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Earth Systems Science Course in Watersheds &
Coastal Zone Simulation Modeling
2 - 13 October 2000

"Eco-Hydrodynamical Models for Coastal Ecosystem Simulation"

A. CRISE
Istituto Nazionale di Oceangrafia e di Geofisica Sperimentale (OGS)
Trieste
Italy

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Biological - hydrodynamical coupling: theoretical considerations

1.The conservative tracer

In an eulerian reference system the advection diffusion equation for a generic tracer is usually presented in its averaged form according the well known Reynolds approach. We assume that c is the generic passive (i.e. not reacting neither with biology not with hydrodynamics). In this case the evolution of its concentration in time and space is governerd by:

$$\partial_t C = -\boldsymbol{U}\cdot\nabla C + \nabla\cdot\left[k\nabla C - \langle \boldsymbol{u}\, c\rangle\right] + q(t) \qquad (1)$$

where k is the molecular diffusion ($k=O[10^{-9} m^2 s^{-1}]$) and c is splitted into a deterministic term C and a stochastic fluctuation c'

$c = c(x,t) = C(x) + c\,(x,t)$

From the above definition it comes:

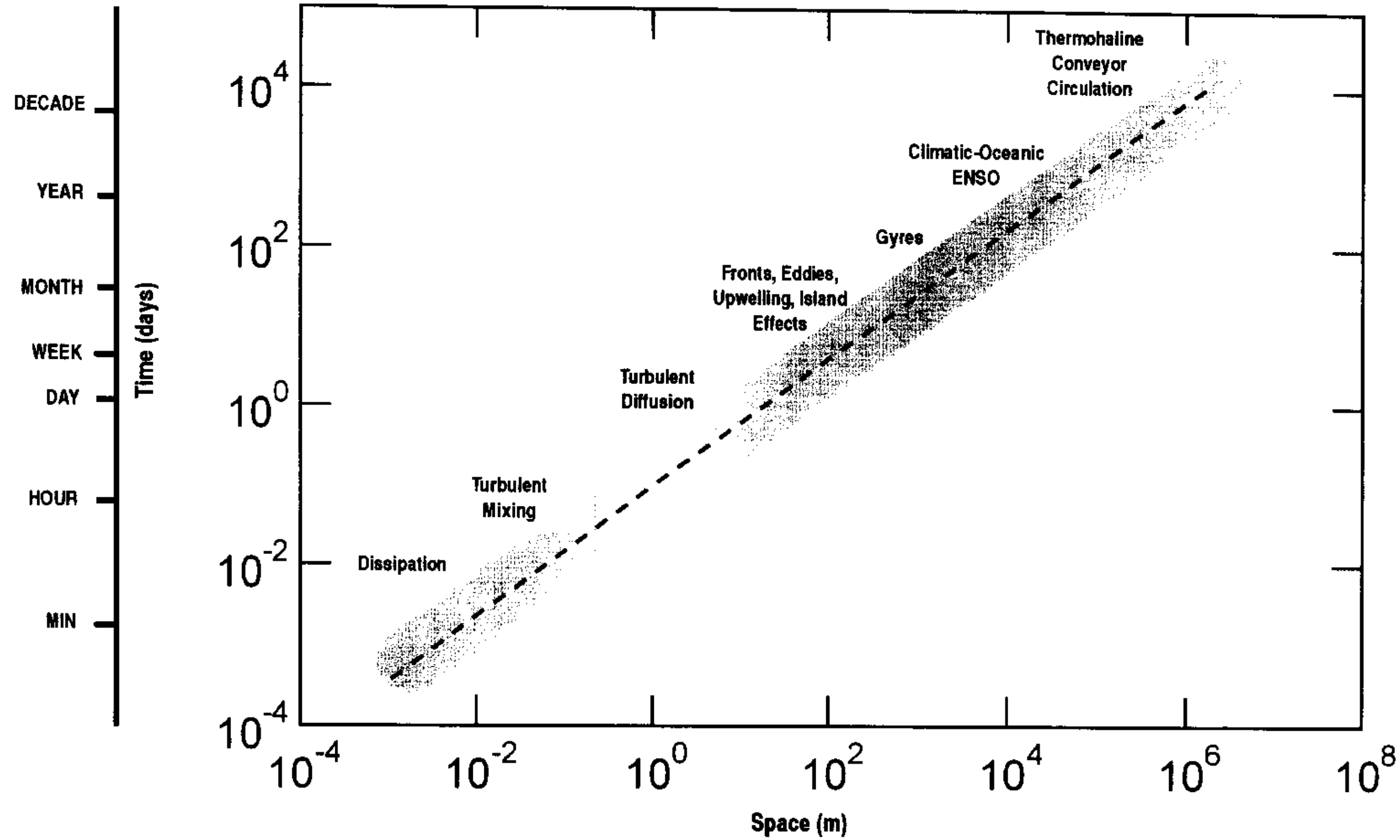
$C = C(\boldsymbol{x}) = \langle c(\boldsymbol{x},t)\rangle$

In eq.(1) $q(t)$ is the source/sink for c. The c eddy flux divergence is usually parametrized in the similar way as for the Reynold stress

$$-\nabla\cdot\langle \boldsymbol{u}\, c\rangle \cong \partial_z K_v \partial_z C + K_H \nabla^{2n} C \qquad n = 1,2,..$$

where the vertical and horizontal eddy coefficients differ when the smallest scales of intererest discriminate horizontal vs vertical turbulence. These coefficients are generally much higher then the molecular diffusion which is therefore neglected.

Dominant space/time scales for physical processes in the ocean (adapted from Hofmann and Lascara, 1997)



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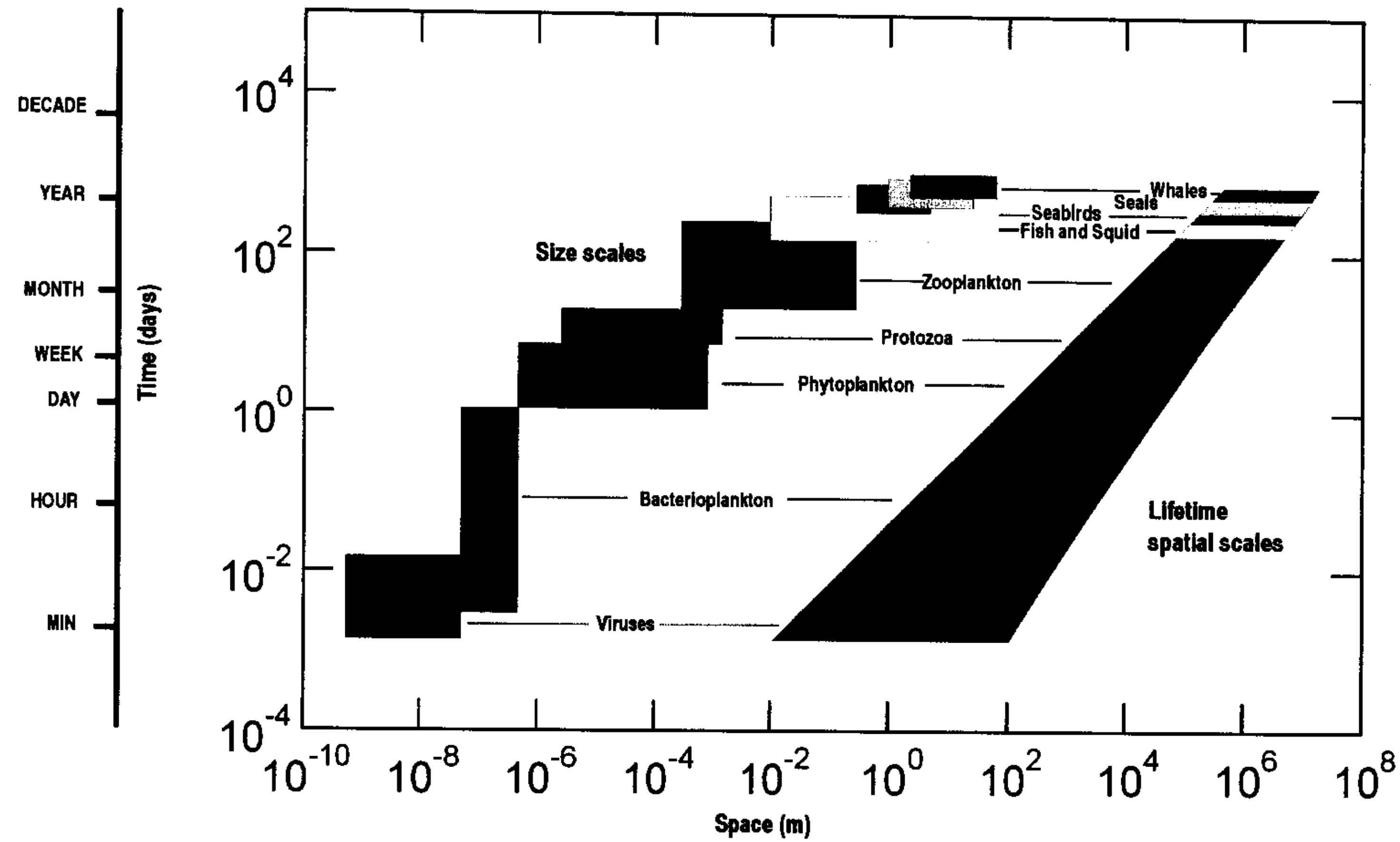
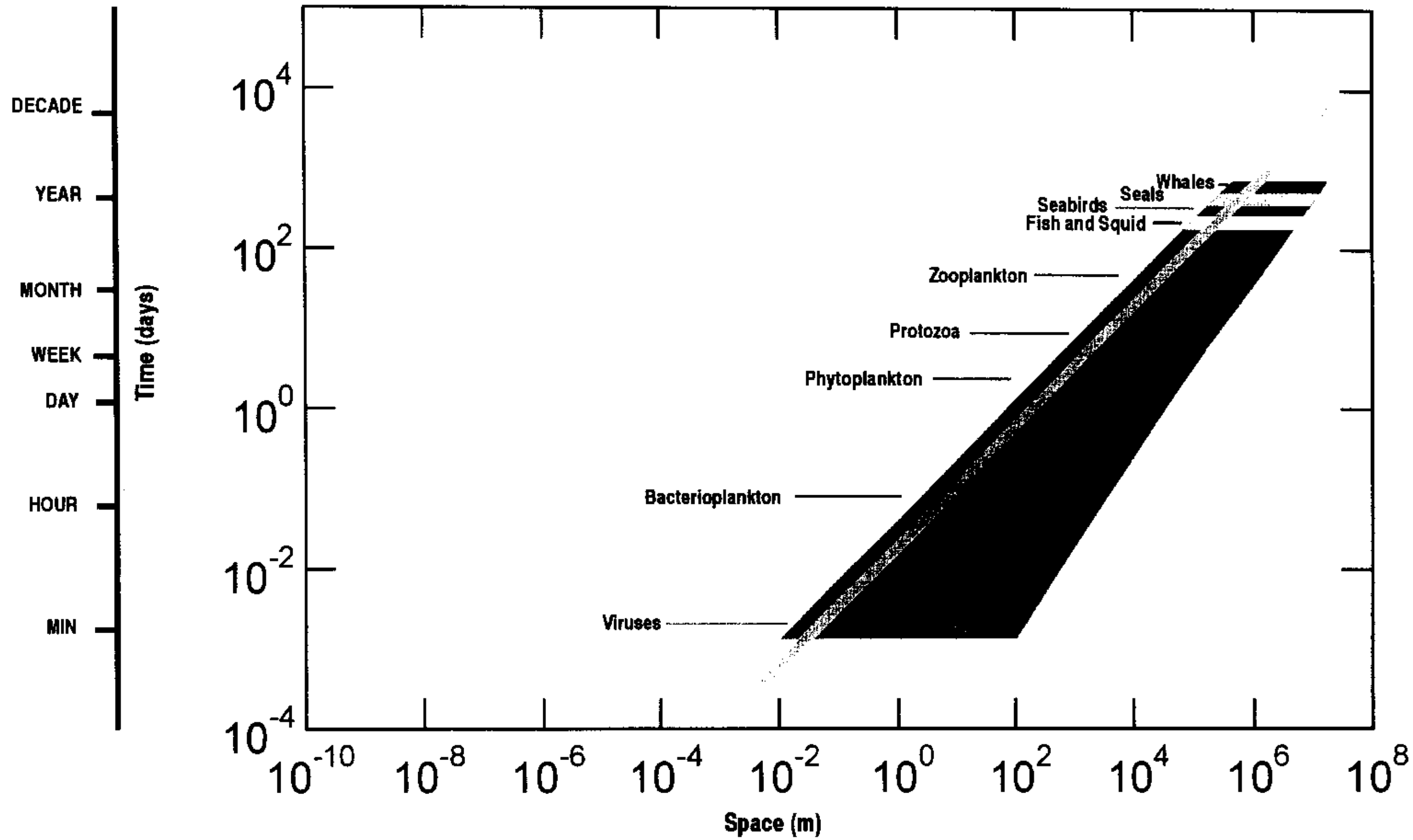
Typical size vs doubling/lifetime scales for marine organisms
(adapted from Hofmann and Lascara, 1997)

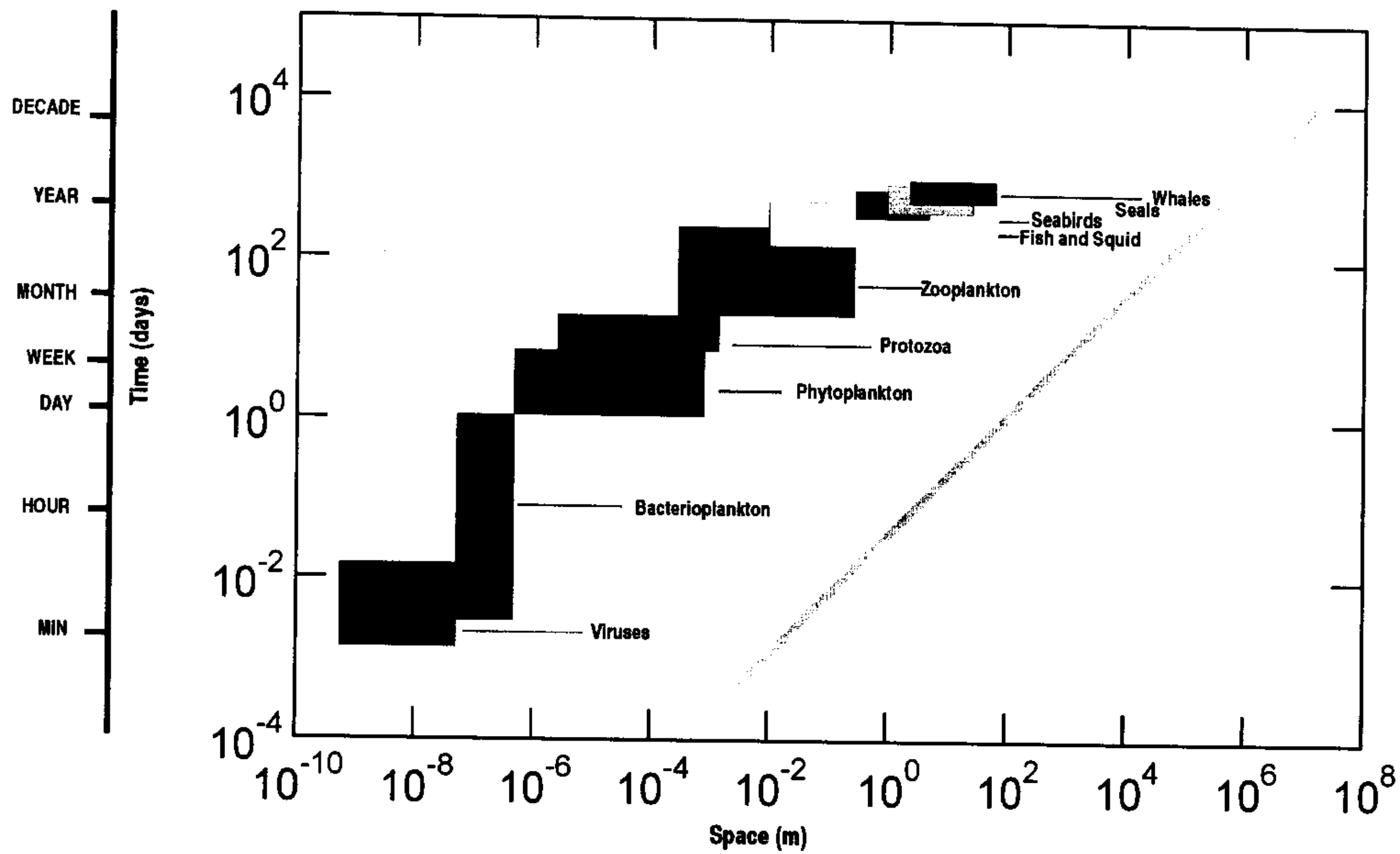


OGS Echo Group

Lifetime spatial scales vs doubling/lifetime scales for marine organisms



Typical size vs doubling/lifetime scales for marine organisms



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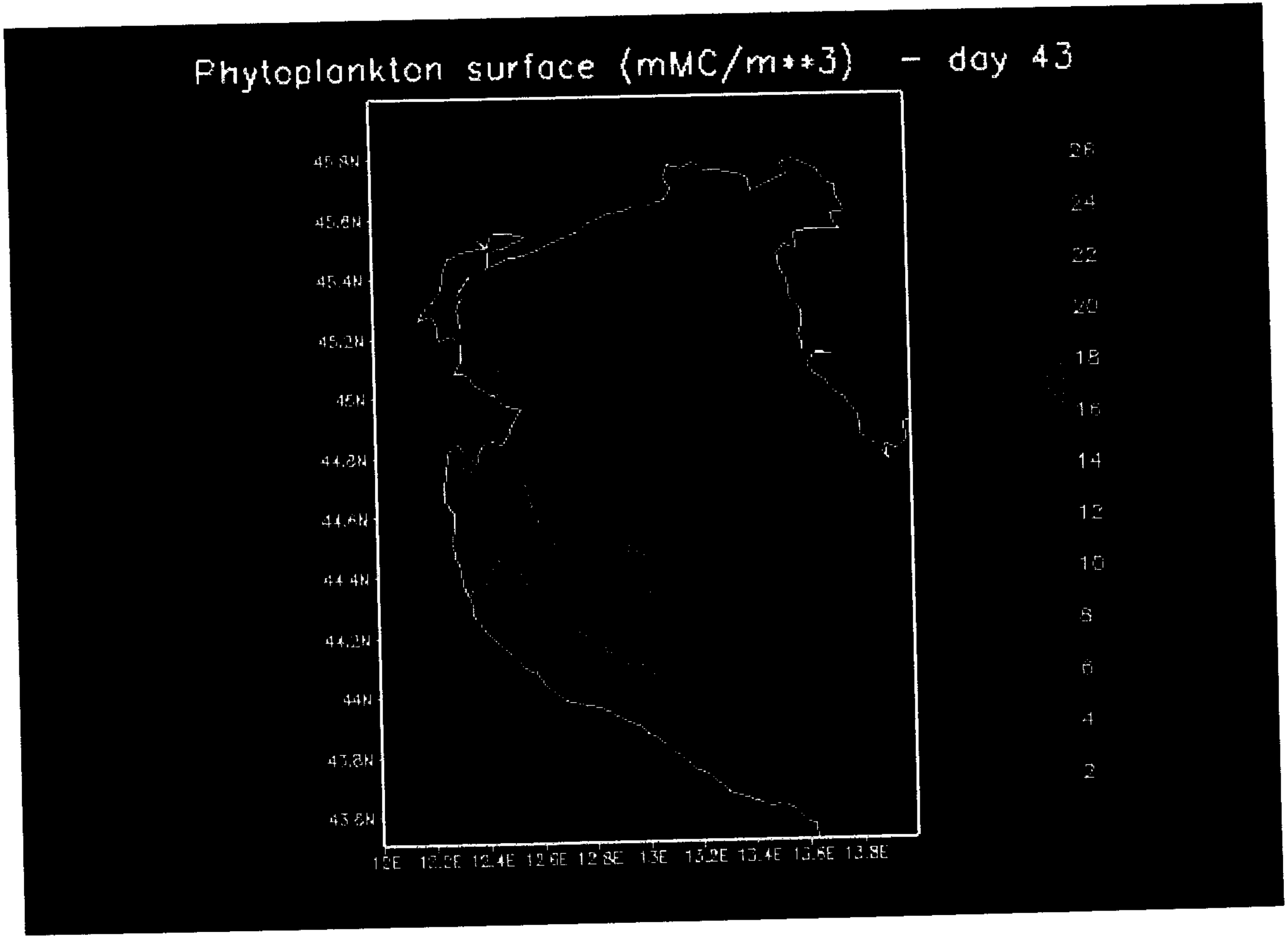
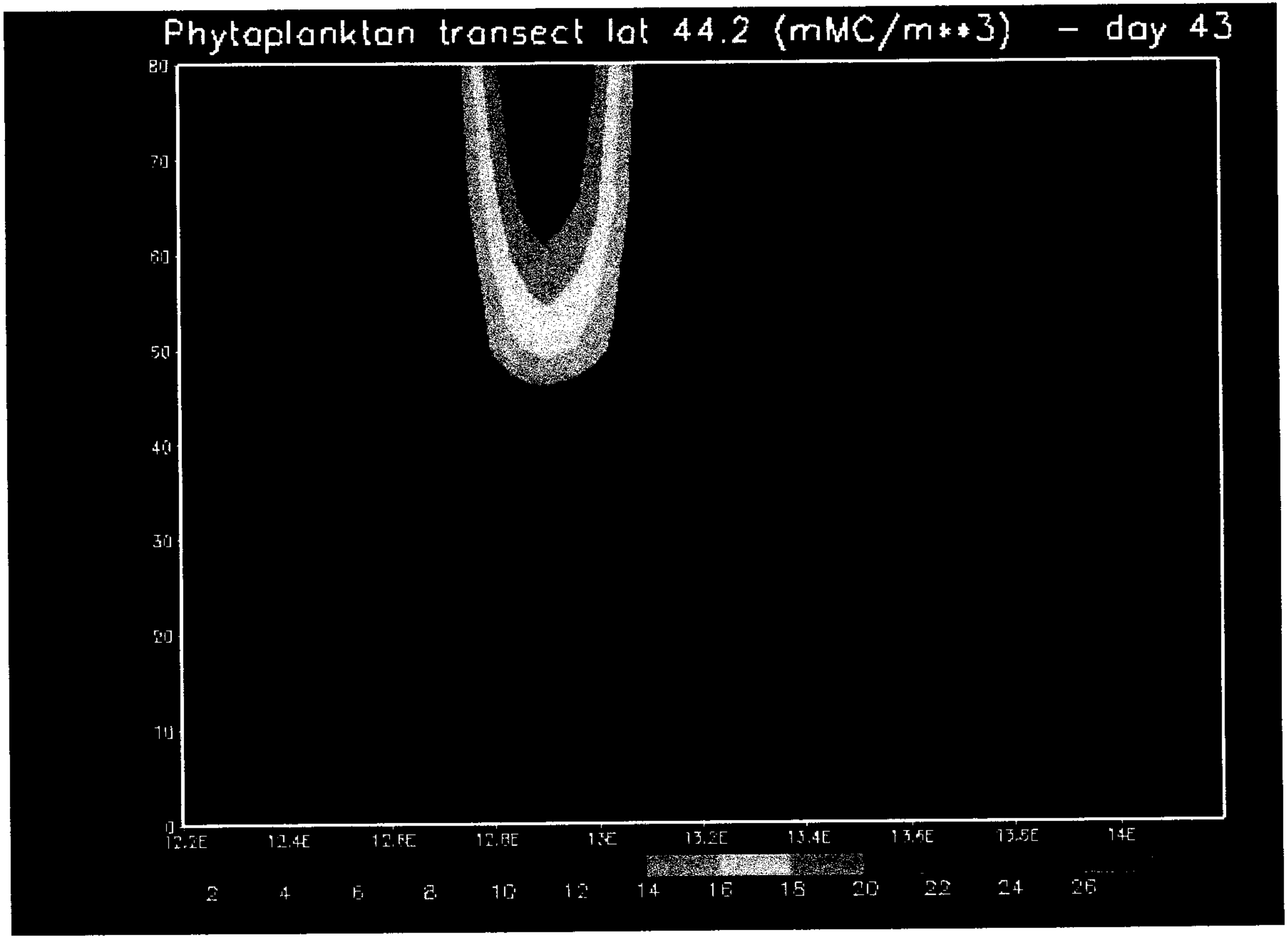

Phytoplankton surface (mMC/m**3) - day 43
45.8N
45.6N
45.4N
45.2N
45N
44.8N
44.6N
44.4N
44.2N
44N
43.8N
43.6N
12E 12.2E 12.4E 12.6E 12.8E 13E 13.2E 13.4E 13.6E 13.8E
26
24
22
20
18
16
14
12
10
8
6
4
2


Phytoplanktan transect lat 44.2 (mMC/m**3) - day 43
80
70
60
50
40
30
20
10
0
12.2E
12.4E
12.6E
12.8E
13E
13.2E
13.4E
13.6E
13.8E
14E
2
4
6
8
10
12
14
16
18
20
22
24
26