SOCIETY FOR EXPERIMENTAL BIOLOGY PRESENTS:
2021 ANNUAL CONFERENCE
29 JUNE - 8 JULY 2021

SEB 2021 ANNUAL CONFERENCE

CAN POLAR FISH GET OUT OF BREATH?

Hypoxia tolerance and aerobic scope of Polar cod, *Boreogadus saida*

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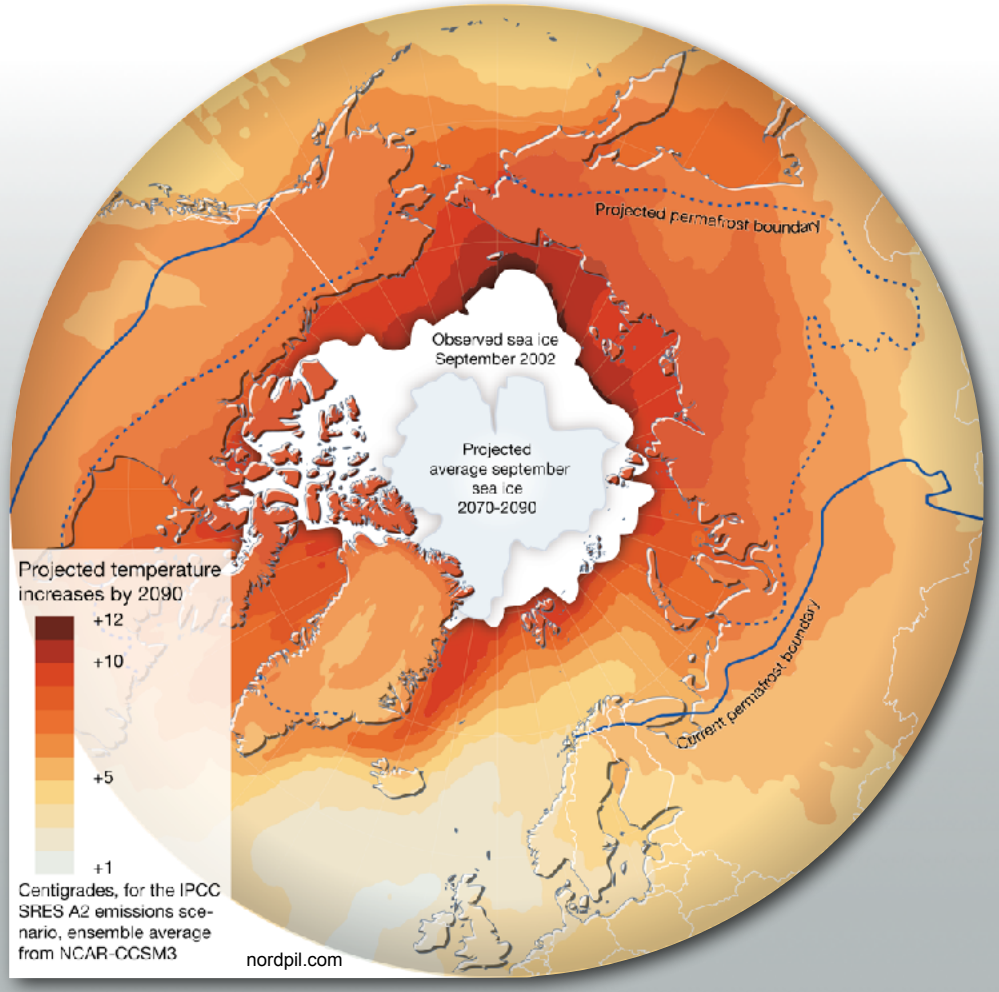
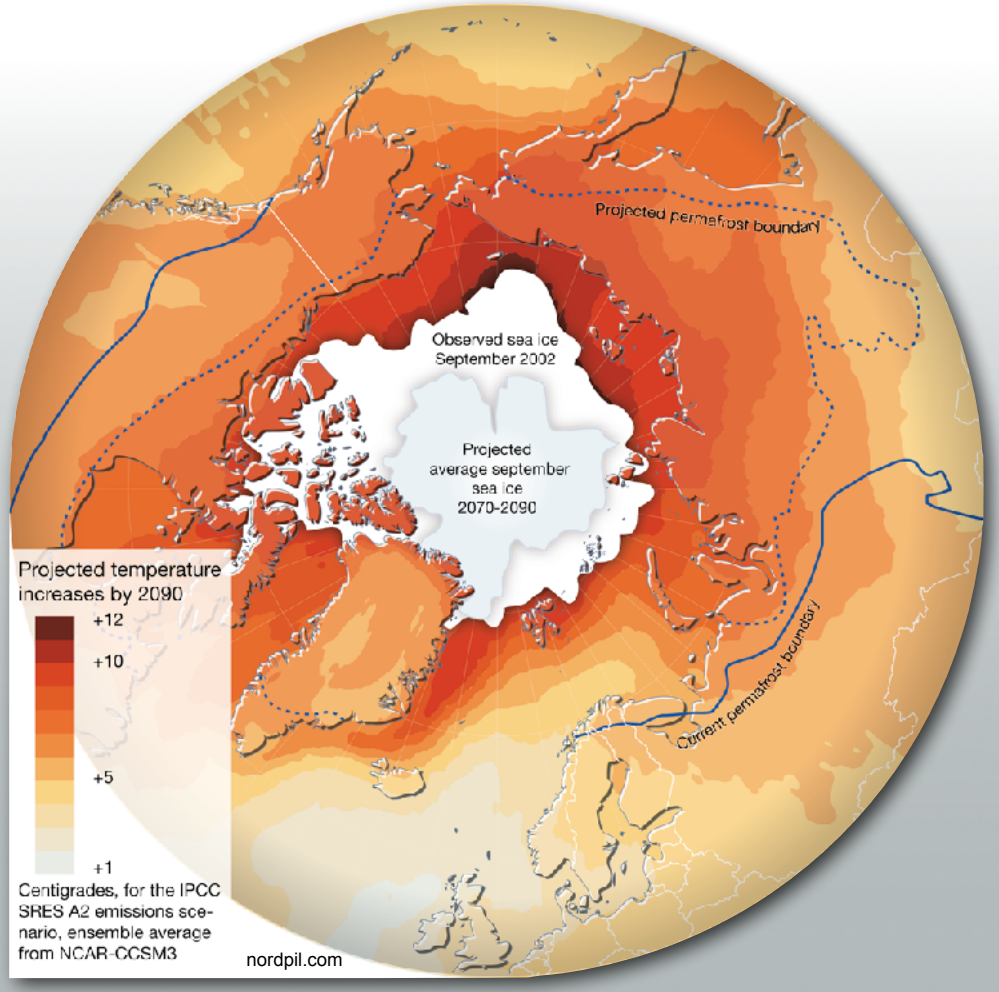
Climate Change in Polar Oceans

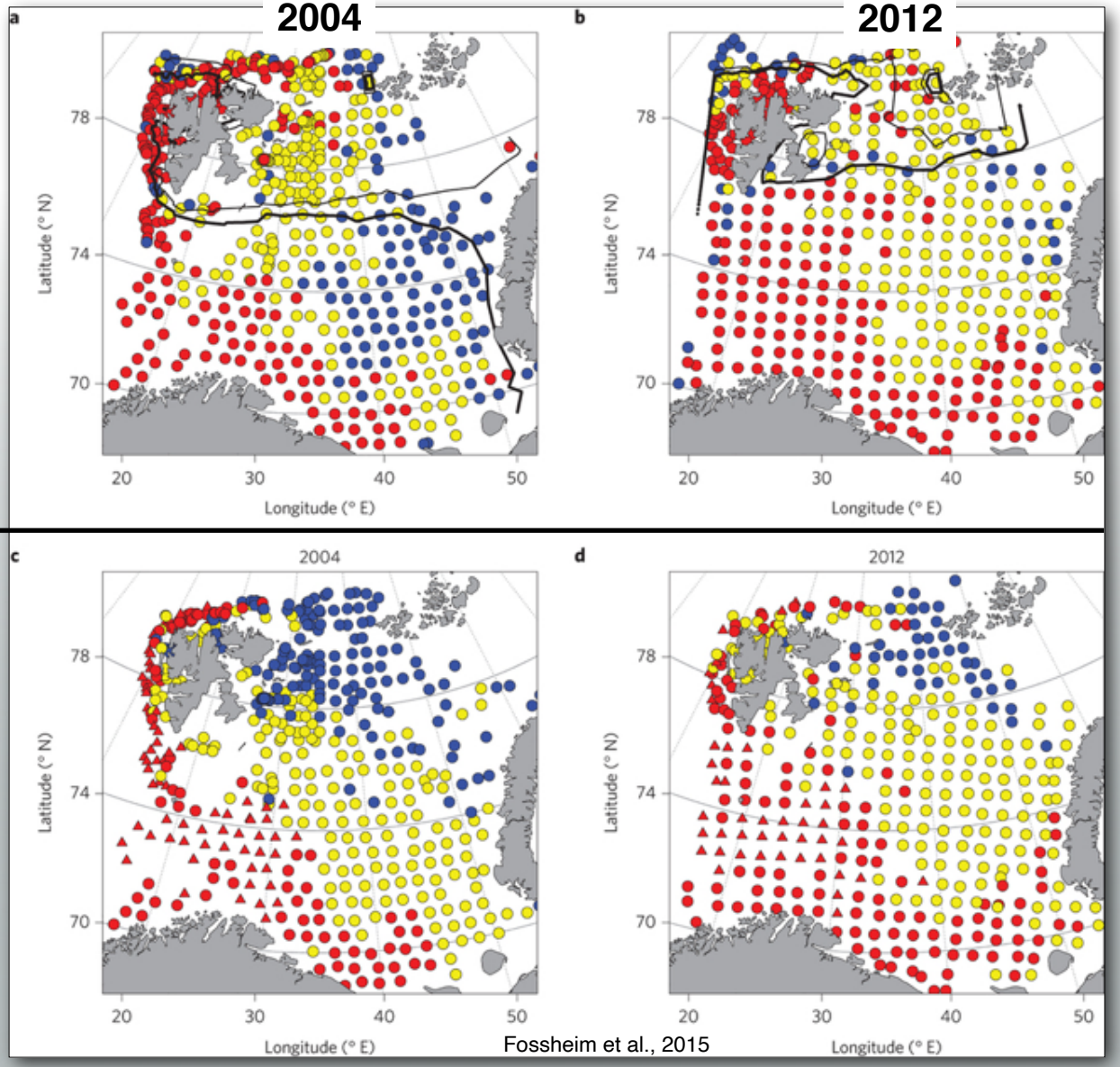


Climate Change in Polar Oceans

- Arctic Ocean expected to rise by up to 1-2°C by 2100
- Ocean warming, acidification, deoxygenation…
- Warmer winters, less sea ice formation
- >20% of Arctic sea ice have melted -> freshening of seawater
- Stenothermal, cold-adapted organisms
- Atlantification of the Arctic Ocean is in progress...



Borealisation of Barents Sea, 2004-2012

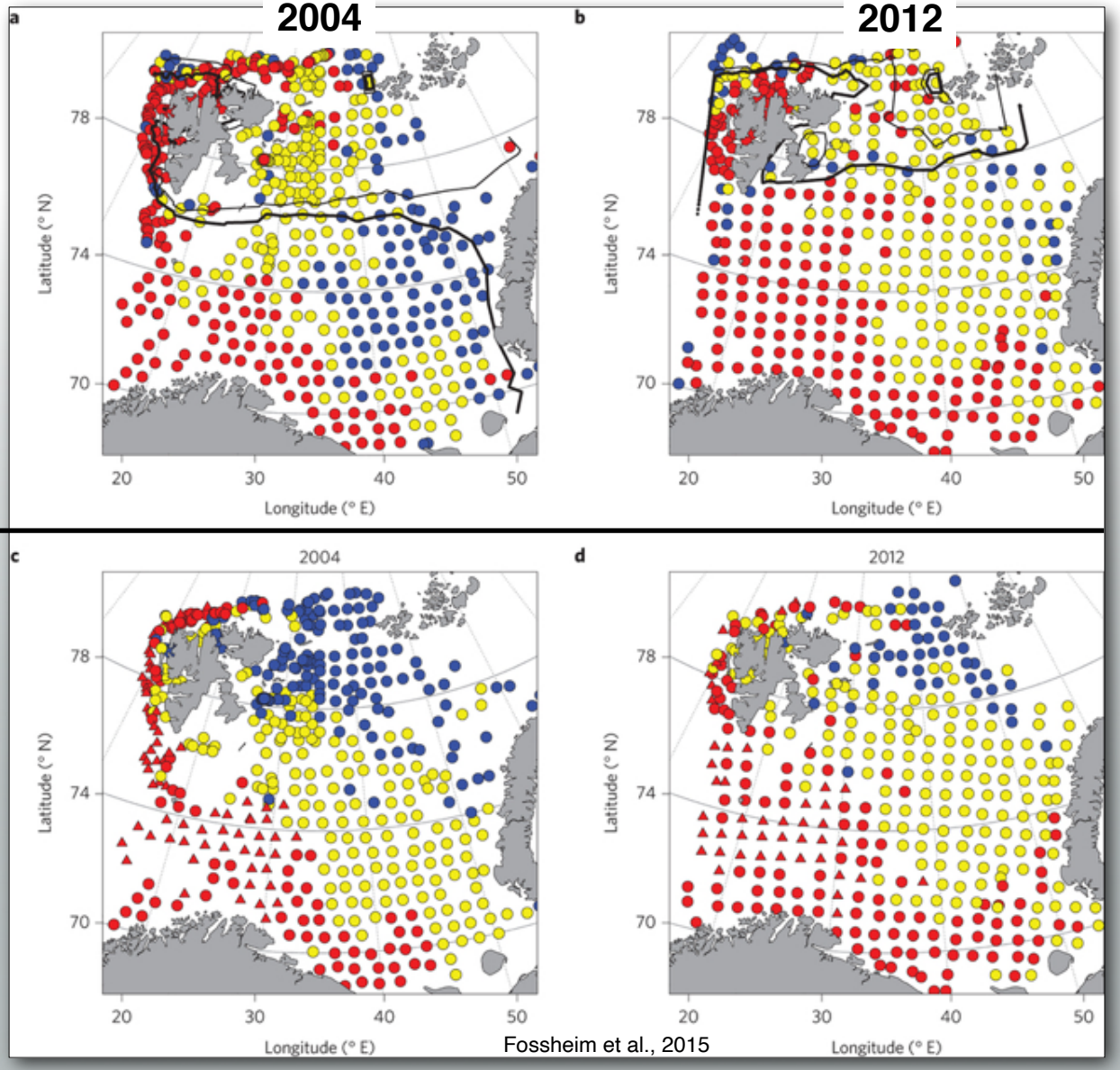


Fossheim et al., 2015

Borealisation of Barents Sea, 2004-2012

- **Water Temperatures**
  - cold water (blue) moving north

- **Fish Communities**
  - Arctic communities (blue) driven out of Barents Sea

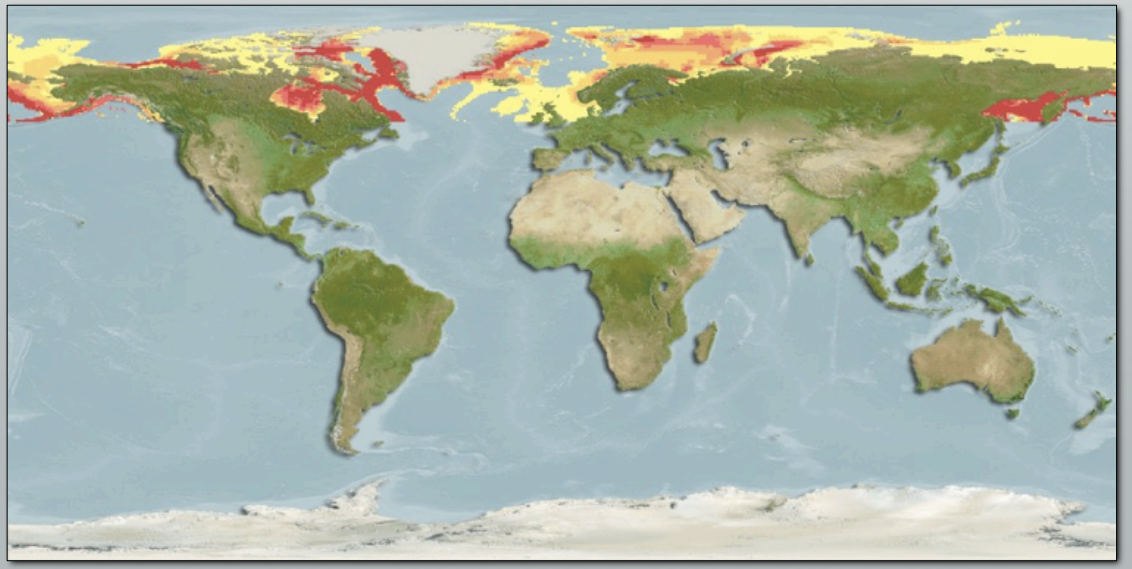


Fossheim et al., 2015

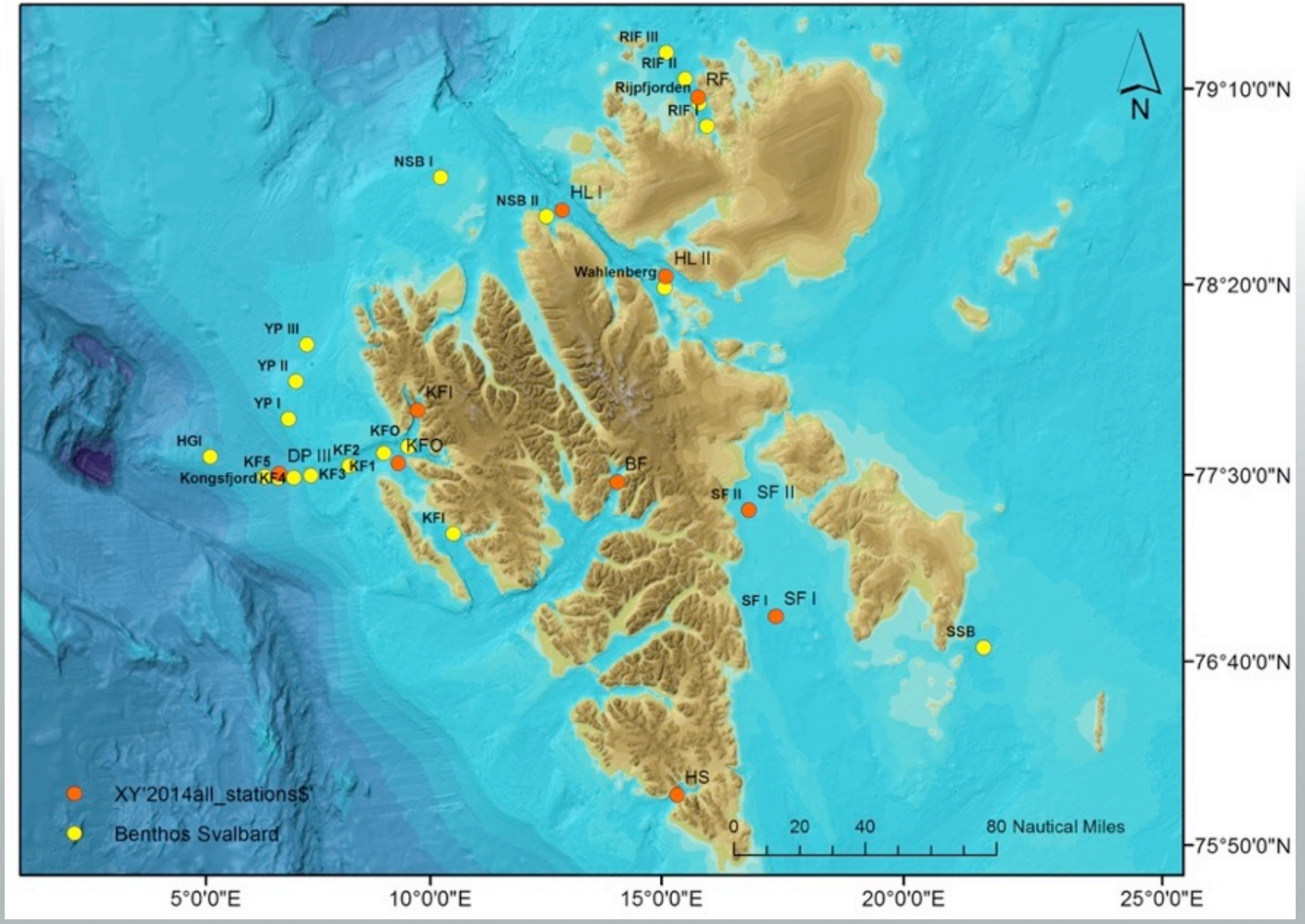
Background – study animal

- Polar cod (*Boreogadus saida*), Gadidae
- core thermal habitat: -1.5 to +2°C
- Arctic circumpolar distribution
- polar key species
  - ideal model organism
  - understand physiological responses to global warming
  - predict future ecosystem scenarios

Boreogadus saida



Study Area Svalbard - two contrasting fjord systems



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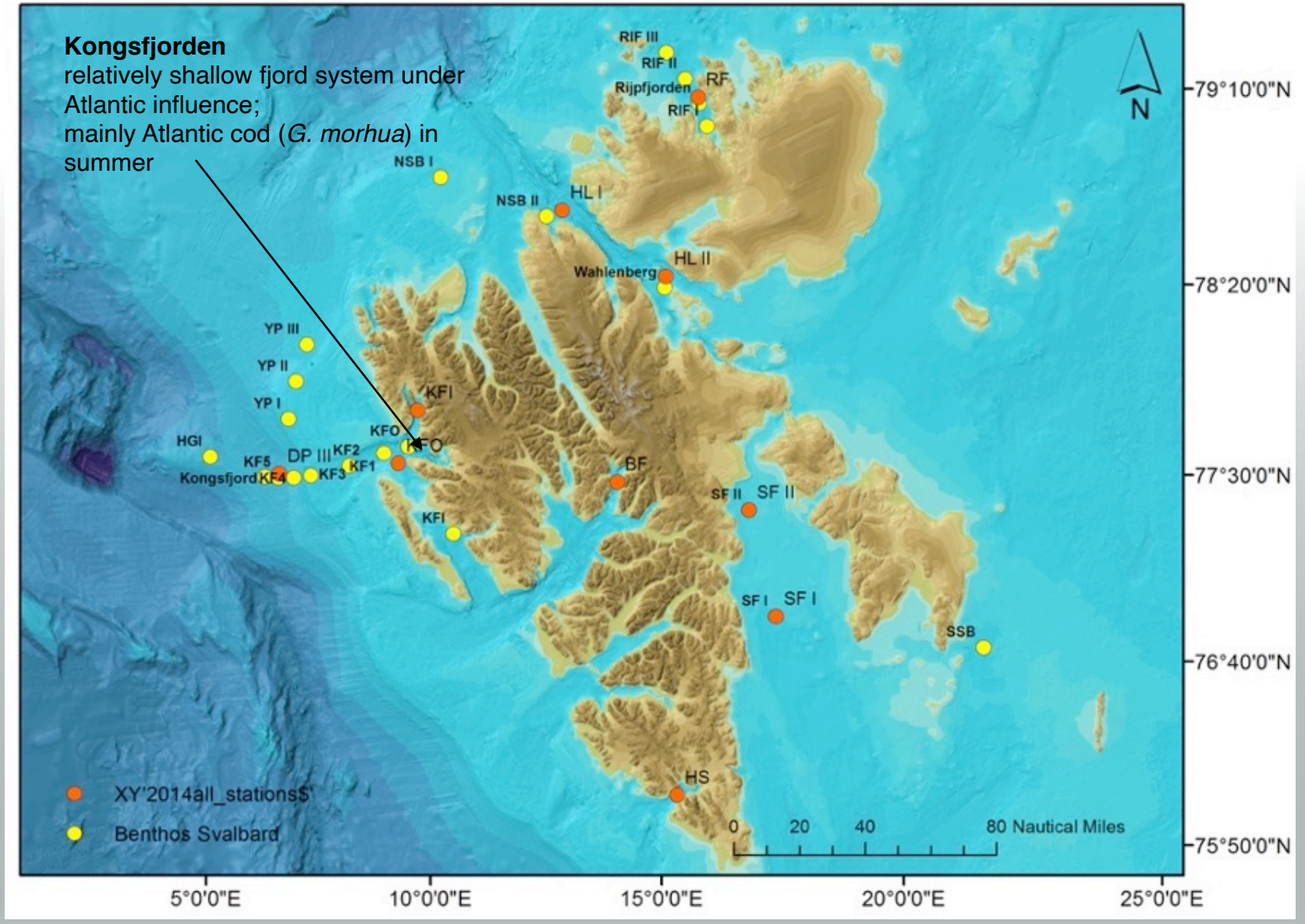

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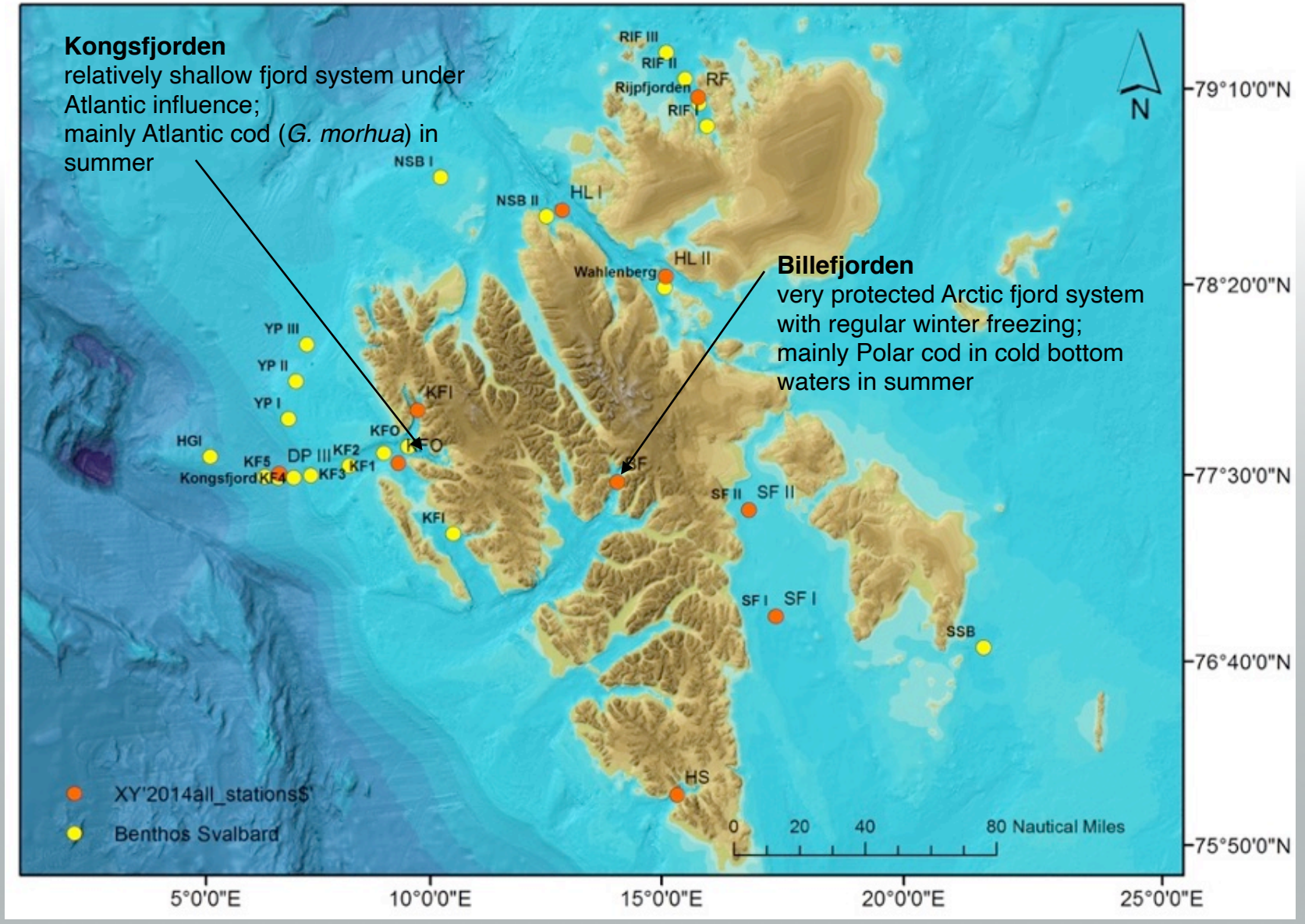
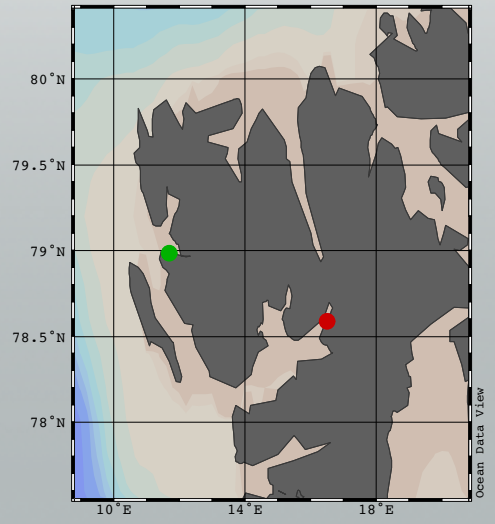
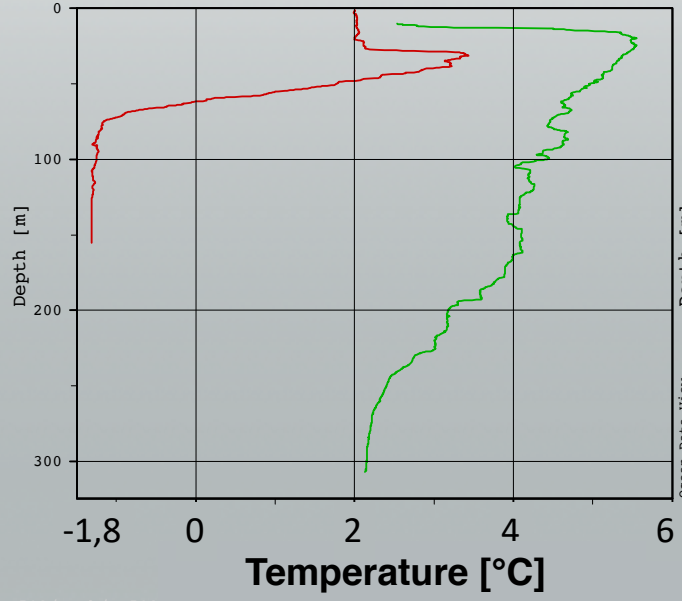
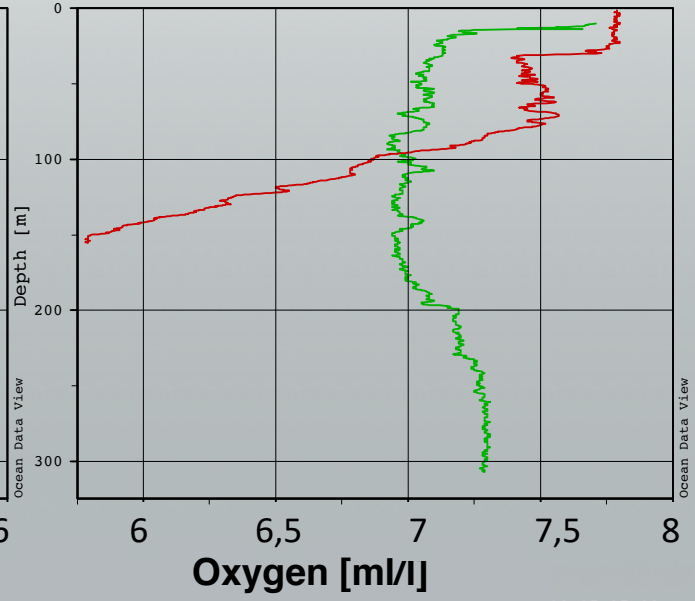


Svalbard in late summer



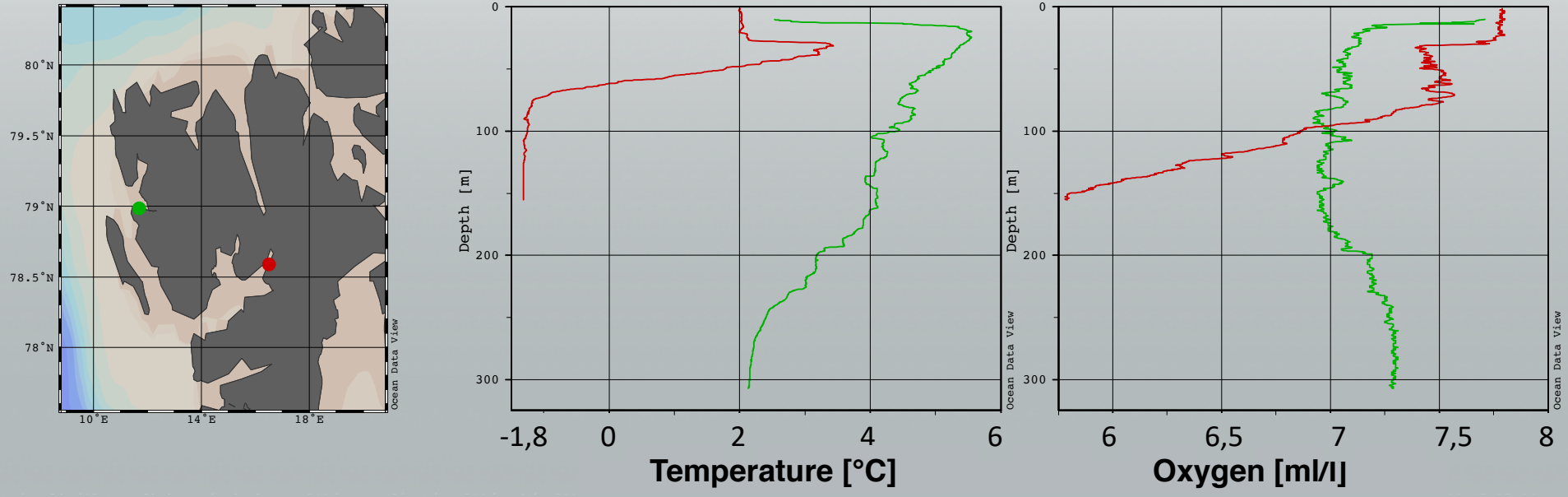
Kongsfjorden
Billefjorden





Svalbard in late summer

- Most fjord systems on the West and North coast are very well mixed and relatively warm: Kongsfjorden



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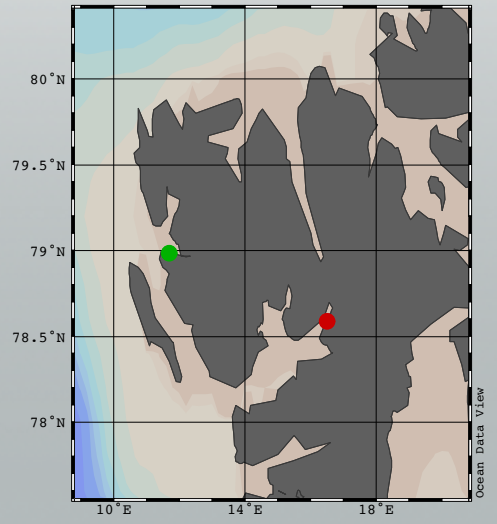
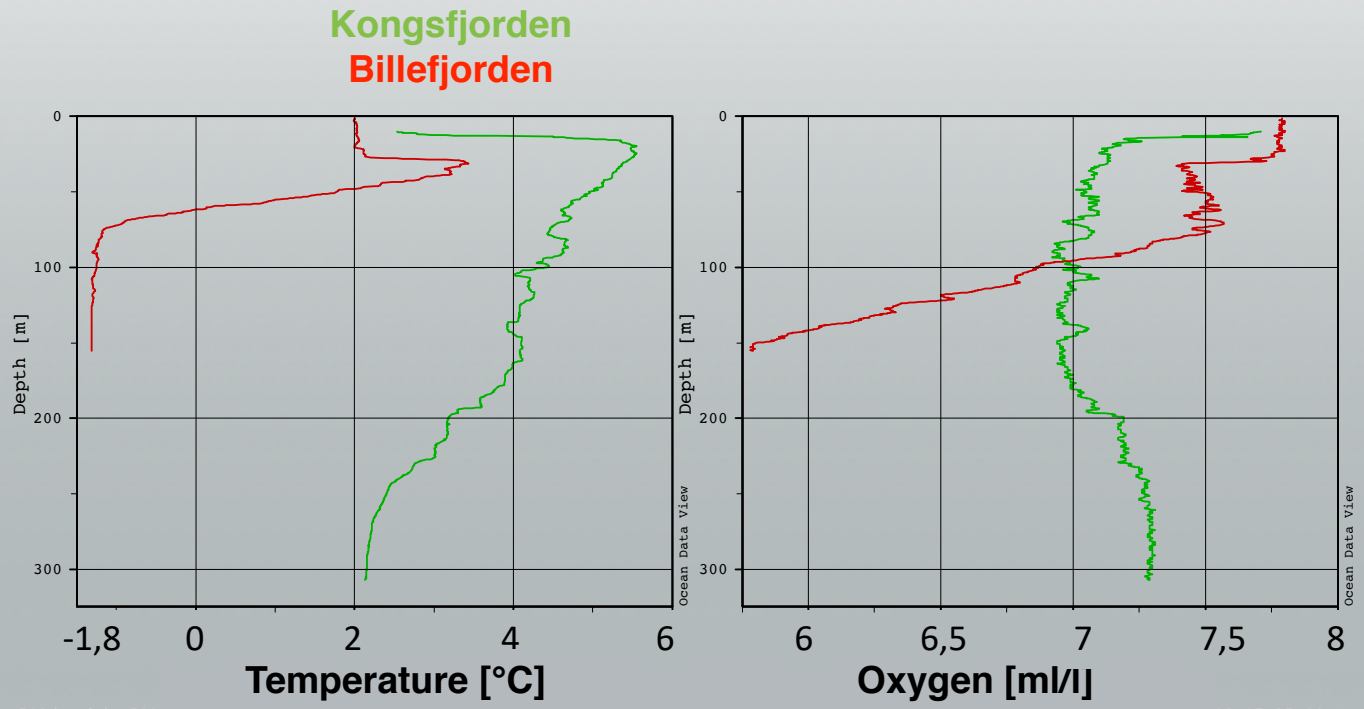
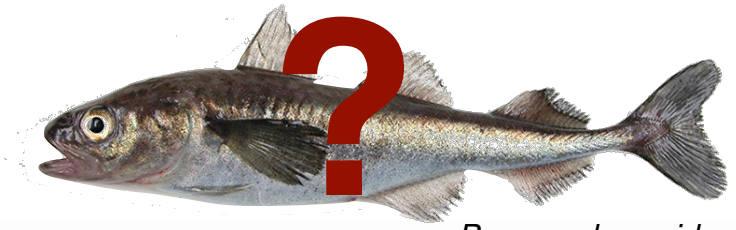
- Only central fjord system, protected by landmasses and high fjord sills remain stratified: Billefjorden





Svalbard in late summer

- Most fjord systems on the West and North coast are very well mixed and relatively warm: Kongsfjorden
- Only central fjord system, protected by landmasses and high fjord sills remain stratified: Billefjorden
- …albeit at the expense of decreased oxygen levels (75% air sat)



Boreogadus saida

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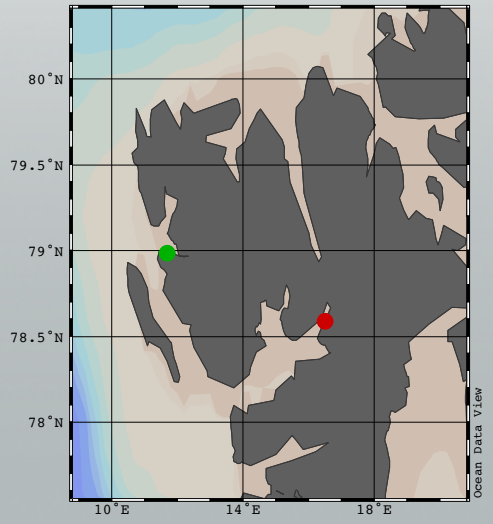

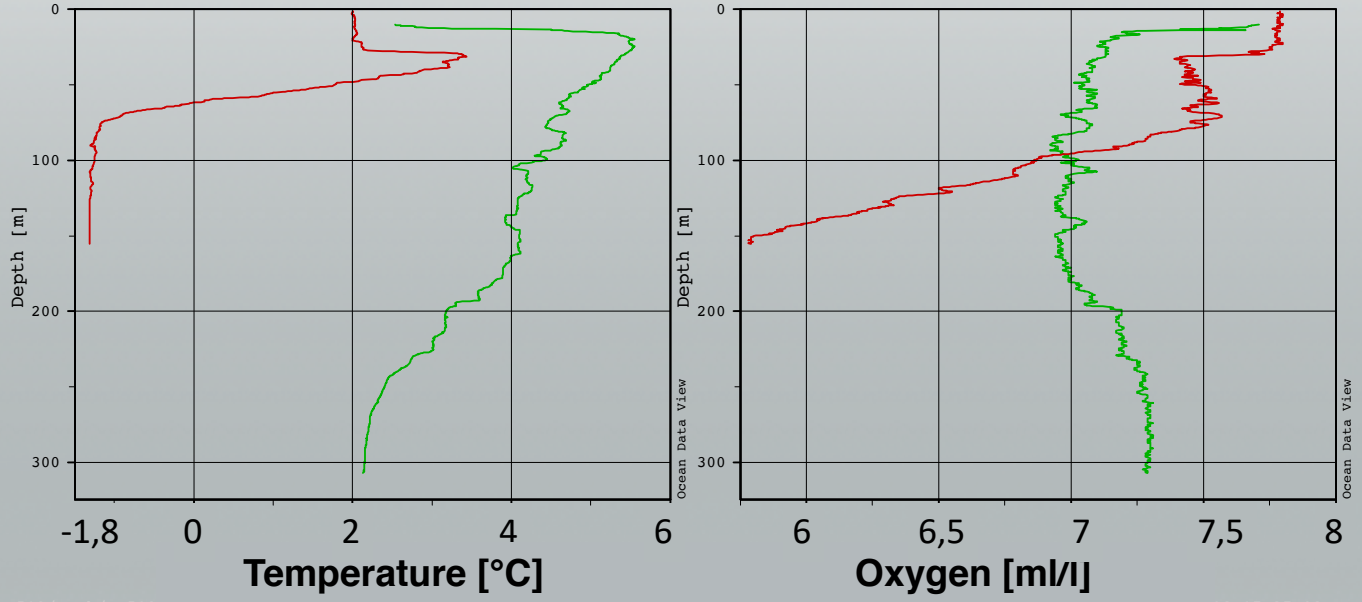

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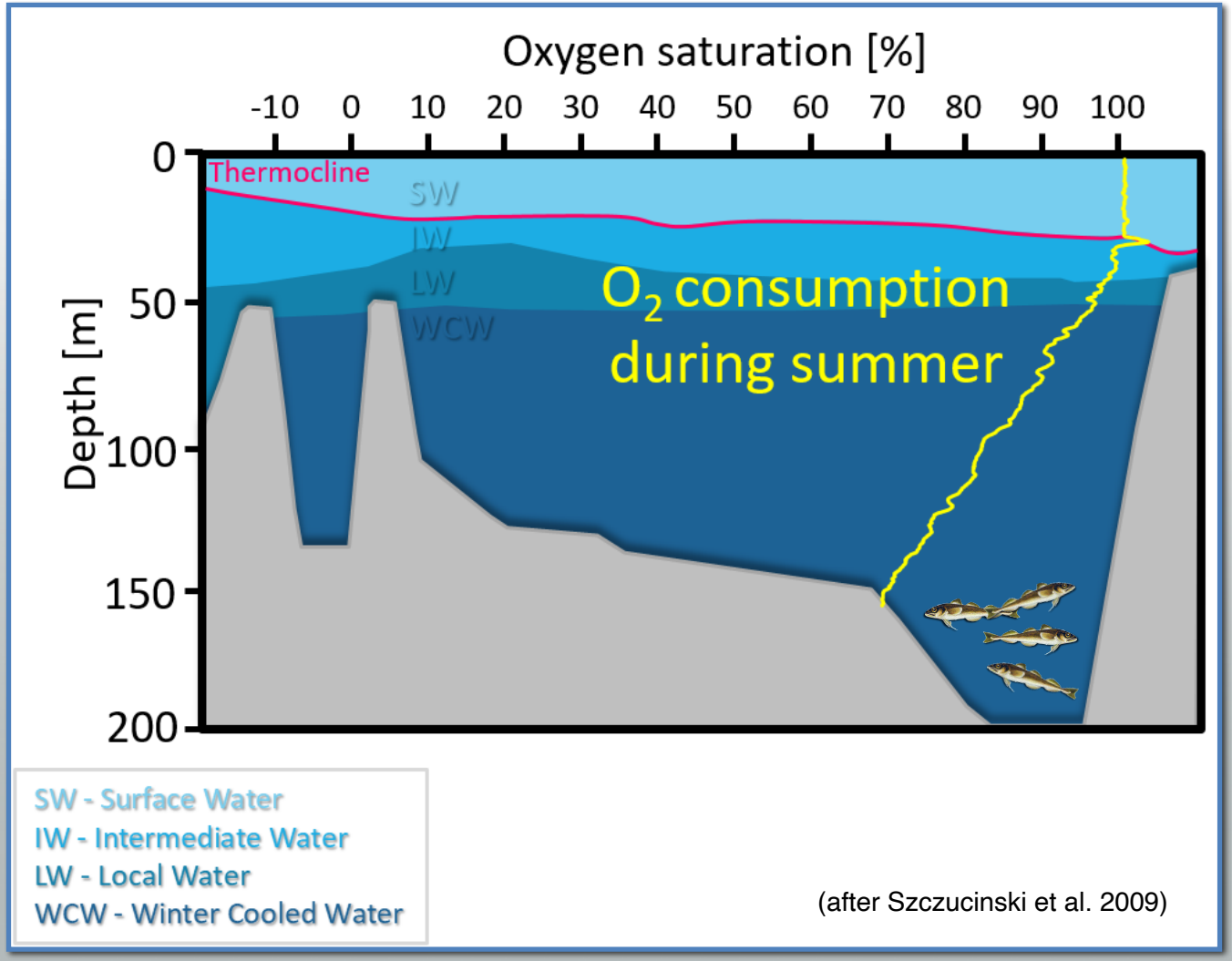

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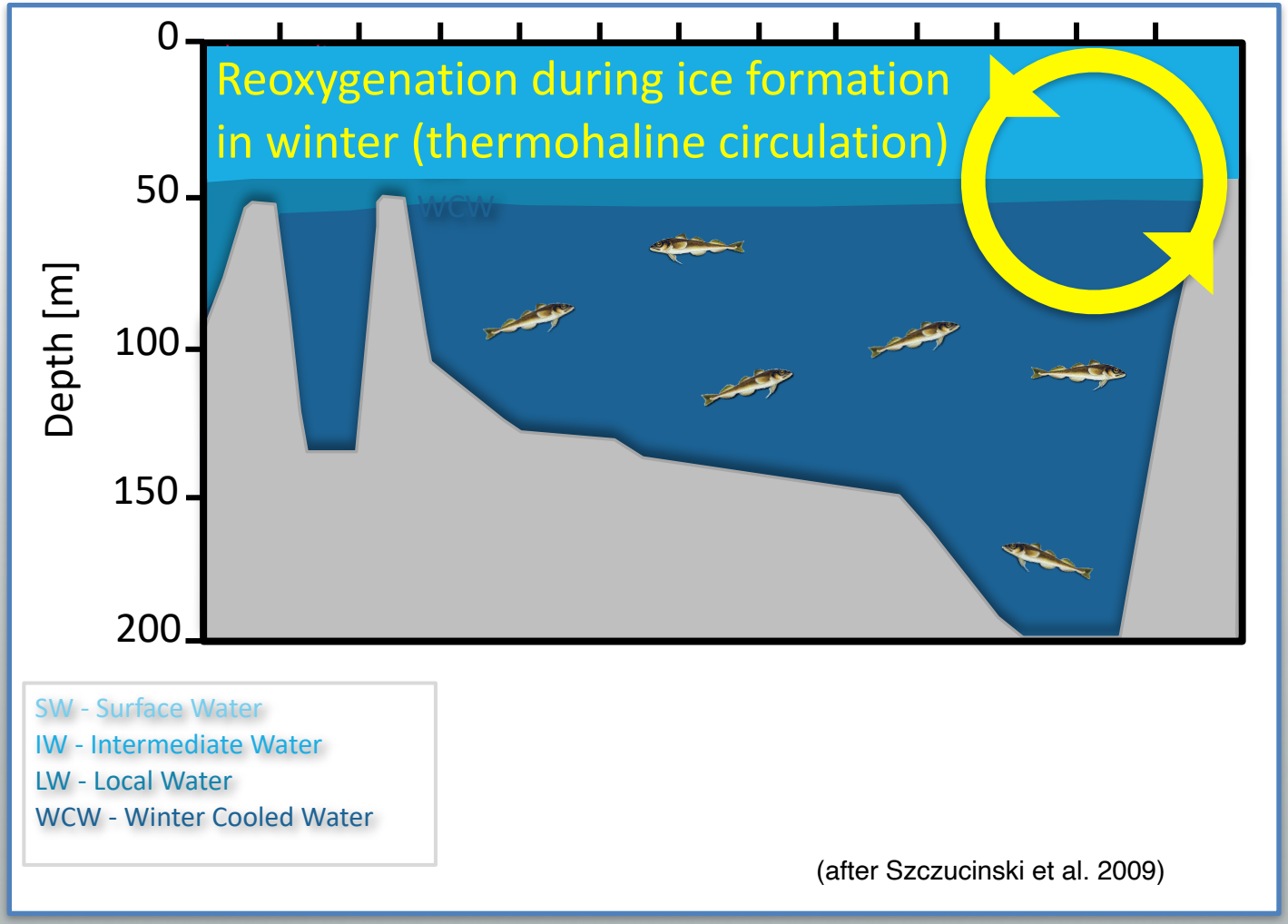

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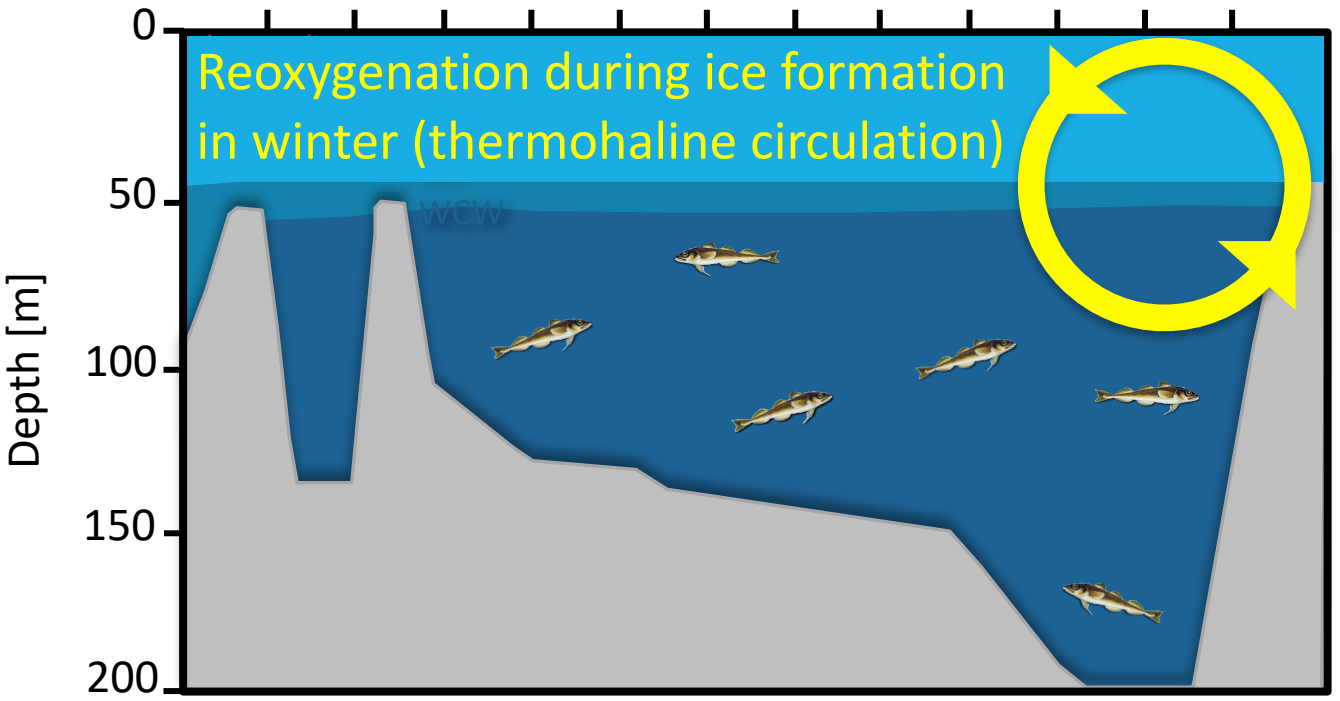

SW - Surface Water
IW - Intermediate Water
LW - Local Water
WCW - Winter Cooled Water

if there is no sea-ice formation in winter, the fjord will become increasingly hypoxic

(after Szczucinski et al. 2009)

Polar paradigm on hypoxia

Boreogadus saida

Polar paradigm on hypoxia

Polar marine fish and invertebrates have a very low hypoxia tolerance (if at all…)

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Polar paradigm on hypoxia

Polar marine fish and invertebrates have a very low hypoxia tolerance (if at all…)

- very low metabolic rates
- good oxygen solubility in cold waters
- cold adapted - low metabolic plasticity
- how hypoxia tolerant is Polar cod?

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Polar paradigm on hypoxia

Polar marine fish and invertebrates have a very low hypoxia tolerance (if at all…)

Experimental setup

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Experimental setup

- static and swim tunnel respirometry @ 2°C
- start at air saturation, decrease of PO_2 in 10 and 5% steps until P_{crit}
- U_{crit} protocol in swim tunnel with 10 min steps of 0,15 BL/s at different PO_2

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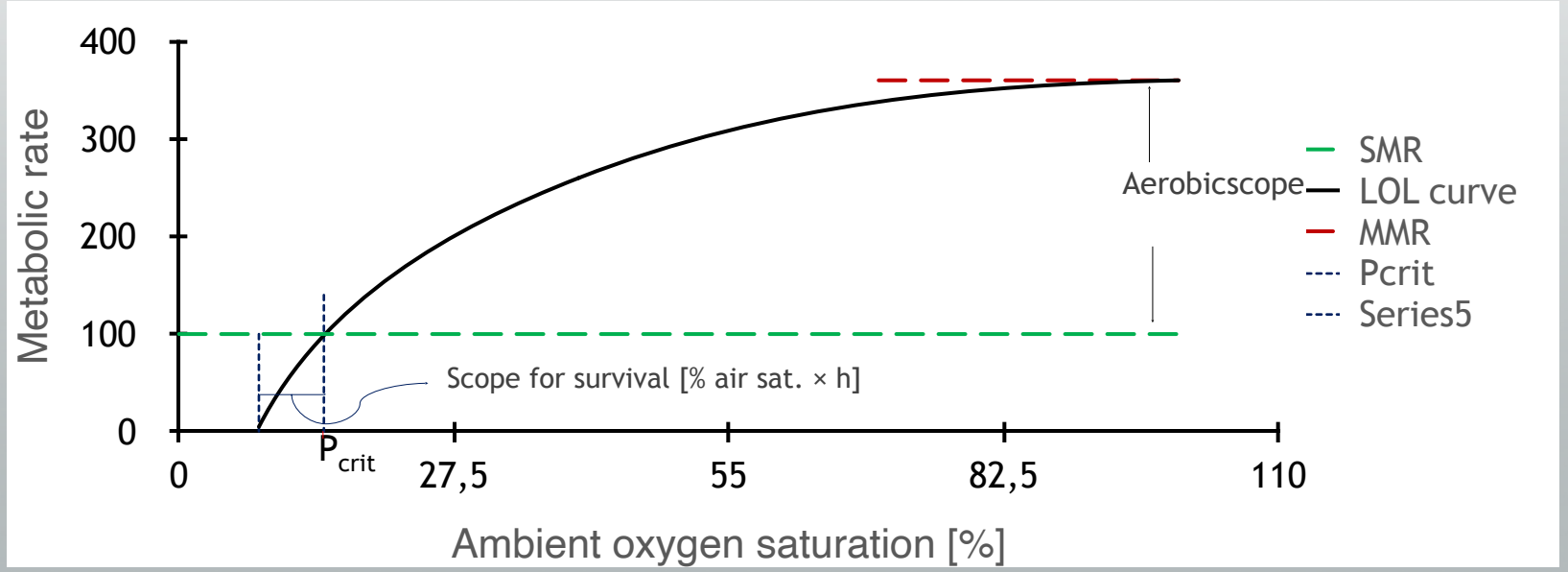
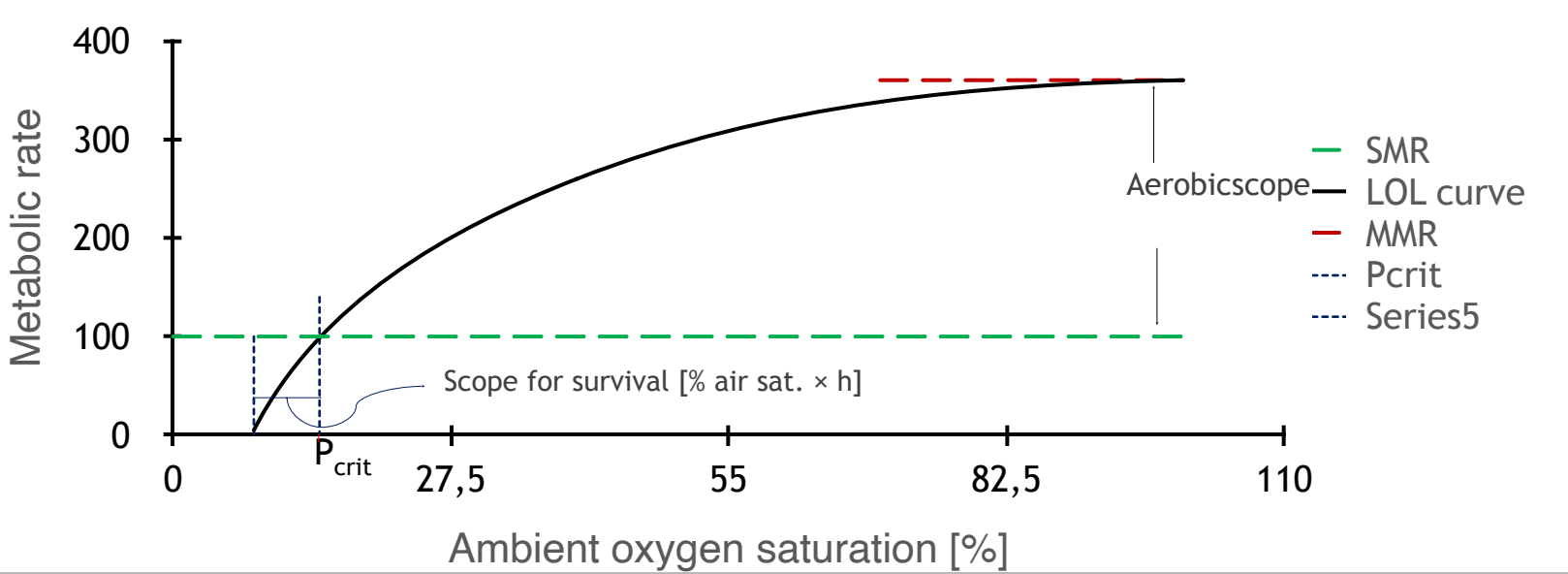
Maximum metabolic rate (MMR) – LOL curve (limiting oxygen level)



(after Neill and Bryan 1991, Claireaux and Chabot 2016)

Maximum metabolic rate (MMR) – LOL curve (limiting oxygen level)

Aerobic Scope = MMR - SMR



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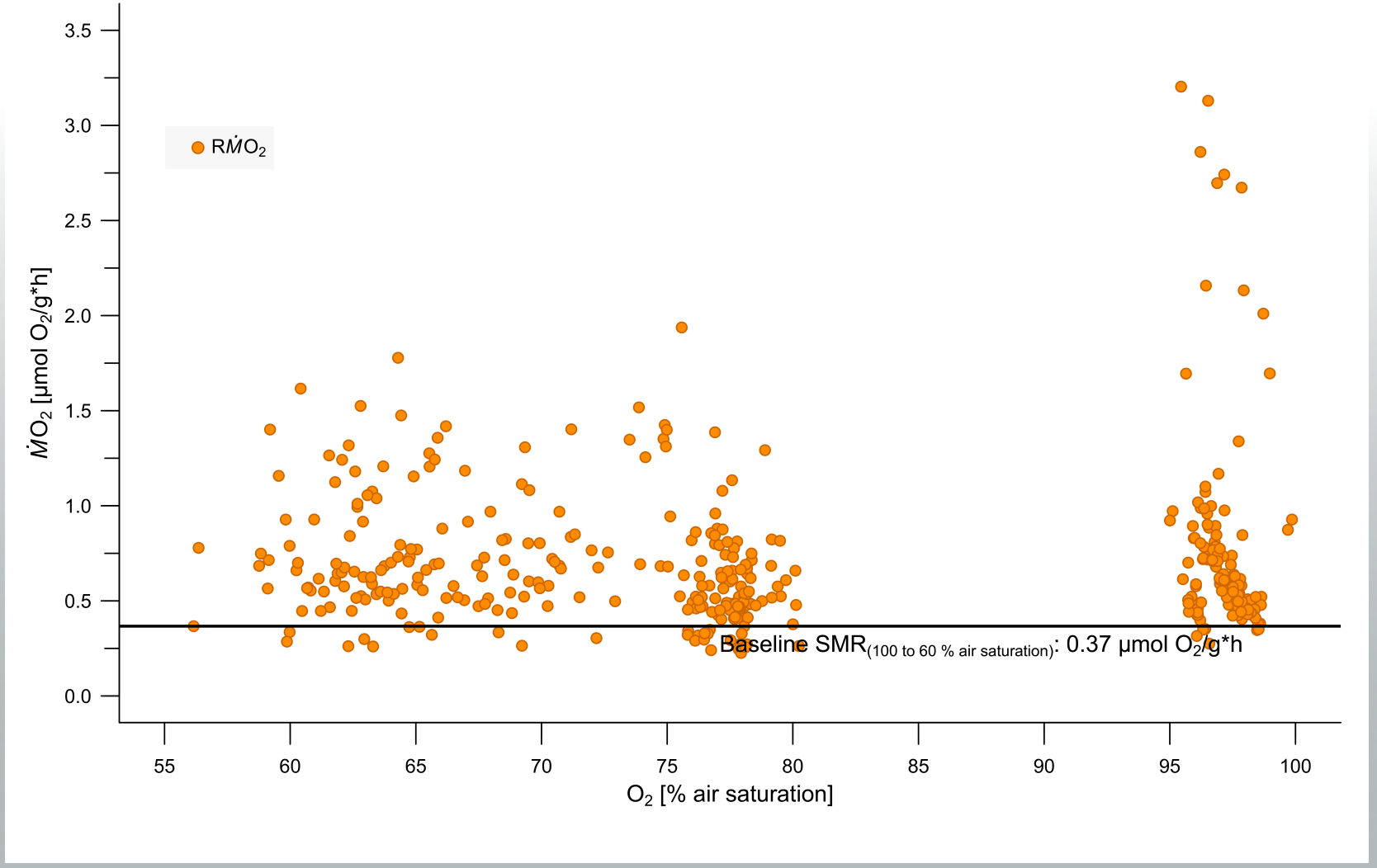
Standard metabolic rate (SMR) between 100 and 60% O_2 saturation



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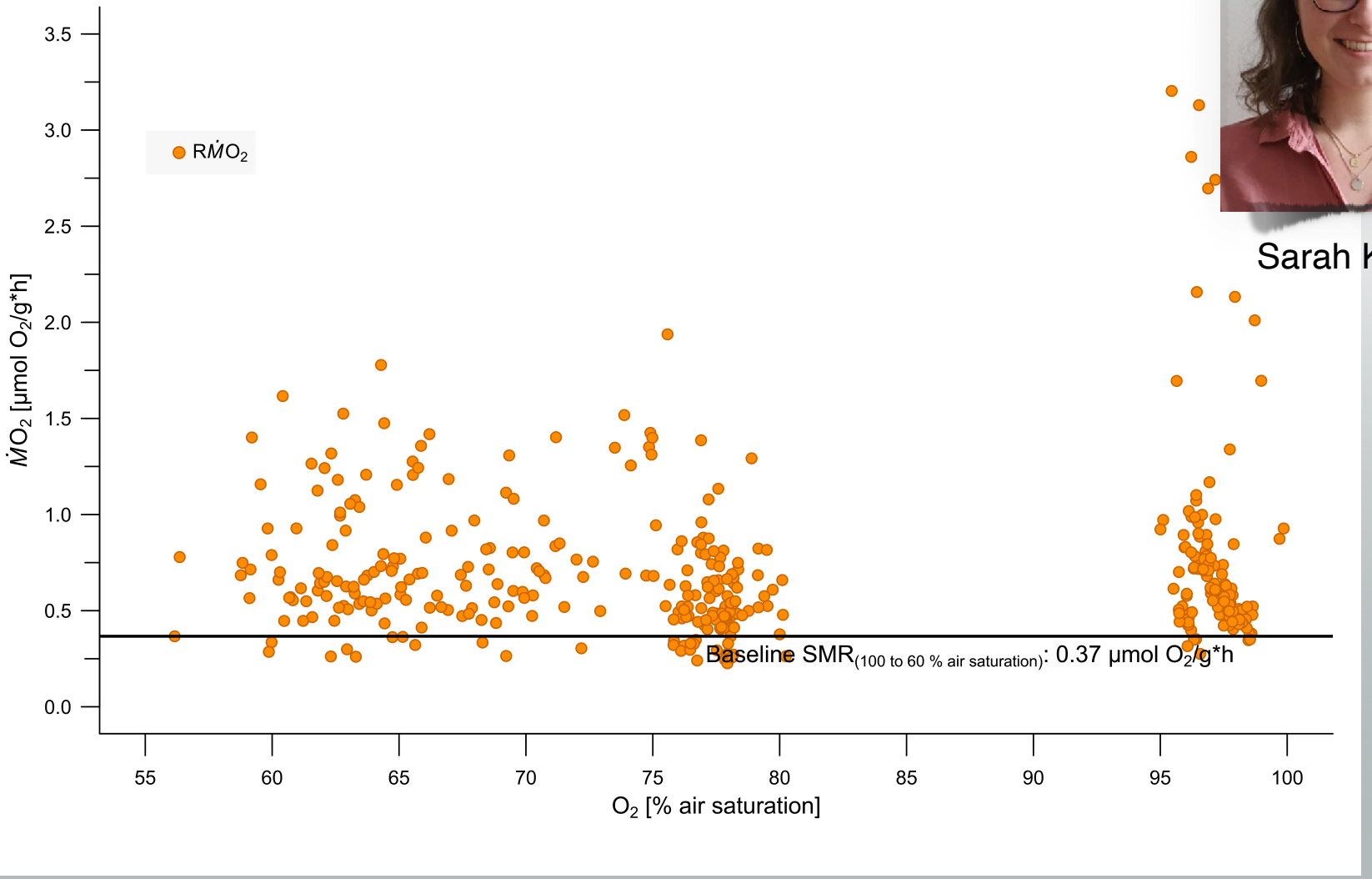

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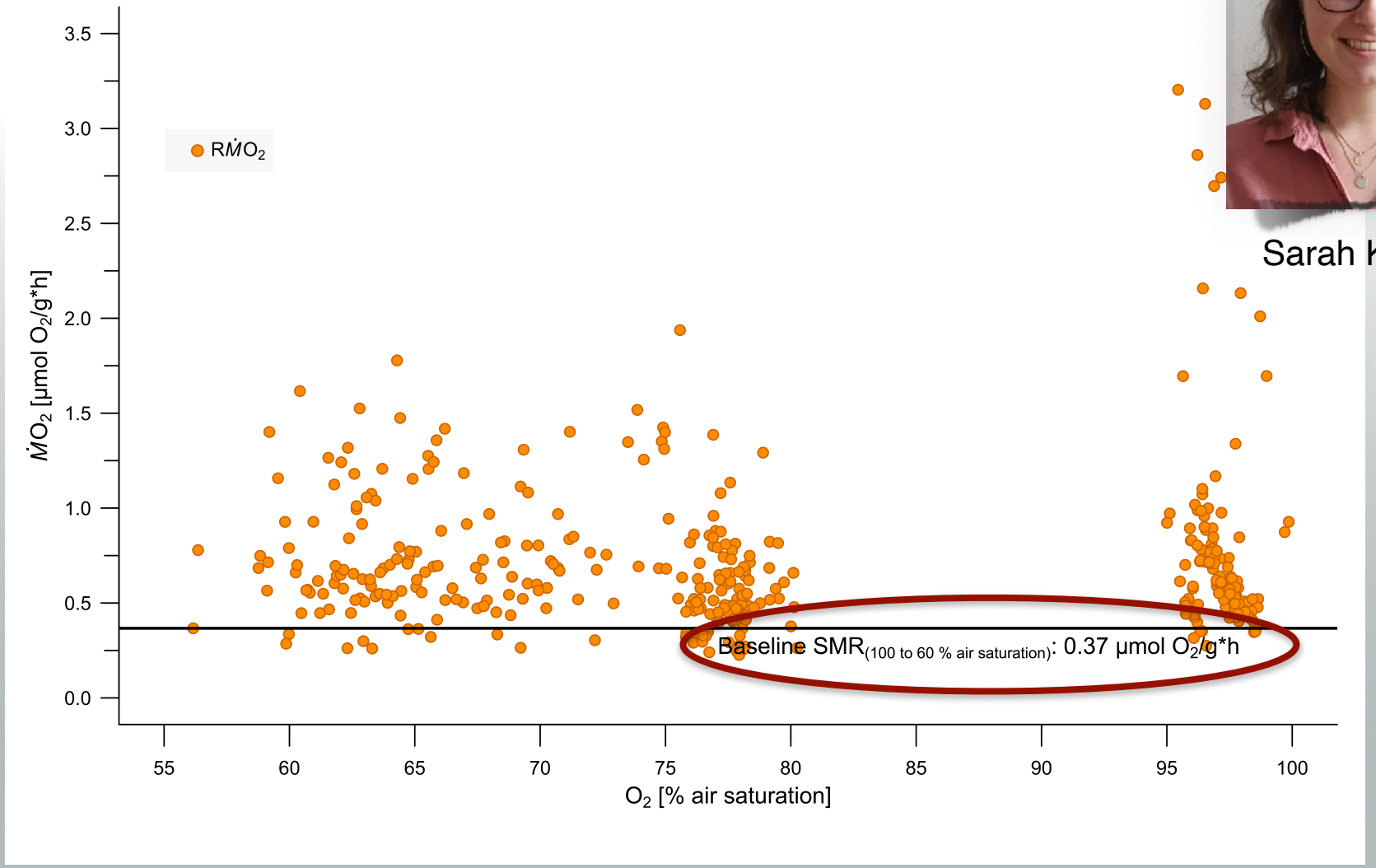
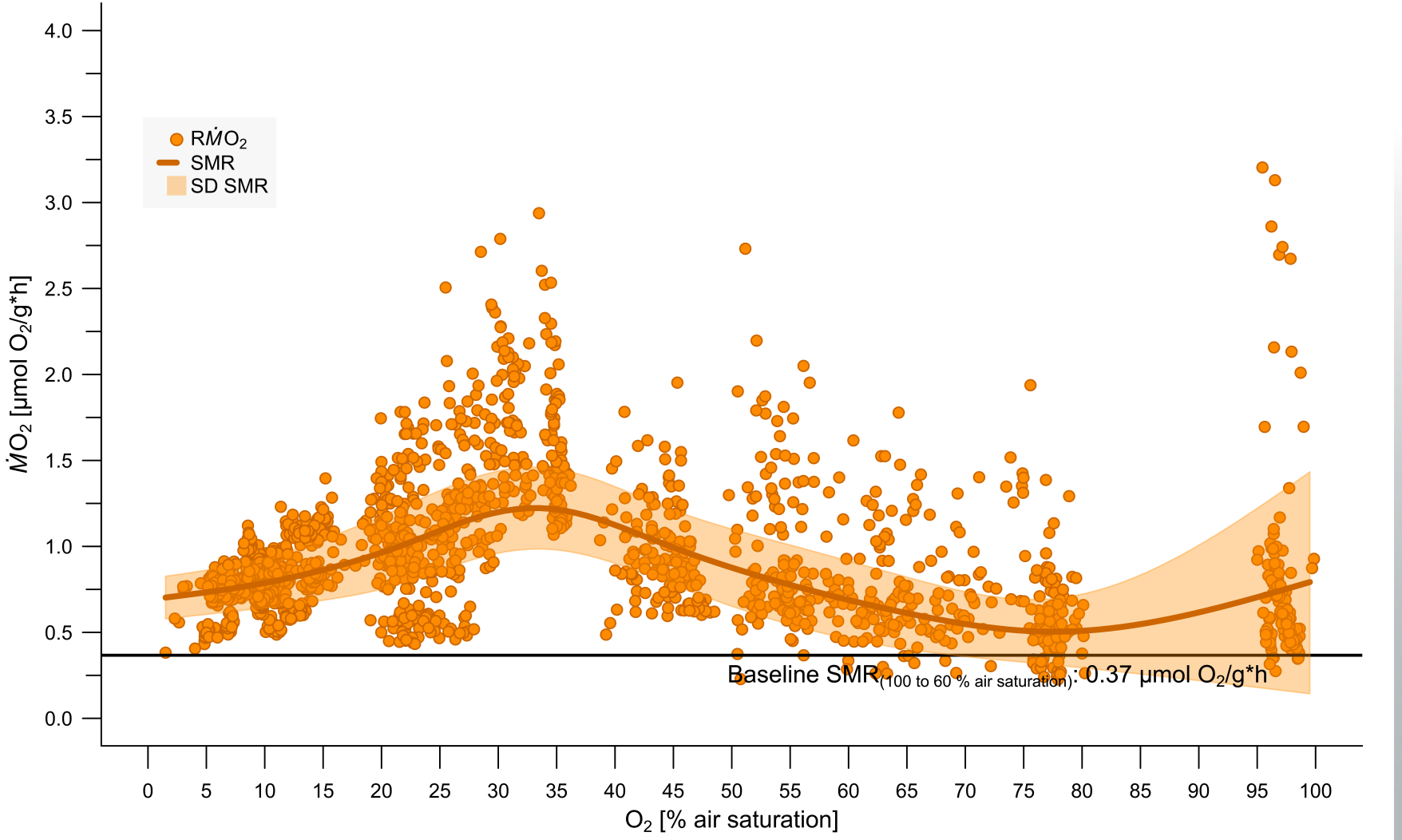


Routine metabolic rate (RMR) from 100-5% O_2 saturation



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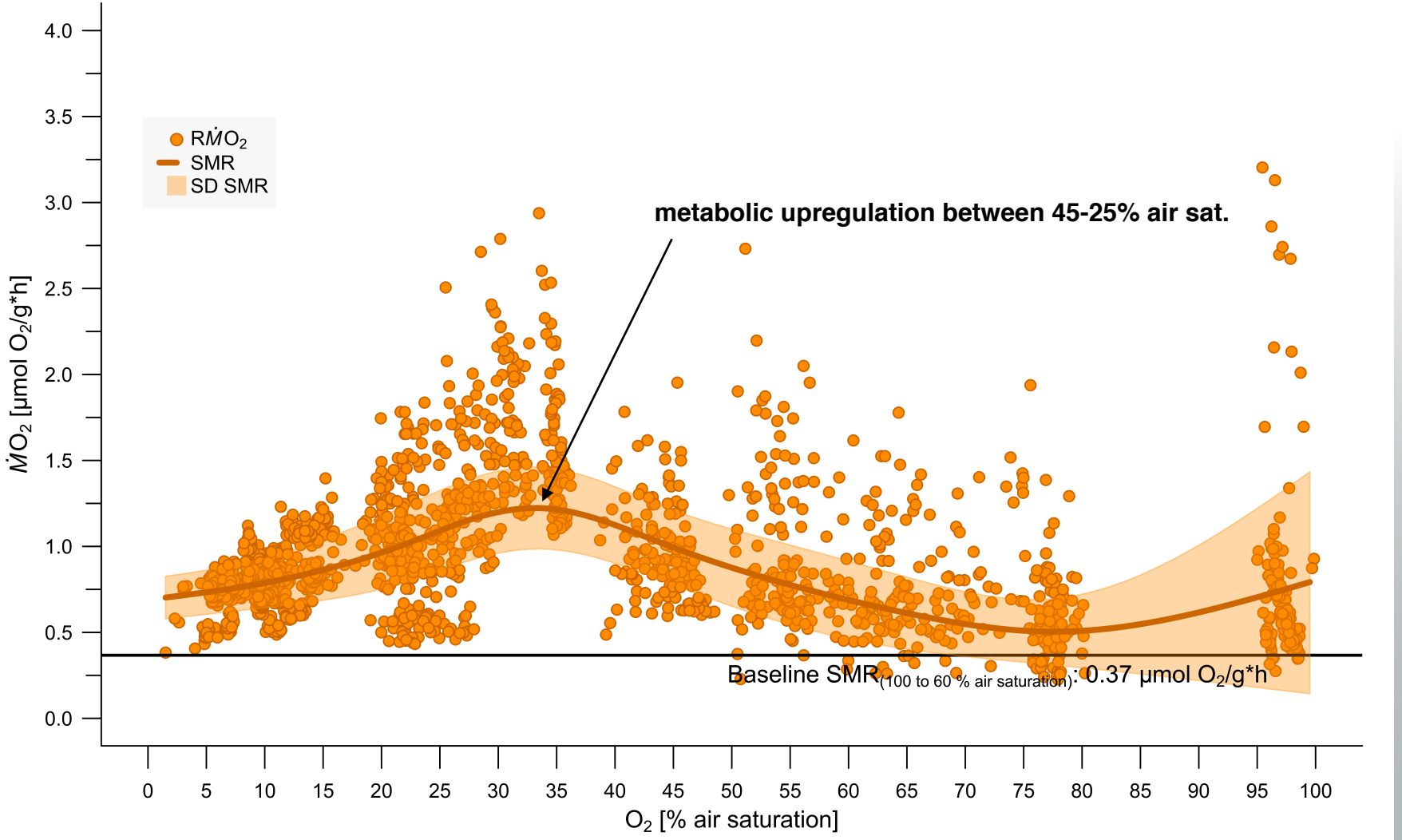

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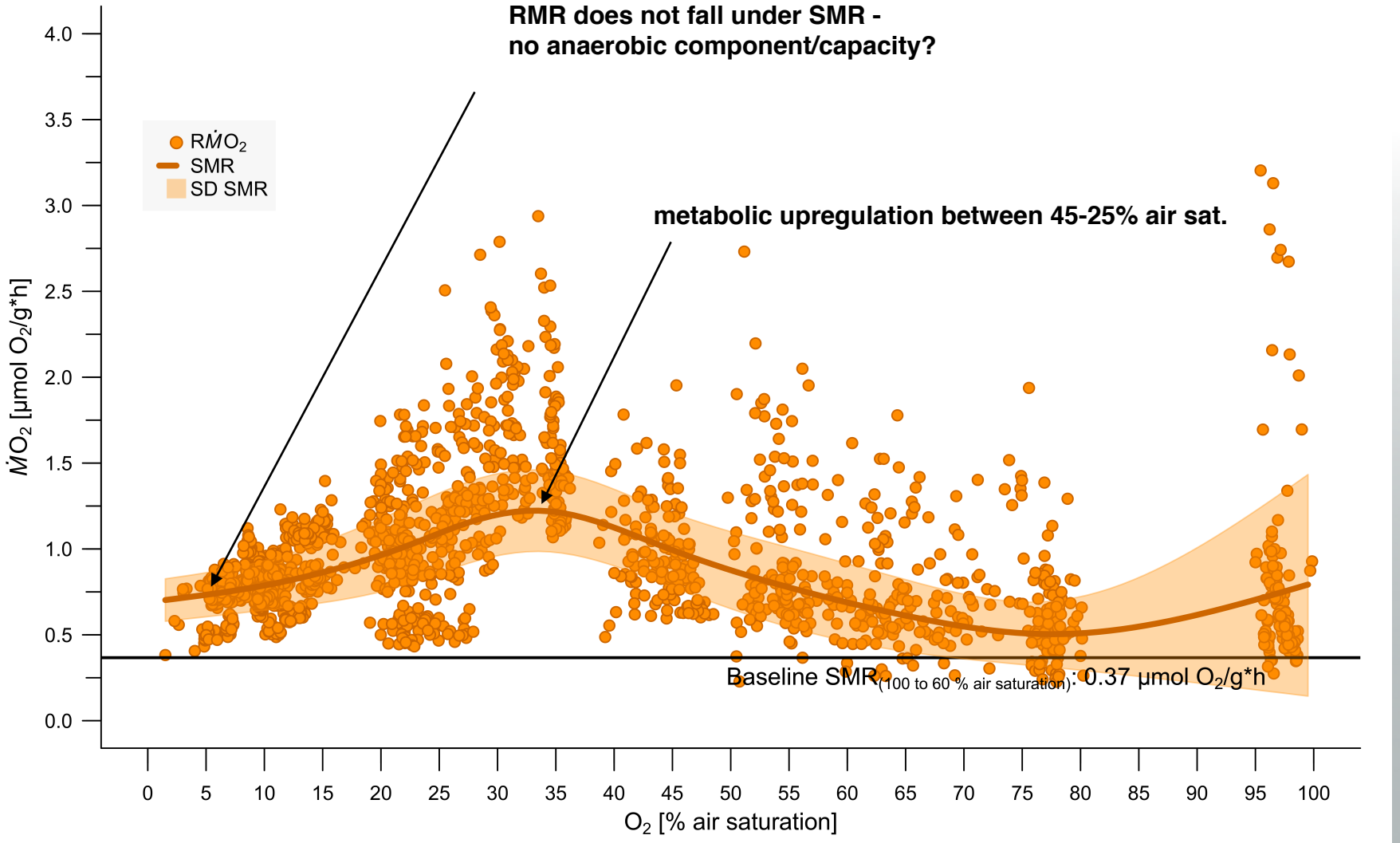

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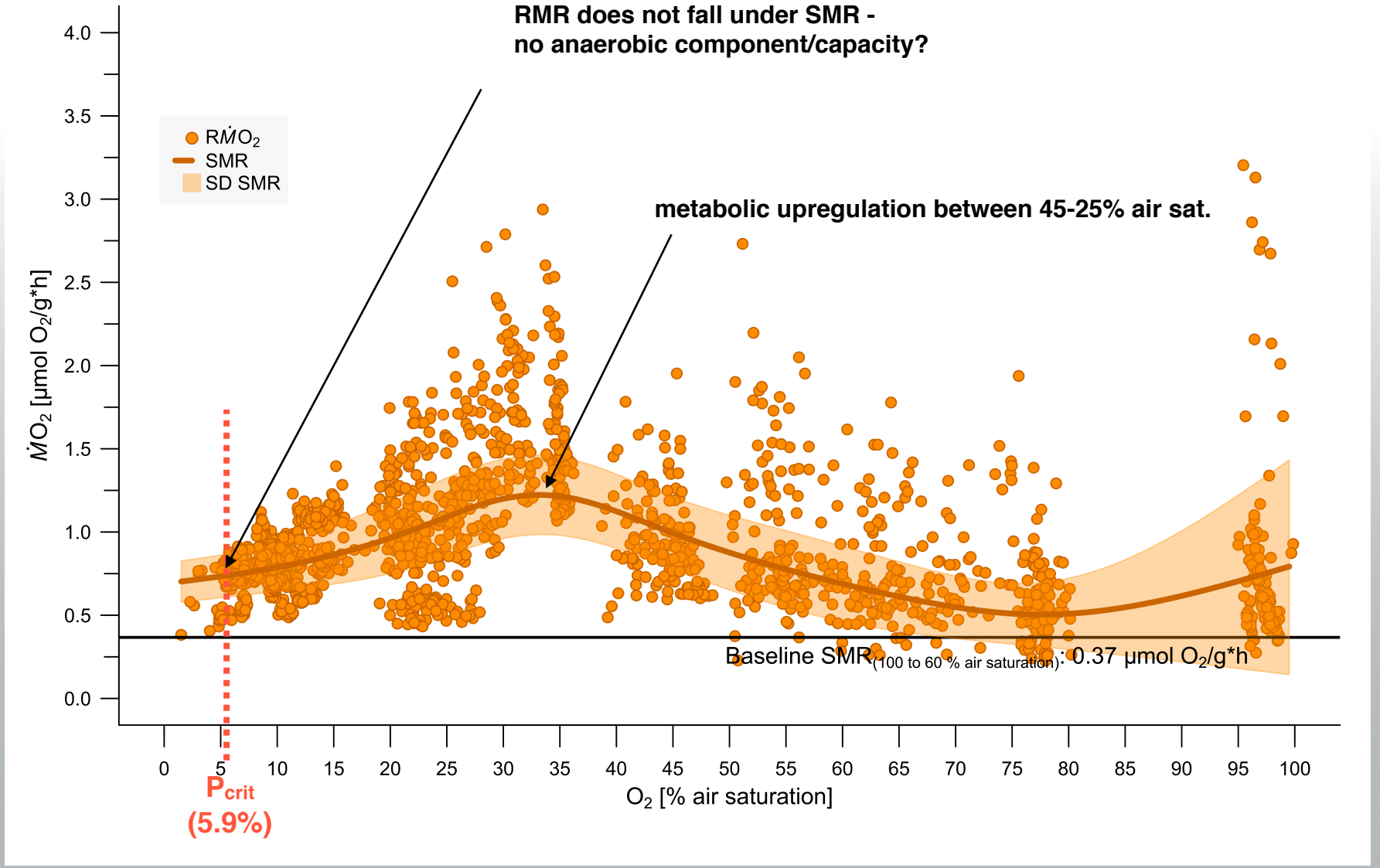
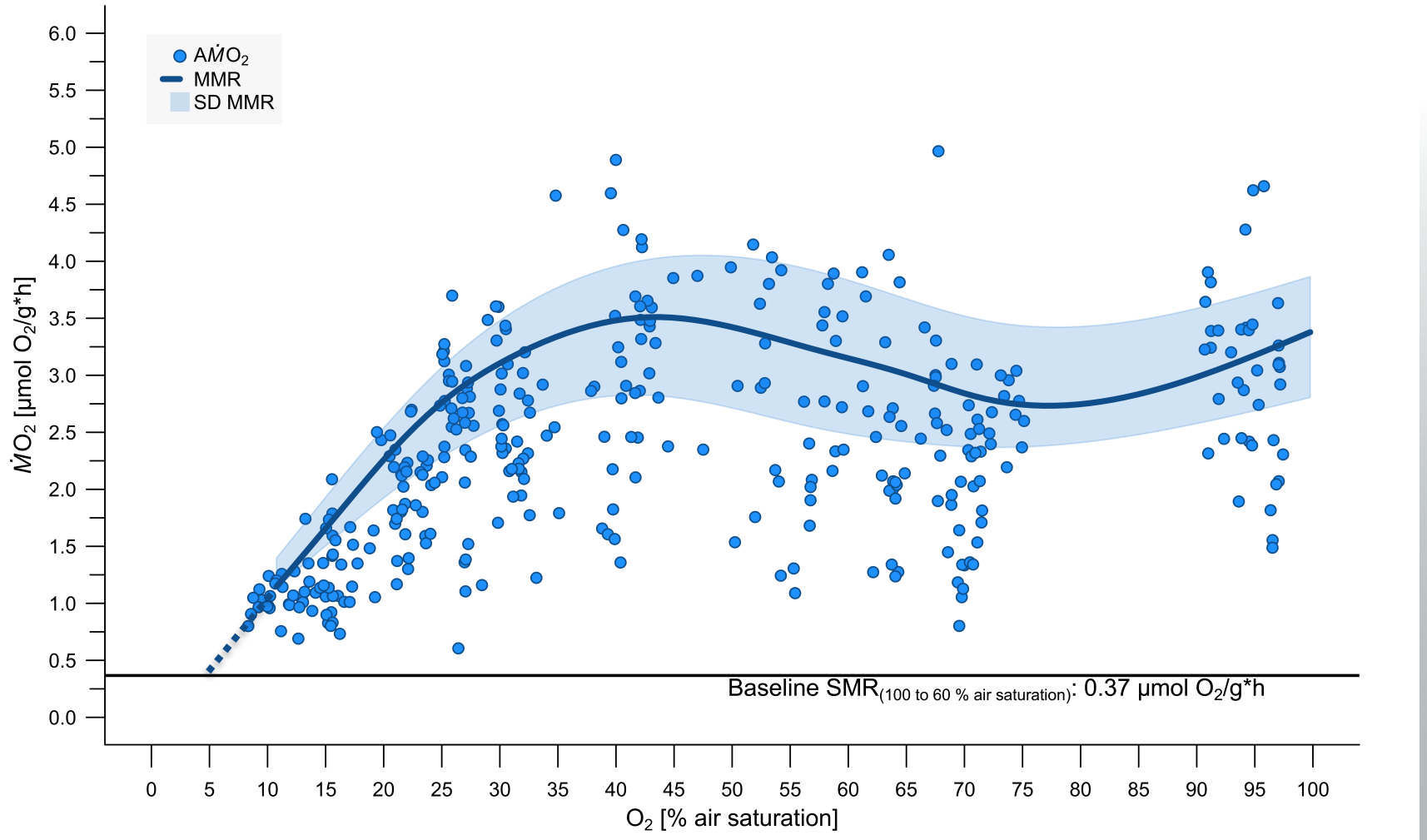


Maximum metabolic rate (MMR) from 100-5% O_2 saturation



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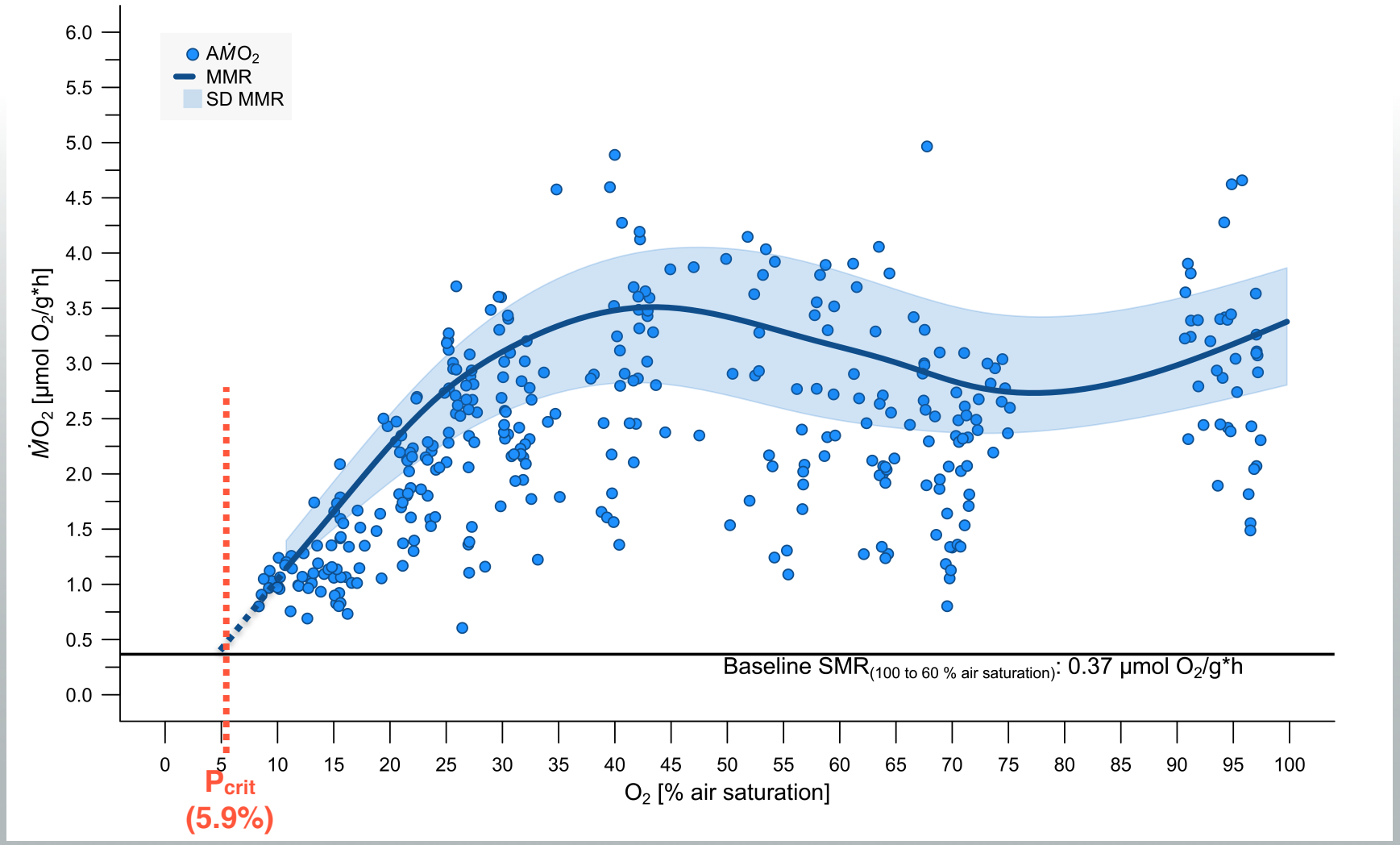
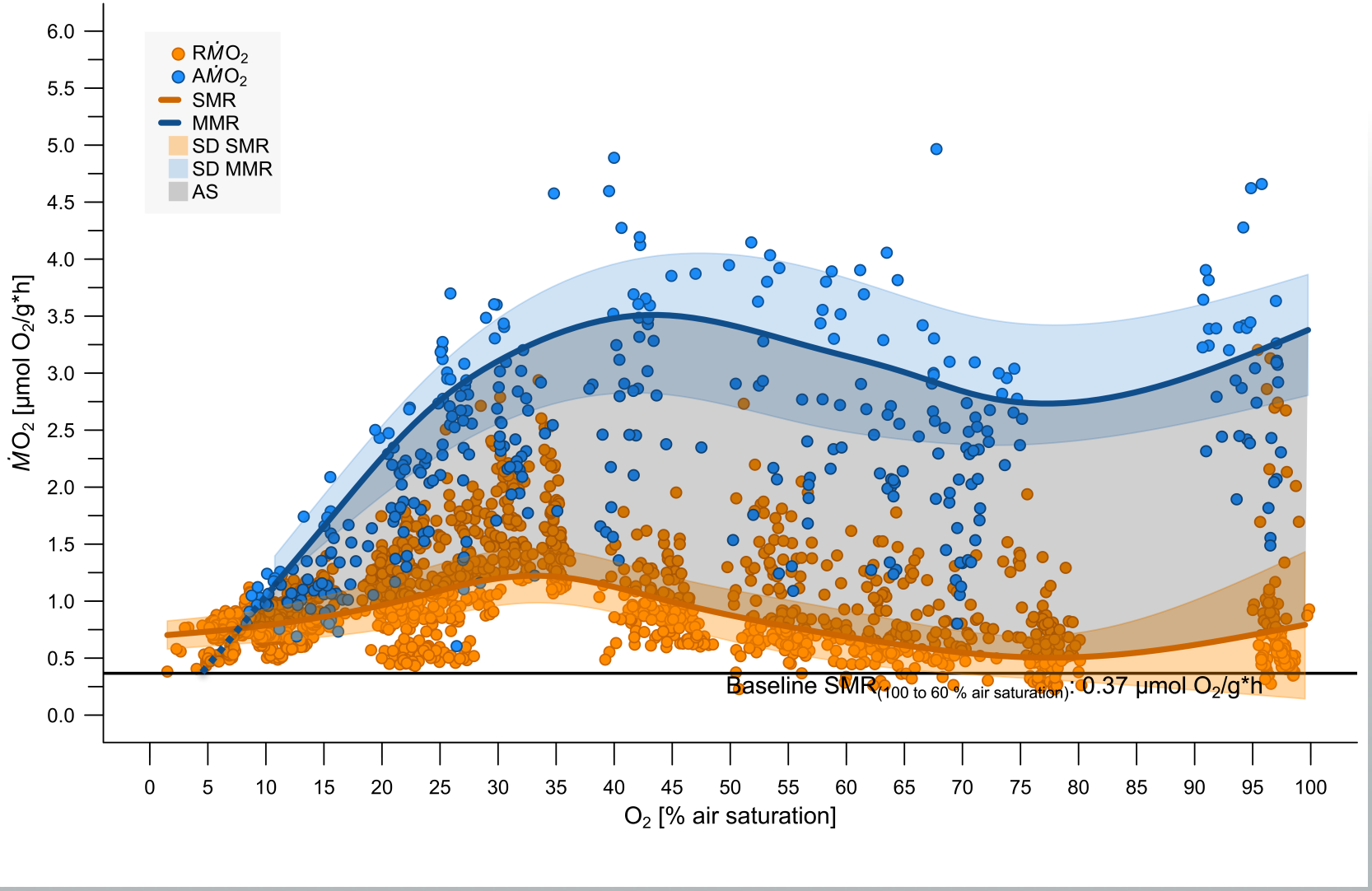


Aerobic scope



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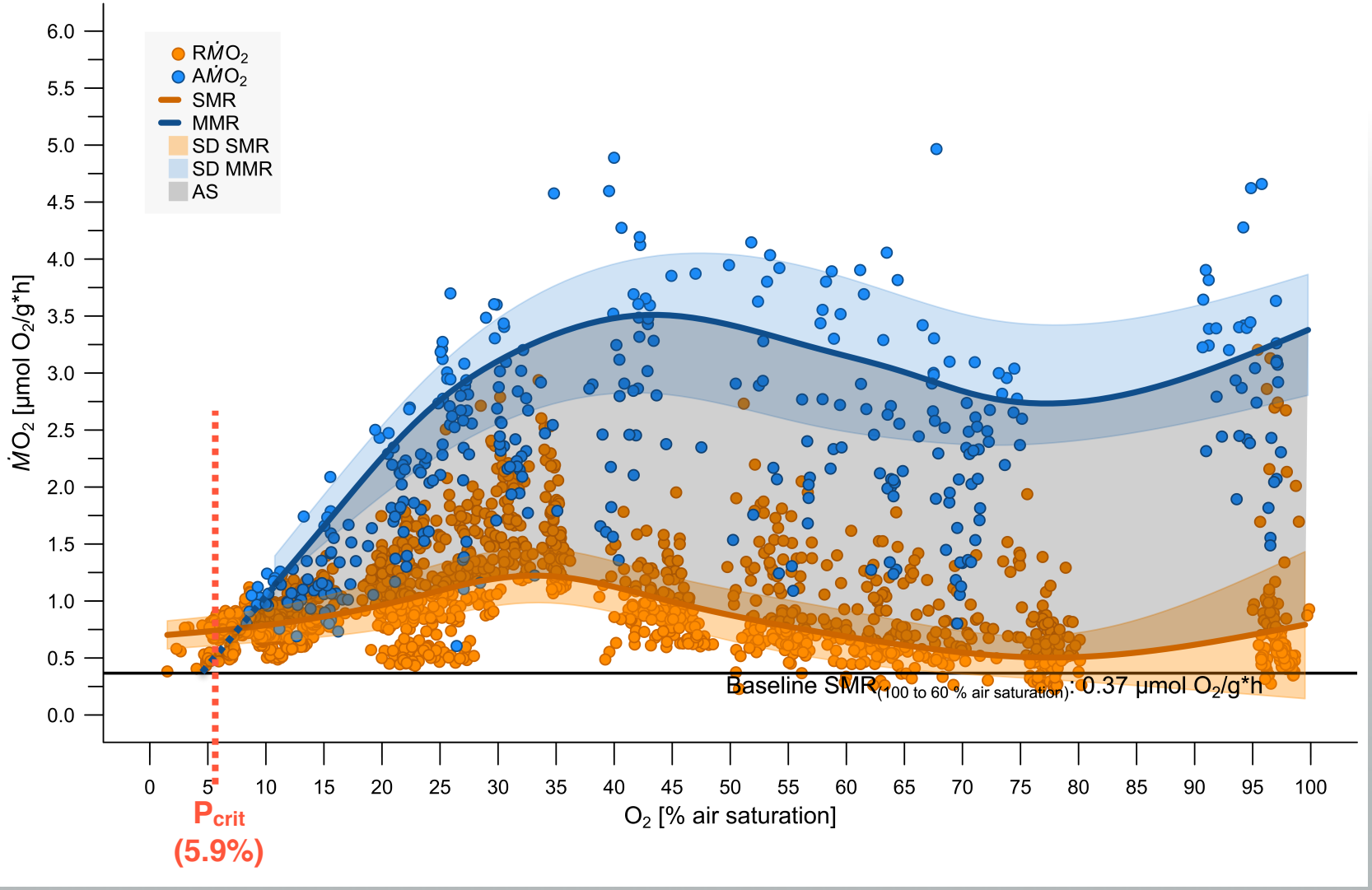
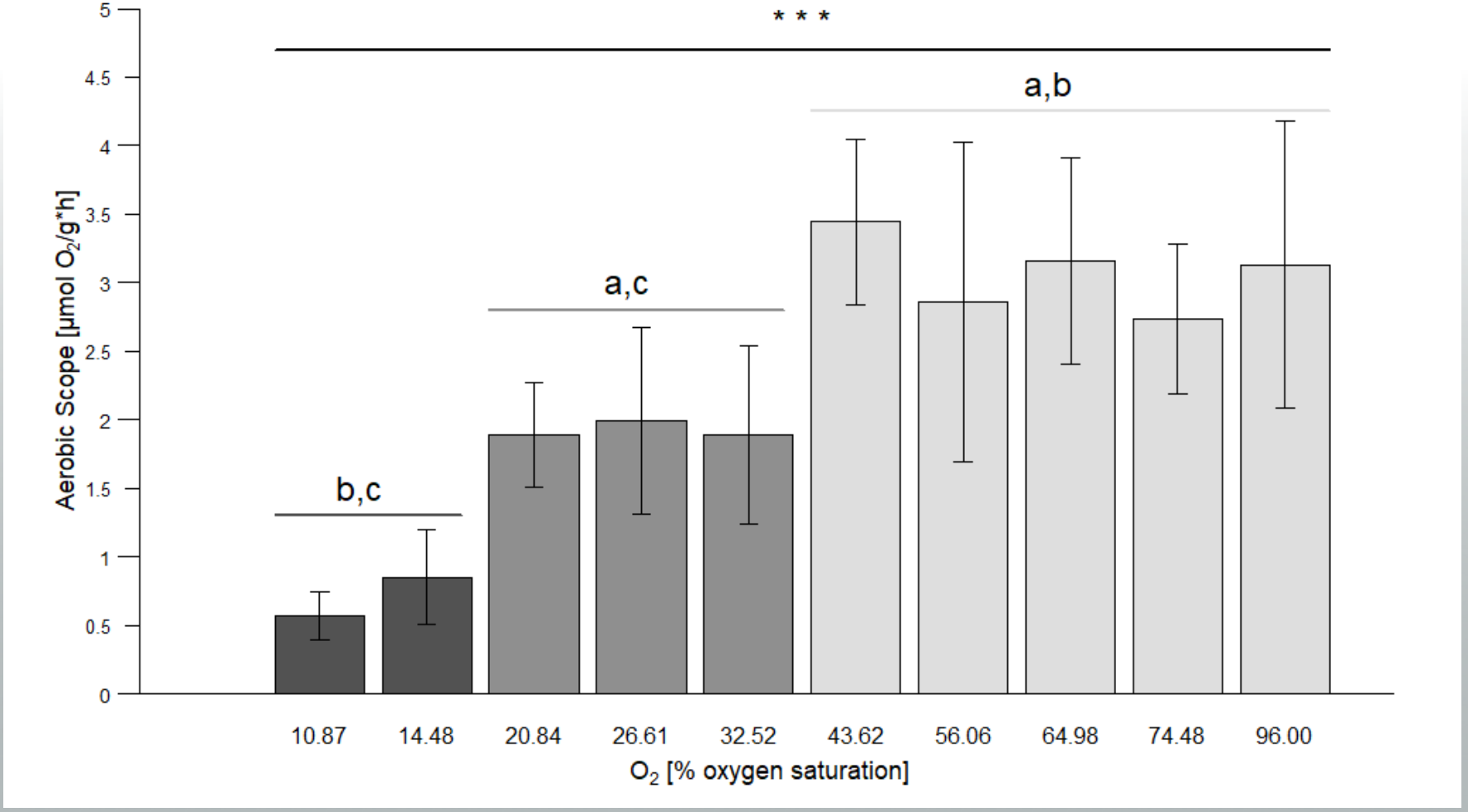


Aerobic scope stable down to 40% O_2 saturation



Hypoxia tolerance after acclimation to 10 °C (T_{crit} is 12,5 °C)

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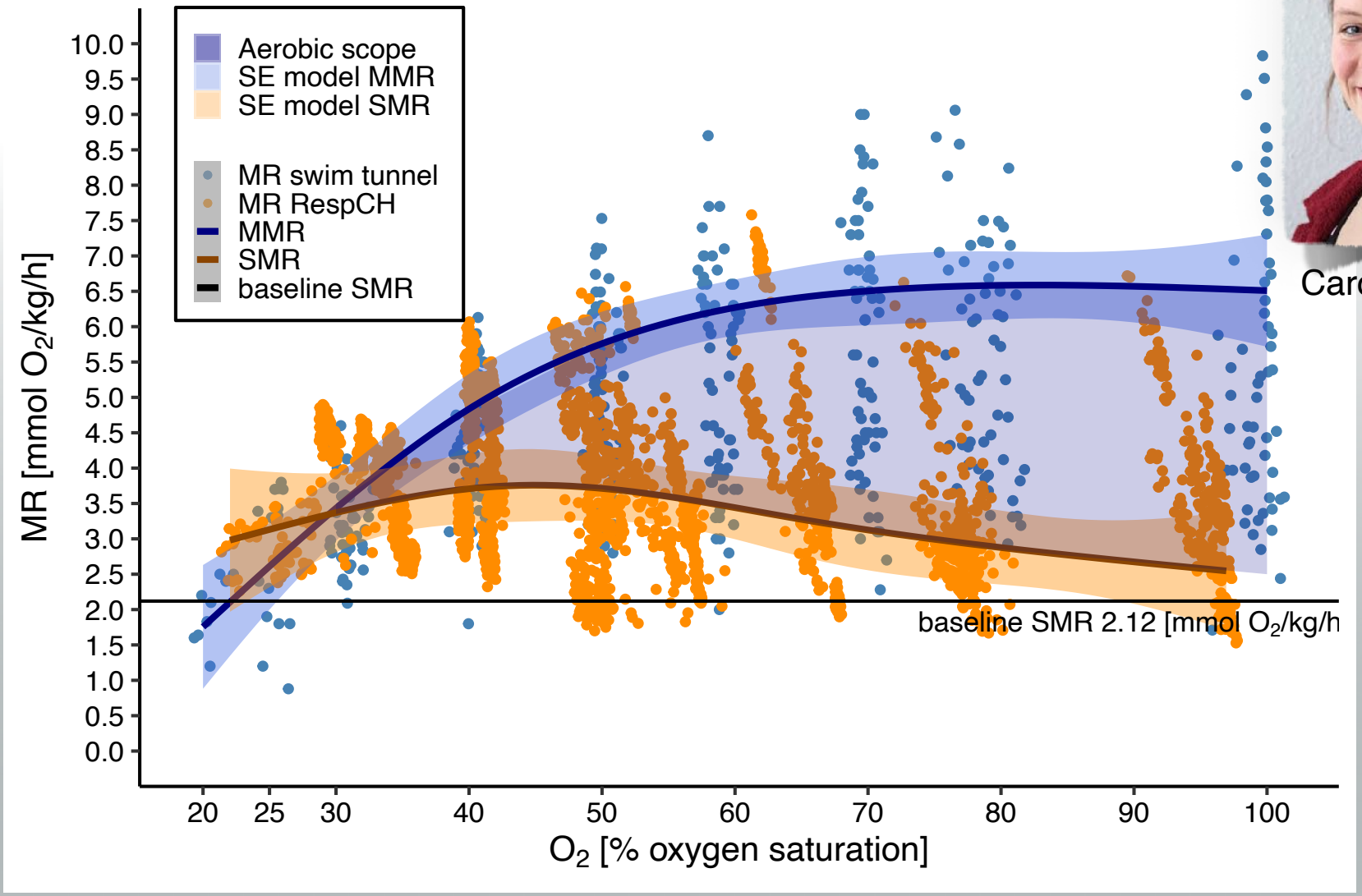

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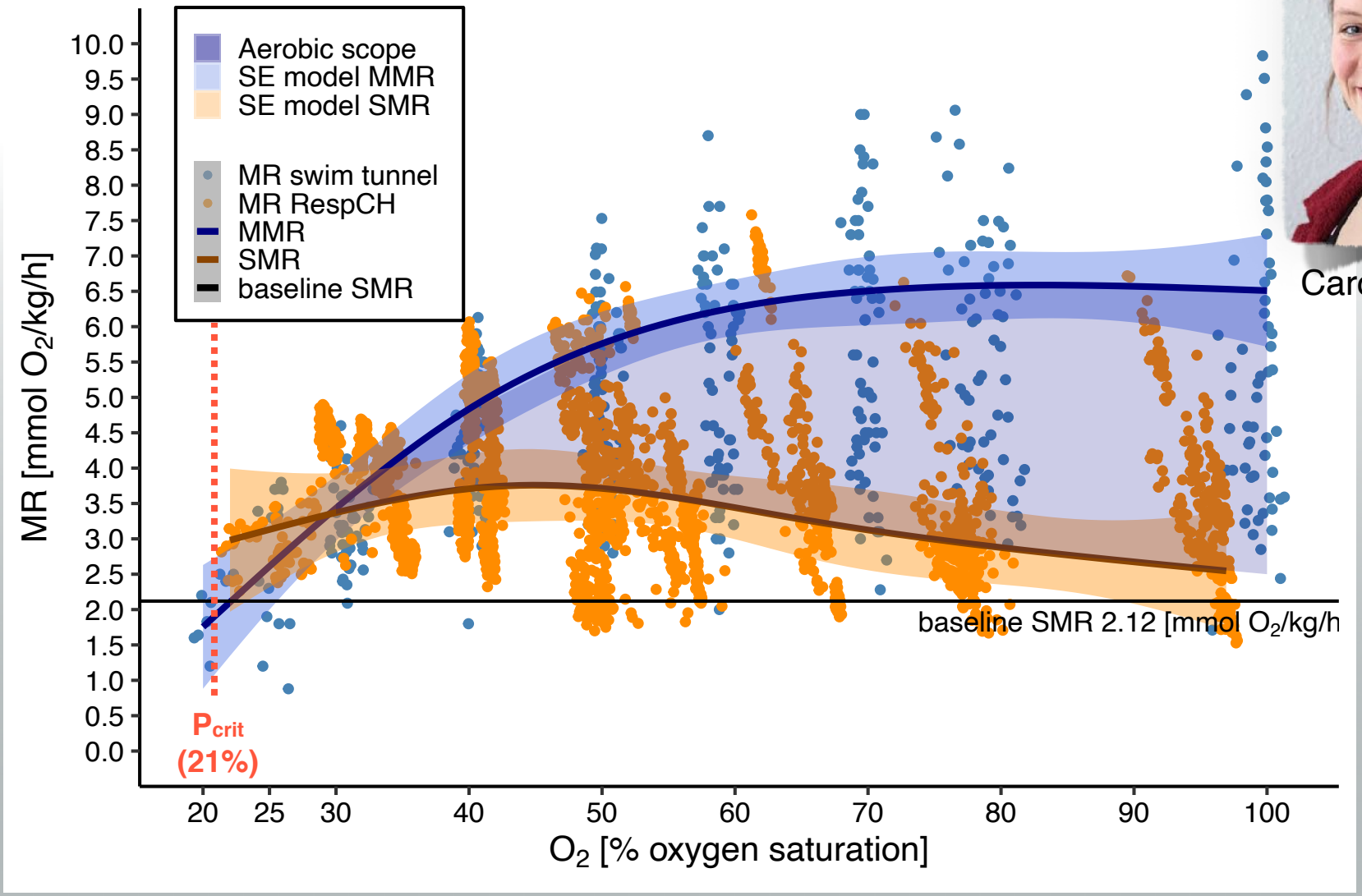

Take home messages

	2 °C	10 °C
Pcrit	5,9% air sat (21 µmol/l)	21,1 % air sat (55 µmol/l)
SMR	0,37 µmol/g*h	2,12 µmol/g*h
MMR	4,25 µmol/g*h	6,5 µmol/g*h
Aerobic scope (absolute)	3,5 µmol/g*h above 40% air sat	4 µmol/g*h above 70% air sat
Factorial aerobic scope	> 10	~ 3

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- **Even close to its T_{crit}, Polar cod still shows a remarkable hypoxia tolerance of 21% air sat. at 10°C, adding competitive capacity in deoxygenated fjord bottom waters**
- **Mechanisms still unclear:**
  - **'normal' metabolic rates**
  - **very low anaerobic capacity**

Thank you!

ALFRED-WEGENER-INSTITUT
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