

Isotope methodology to estimate aquatic production

Boaz Luz

Institute of Earth Sciences, Hebrew University, Jerusalem

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Collaboration:

E. Barkan

Y. Yacobi

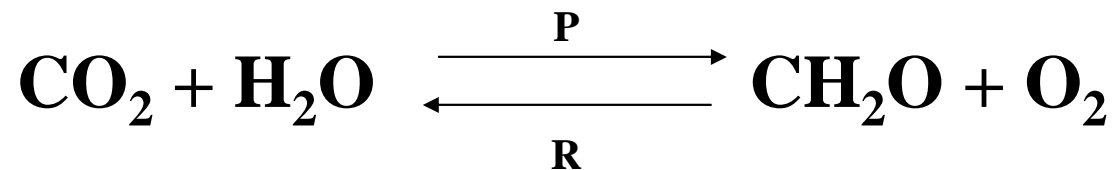
Y. Sagi

Aquatic production: Some terminology

P – gross production (C-fixation or O₂-formation)

R – “respiration” (C-oxidation or O₂-consumption)

P-R = N – net production



Our goal is to estimate community net and gross production

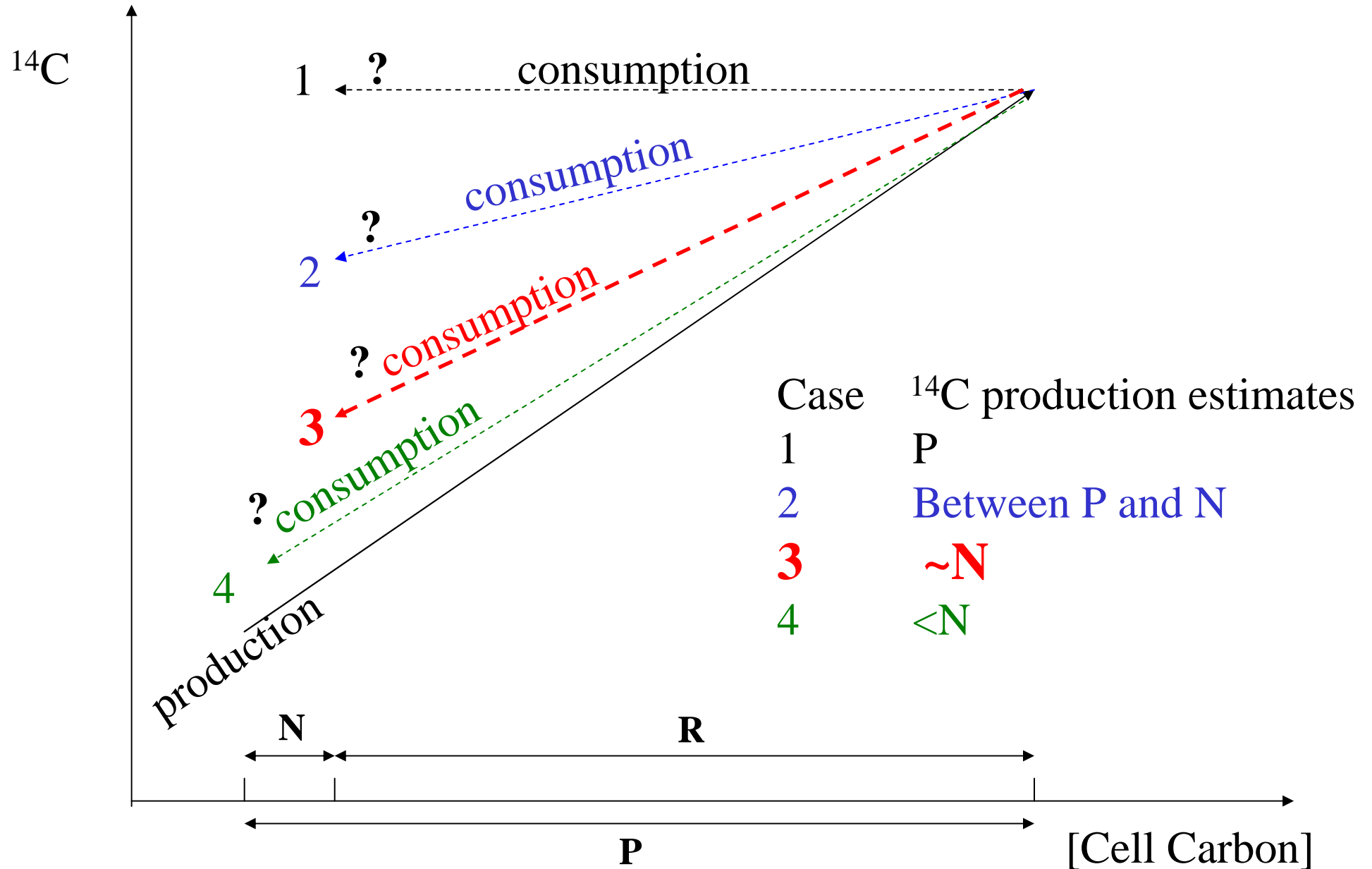
In practice we run:

- Bottle incubations with: ^{14}C , ^{15}N and ^{18}O
- Field measurements of $[\text{O}_2]$, $[\text{Ar}]$ and oxygen isotope ratios

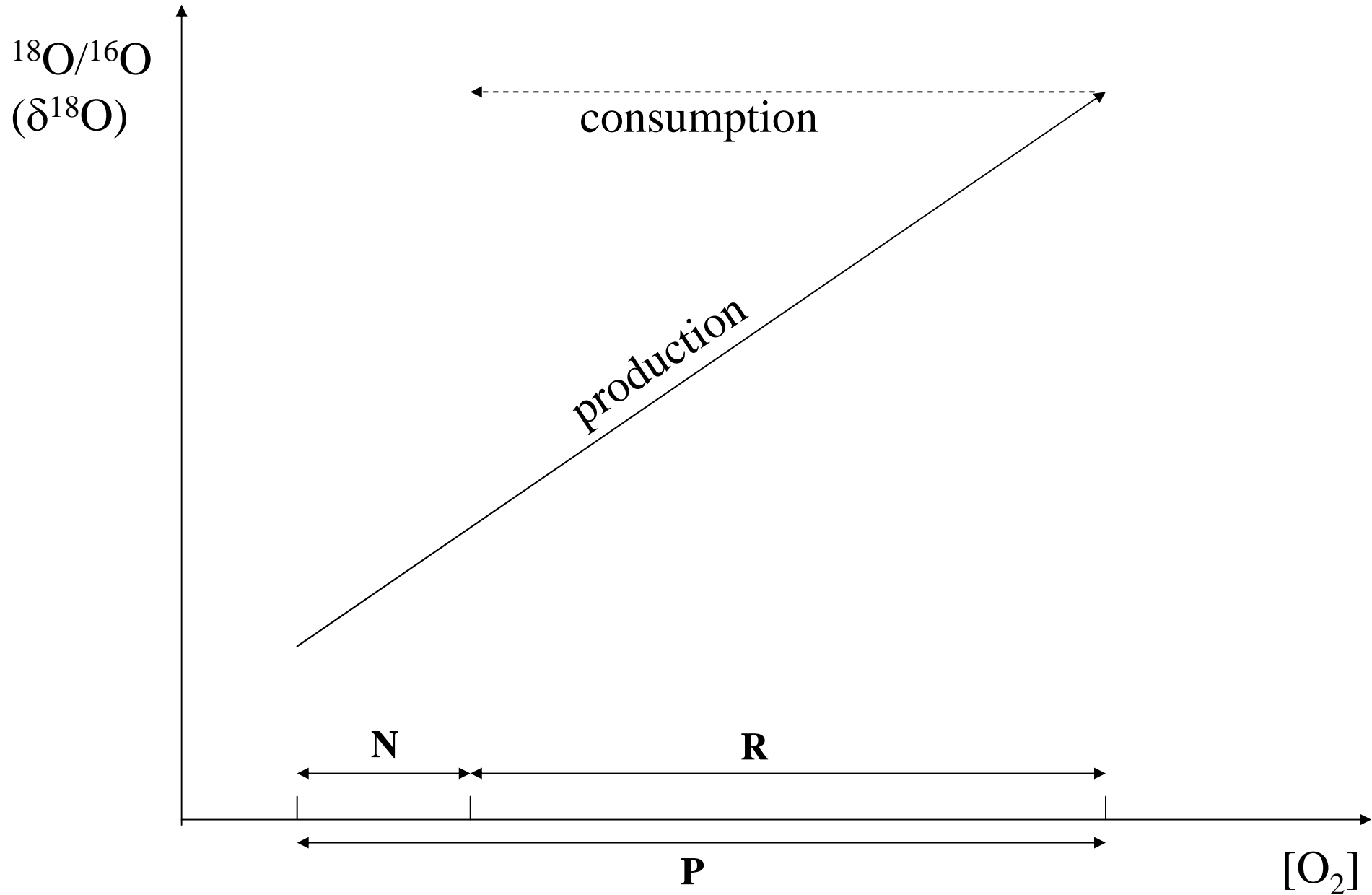
Which bottle incubation method is better?

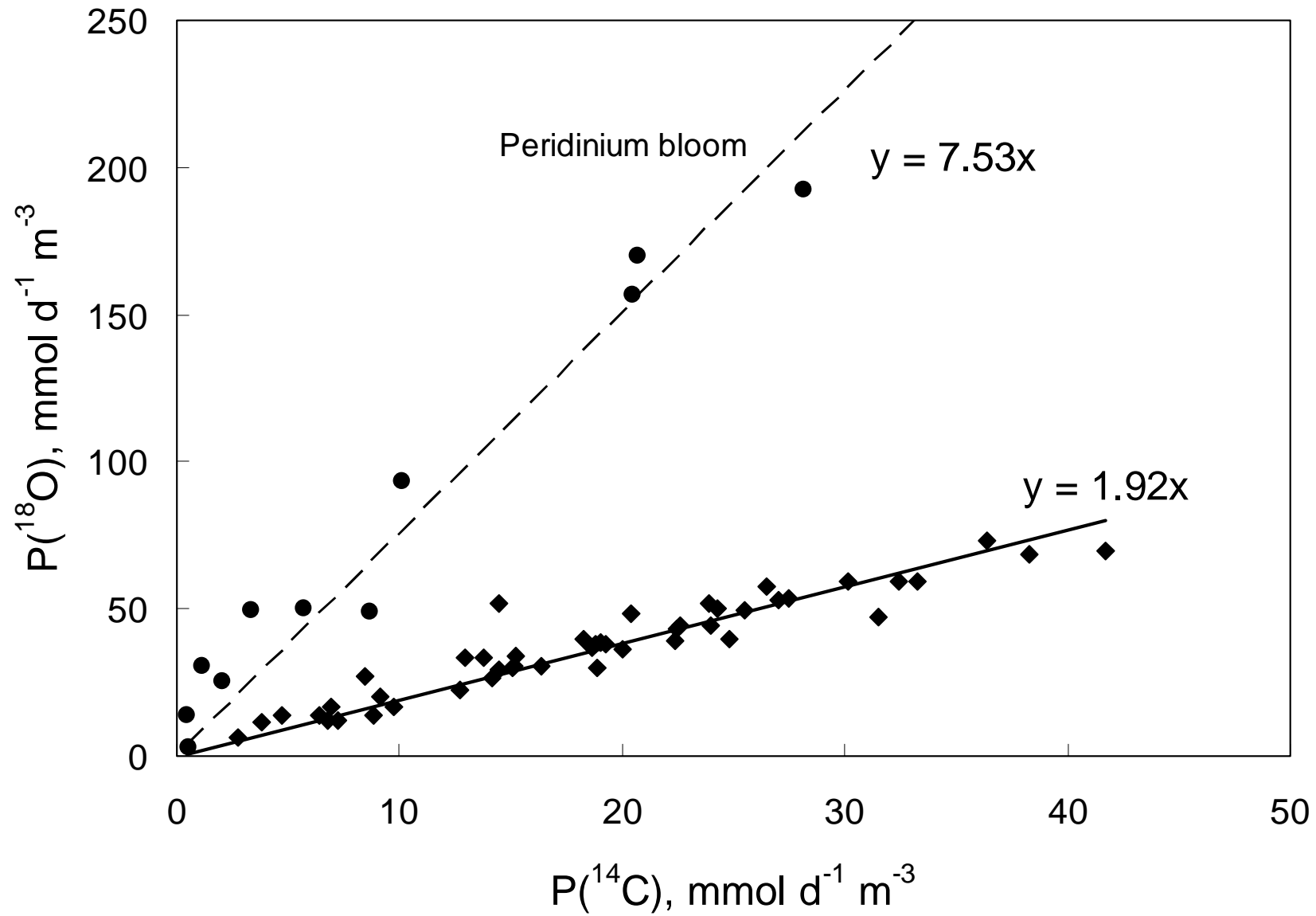
- The ^{14}C method is relatively easy, but
- Suffers from uncertainty due to recycling of the ^{14}C spike
- The ^{15}N method measures net nitrogen fixation
- The ^{18}O measures gross production and also net as a byproduct

Graphic presentation of the ^{14}C method

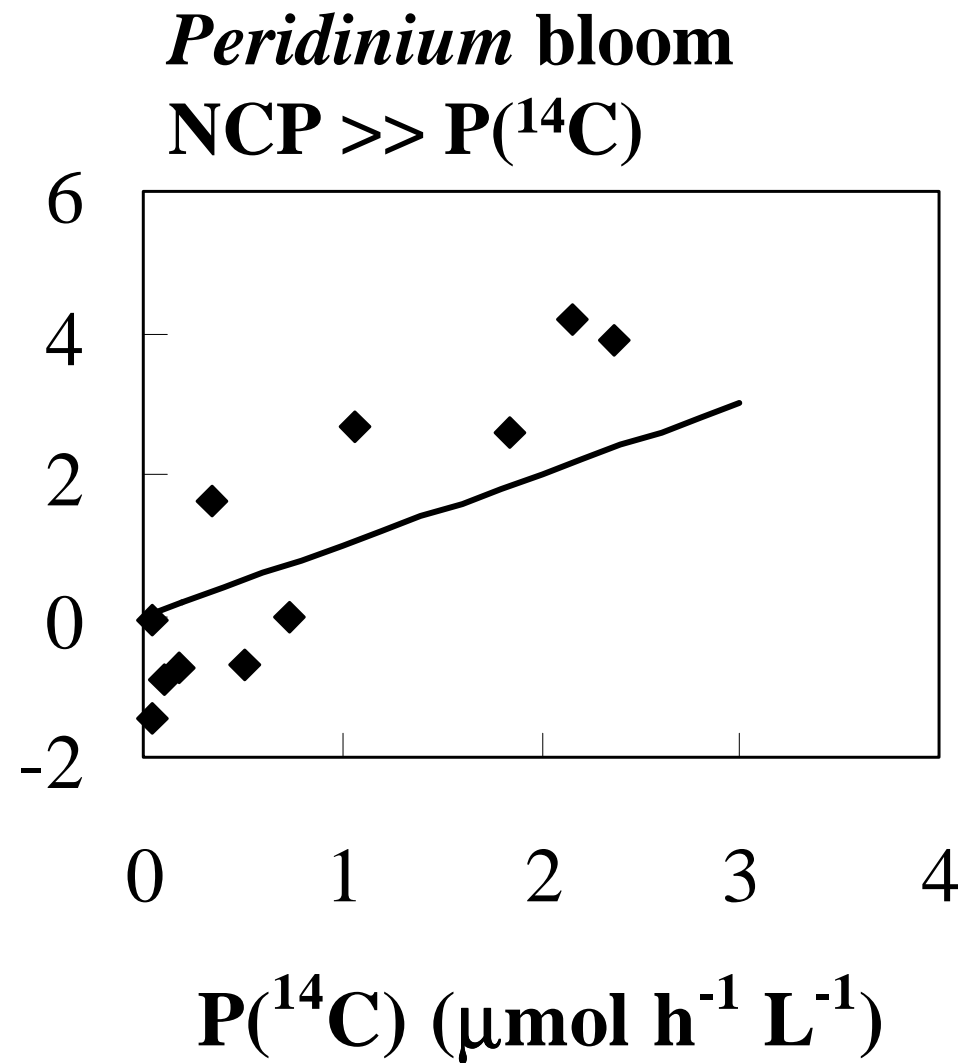
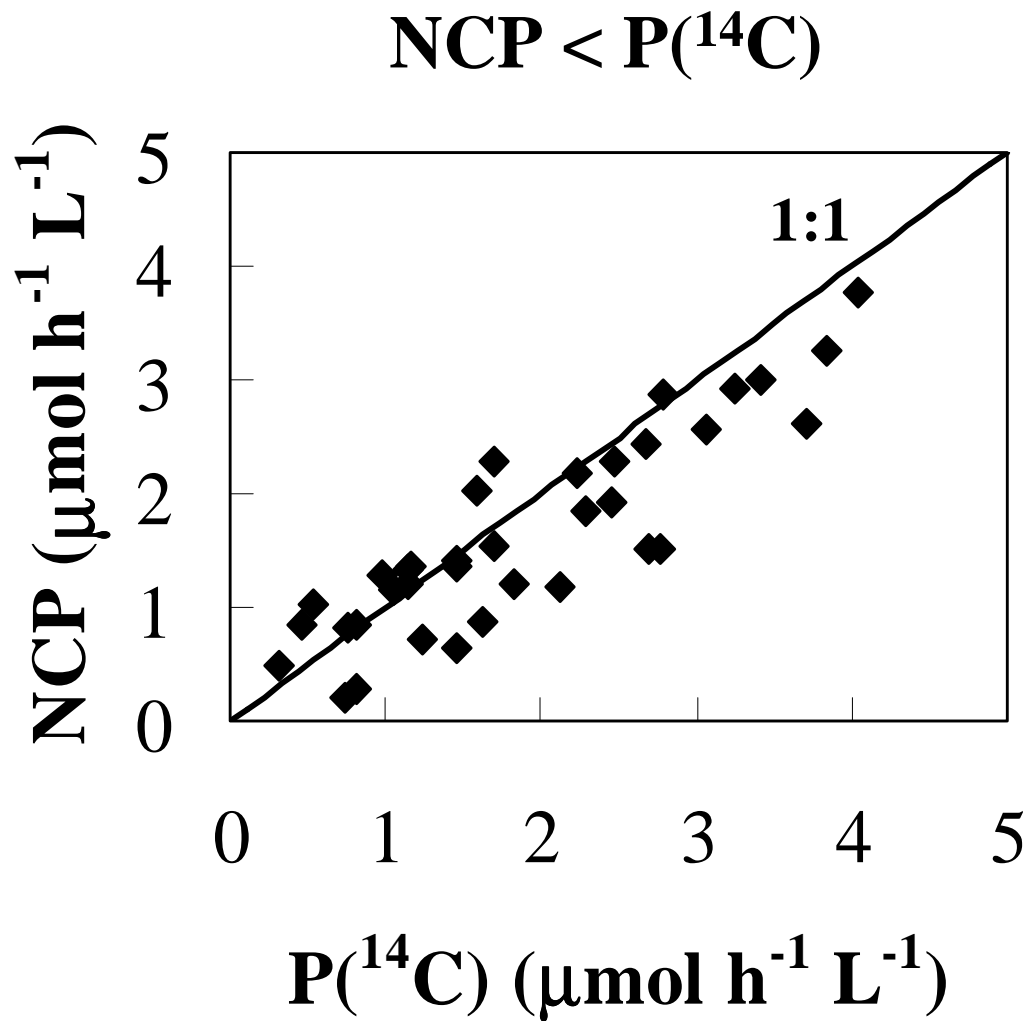


Graphic presentation of the ^{18}O method

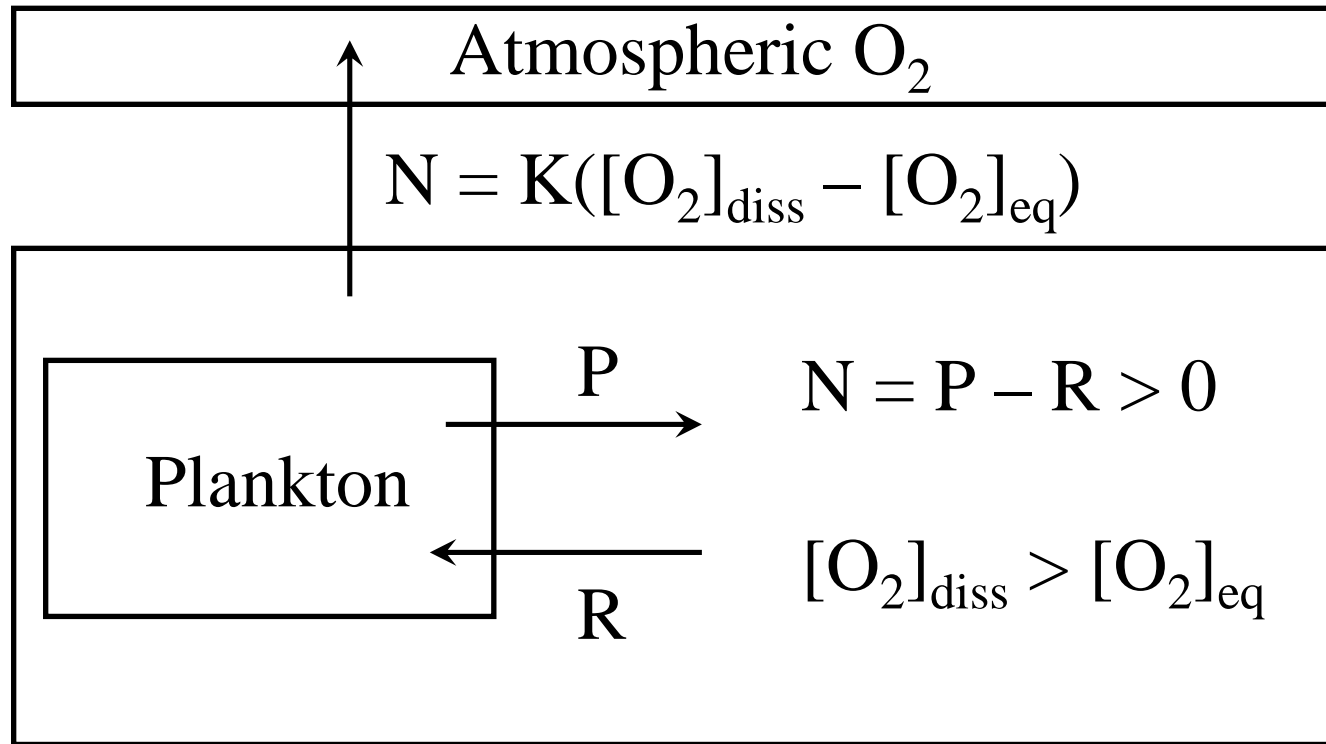




Collaborators: Barkan, Sagi, Yacobi (L&O 2002)



How these (bottle) rates compare with true NCP?



Net production ($N = P - R$)

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

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

K – gas transfer velocity

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

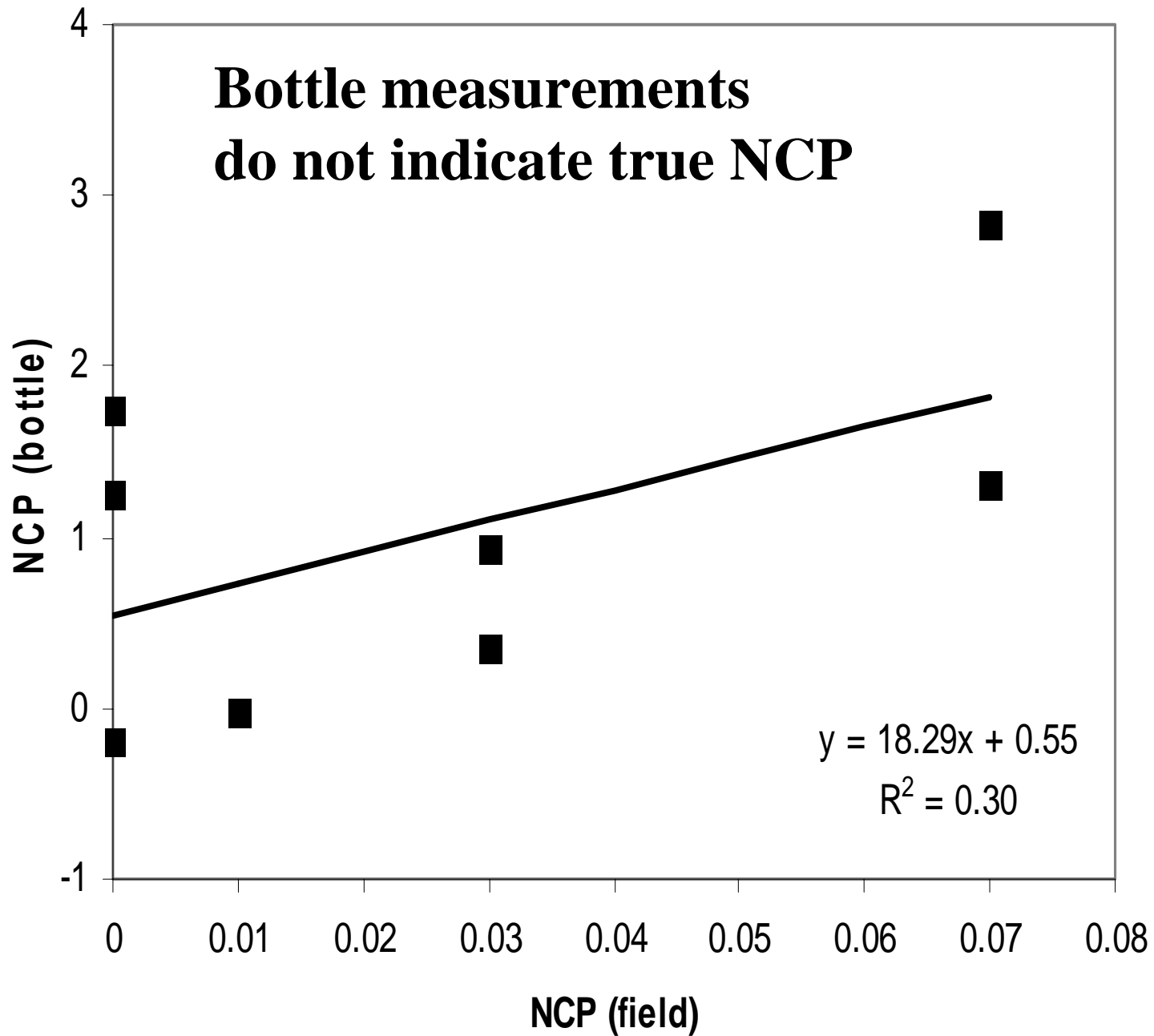
NCP – L. Kinneret

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 O₂/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

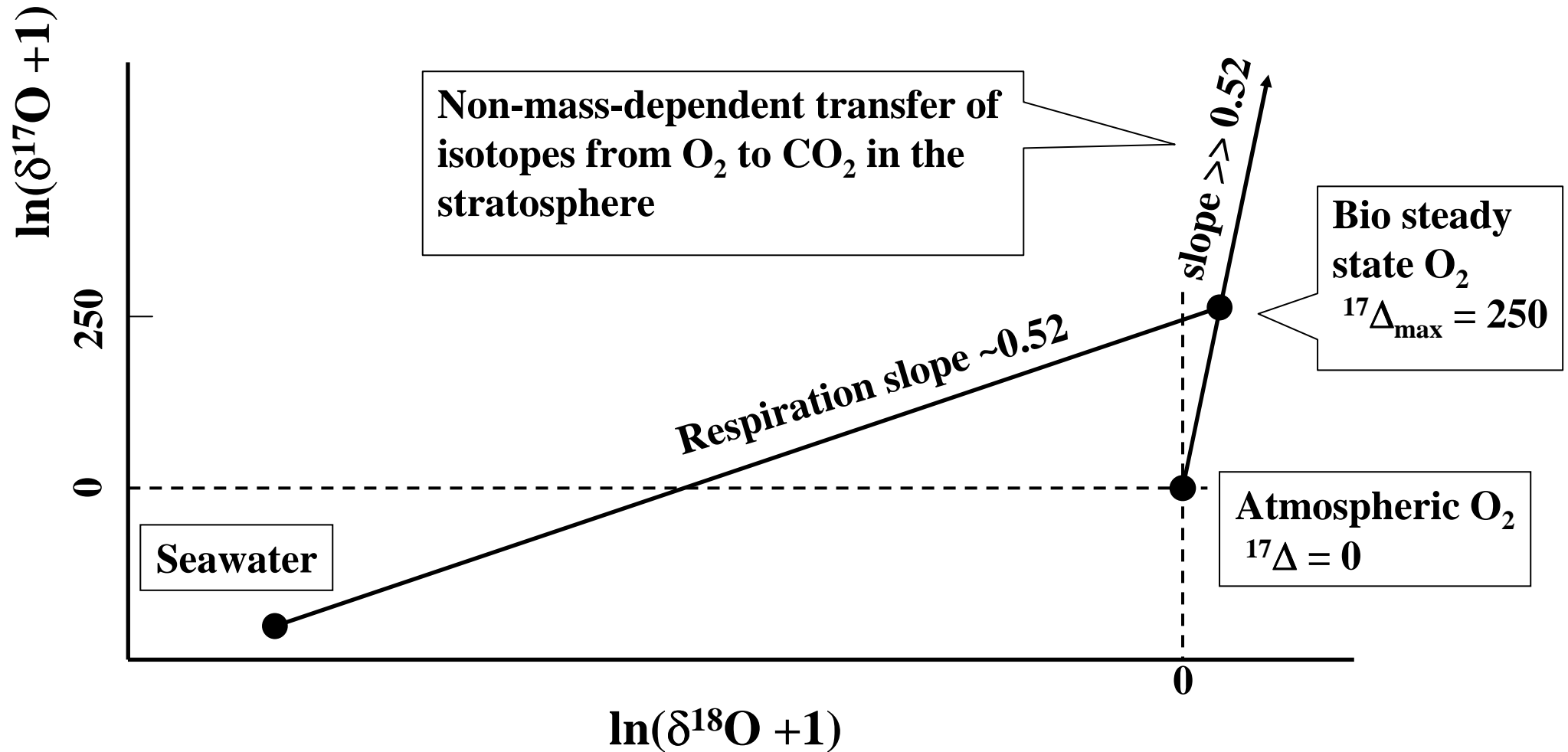


Bottle measurements do not indicate true NCP

What about gross community production?

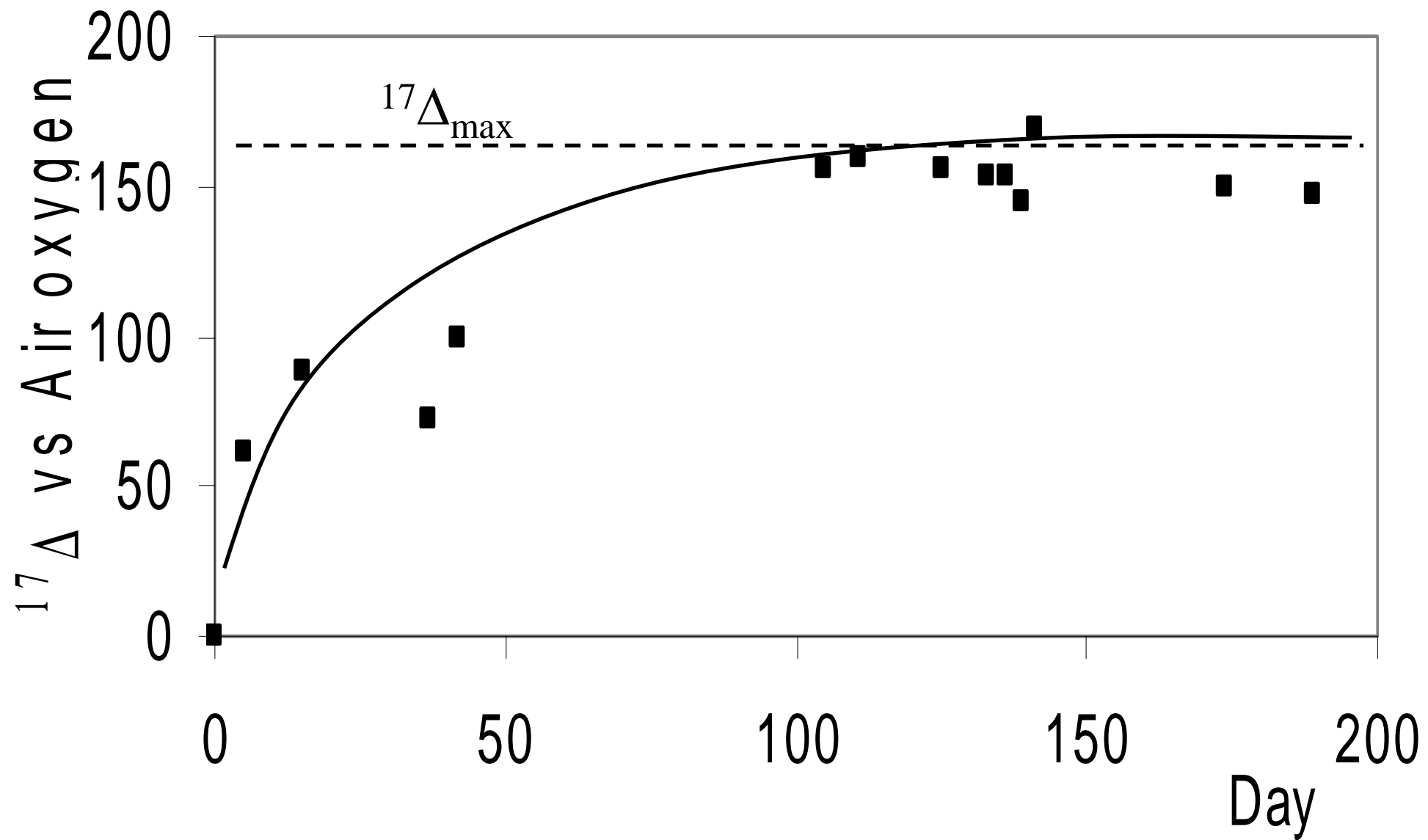
The answer is possible by using a natural spike to measure gross production

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



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

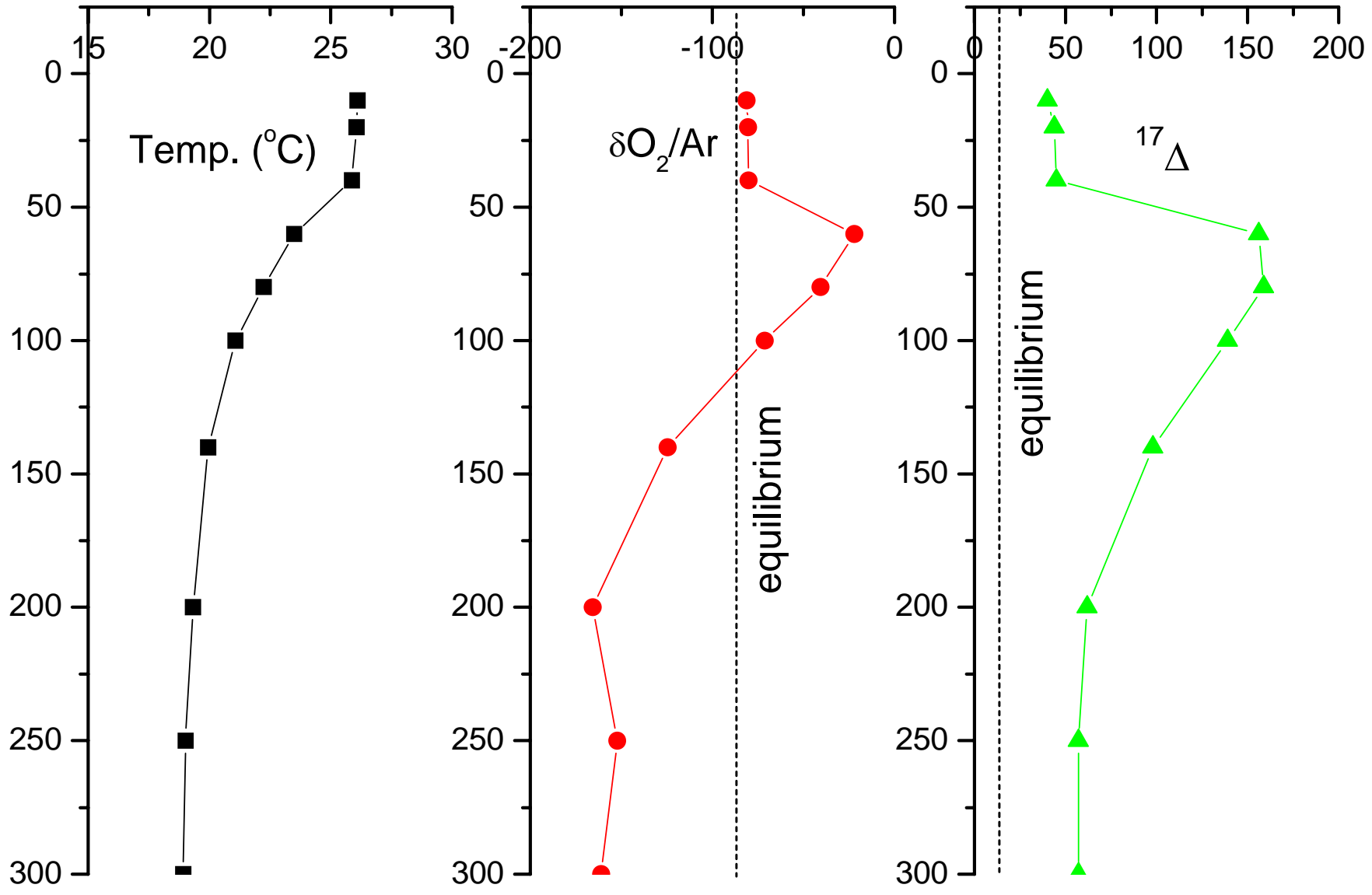
The deviation – $^{17}\Delta$ – can be used to estimate gross production just as $\delta^{18}\text{O}$ is used in ^{18}O spike experiments



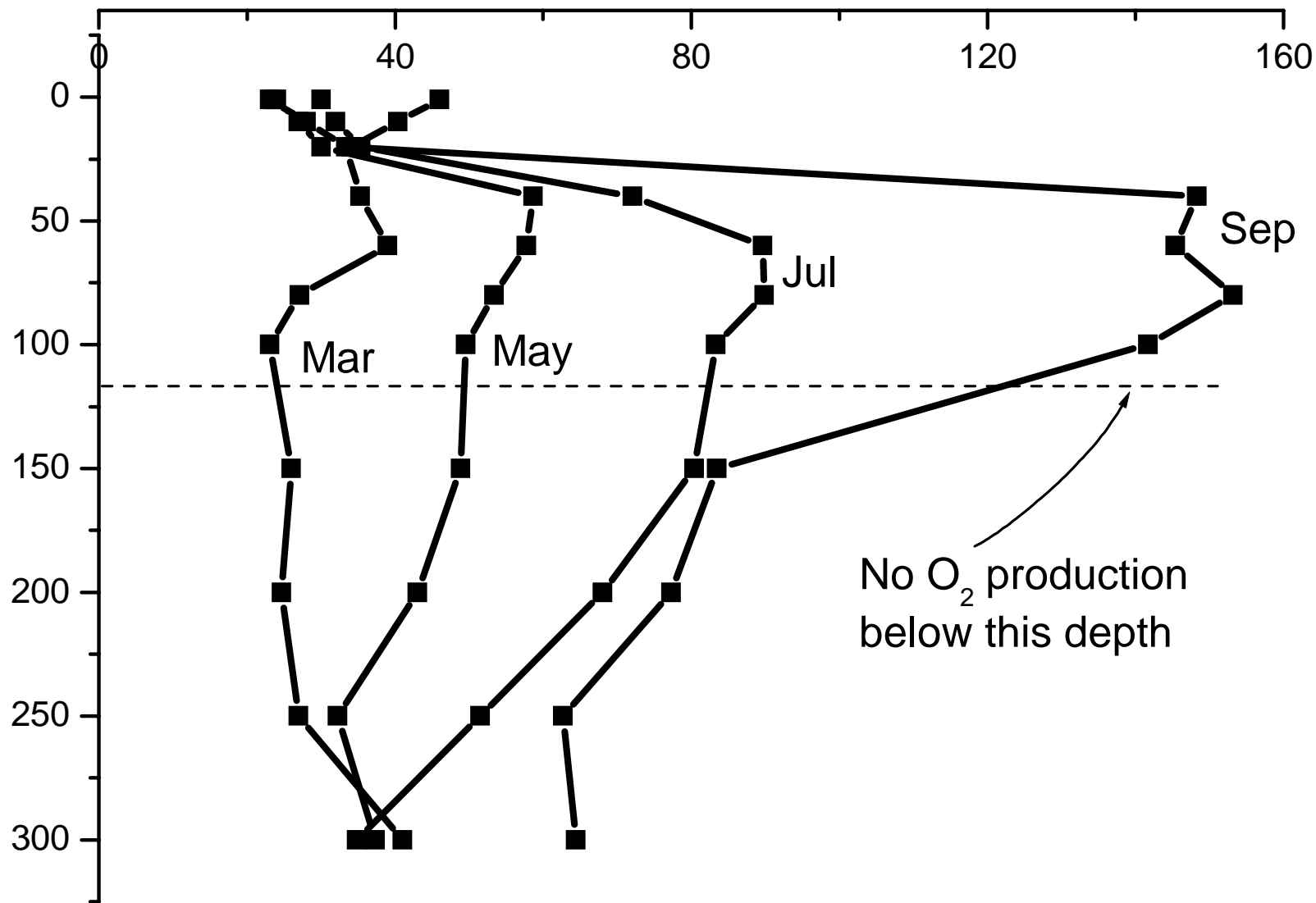


Atlantic Ocean station BATS
(Bermuda Atlantic Time-series Study)

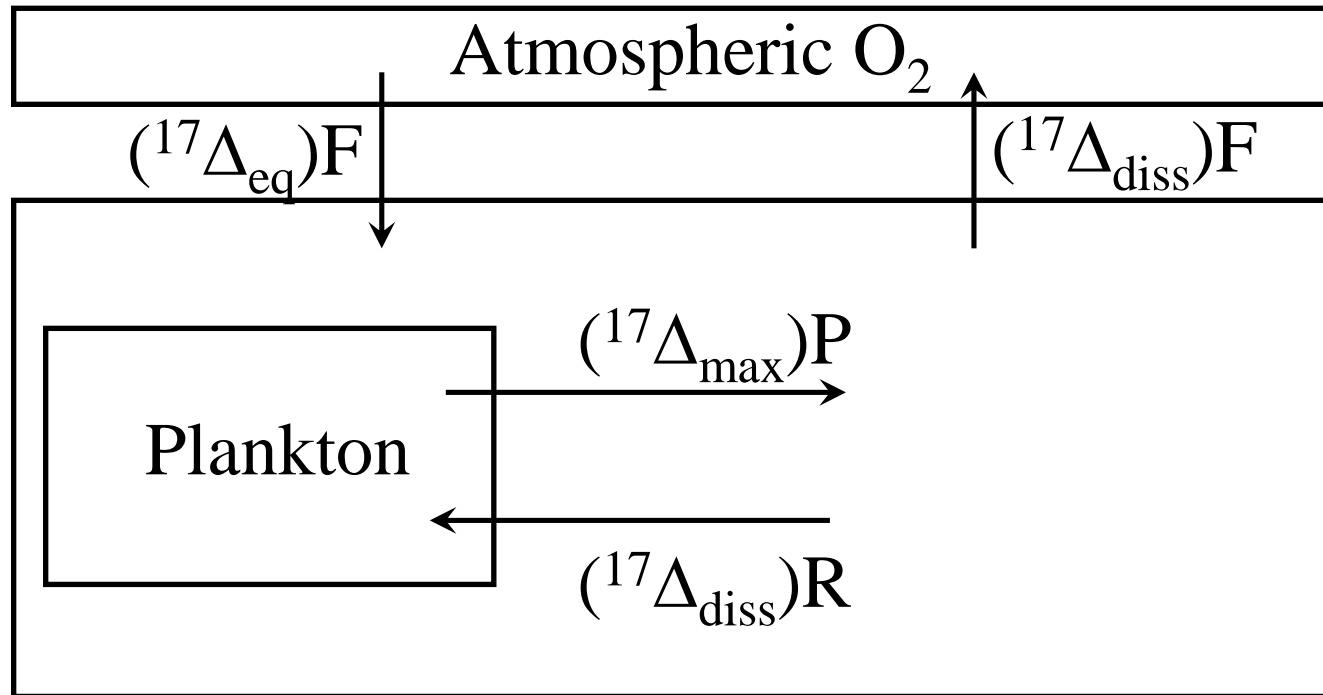
Atlantic Ocean, Bermuda



$^{17}\Delta$ Mar-Sep 2000



Large scale “incubation experiment”



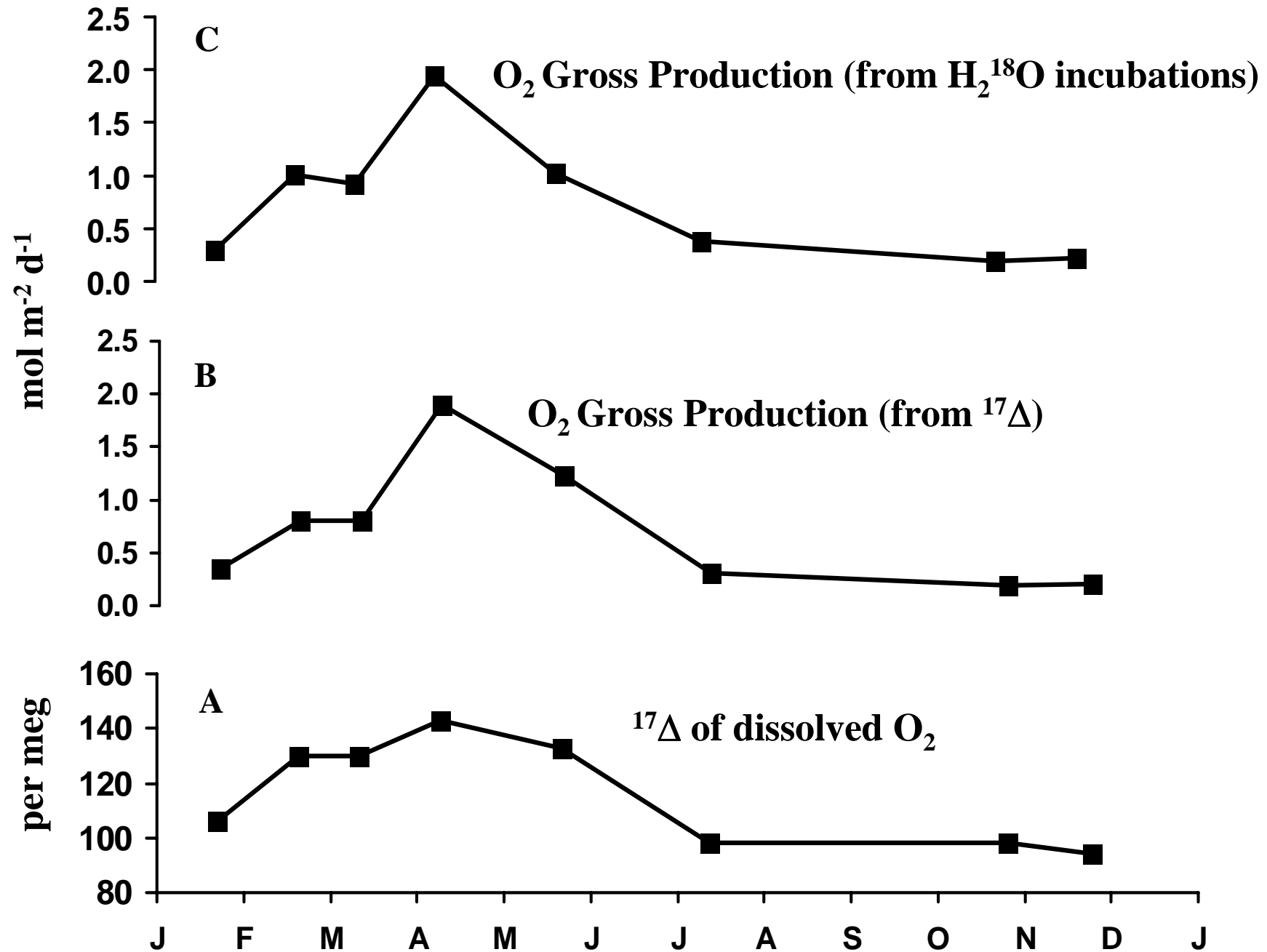
At steady state $^{17}\Delta$ flux balance is:

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

$$P(^{17}\Delta_{\text{max}} - ^{17}\Delta_{\text{diss}}) = F(^{17}\Delta_{\text{diss}} - ^{17}\Delta_{\text{eq}}); \quad F = KC_o$$

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

Gross Production in L. Kinneret



Conclusions

1. It is not clear what ^{14}C incubations measure.
(Gross production? Net production? In between?)
2. $[\text{O}_2]$ 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**