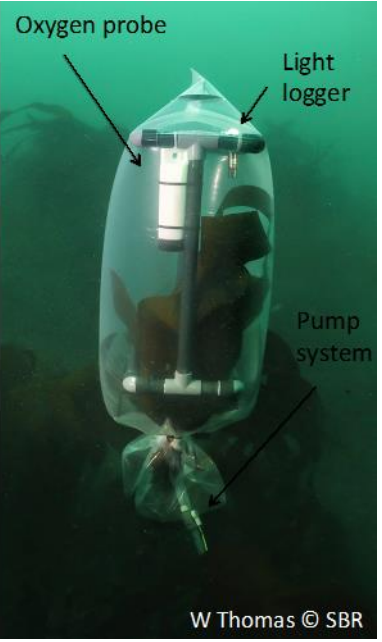

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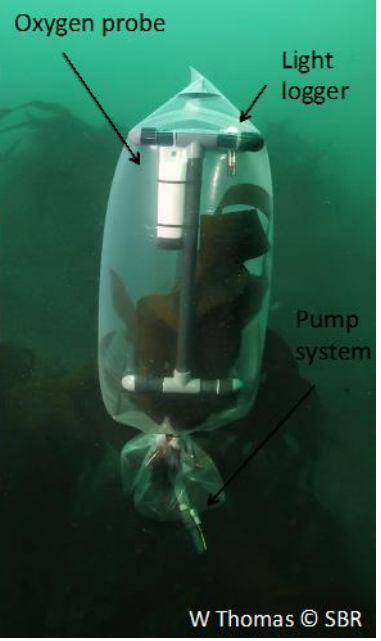
Comparison of *in situ* productivity of co-occurring kelps

Dominique Davoult & Lydia White

Sorbonne Université, CNRS, UMR 7144, Station Biologique de Roscoff, France



Comparison of *in situ* productivity of co-occurring kelps

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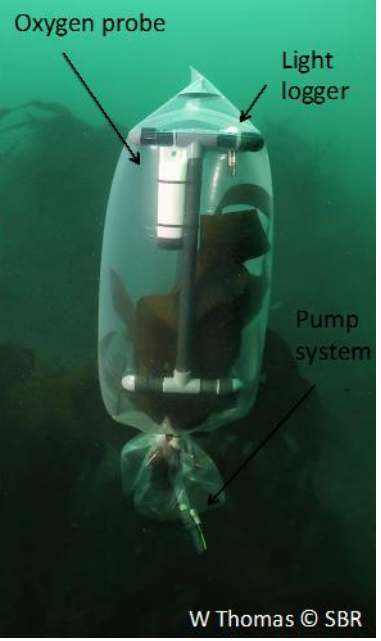
- Kelps dominate rocky reefs throughout temperate marine regions
- They are considered as foundation species, providing biogenic habitat, altering critical environmental parameters (light, water flow, sedimentation rates)

<u>They are characterized by</u>:

- High primary productivity
- Supporting high secondary production



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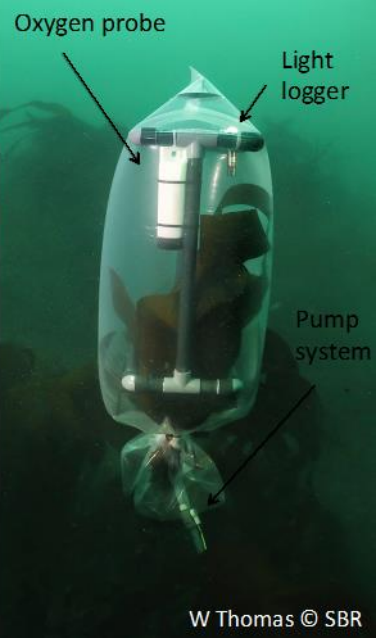
- High primary productivity
- Supporting high secondary production

Measuring primary productivity is crucial to:

- Estimate the amount of organic matter available for local food web
- Estimate the potential for carbon export



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We already developed benthic chambers to measure intertidal primary productivity of macroalgae-dominated communities and the annual gross productivity derived from these measurements was much higher that previous estimates (1300 $gC.m^{-2}.y^{-1}$)

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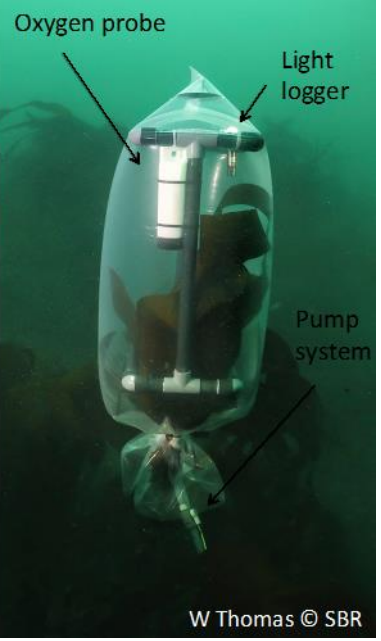
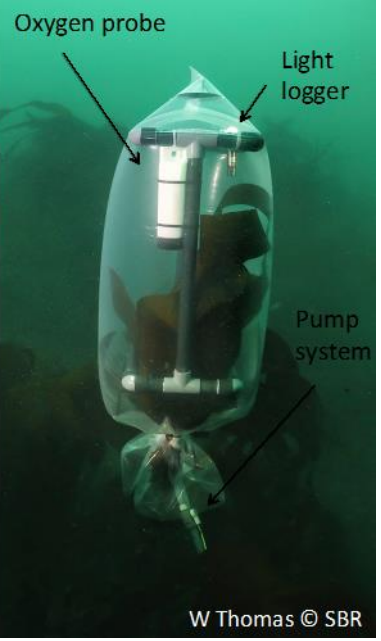


We already developed benthic chambers to measure intertidal primary productivity of macroalgae-dominated communities and the annual gross productivity derived from these measurements was much higher that previous estimates (1300 $gC.m^{-2}.y^{-1}$)

However, measuring primary productivity at the community level is more difficult because of the large size of kelps, from several tens of cm to several meters, and of the spatial distribution of individuals that prevents to build chambers adapted both in surface and volume to integrate all components of the community



Comparison of *in situ* productivity of co-occurring kelps

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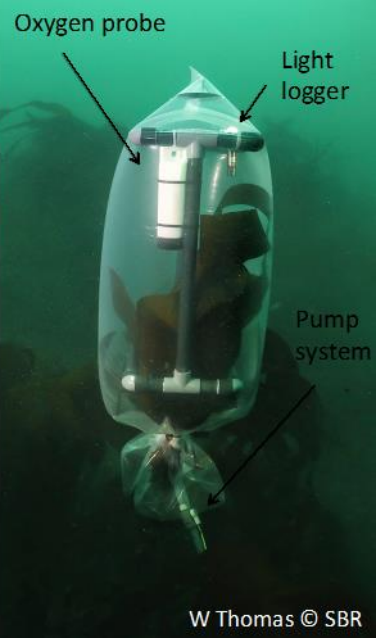
Several authors already developed benthic chambers adapted for kelps, some for fronds (e.g., Rodgers et al., 2015), others for the entire sporophyte (e.g., Gevaert et al., 2011)

All presented advantages and disadvantages, being rigid or needing to cut the individual before measurements

White et al., 2021, *Limnology & Oceanography*



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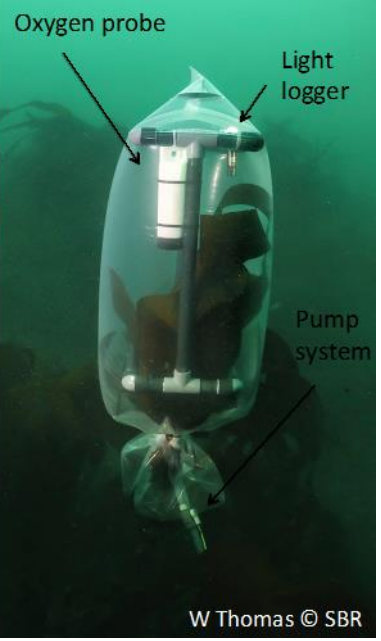
All presented advantages and disadvantages, being rigid or needing to cut the individual before measurements

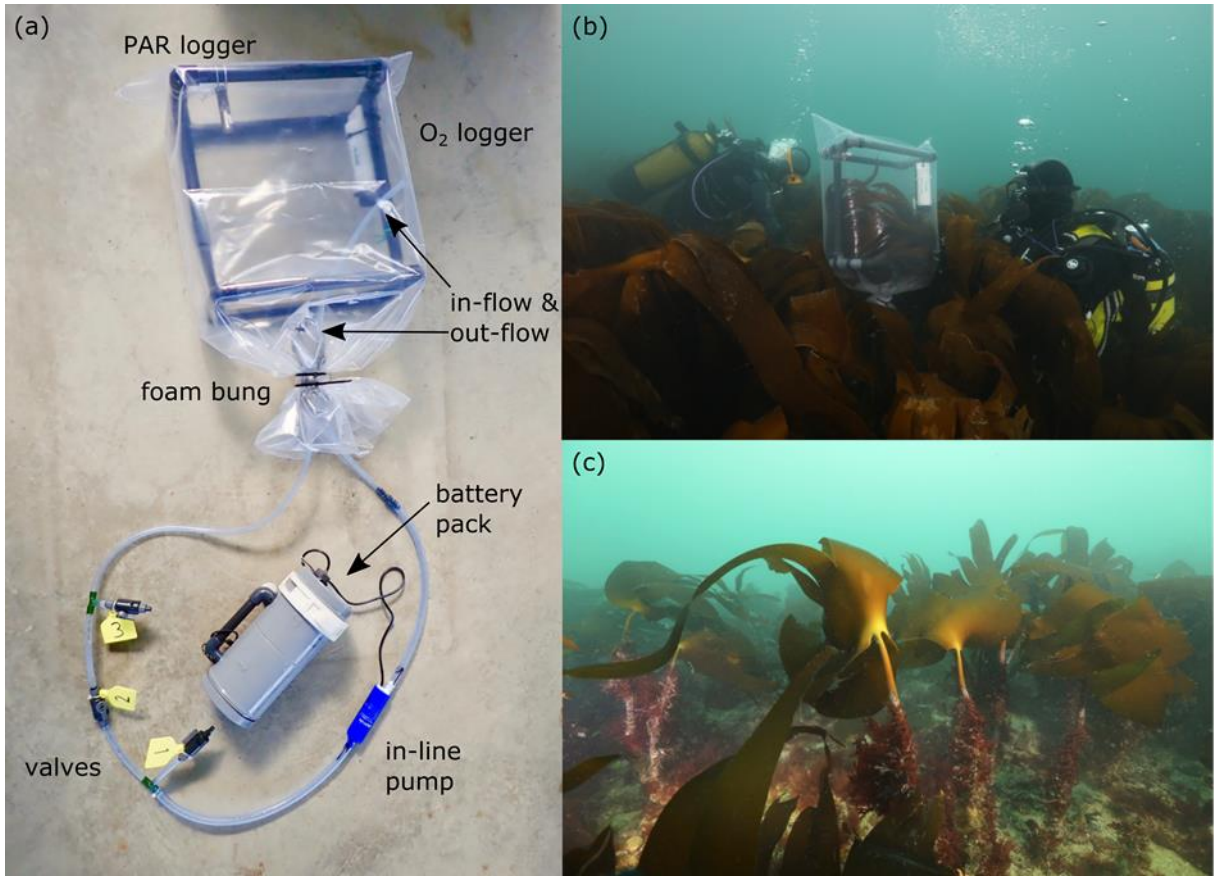
We chose to build a new chamber, adapted from various existing photorespirometry methods, respecting several conditions:

- A low-cost system (except the oxygen probe), versatile enough to be used at several sizes and volumes (both canopy and subcanopy individuals)
- A flexible system moving with hydrodynamism
- An easy renewal of water at the beginning and at the end of short incubations using a pump

White et al., 2021, *Limnology & Oceanography*

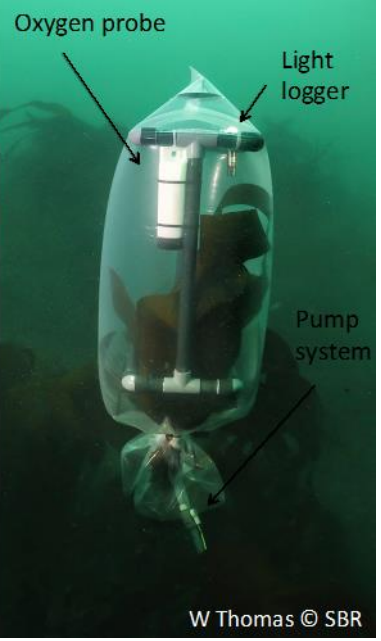
Comparison of *in situ* productivity of co-occurring kelps





(a) The system used for in situ incubations, (b) example of in situ incabation of *L. hyperborea* lamina, (c) large *L. hyperborea* individuals with epiphytes on their stipes

White et al., 2021, *Limnology & Oceanography*



Comparison of *in situ* productivity of co-occurring kelps

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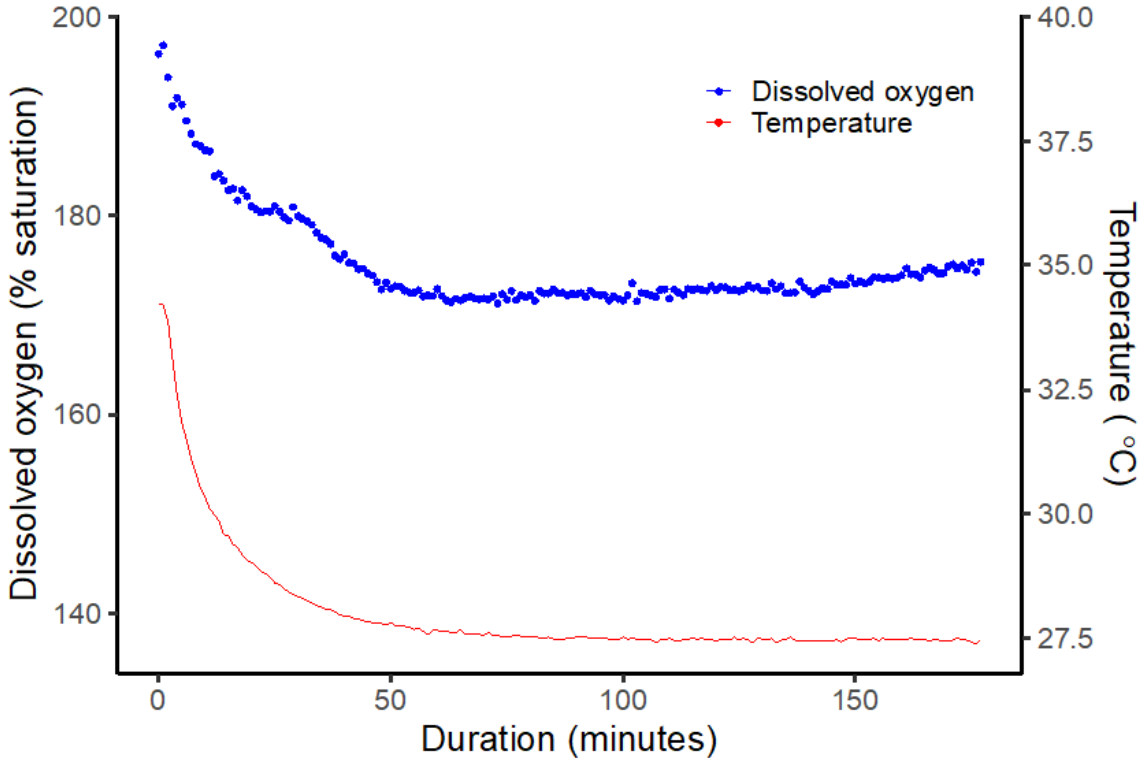
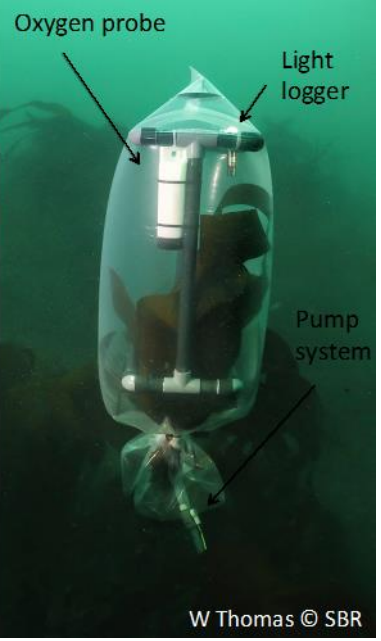
During the development of the system, we checked:

- Permeability of material with oxygen-enriched seawater



A 3-hour test of permeability. Once temperature has stabilised, oxygen concentration remained constant

White et al., 2021, *Limnology & Oceanography*



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During the development of the system, we checked:

- Permeability of material with oxygen-enriched seawater
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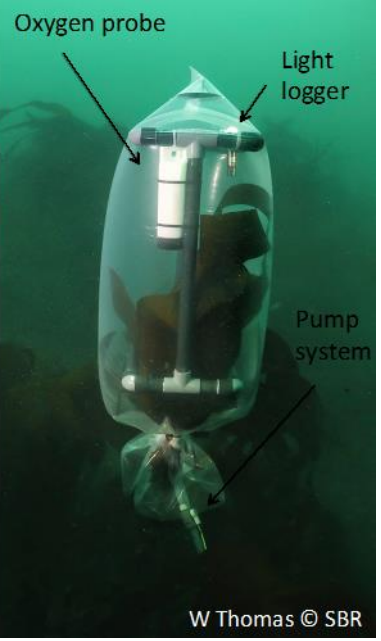
White et al., 2021, *Limnology & Oceanography*



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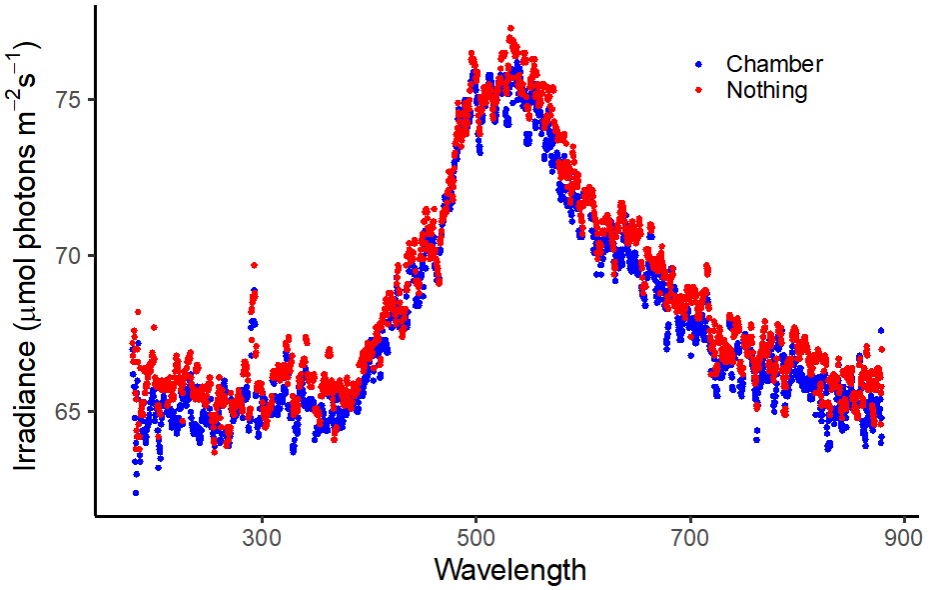
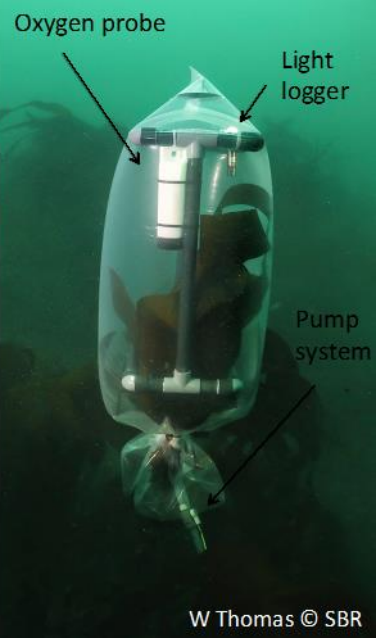
- Light transmission (PAR intensity reduced by 5%, no significant alteration of light spectrum)



Light spectrum of artificial LED light outside (red) and inside (blue) the 100 µm-thick polyethylene chamber

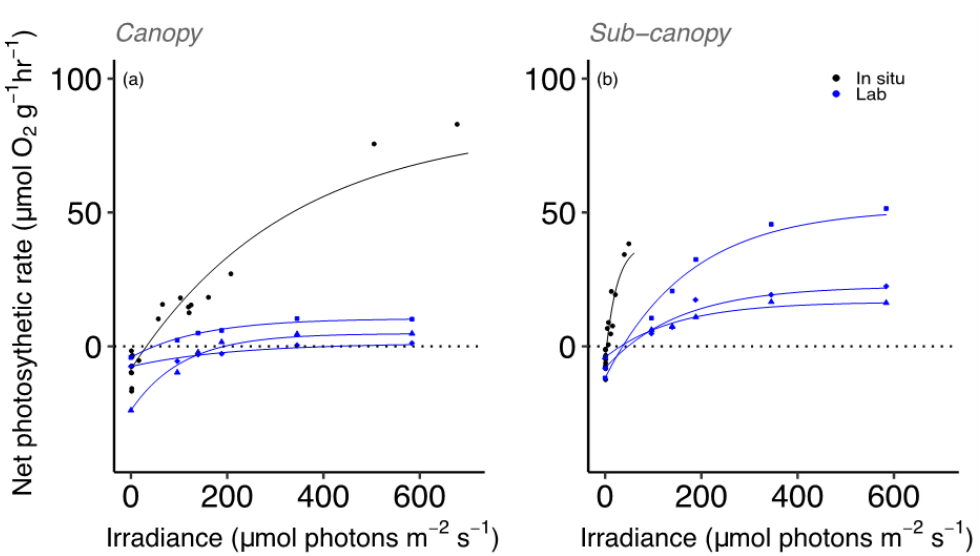
White et al., 2021, *Limnology & Oceanography*

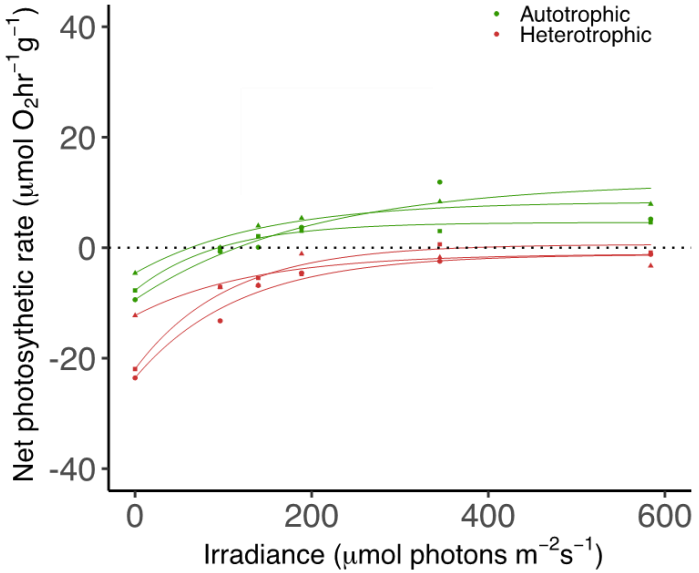
Comparison of *in situ* productivity of co-occurring kelps



We performed first experiments on the dominant kelp in our area, *Laminaria hyperborea*

As the stipe is a substrate of numerous algal and animal species, we also performed specific measurements on stipes





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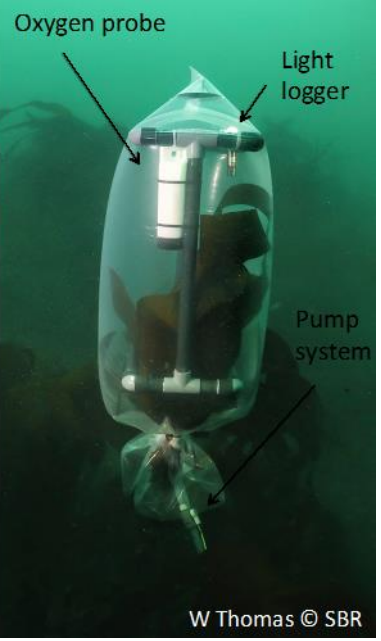

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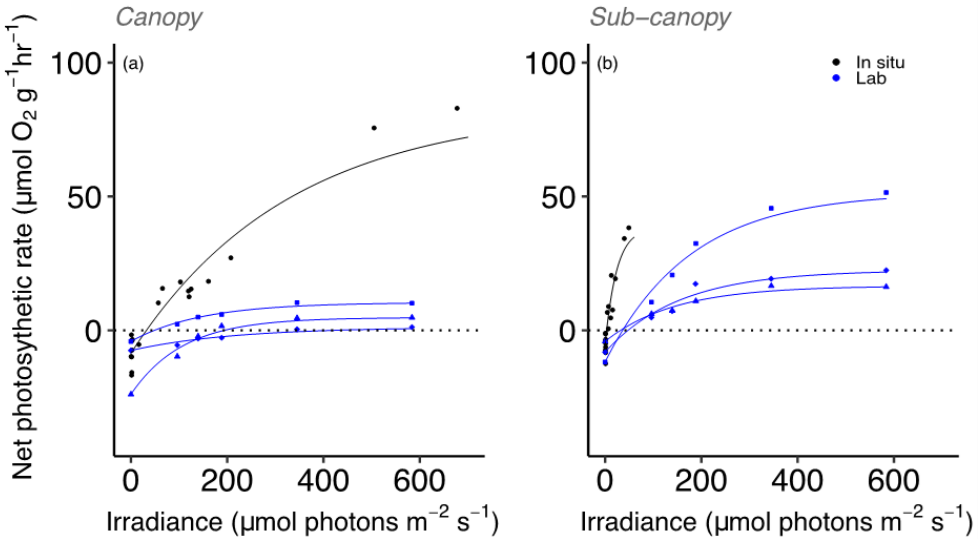
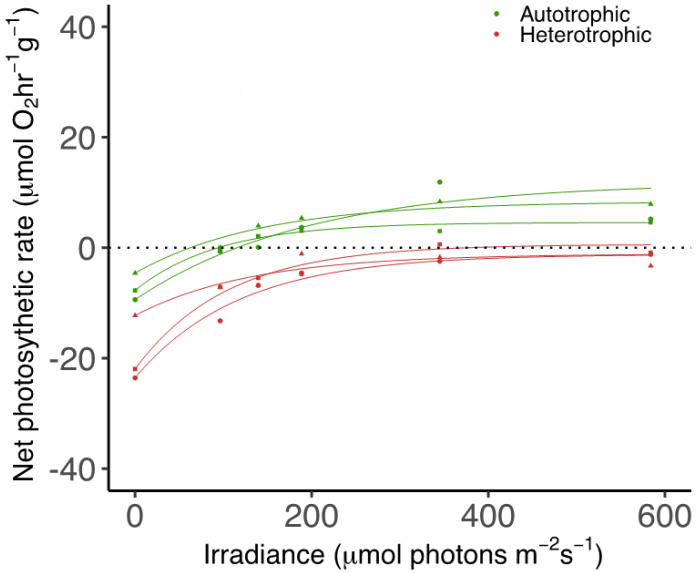
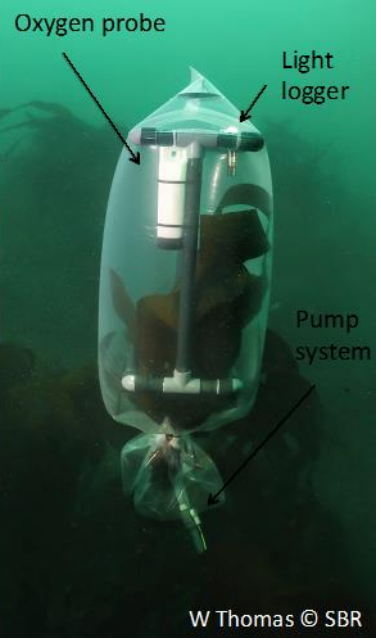




- First results led to estimates at saturating irradiance of net and gross productivity of 9.4 and 12 gC.m^{-2}.h^{-1}, respectively
- Mean daily net productivity of the local population was estimated to be 13.3 gC.m^{-2}.d^{-1} in late summer
- *In situ* results are always much higher than those obtained in the lab, even if performed within 24 hrs

White et al., 2021, *Limnology & Oceanography*



Comparison of *in situ* productivity of co-occurring kelps

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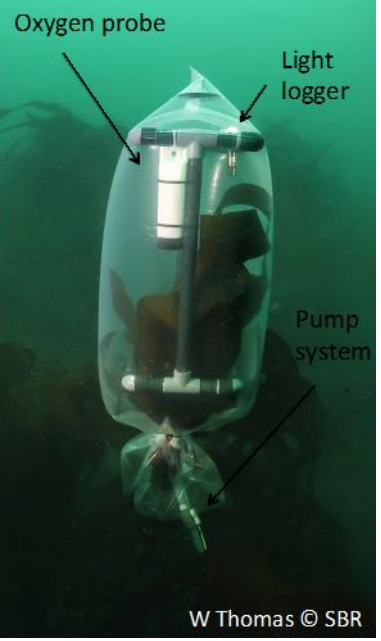
We then tried to compare productivity of three co-occurring kelp species:

- *Laminaria hyperborea*, dominant and located here in the centre of its distribution range
- *Laminaria ochroleuca*, in the leading-edge of its range and now coexisting with *L. hyperborea*
- *Undaria pinnatifida*, an invasive species in The English Channel, and cultivated in the Bay of Morlaix

White & Davoult, 2022, *Mar. Ecol. Prog. Ser.*



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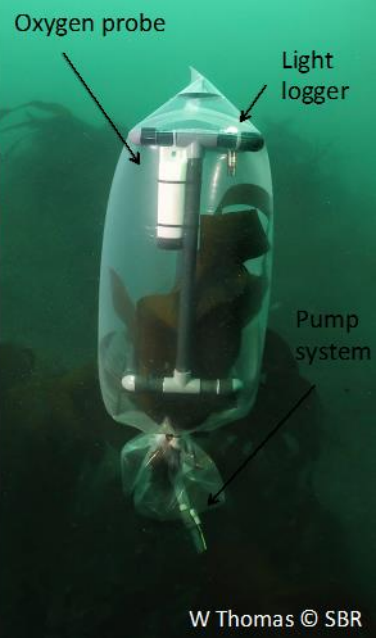
<u>The objectives were to</u>:

- Provide P-I curves for these 3 common species from *in situ* measurements during early summer
- Verify the hypothesis that the annual and invasive *Undaria pinnatifida* has the highest photosynthetic capacity
- Verify the hypothesis that *L. ochroleuca* has a higher productivity rate than *L. hyperborea*, as this period coincides with its peak biomass accumulation rates (Pessarrodona et al., 2019)
- Compare stipe productivity of these latter species

White & Davoult, 2022, *Mar. Ecol. Prog. Ser.*



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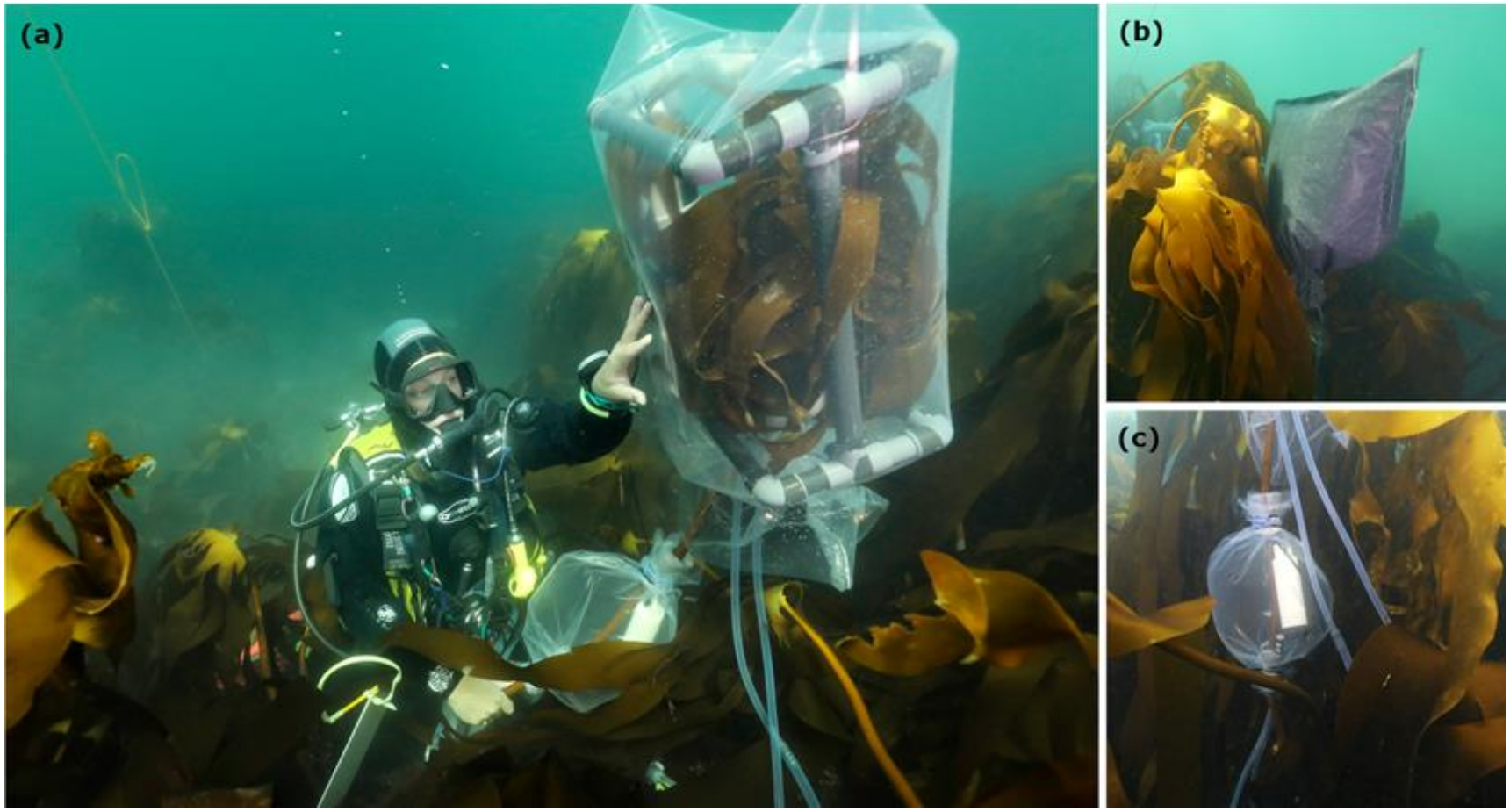
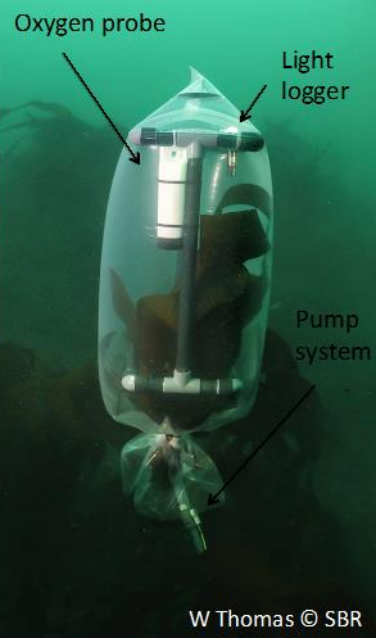


Examples of *in situ* incubations. (a) light incubation of lamina and stipe of *L. Ochroleuca*, (b) dark incubation of lamina of *L. hyperborea*, (c) light incubation of stipe of *L. ochroleuca*

White & Davoult, 2022, *Mar. Ecol. Prog. Ser.*



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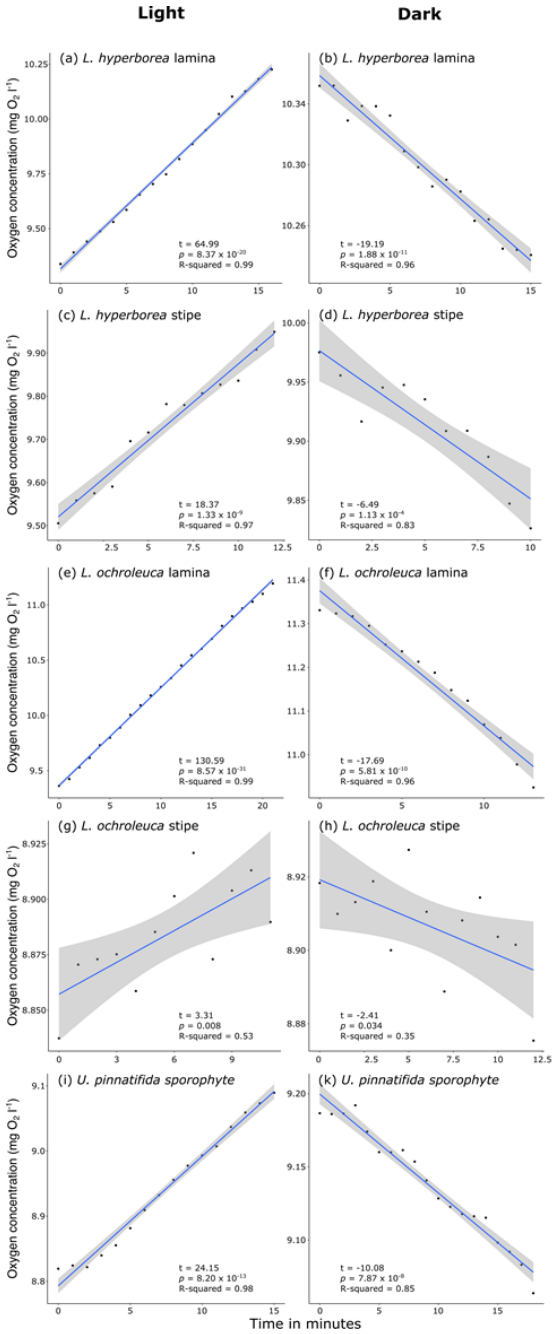
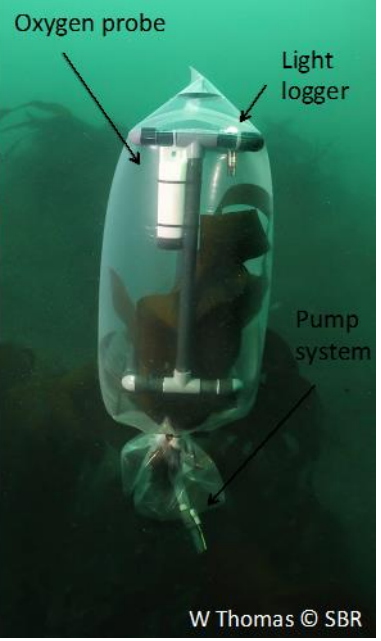


- Examples of *in situ* incubation data under light and dark conditions for lamina and stipes of *L. hyperborea* and *L. ochroleuca* and for *U. pinnatifida* sporophytes
- Rates of net primary production and respiration were calculated from the linear slope of oxygen concentration

White & Davoult, 2022, *Mar. Ecol. Prog. Ser.*



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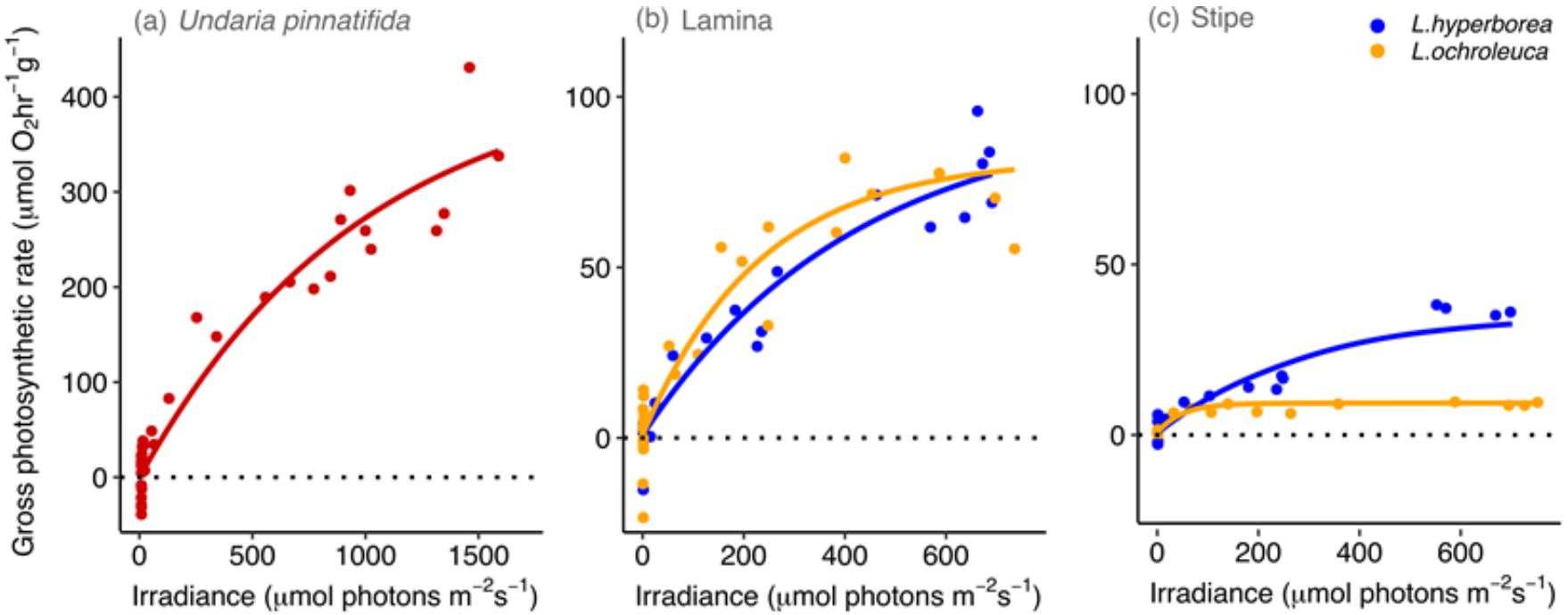
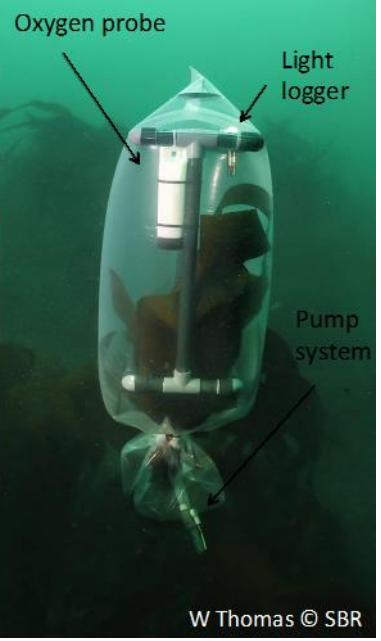
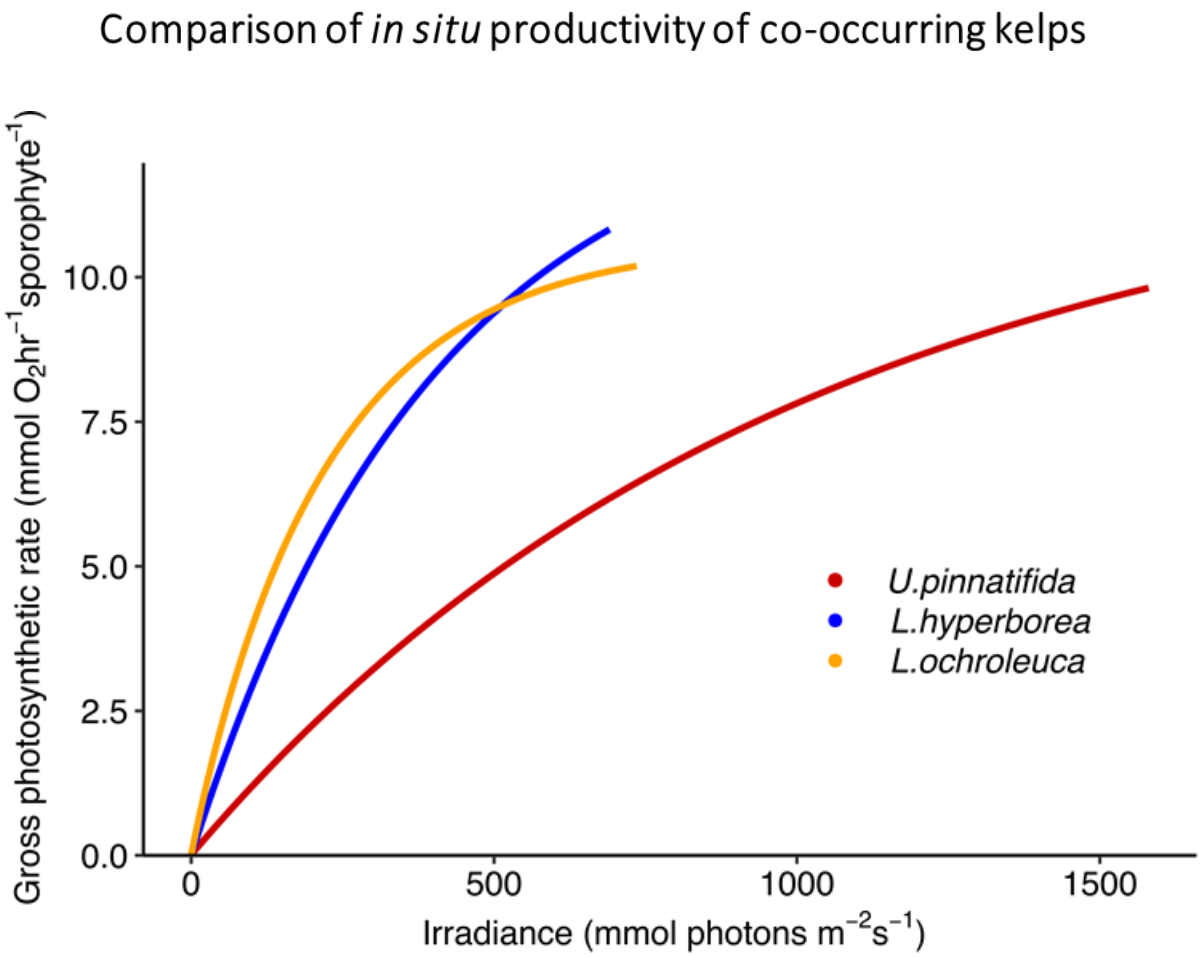


- P-I curves confirmed the highest productivity of *Undria pinnatifida*
- P-I curves for lamina sections were similar for *L. hyperborea* and *L. ochroleuca*
- Stipes of *L. hyperborea* displayed higher photosynthetic rates than the ones of *L. ochroleuca*

White & Davoult, 2022, *Mar. Ecol. Prog. Ser.*



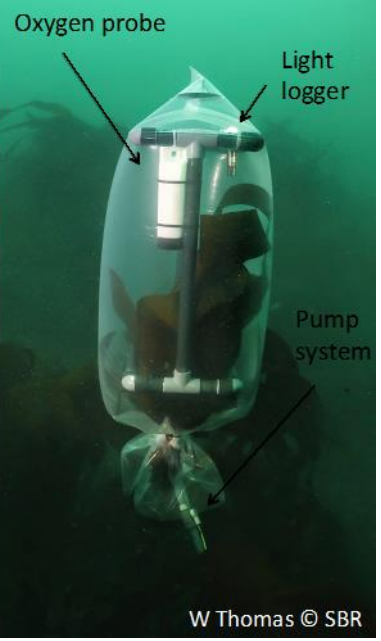


- Scaling up P-I curves based on mean species-specific biomass values resulted in similar curves for the 2 *Laminaria* species

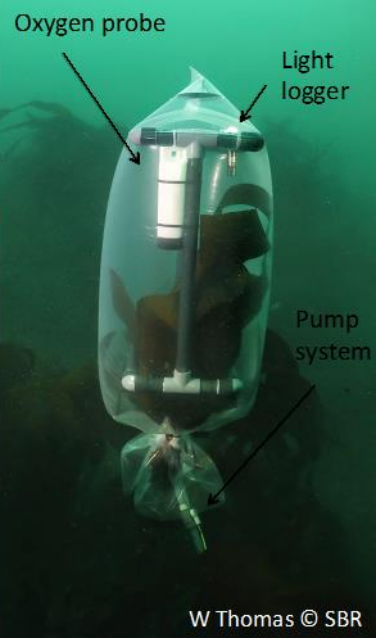
- P-I curve for *U. pinnatifida* had a lower initial slope α than *Laminaria* species. However, the species could achieve similar maximum rates of oxygen production, albeit at higher irrandiances

White & Davoult, 2022, *Mar. Ecol. Prog. Ser.*

Comparison of *in situ* productivity of co-occurring kelps



- These are the first *in situ* productivity estimates for these 3 co-occurring species, each found growing in distinctly different regions of their geographical distributions



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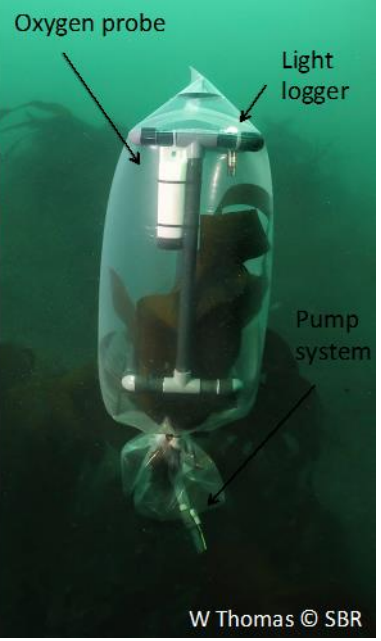

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- Considering the contribution of stipes to photosynthesis allows a better estimate of the population productivity

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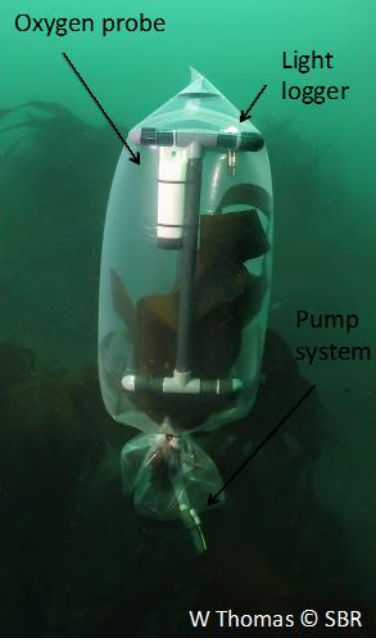

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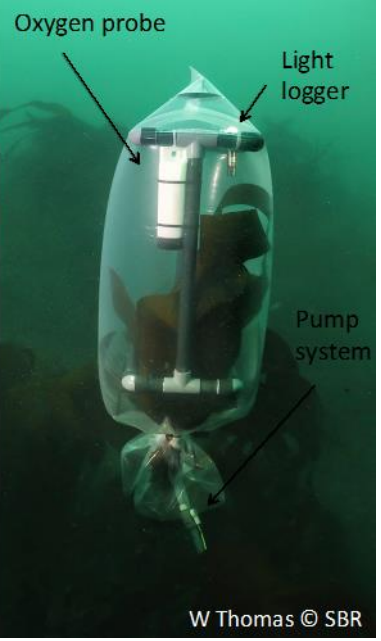

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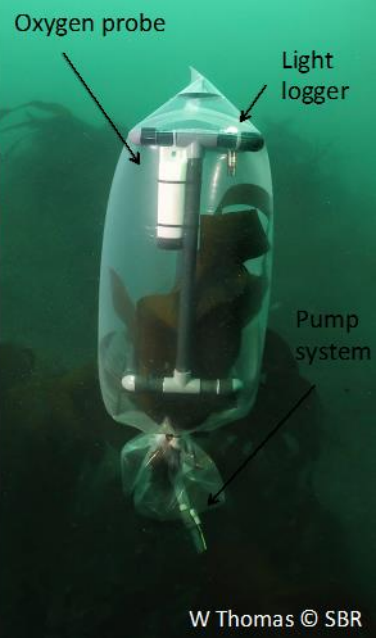

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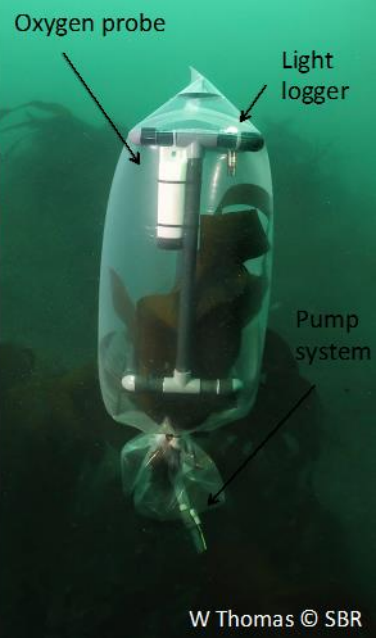
- We now need to obtain seasonal P-I curves for each species in the aim to build a fiable estimate of annual gross and net production
- Our results suggest that any replacement of *L. hyperborea* by *L. ochroleuca* due to further northward expansion or increases in relative abundance might lead to reduced net rates of productivity (increased lamina respiration and reduced photosynthetic capacity of stipes)

Comparison of *in situ* productivity of co-occurring kelps



- These are the first *in situ* productivity estimates for these 3 co-occurring species, each found growing in distinctly different regions of their geographical distributions
- The cold-water *L. hyperborea* and the warm-temperate *L. ochroleuca* showed similar productivity in summer. As *L. hyperborea* is growing from January to June whereas *L. ochroleuca* is still growing in summer, this result could be due to an underestimation of the maximum productivity of the first species
- Considering the contribution of stipes to photosynthesis allows a better estimate of the population productivity
- The invasive *U. pinnatifida* had the highest photosynthetic capacity and dispayed 2.5-3 fold higher P max than any other species reported in the literature, helping to explain its high success as an invader
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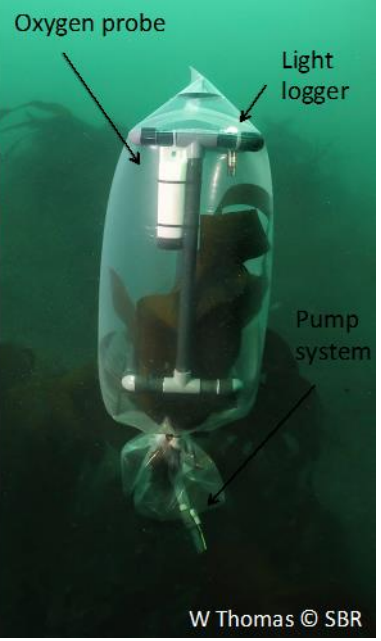

Thank you for your attention