16-45)	Hernández-León *et al.* (2001a)
Canary Islands	June	48-107	0.19-0.70	0.01-0.04	-	15-53	Yebra *et al.* (2005)
Canary Islands	March	9.0-28.46	0.04-0.11	0.005-0.015	-	1.1-2.7	Putzeys et al. (submitted)

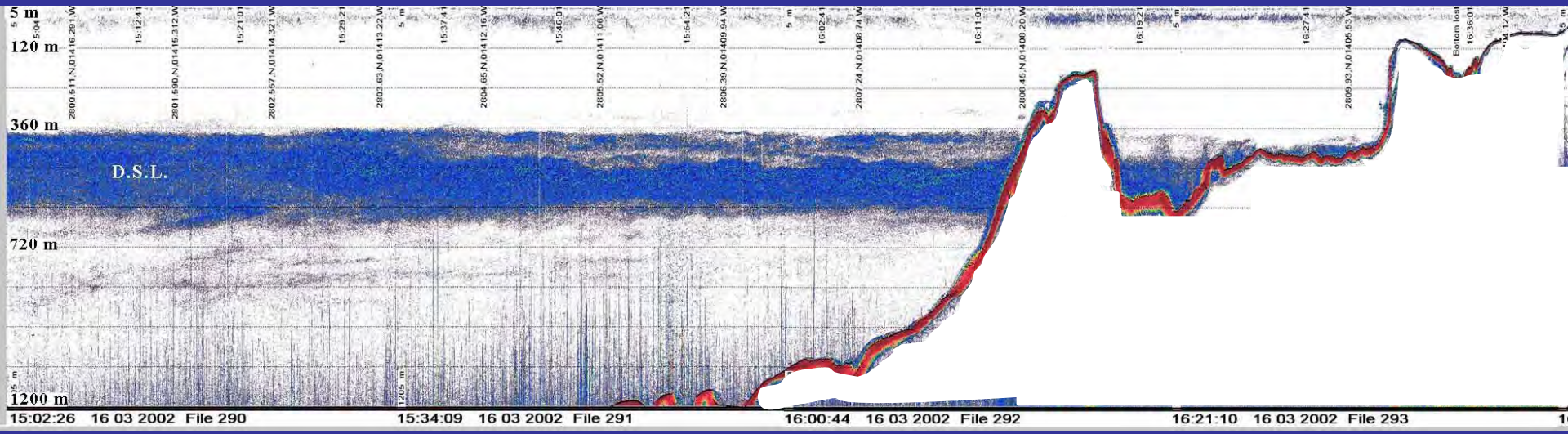
Revised from Ducklow et al (2001) in Putzeys et al. (submitted)



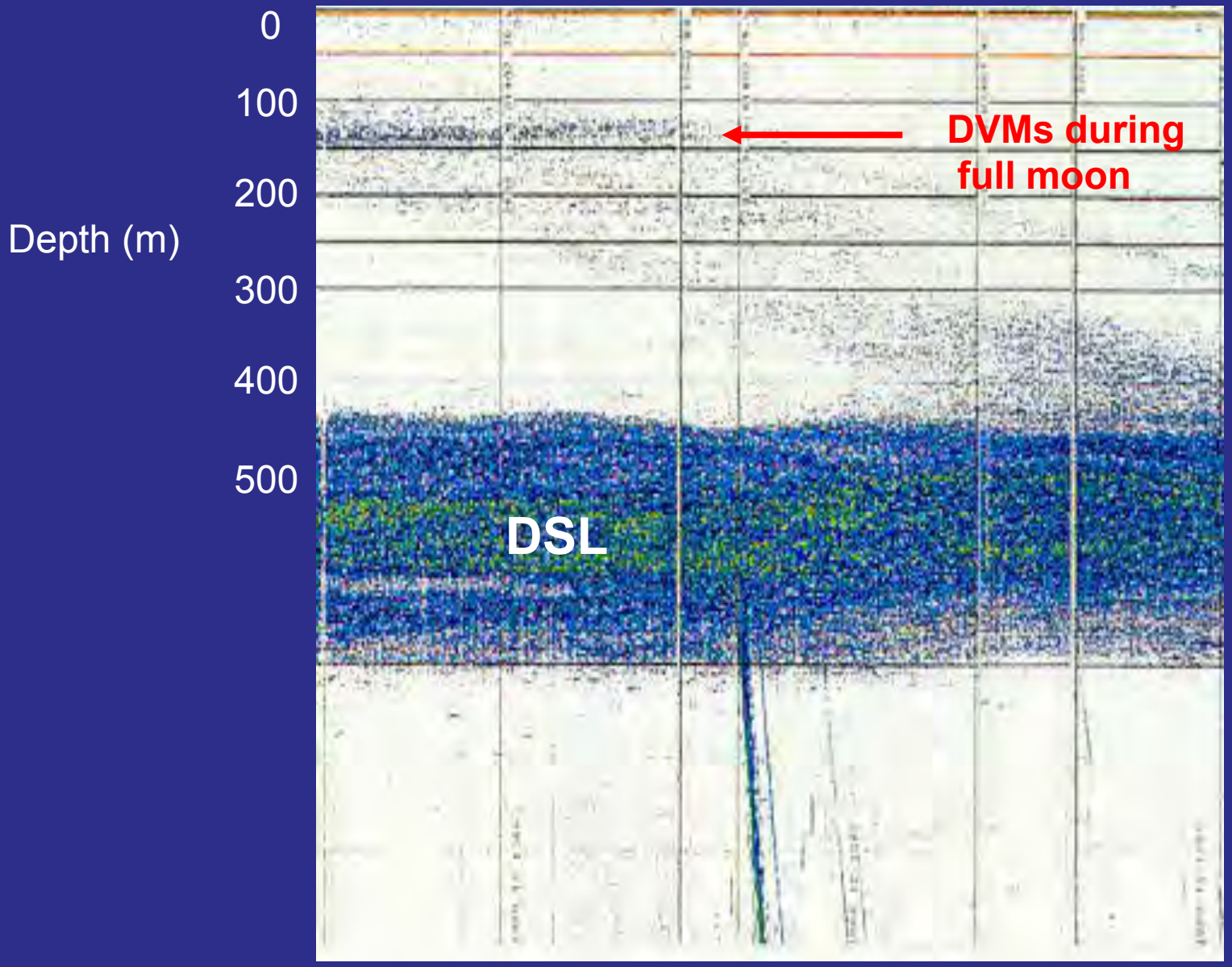
Hernández-León (1998)

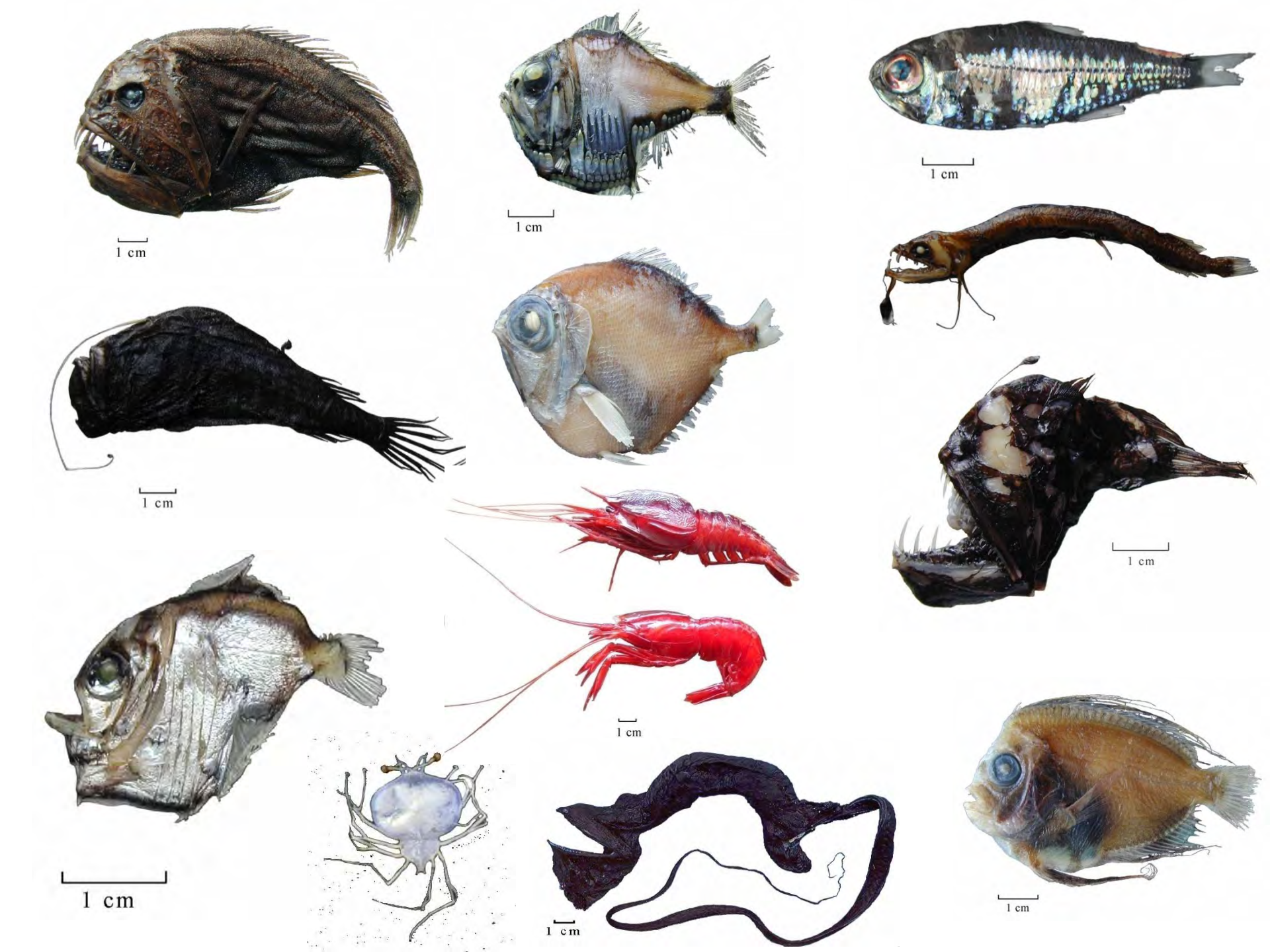


Gliwicz (1986)

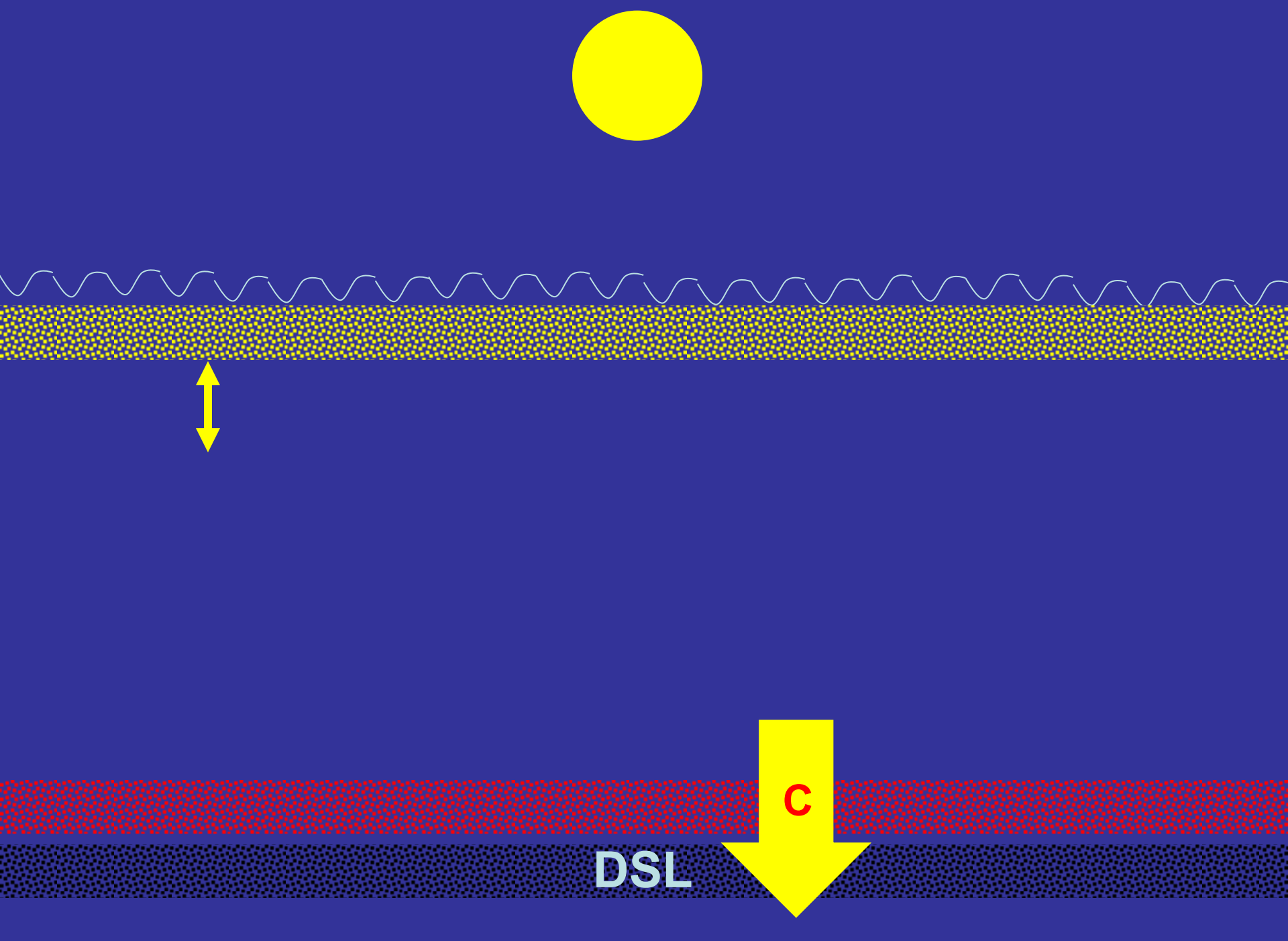


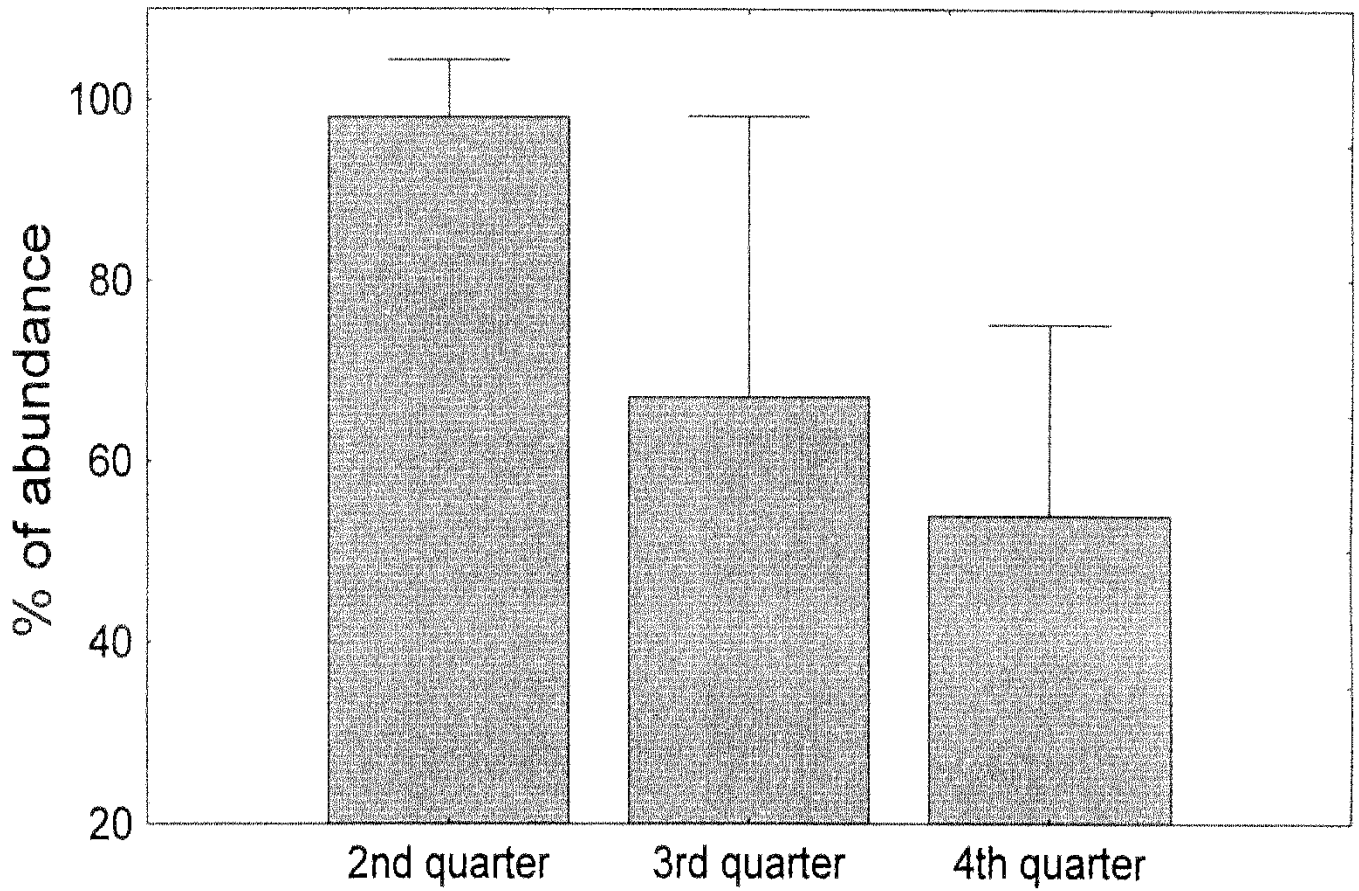
Bordes et al. (2010)


Depth (m)
0
100
200
300
400
500
DVMs during
full moon
DSL

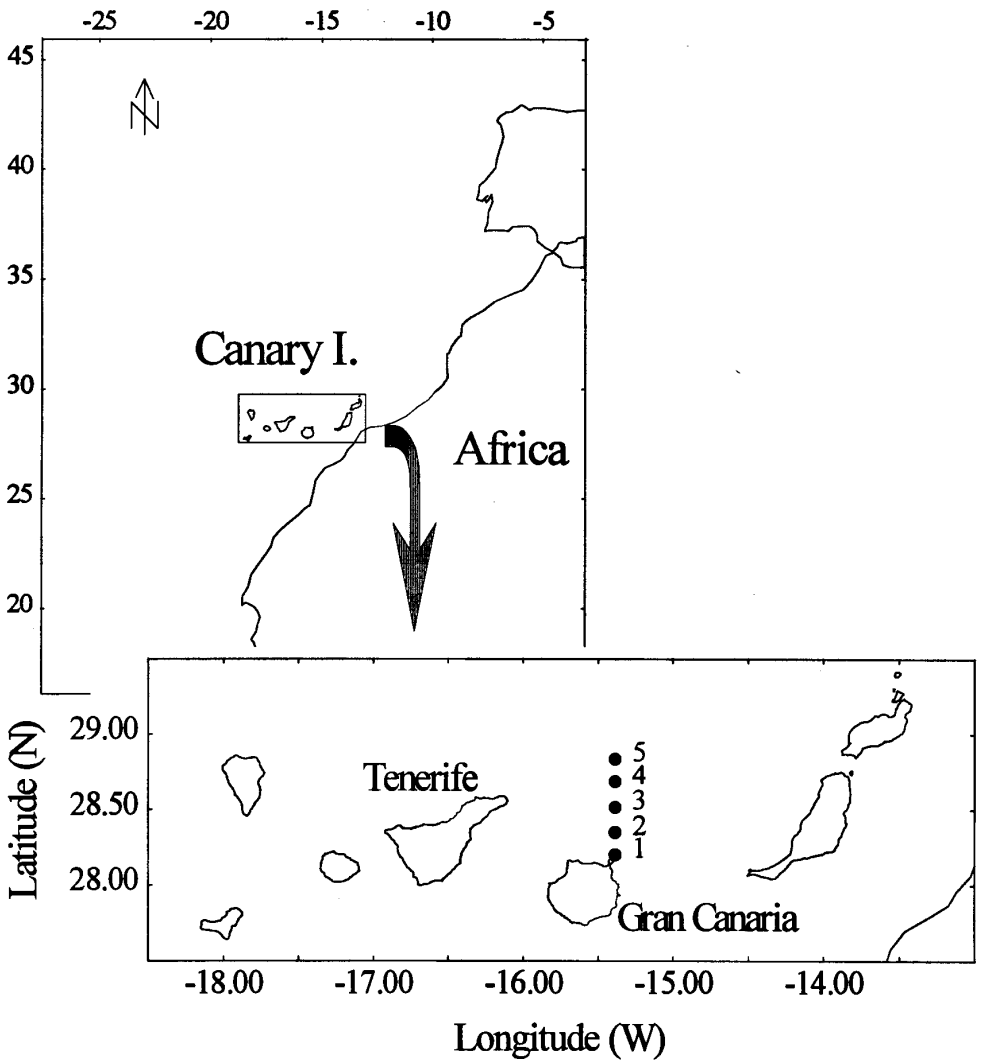

1 cm
1 cm
1 cm
1 cm
1 cm
1 cm
1 cm
1 cm
1 cm
1 cm

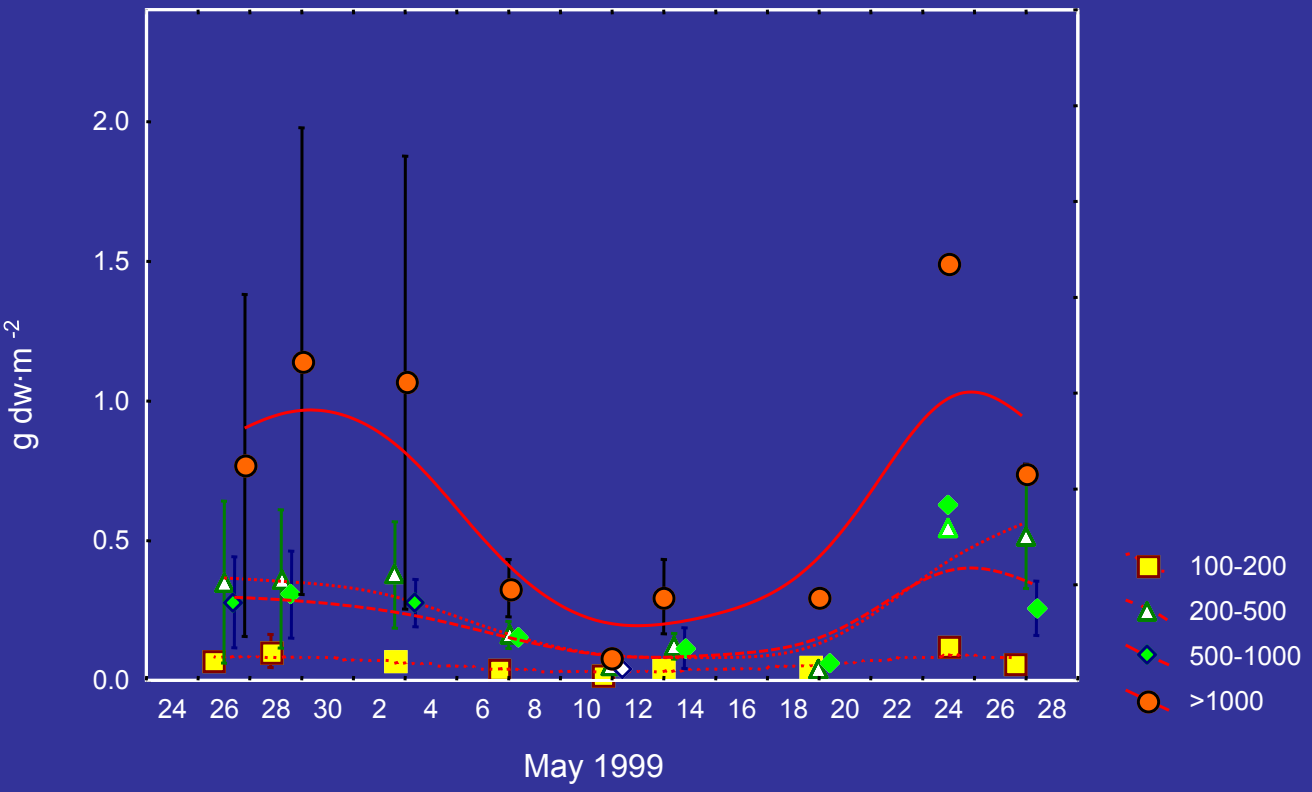
MOHT net
Oozeki et al. (2004)

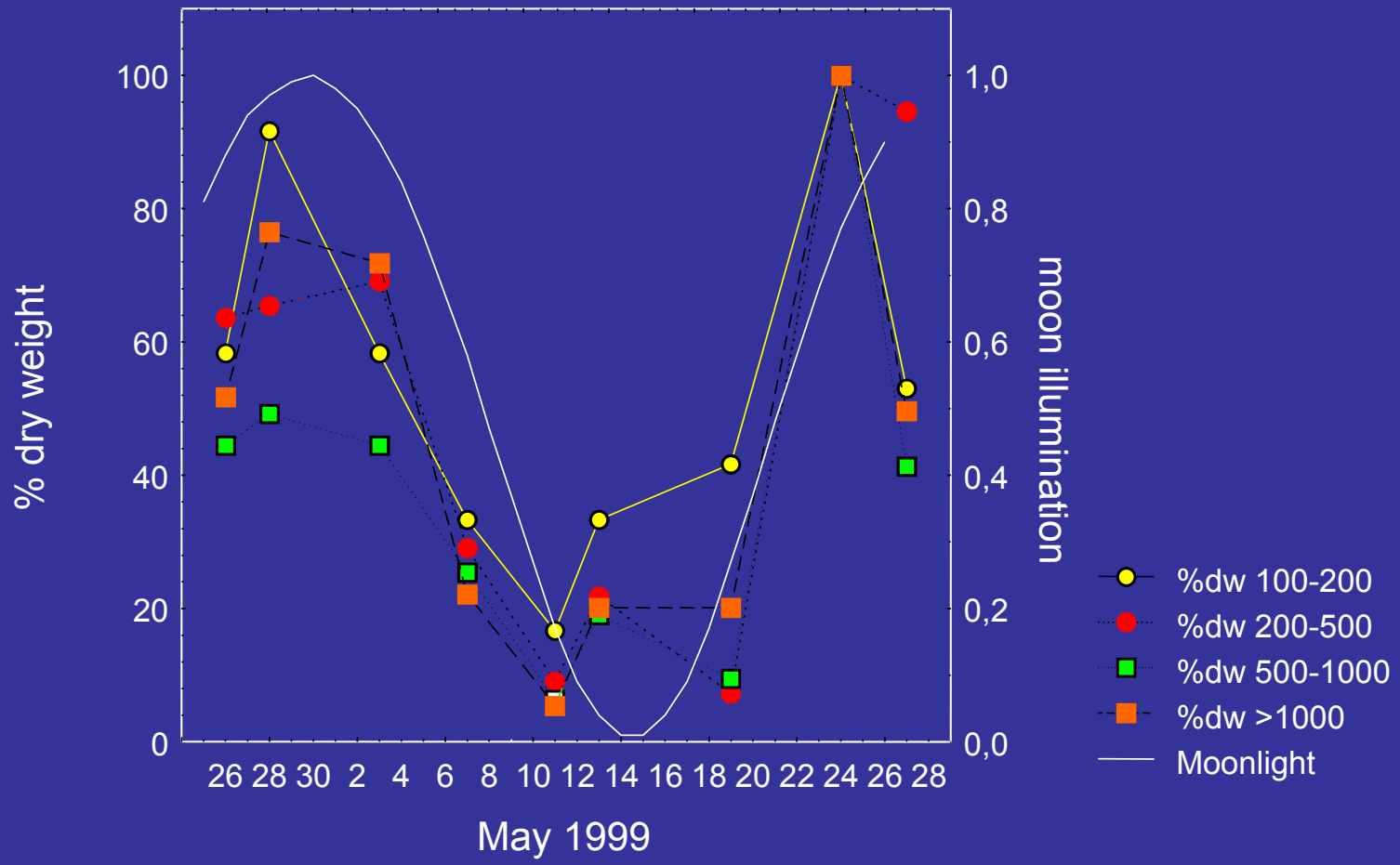

C
DSL

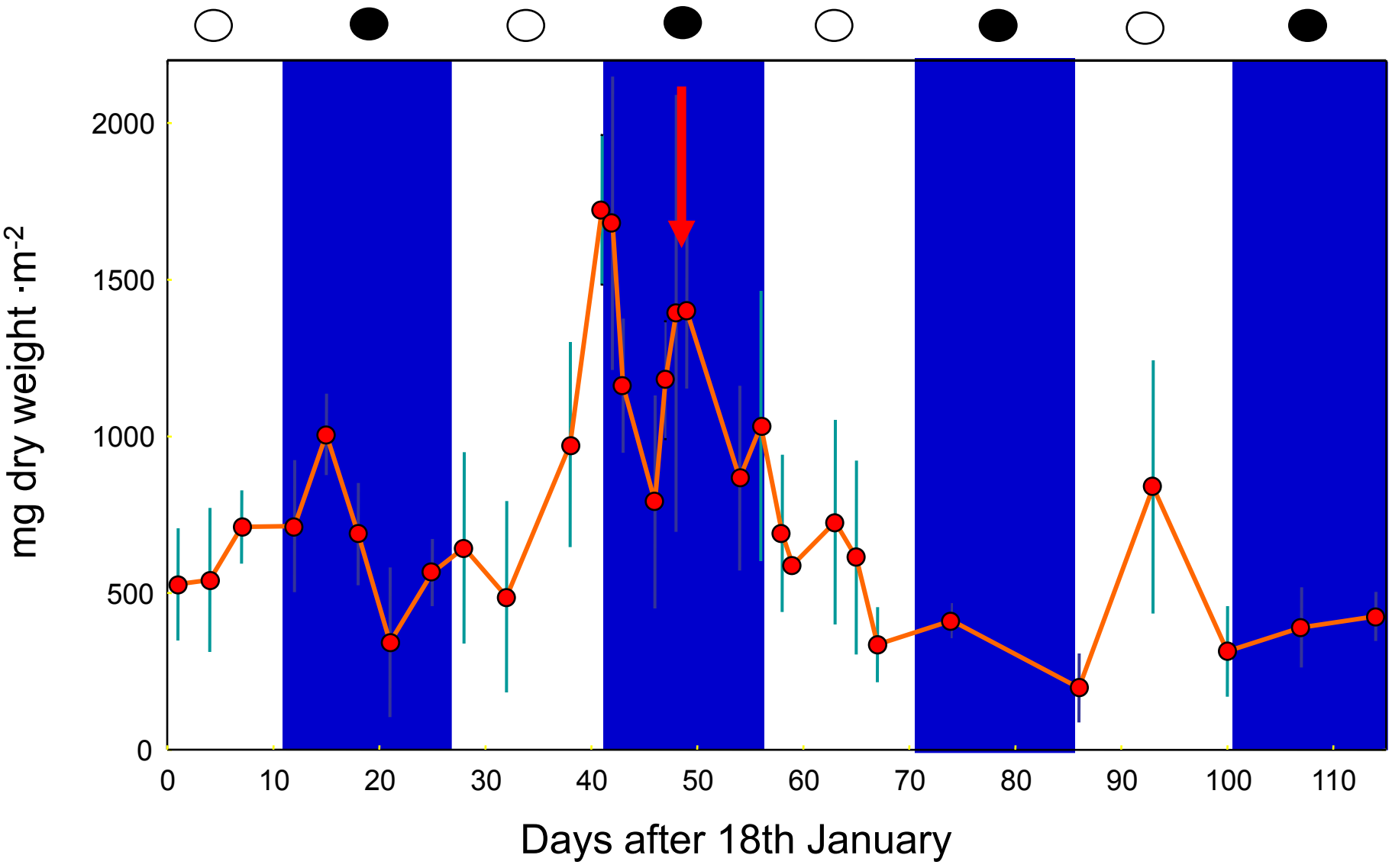


Hernández-León *et al*. (2001)

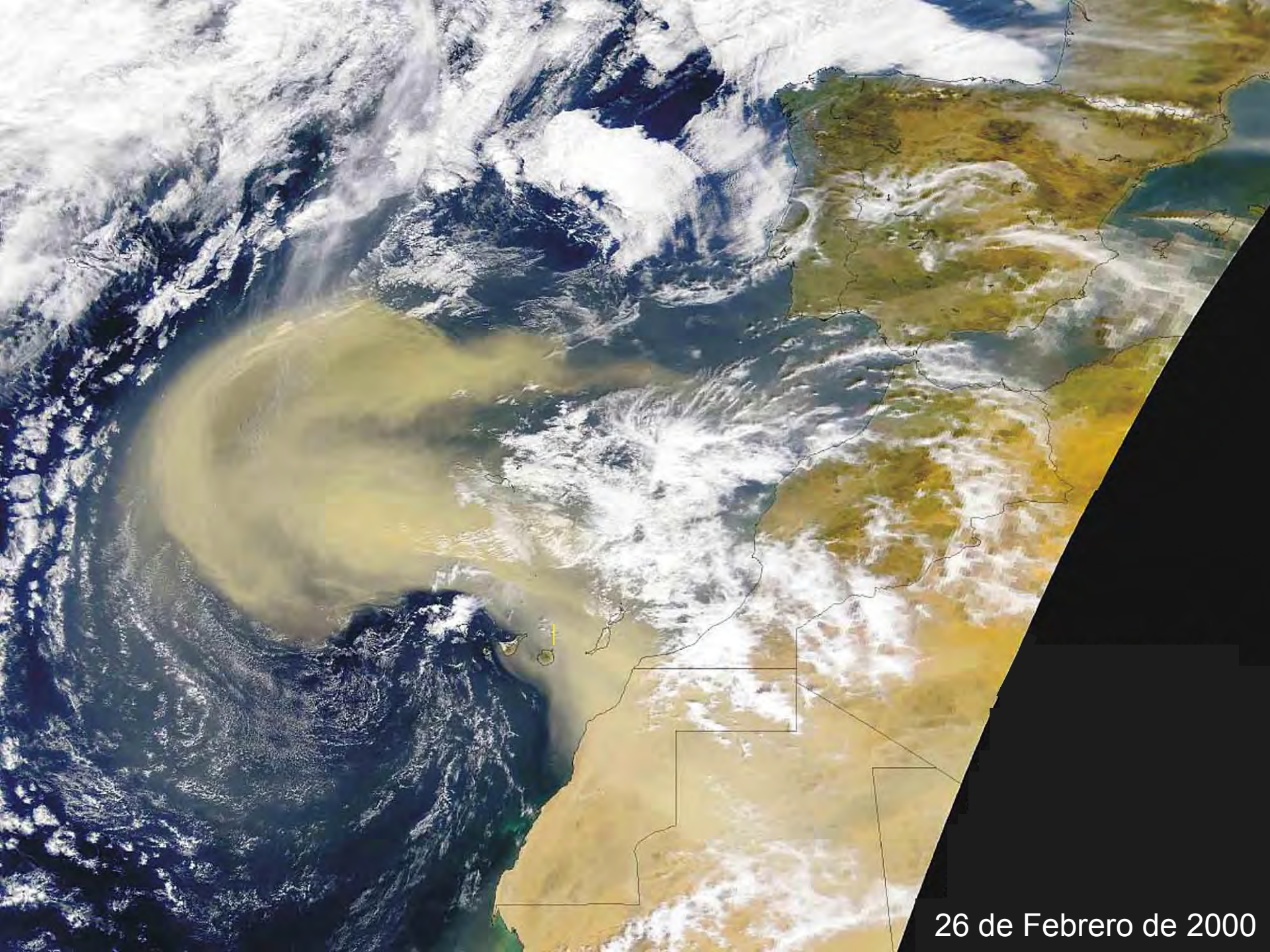

-25
-20
-15
-10
-5
45
40
35
30
25
20
Canary I.
Africa
Latitude (N)
29.00
28.50
28.00
Tenerife
5
4
3
2
1
Gran Canaria
-18.00
-17.00
-16.00
-15.00
-14.00
Longitude (W)

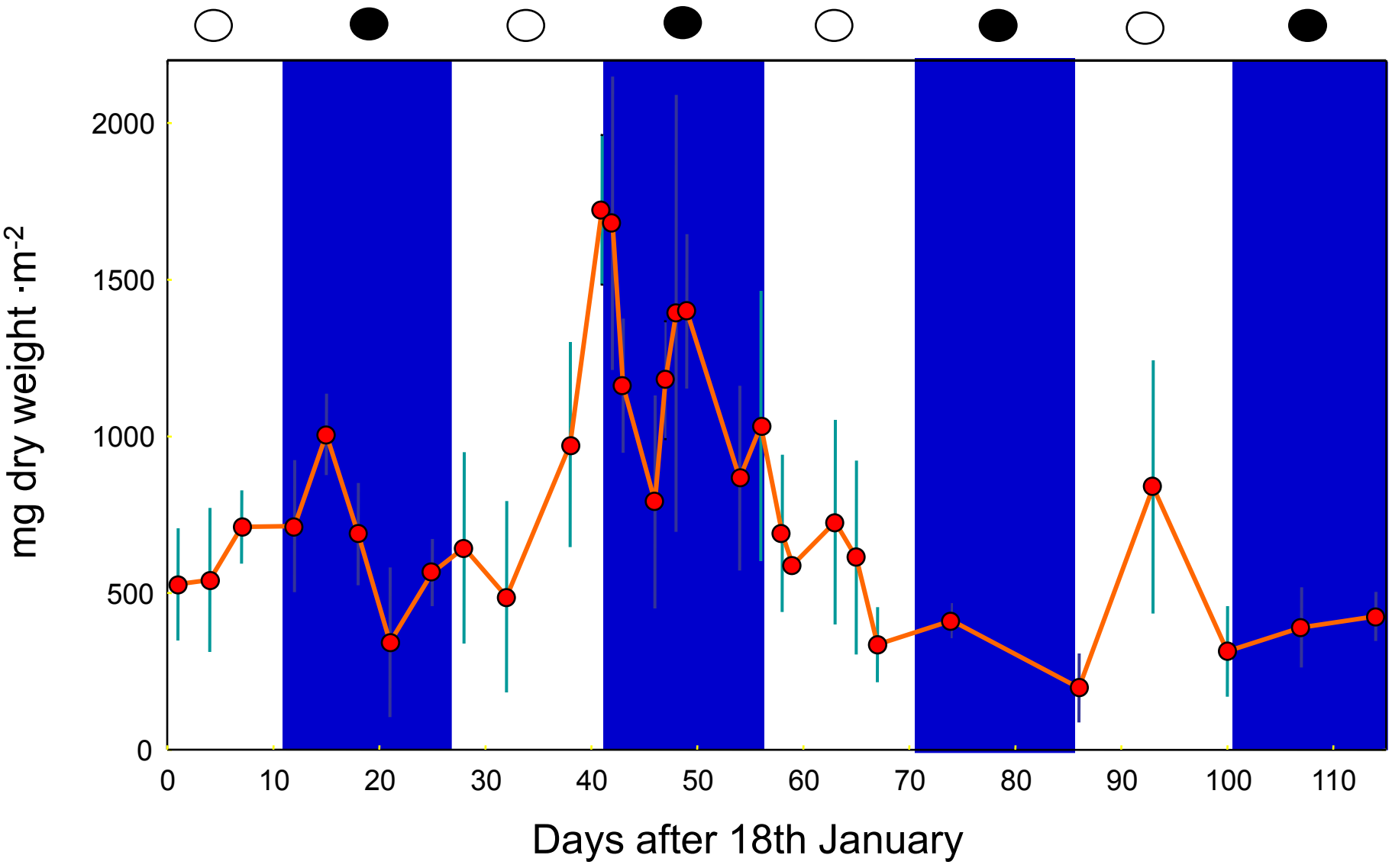

2.0
1.5
1.0
0.5
0.0
g dw·m -2
24 26 28 30 2 4 6 8 10 12 14 16 18 20 22 24 26 28
May 1999
100-200
200-500
500-1000
>1000


% dry weight
moon illumination
100
80
60
40
20
0
1,0
0,8
0,6
0,4
0,2
0,0
26 28 30 2 4 6 8 10 12 14 16 18 20 22 24 26 28
May 1999
%dw 100-200
%dw 200-500
%dw 500-1000
%dw >1000
Moonlight

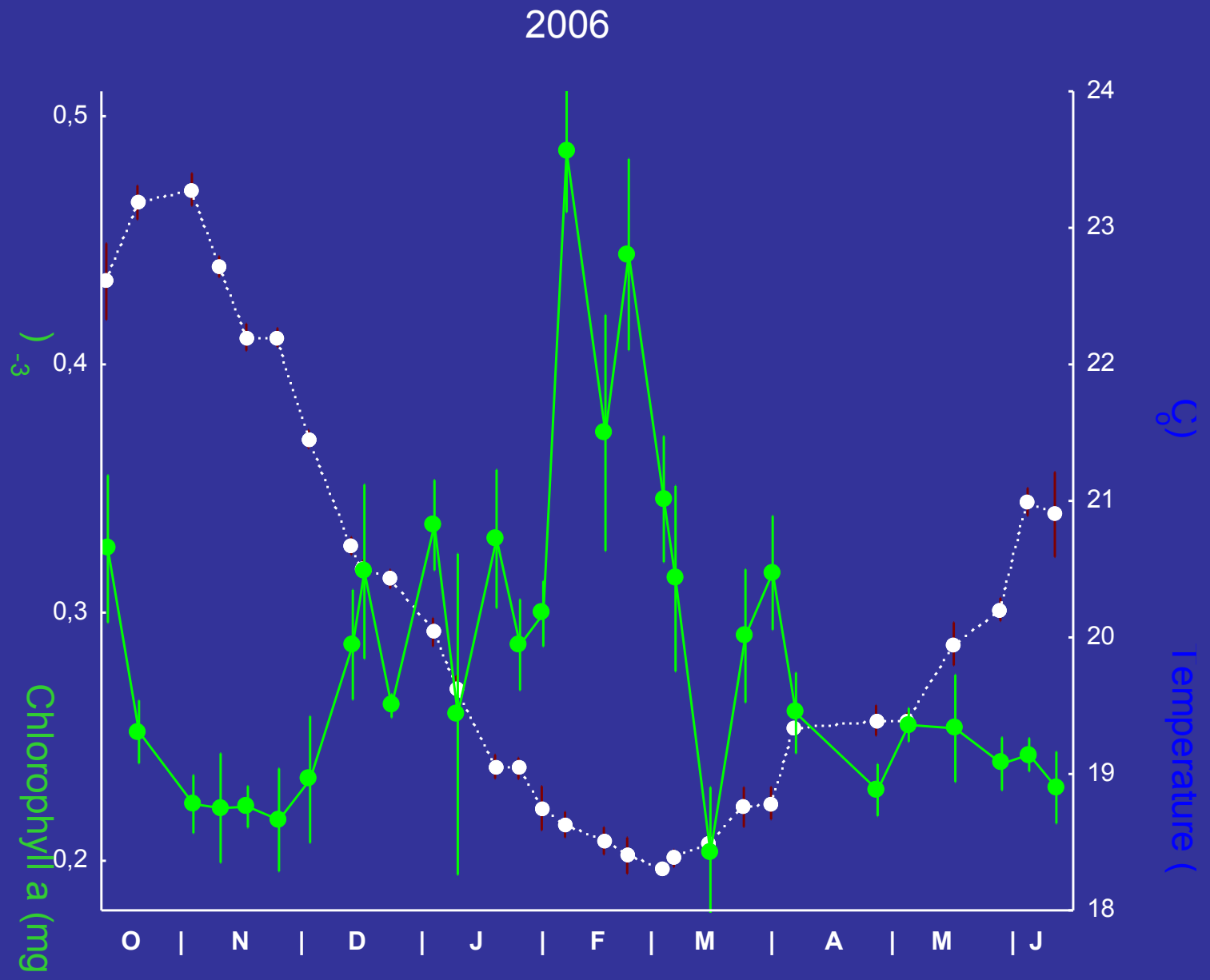


Hernández-León *et al*. (2004)

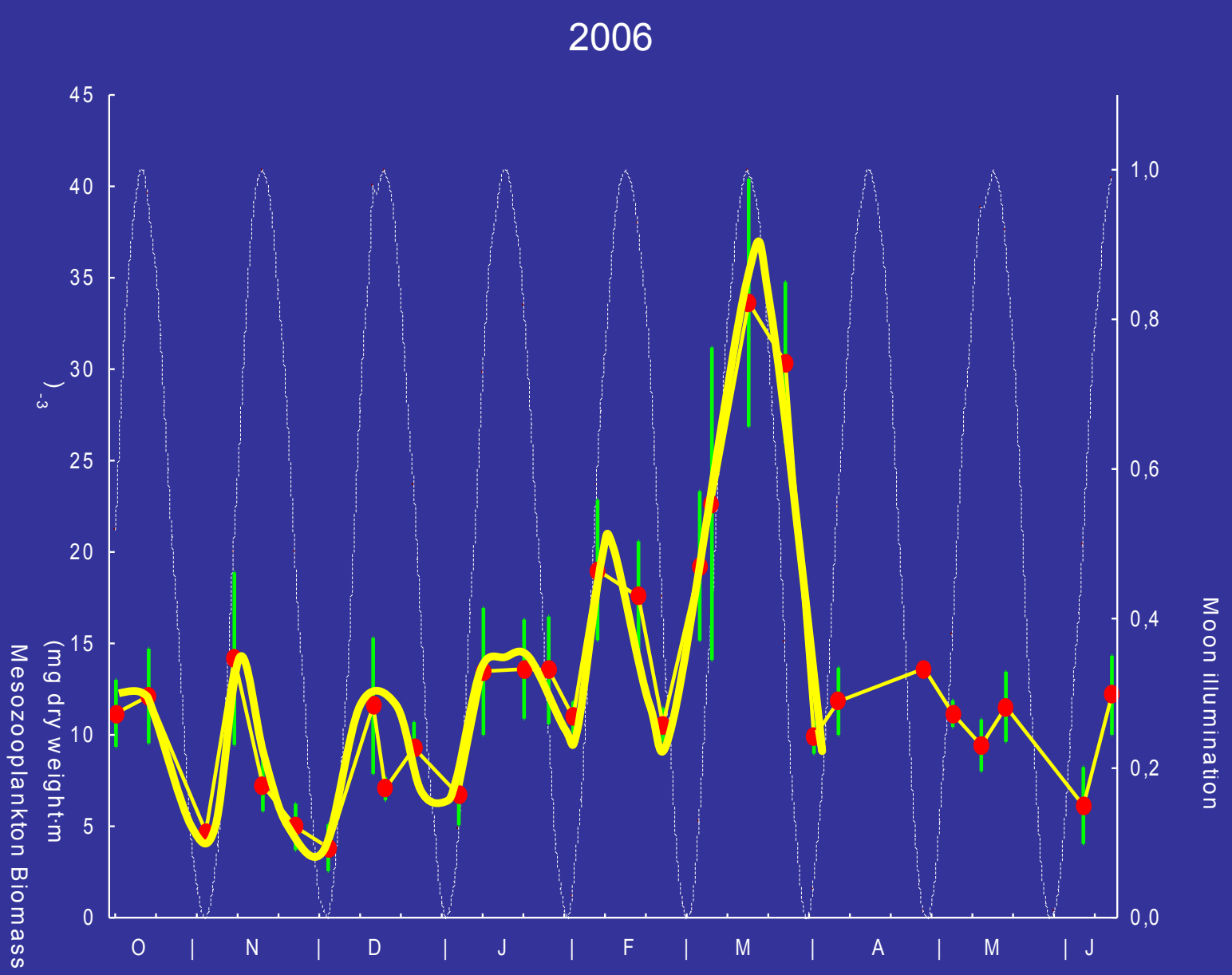

26 de Febrero de 2000



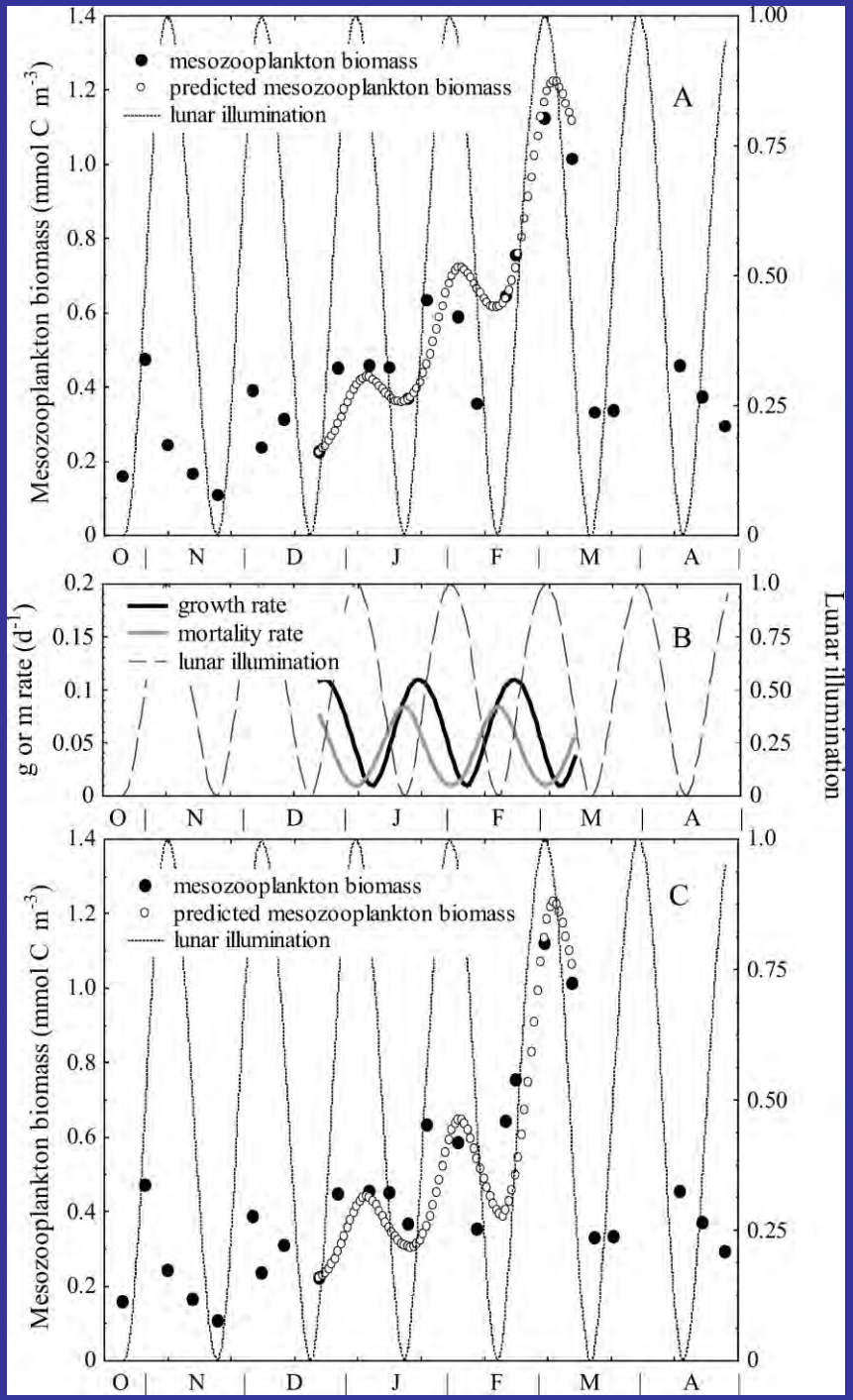
Hernández-León *et al*. (2004)



Hernández-León et al. (2010)



Hernández-León et al. (2010)



Hernández-León et al. (2010)

Values of active flux:

• No-bloom	May	1999	1.9	mmolC·m^{-2}·d^{-1}
• No-bloom	January	2006	1.8-2.7	“
• Bloom	February-March	2000	2.9	“
• Bloom	March-May	2005	1.8-3.3	“
• Bloom	February-March	2006	3.8-6.2	“
• Bloom	February-March	2007	2.6-10.1	“

Values of gravitational flux:

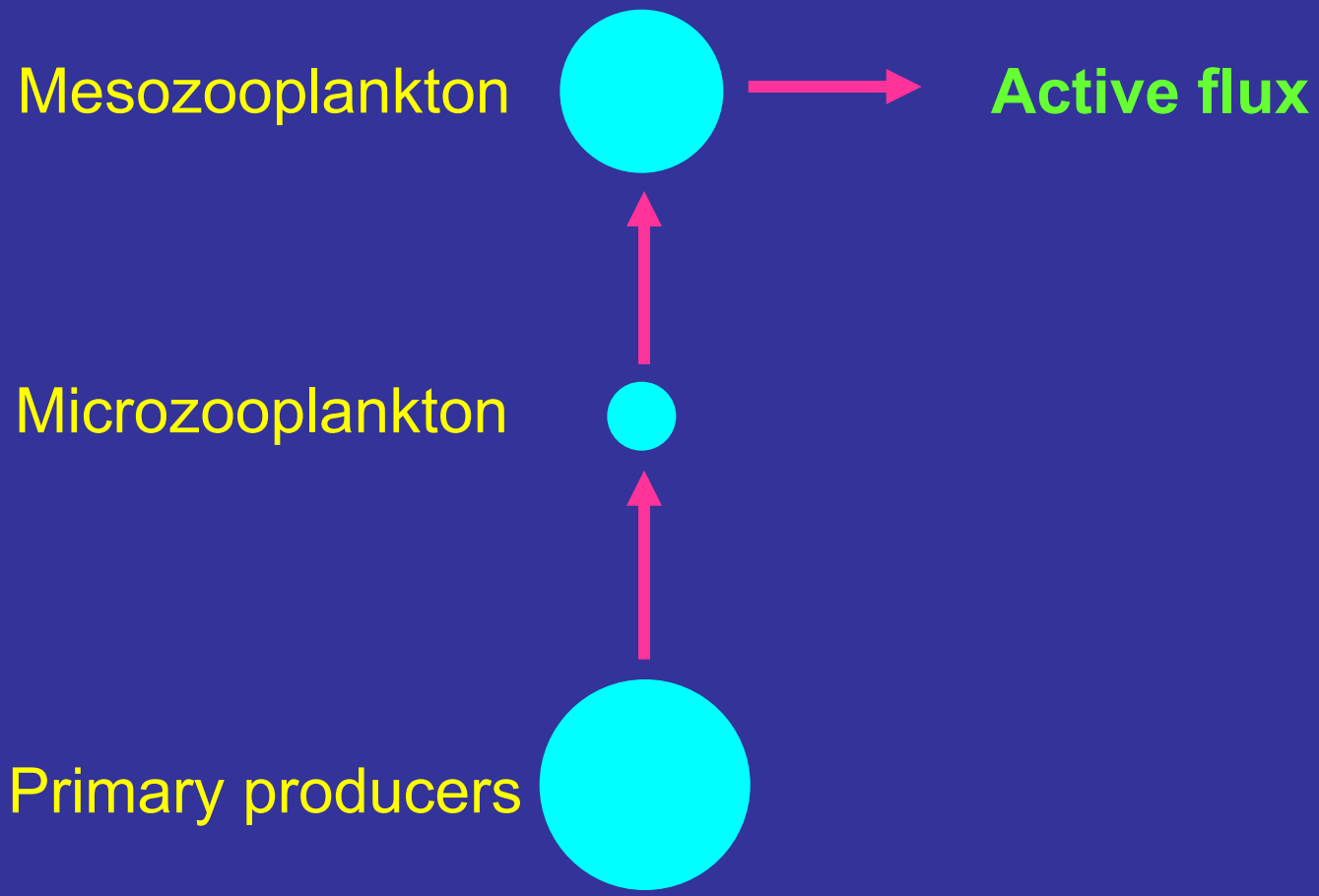
• Canary Current	Neuer *et al.* (2007)	0.1-1.3	mmolC·m^{-2}·d^{-1}
• Canary Current	Alonso-G. *et al*. (2009)	5.8-9.7	“
• Canary Current	Alonso-G. *et al*. (2010)	0.1-2.0	“
• Hawaii	Karl *et al*. (2001)	2.3-6.0	“
• Bermuda	Karl *et al*. (2001)	2.4-6.0	“

Moreover,

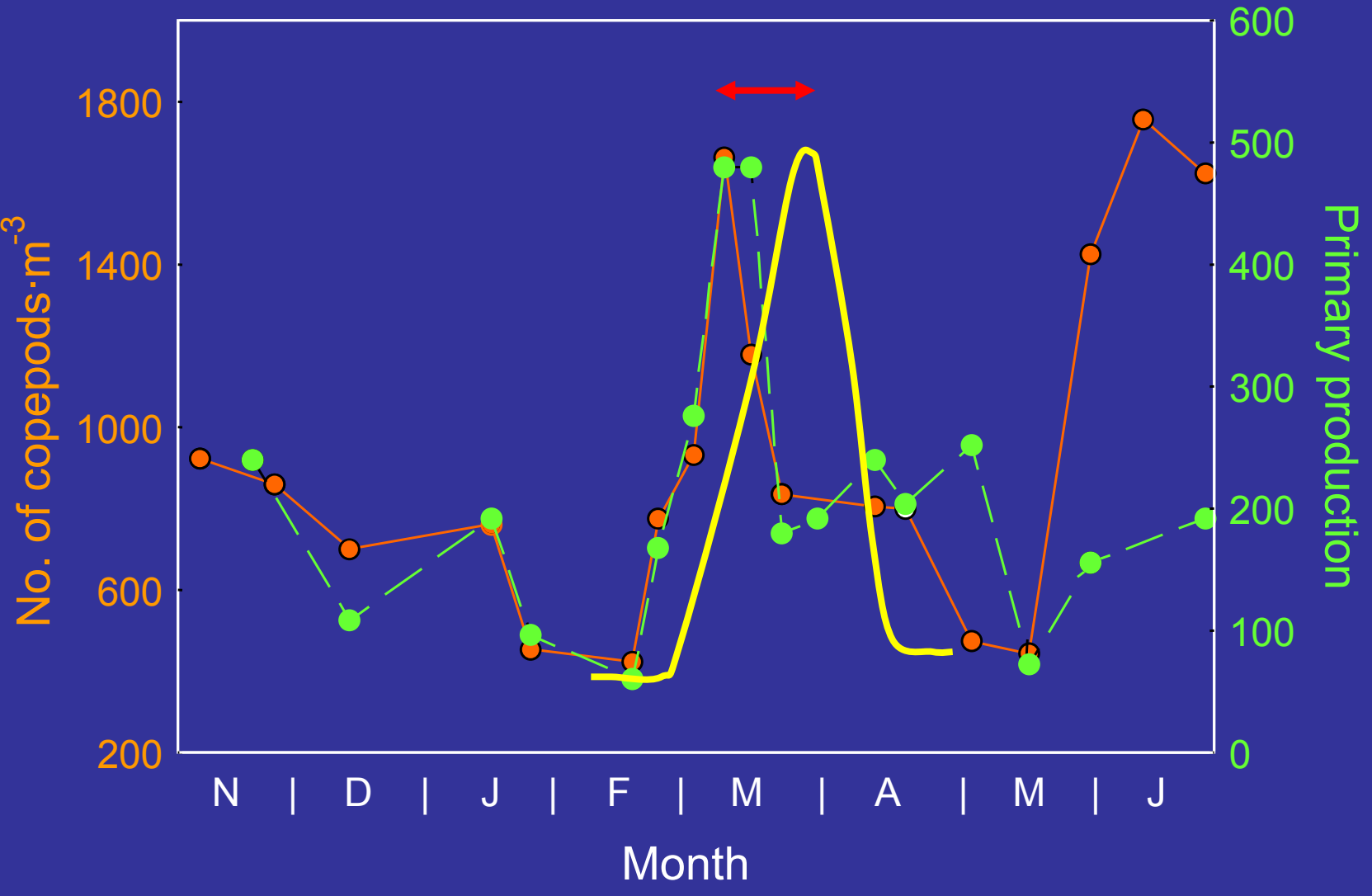
- Hidaka et al. (2001) showed that flux due to micronektonic organisms was 56-60% of total active flux.

- Geochemical estimates
- of new production : 6.8-14.6 mmolC·m^{-2}·d^{-1}

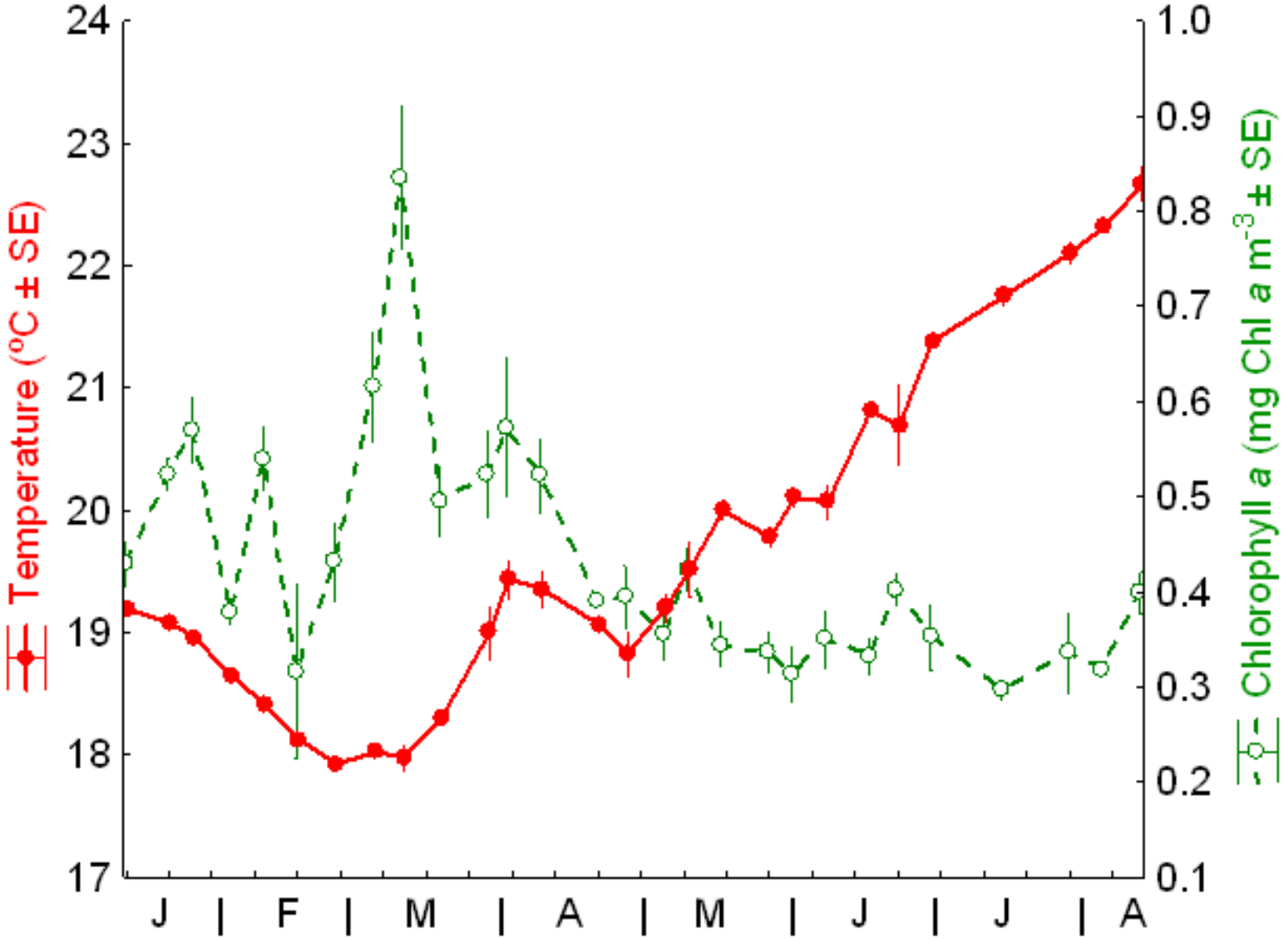
- Gravitational flux : ~2-6 mmolC·m^{-2}·d^{-1}
- Active flux : ~2-6 “
- Others (DOC,...) : ?


Mesozooplankton
Active flux
Microzooplankton
Primary producers

- **Which are the consequences of this predatory cycle for the euphotic zone?**


No. of copepods·m-3
1800
1400
1000
600
200
Primary production
600
500
400
300
200
100
0
N
D
J
F
M
A
M
J
Month

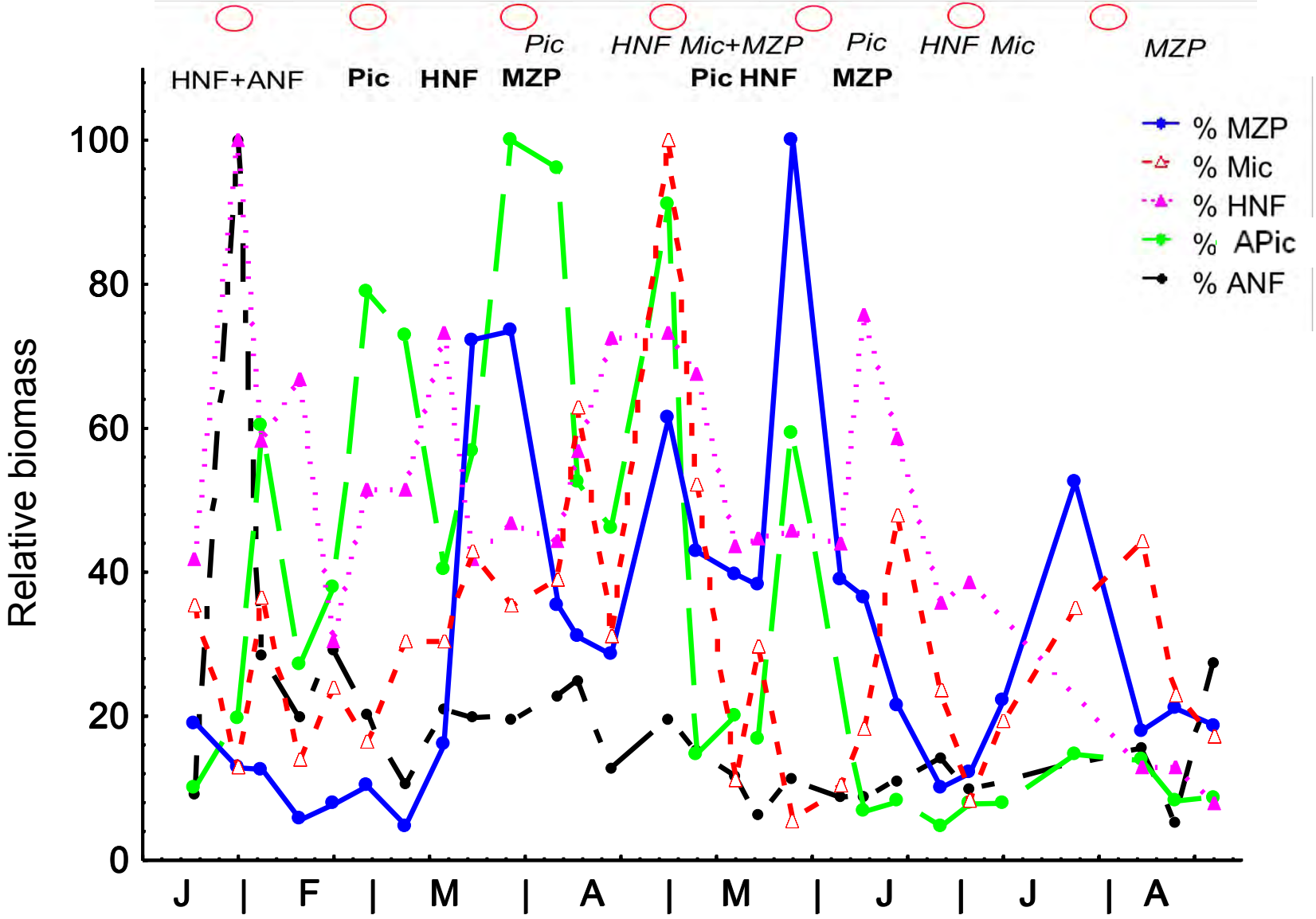
The late winter bloom - 2005



Schmoker et al. (submitted)

Late winter bloom 2005

Schmoker et al. (submitted)



In summary,

- 1. Microbial loop scenario: energy and matter in the euphotic zone is naturally recycled promoting low values of gravitational flux
- 2. Mesozooplankton is temporarily enhanced during the lunar cycle
- This energy and matter is shunt to the mesopelagic zone
- Active flux seems similar to gravitational flux
- And finally,
- Oceanographers are mostly educated in the bottom-up controls but top-down forces are also important to understand the carbon cycle
- Light is important in structuring the marine ecosystems
- There is a gap in our knowledge of the biological pump, mainly due to a gap in sampling the ocean

Collaborators:

- Claire Schmoker
- Inma Herrera-Rivero
- Gara Franchy
- Alejandro Ariza
- Marta Moyano
- Pascal Lehette
- Lidia Yebra
- Sébastien Putzeys
- Laia Armengol
- Lidia Nieves

No más…