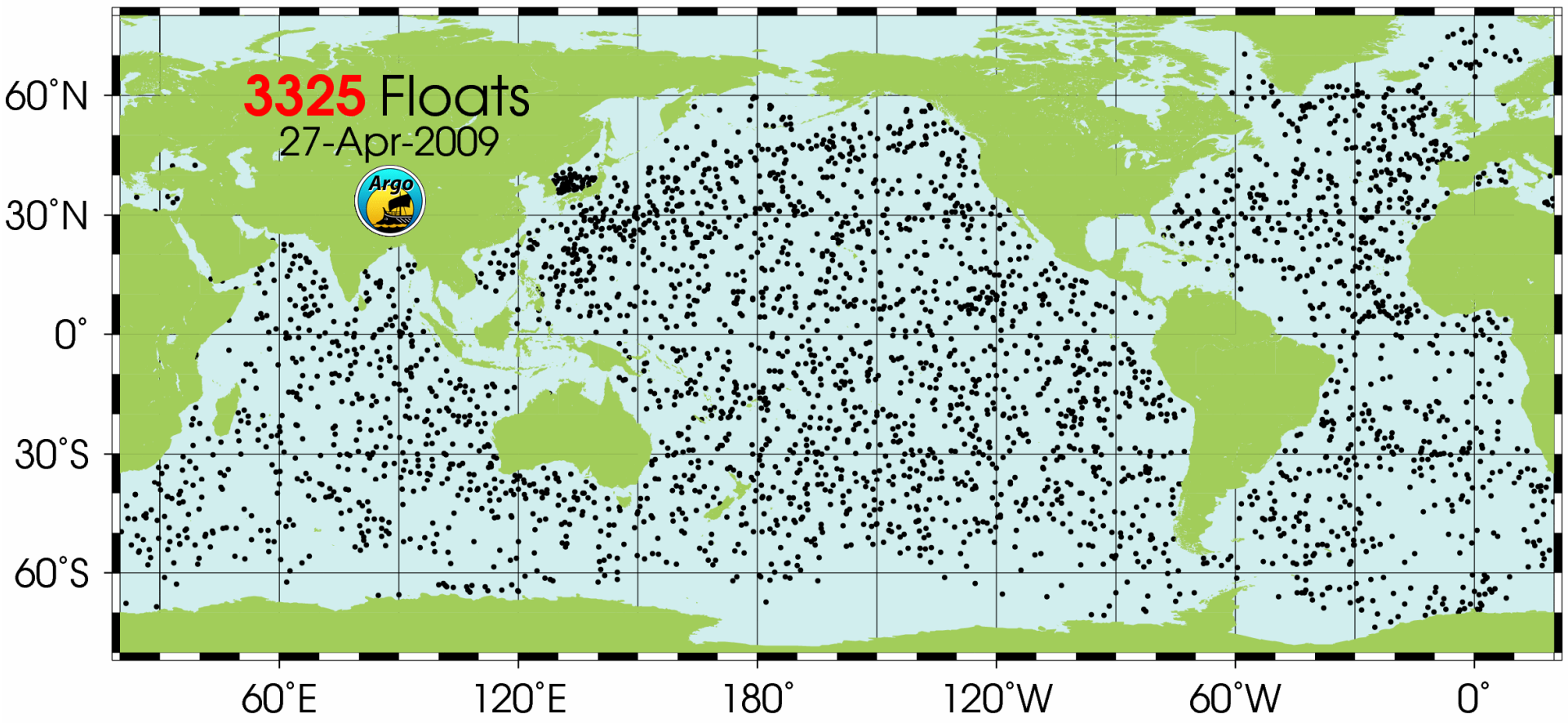
# Testing Sverdrup's hypothesis with a profiling float

Emmanuel Boss and Michael Behrenfeld
(+UW, WETLabs, Perry)

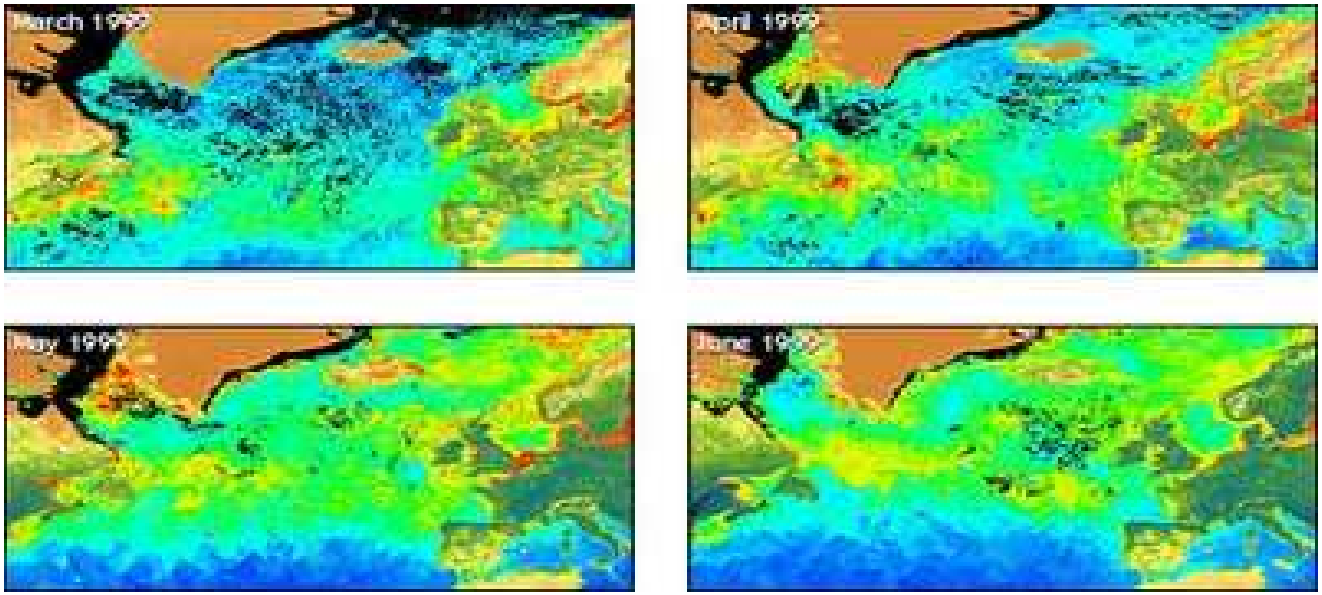
The hypothesis: in the sub-polar North Atlantic spring restratification (following winter mixing) is required for phytoplankton biomass to accumulate (have positive net community growth).

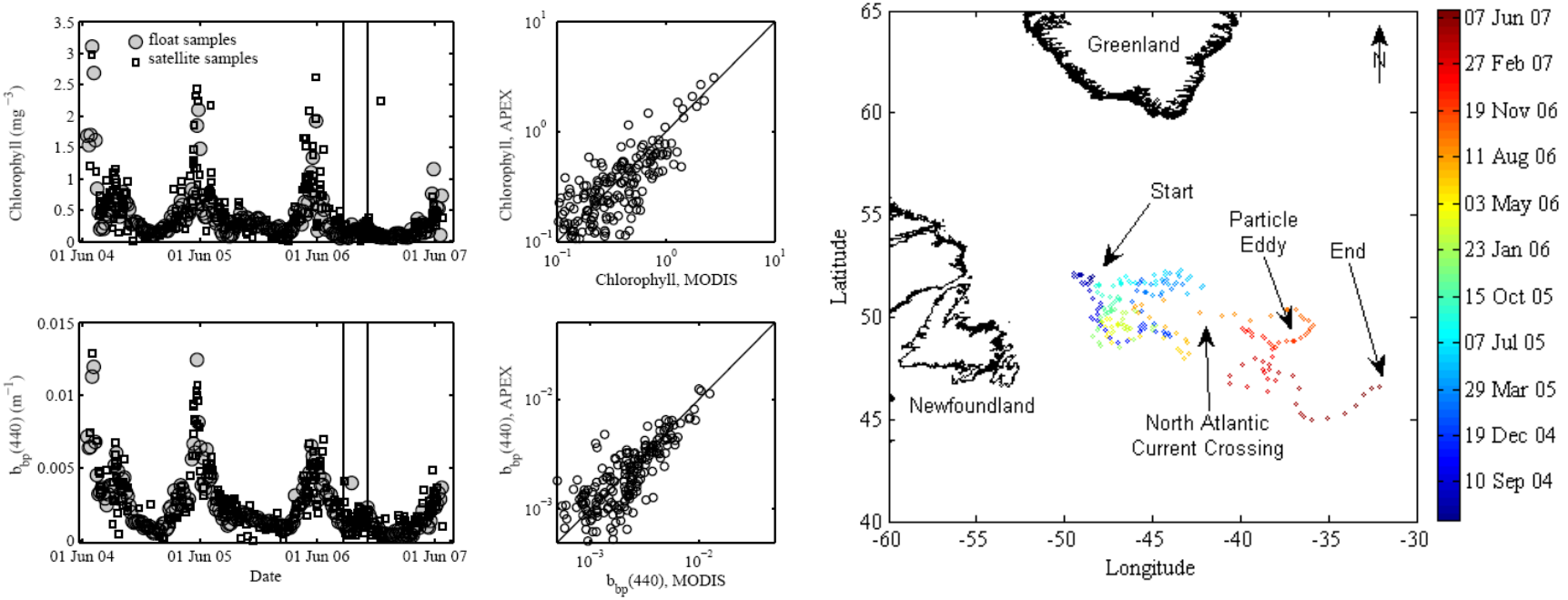
# Distribution of ARGO floats




Float profiles every 5days from 1000m, CTD + $b_{bp}$ and $F_{chl}$

# The NA spring bloom (most studied phenomena in Biological Oceanography):



# On Conditions for the Vernal Blooming of Phytoplankton.

By

**H. U. Sverdrup,**
Norsk Polarinstitutt, Oslo.

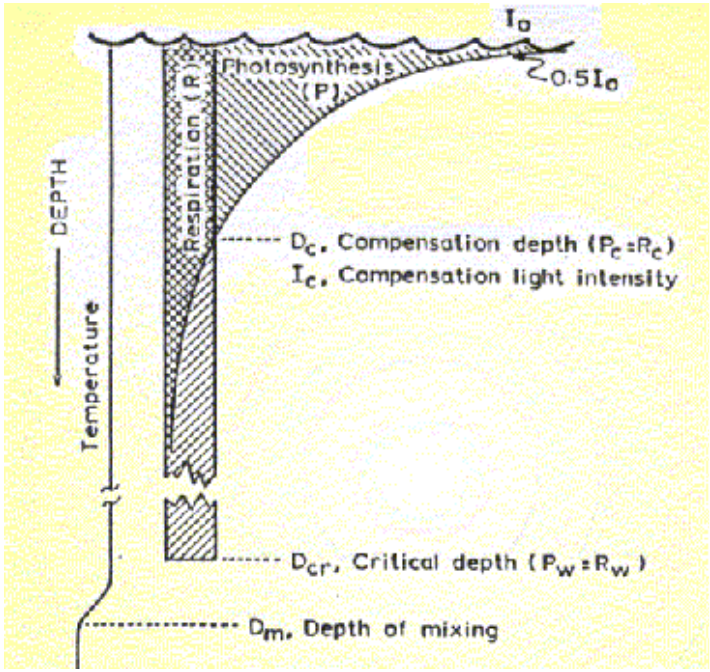
1953

$$\frac{\partial P}{\partial t} = (\alpha I - r)P, \qquad \alpha, r - const.$$

Blooming: $\partial P/\partial t > 0$.

In the oceans: $I(z) = I_0 e^{-kz}$

When phytoplankton are mixed too deep they cannot bloom.

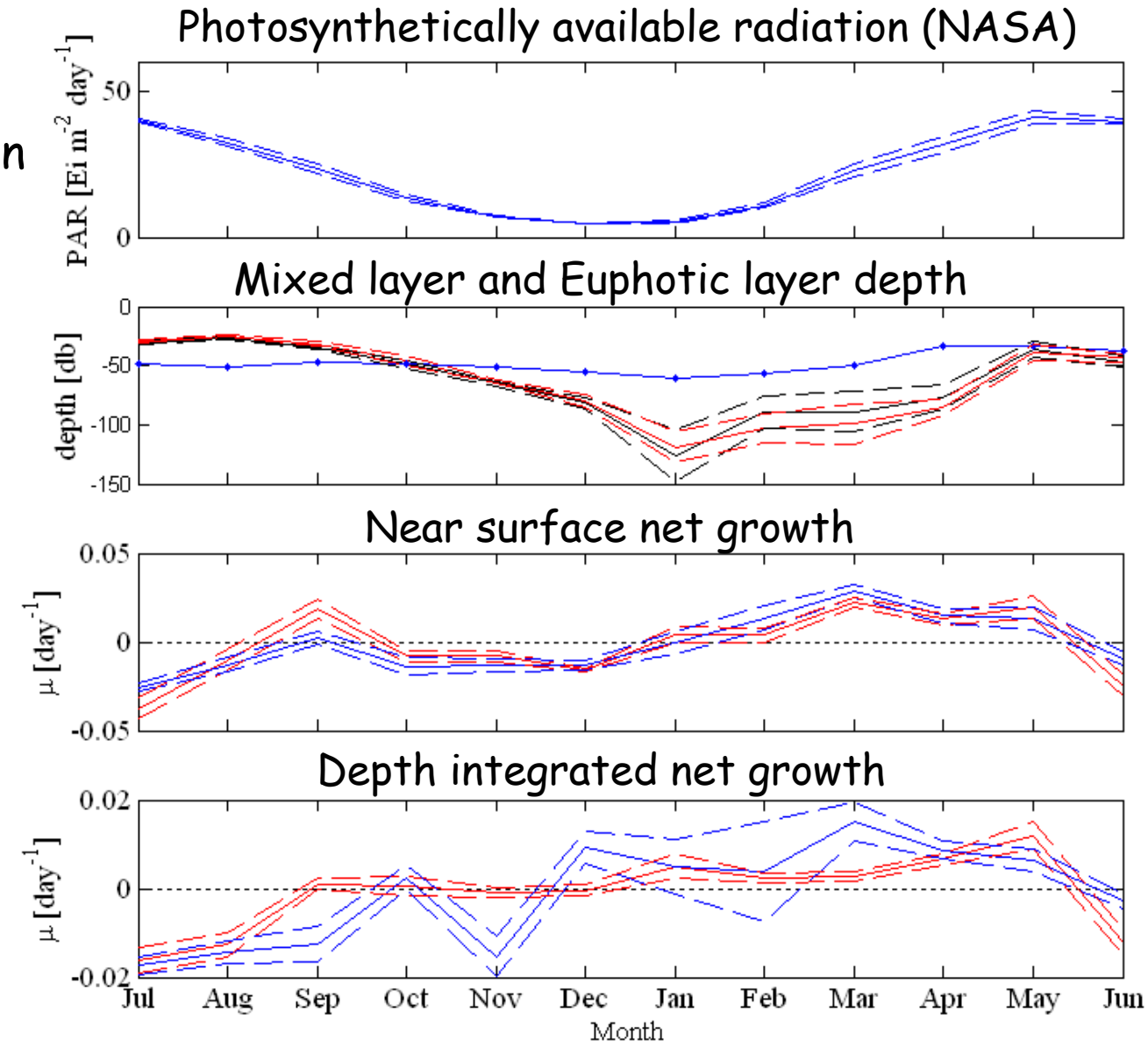


# Float results (monthly averages):

First: how do we estimate phytoplankton biomass?

Net growth is positive even when mixing is deepest and light is least.

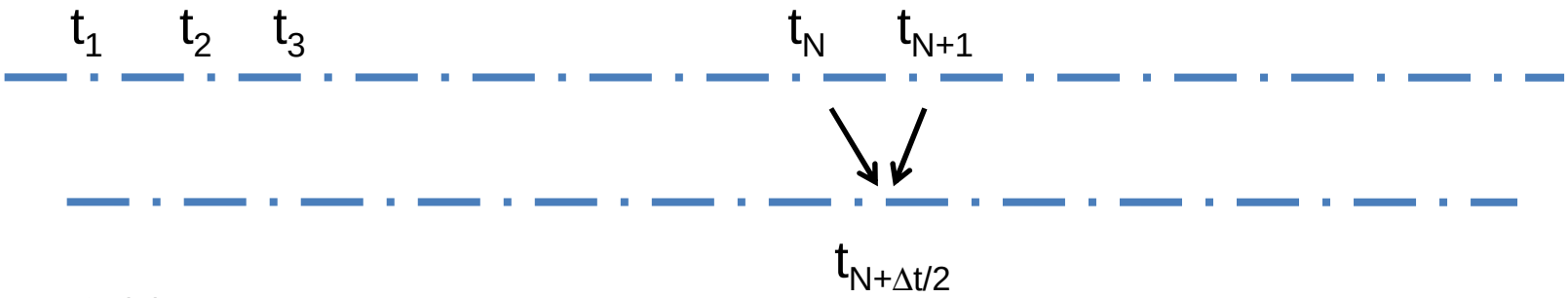
$$\mu_{net} \equiv \frac{1}{P}\frac{dP}{dt} = \frac{d \ln P}{dt}$$




$\mu_{net}$=0.05d$^{-1}$ → $T_{double}$=14 days

Method: $F_{chl}$ – red, $b_{bp}$ - blue

# Numerical recipes:




Center difference:

$$\mu_{net} = \frac{1}{P}\frac{dP(t_{N+\Delta t/2})}{dt} = \frac{d\ln P(t_{N+\Delta t/2})}{dt} \approx \frac{\ln P(t_{N+1}) - \ln P(t_N)}{\Delta t}$$

→Have approximately 6 estimates of growth rates per month each year

Uncertainty ≡ standard error of the mean

Vertical integration: to 300m depth (differences are very small compared to integrating to max(MLD, Euphotic depth).

Findings:

We observe values of net growth suggesting grazing rate ≈ phytoplankton growth.

Net growth becomes positive near when the light is minimal.

Traditional views of the 'bloom' are biased by focusing on $dP/dt$ rather than $dlnP/dt$.

Sverdrup hypothesis has a simplistic parameterization of the loss term ($-rP$):

$$\frac{\partial P}{\partial t} = (\alpha I - r)P, \qquad \alpha, r - const.$$

At least two additional nonlinear loss rates are currently recognized:

$$-gPZ - \beta P^2$$

When the water is mixed to depth in the winter, both are reduced (dilution).

In addition, phytoplankton respiration has been found to be almost negligible in cold dark conditions.

# A vision for the future: the Riley (or NPZ) float

Boss et al., 2008, *EOS*

N: ISUS

P: FL-NTU

Z: LOPC/Gorsky/novel cheap acoutic $b_b$

+PAR & $O_2$

Minimum sensor-suite to constrain ecosystem models.

Our current vision is constrained to be 'bottom-up' by the lack of cheap zooplankton sensors

The age of exploration is not over!

# Histograms of estimated $\mu_{Net}$