Isotope methodology to estimate aquatic production

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Aquatic production: Some terminology

P – gross production (C-fixation or O_2-formation)
R – "respiration" (C-oxidation or O_2-consumption)
P-R = N – net production

$$CO_2 + H_2O \underset{R}{\overset{P}{\rightleftharpoons}} CH_2O + O_2$$

Our goal is to estimate community net and gross production

In practice we run:
- Bottle incubations with: ^{14}C, ^{15}N and ^{18}O
- Field measurements of [O_2], [Ar] and oxygen isotope ratios

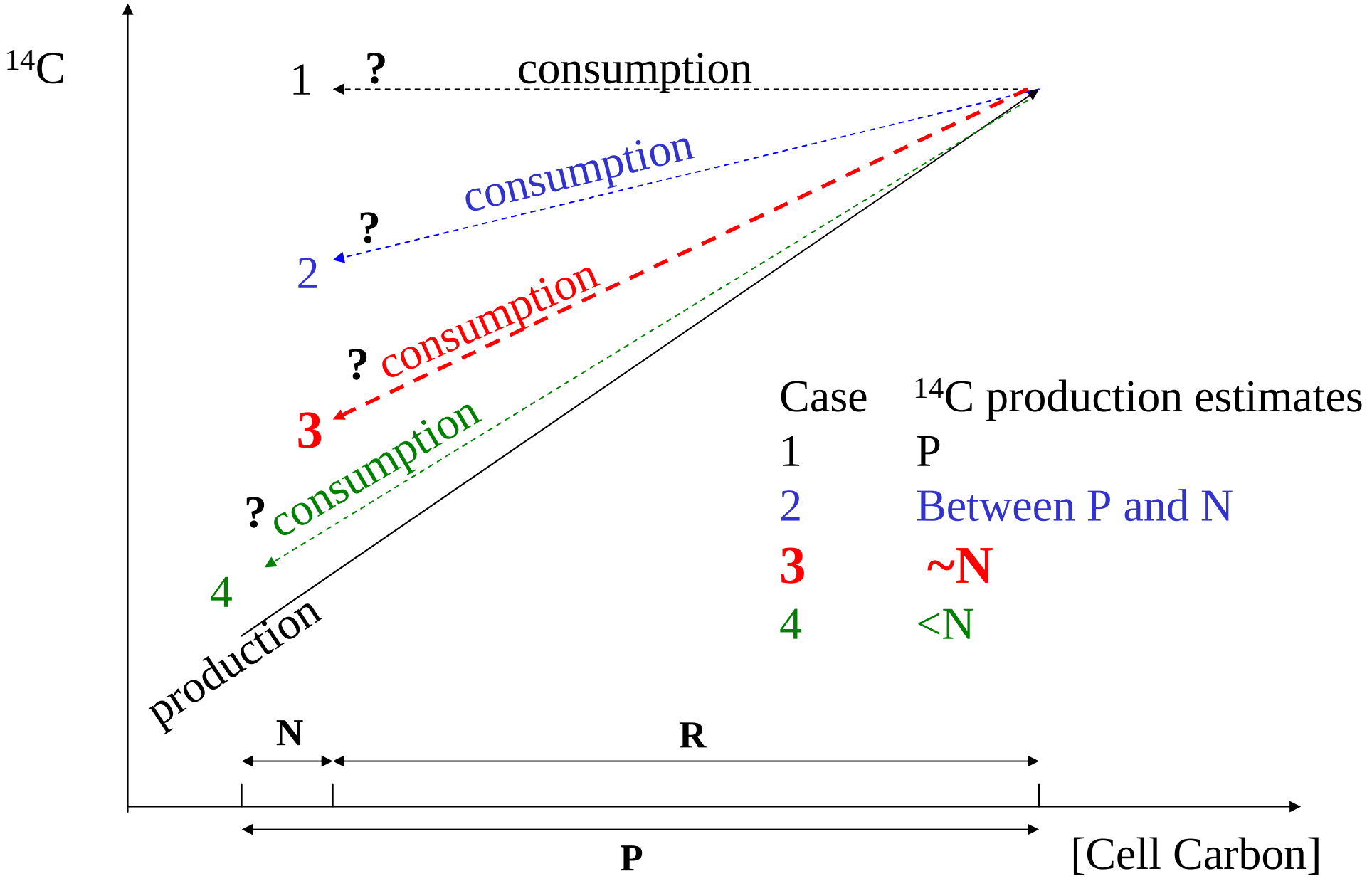
Which bottle incubation method is better?

- The ^{14}C method is relatively easy, but
- Suffers from uncertainty due to recycling of the ^{14}C spike

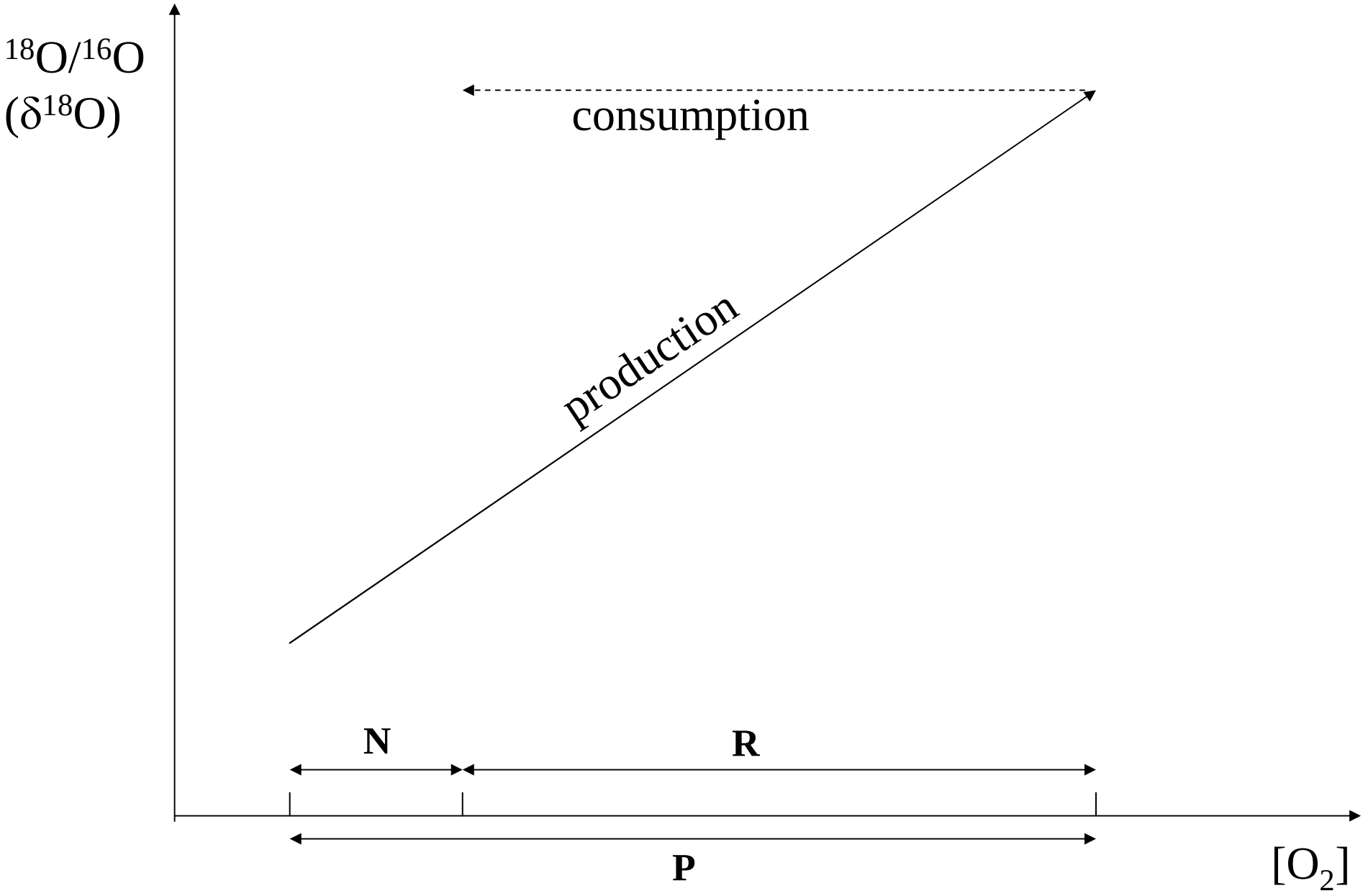
- The ^{15}N method measures net nitrogen fixation

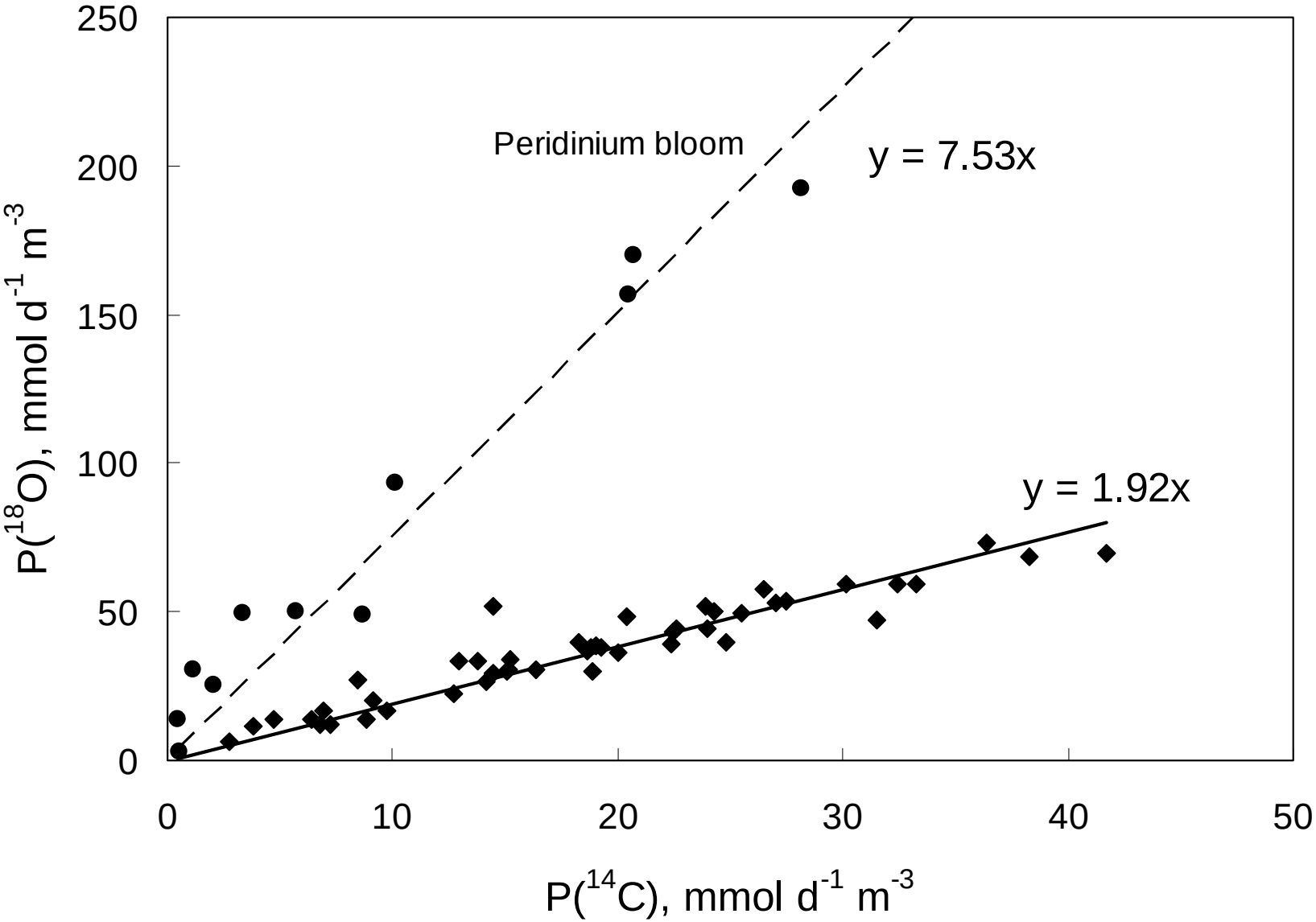
- The ^{18}O measures gross production and also net as a byproduct

Graphic presentation of the ^{14}C method

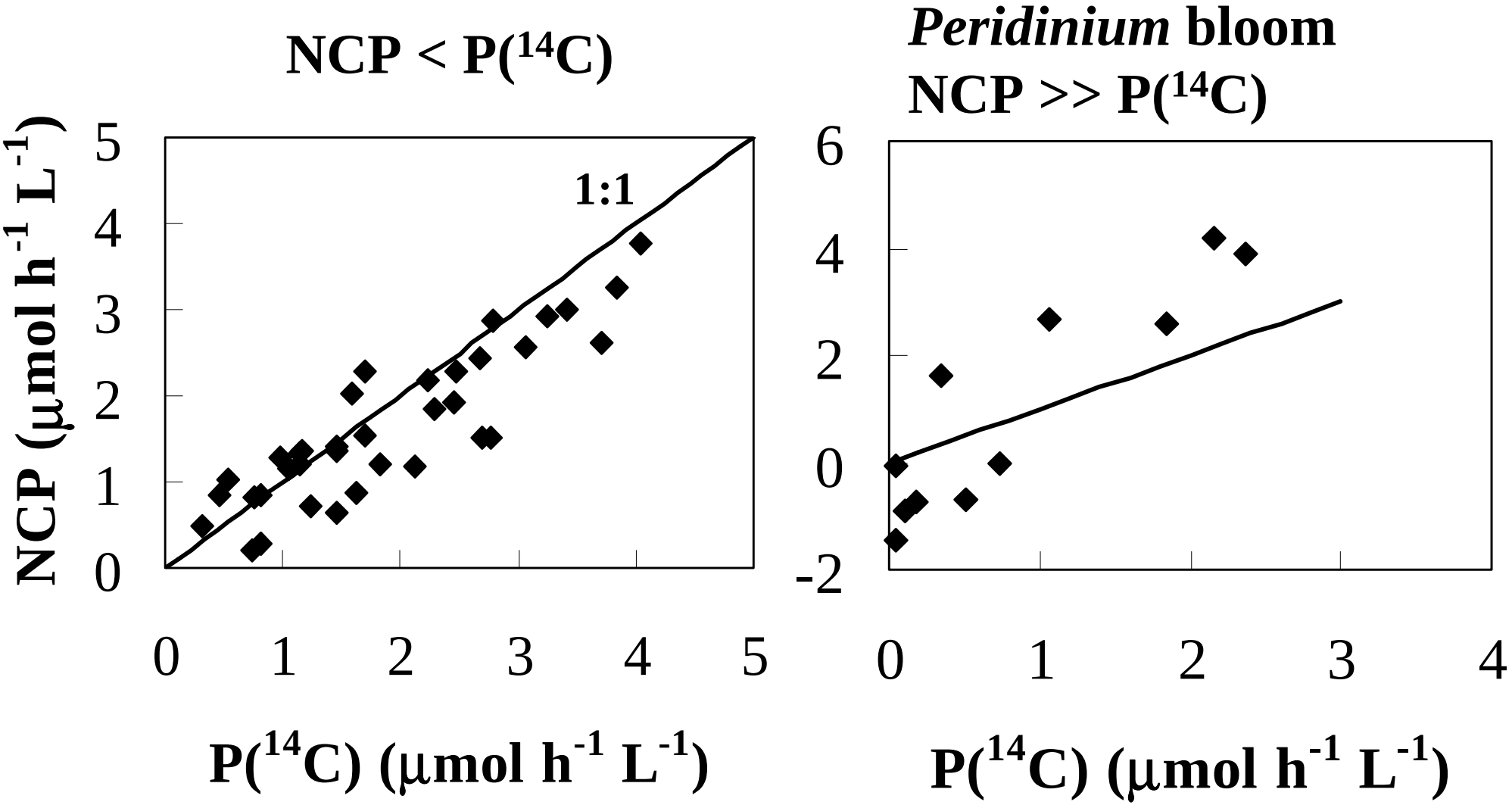


Graphic presentation of the ^{18}O method

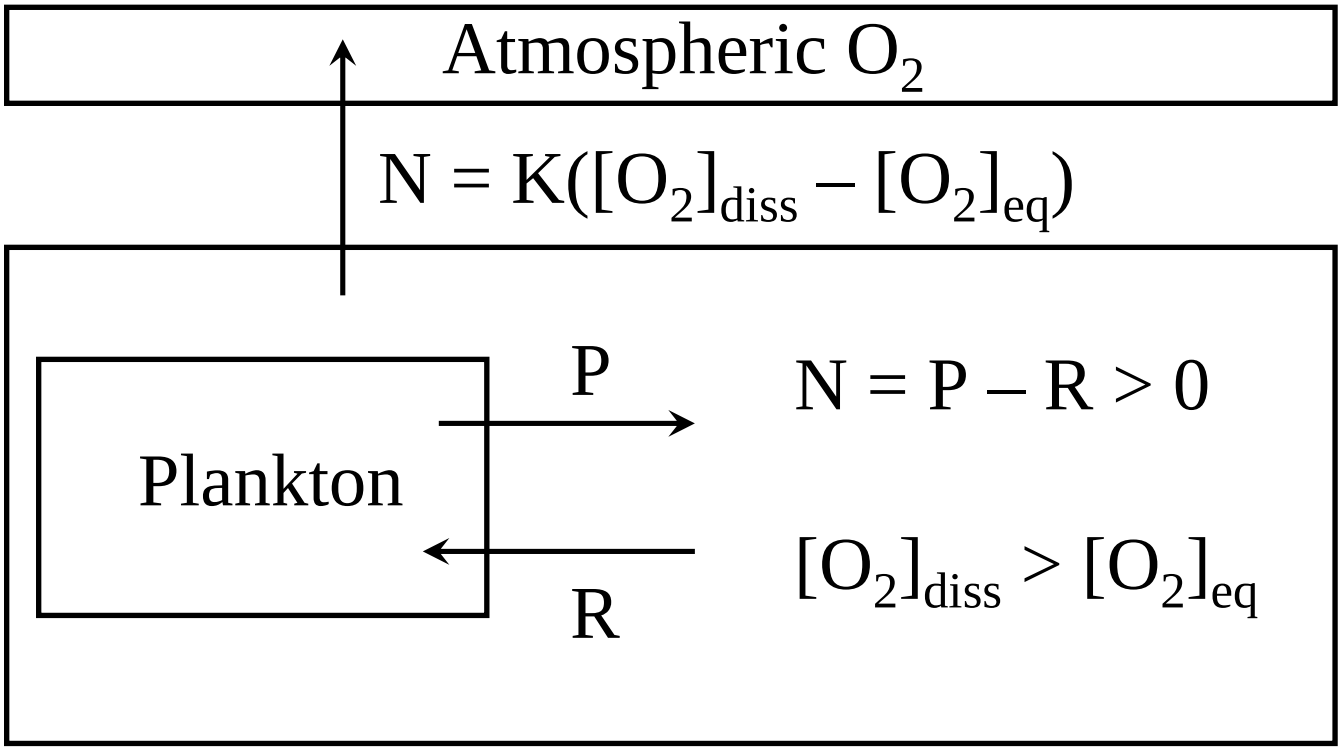




Collaborators: Barkan, Sagi, Yacobi (L&O 2002)



How these (bottle) rates compare with true NCP?



Net production ($N = P - R$)

$[O_2]_{diss}$ – measured concentration of dissolved oxygen in

$[O_2]_{eq}$ – equilibrium oxygen concentration

K – gas transfer velocity

$$N = K([O_2]_{diss} - [O_2]_{eq})$$

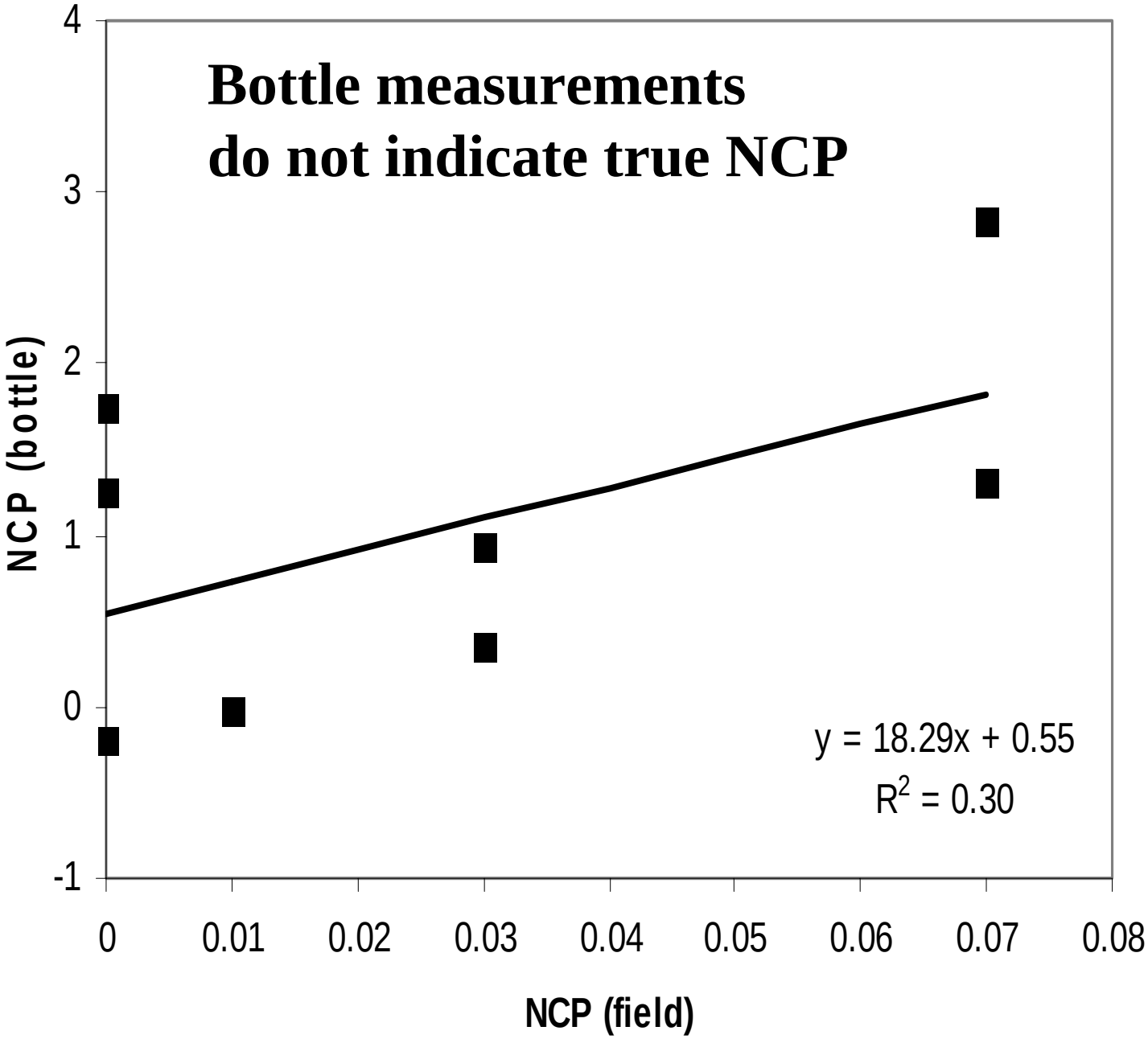
NCP – L. Kinneret

Date	field	bottle
11-Jul-96	0	1.25
26 Sept 96	0	-0.19
17-Apr-97	0.01	-0.02
06-May-97	0.03	0.36
04-Apr-98	0.03	0.93
03-May-98	0.07	1.31
14-Jun-98	0.07	2.84
04-Aug-98	0	1.74

We measure biological oxygen saturation directly from O_2/Ar (as a byproduct of the isotopic measurements) and calculate

NCP – net community production

In L. Kinneret, **bottle** estimates of NCP are **un-realistically exaggerated** because much of the respiration in the lake is not represented in the bottle measurements

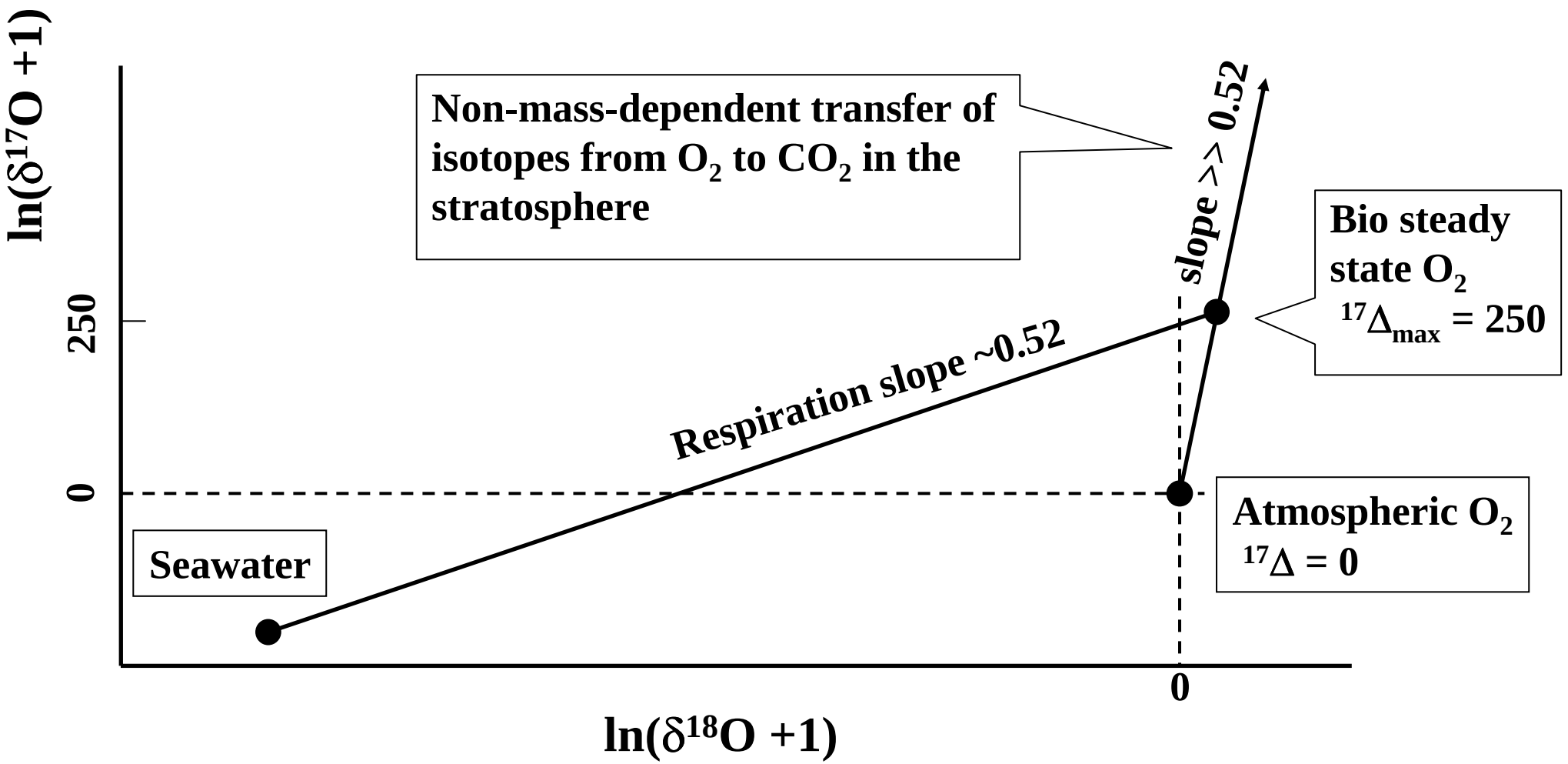

Bottle measurements
do not indicate true NCP
NCP (bottle)
NCP (field)
4
3
2
1
0
-1
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
y = 18.29x + 0.55
R2 = 0.30

Bottle measurements do not indicate true NCP

What about gross community production?

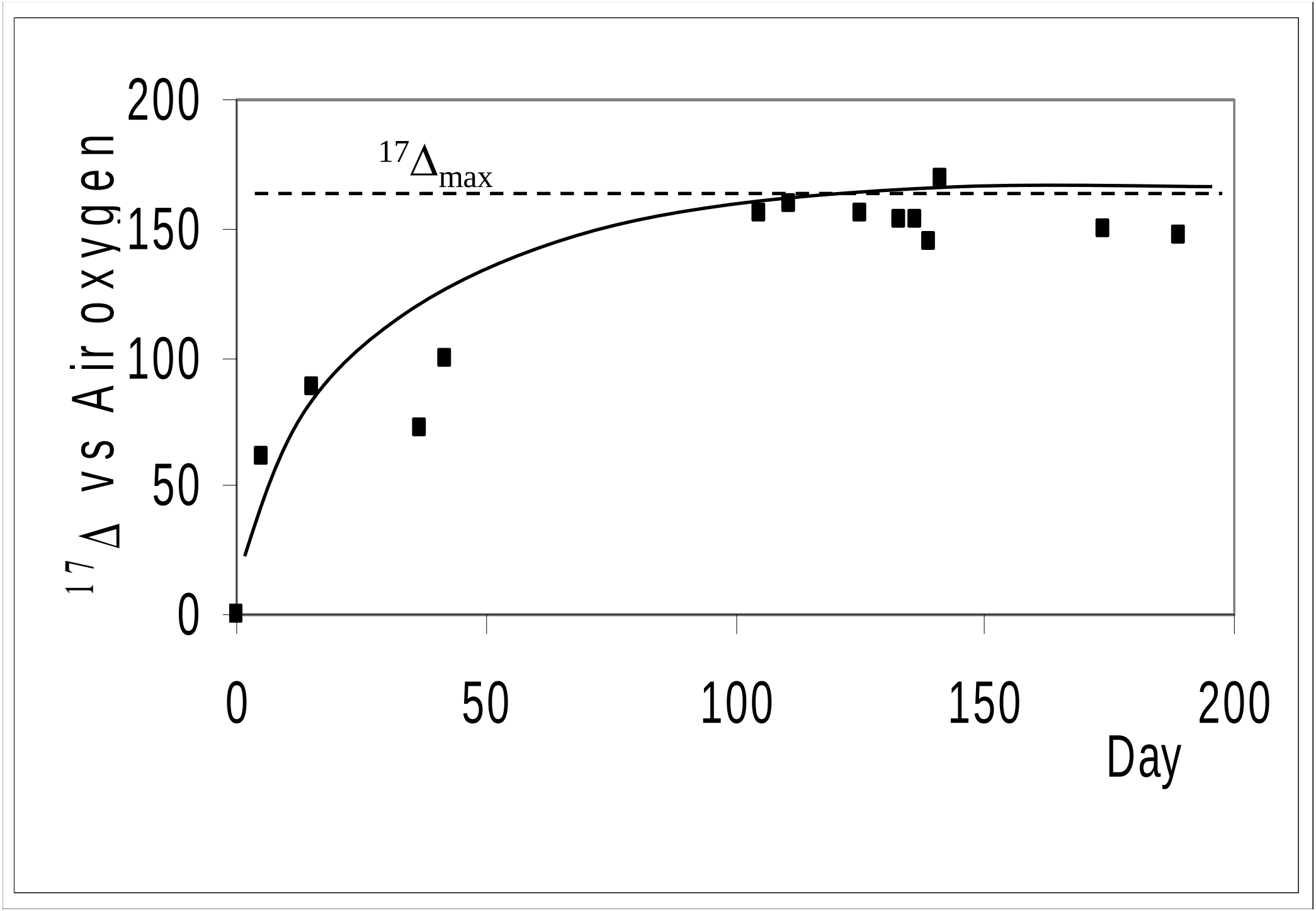
The answer is possible by using a natural spike to measure gross production

The spike is found in the $^{17}O/^{16}O$ and $^{18}O/^{16}O$ in air O_2

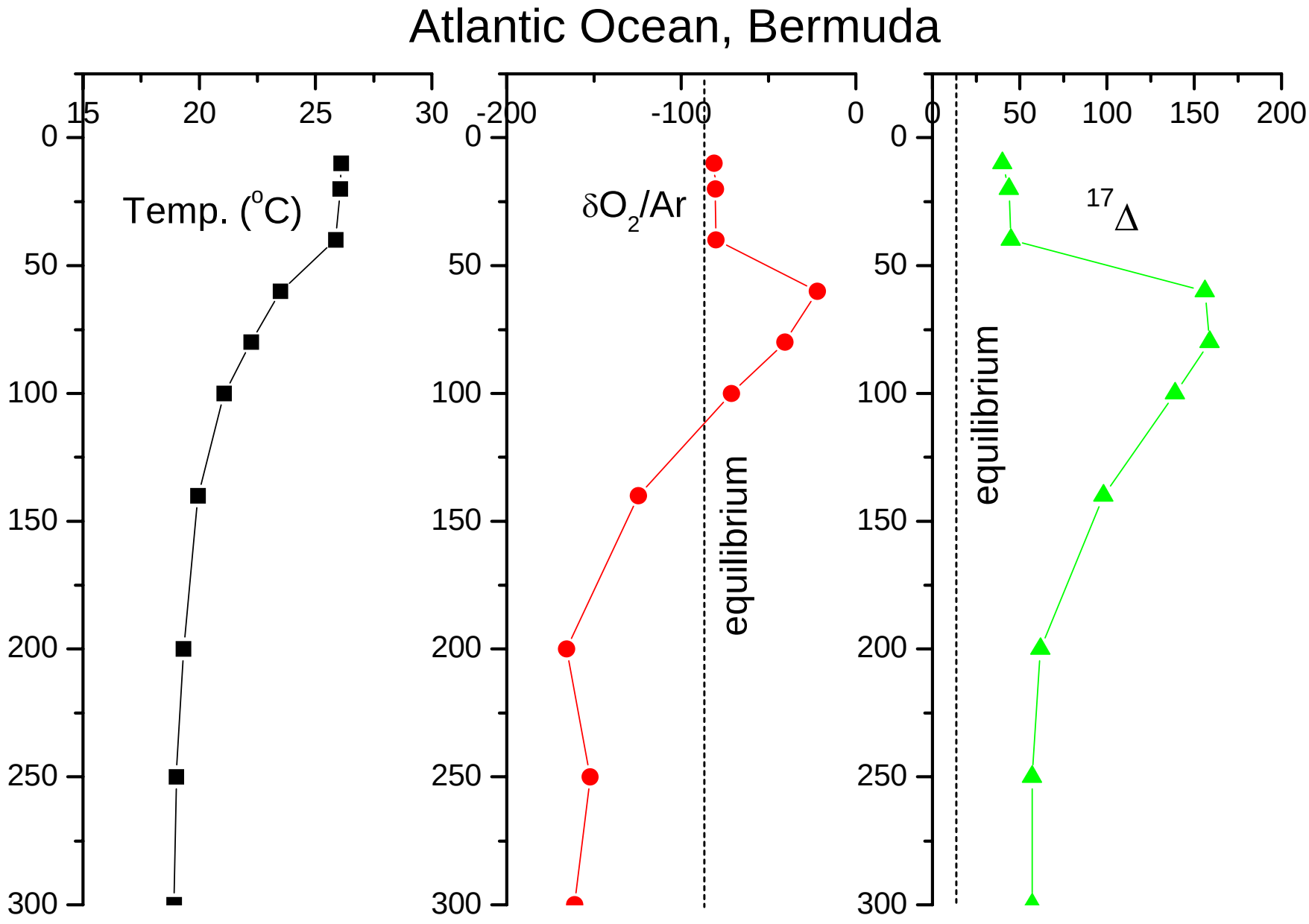


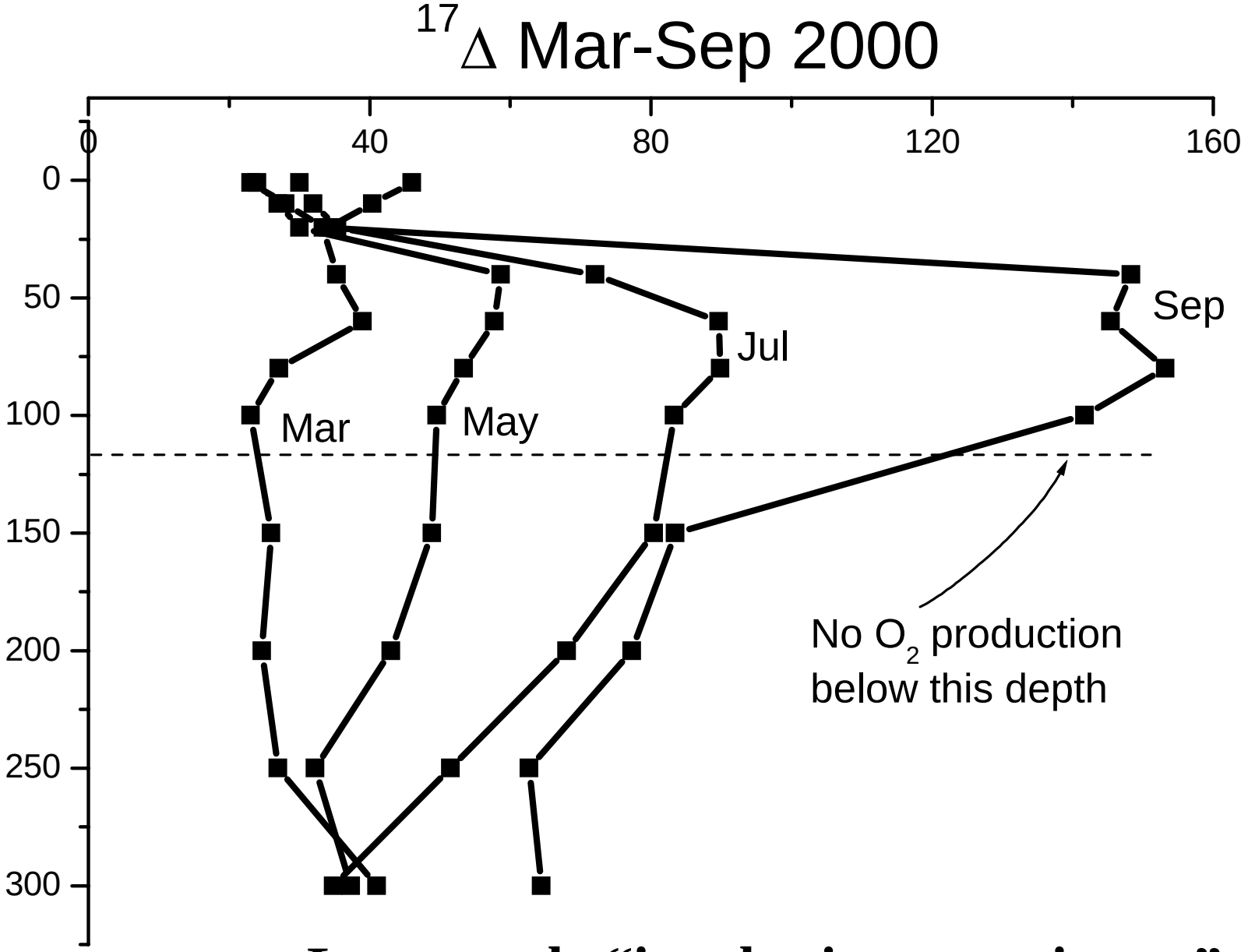
Atmospheric O_2 is different than O_2 affected only by photosynthesis and respiration

The deviation – $^{17}\Delta$ **– can be used to estimate gross production** just as $\delta^{18}O$ is used in ^{18}O spike experiments

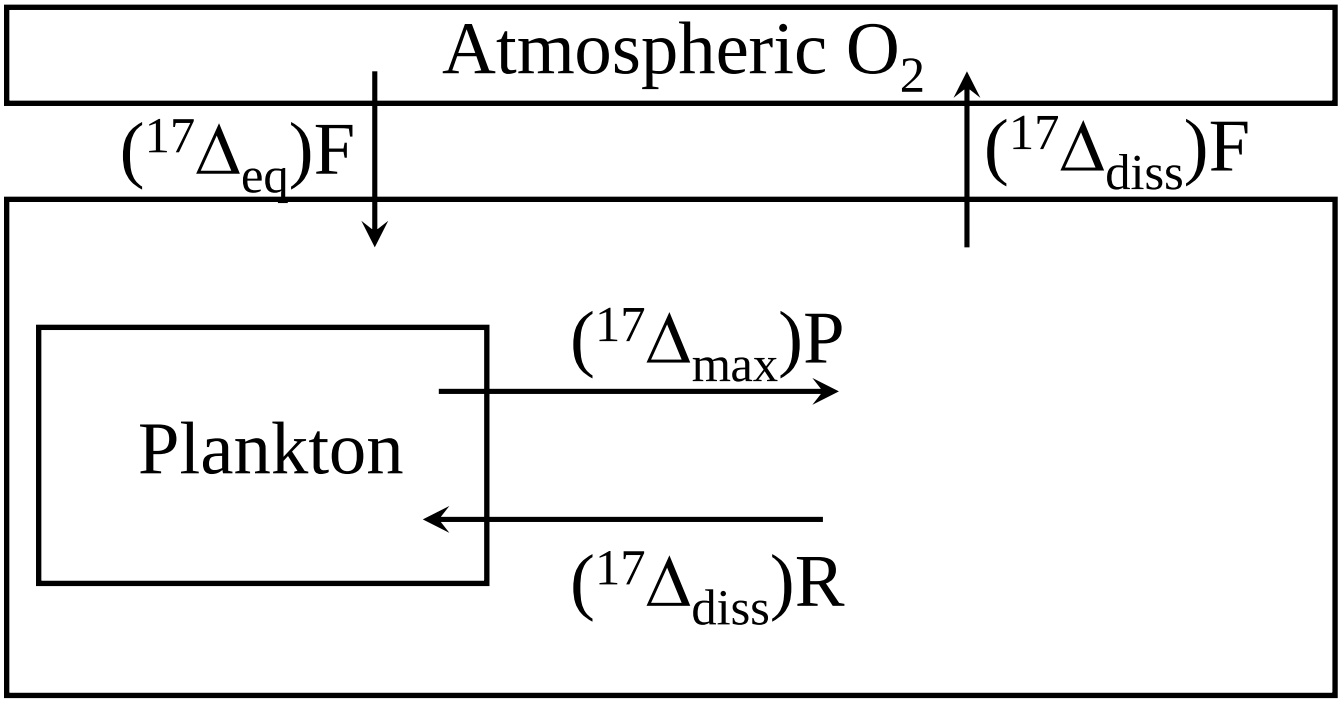

200
150
100
50
0
$^{17}\Delta$ vs Air oxygen
$^{17}\Delta_{max}$
0
50
100
150
200
Day

Atlantic Ocean station BATS
(Bermuda Atlantic Time-series Study)


Atlantic Ocean, Bermuda
Temp. (°C)
δO2/Ar
17Δ
equilibrium
equilibrium
15
20
25
30
-200
-100
0
0
50
100
150
200
0
50
100
150
200
250
300



Large scale "incubation experiment"



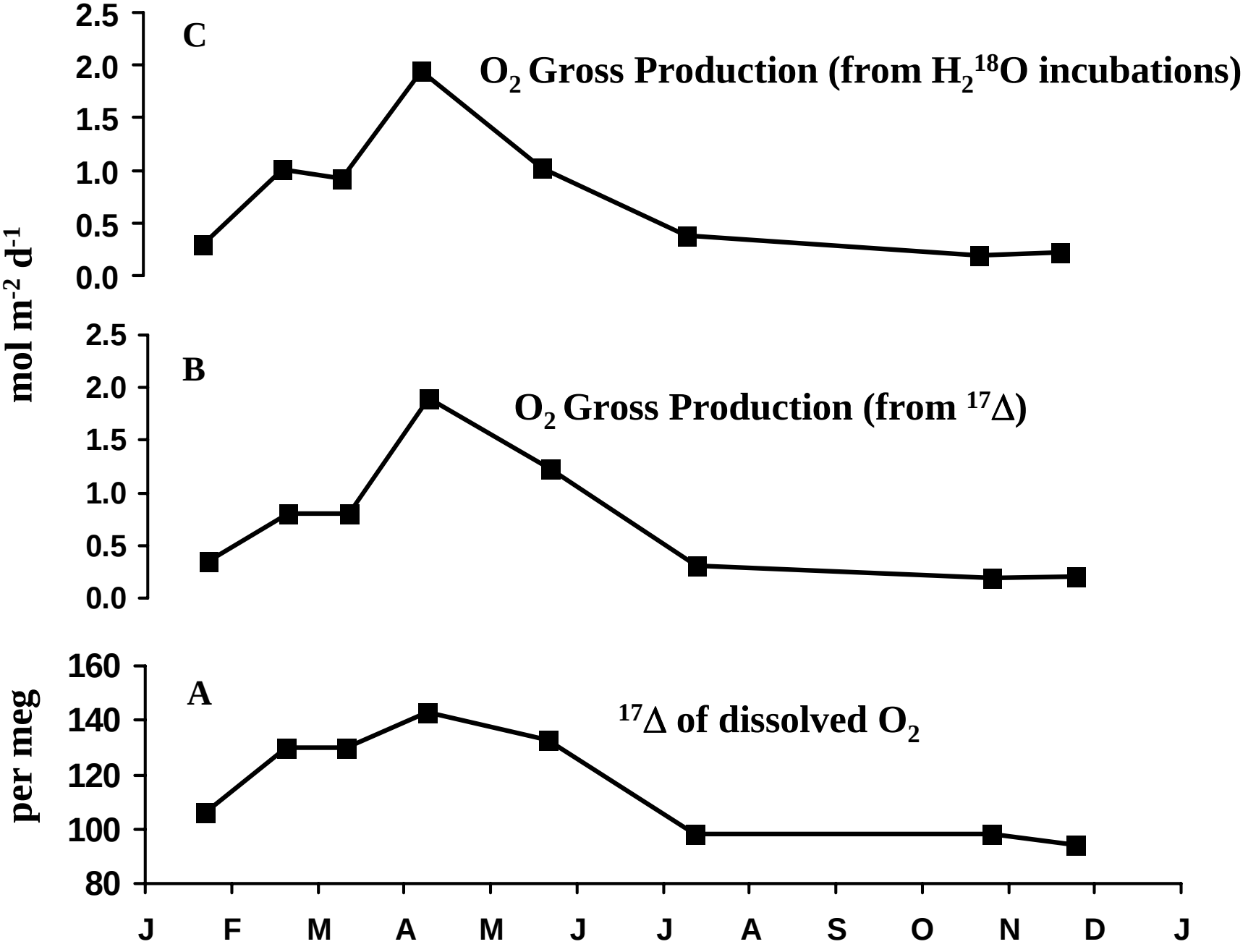
At steady state $^{17}\Delta$ flux balance is:

$$(^{17}\Delta_{eq})F + (^{17}\Delta_{max})P = (^{17}\Delta_{diss})R + (^{17}\Delta_{diss})(F + N)$$

$$P(^{17}\Delta_{max} - {}^{17}\Delta_{diss}) = F(^{17}\Delta_{diss} - {}^{17}\Delta_{eq}); \qquad F = KCo$$

$$P = (^{17}\Delta_{diss} - {}^{17}\Delta_{eq})/(^{17}\Delta_{max} - {}^{17}\Delta_{diss})KC_o$$

Gross Production in L. Kinneret



Conclusions

1. It is not clear what ^{14}C incubations measure.
   (Gross production? Net production? In between?)

2. [O_2] incubations measure net O_2 production in the bottle but not true community production

3. $H_2{}^{18}O$ incubations measure gross O_2 production in the bottle and also in the field as confirmed by the $^{17}\Delta$ method

4. The $^{17}\Delta$ method gives integrated estimates of gross community production and O_2/Ar measurements give net community production and **there is no need for bottle incubations**