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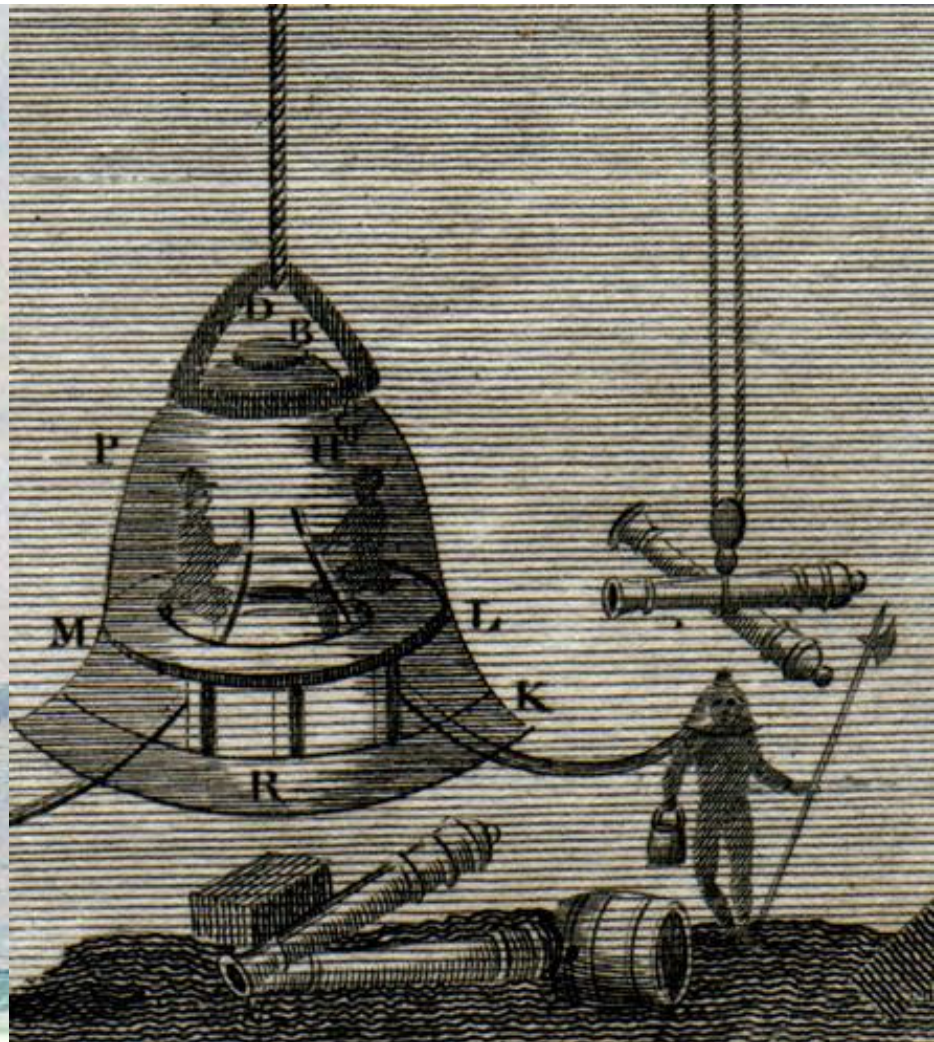
The future of Swedish military diving

LtCdr Mårten Silvanius, M.Sc

Agenda

Historical review

The faith of Vasa



Historical review

The faith of U-3503

Historical review

The faith of U-3503

Historical review

The faith of Arne Zetterström

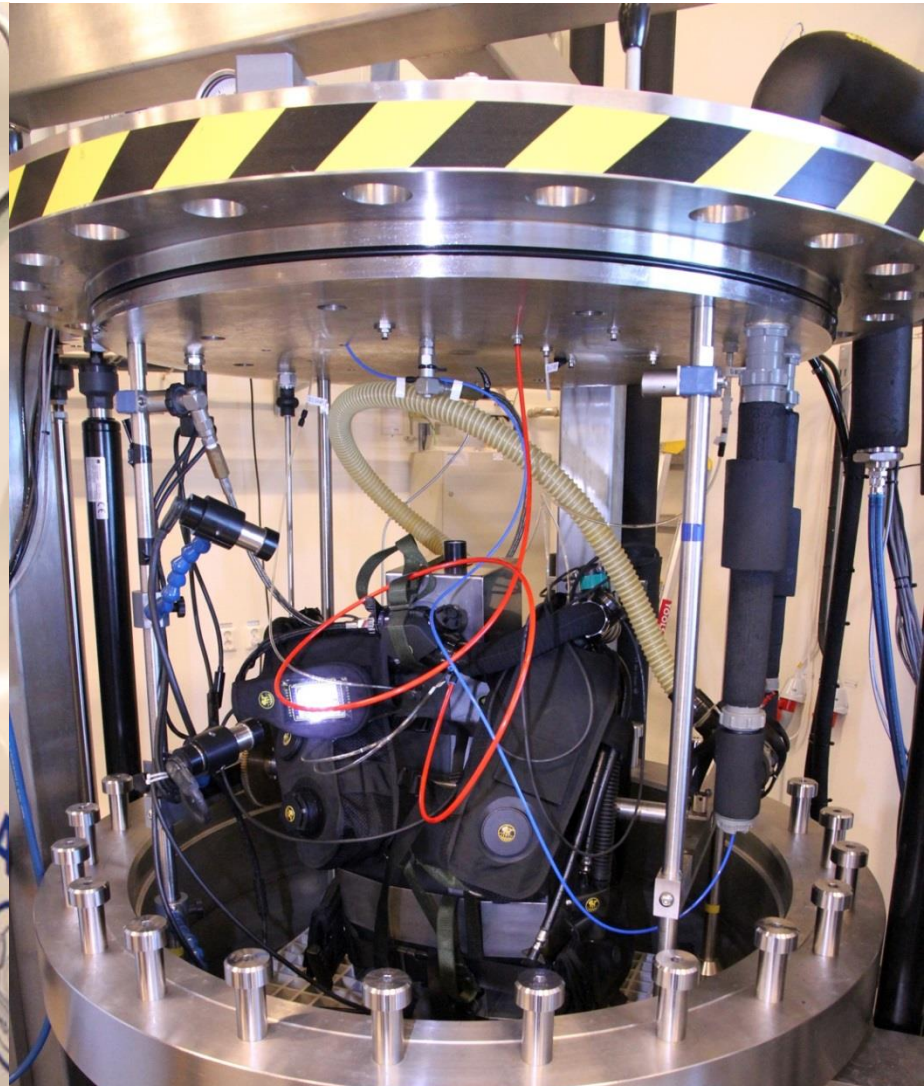
FM DNC - Karlskrona

Swedish Armed Forces Diving and Naval Medicine Centre

FM DNC

FM DNC

FM DNC



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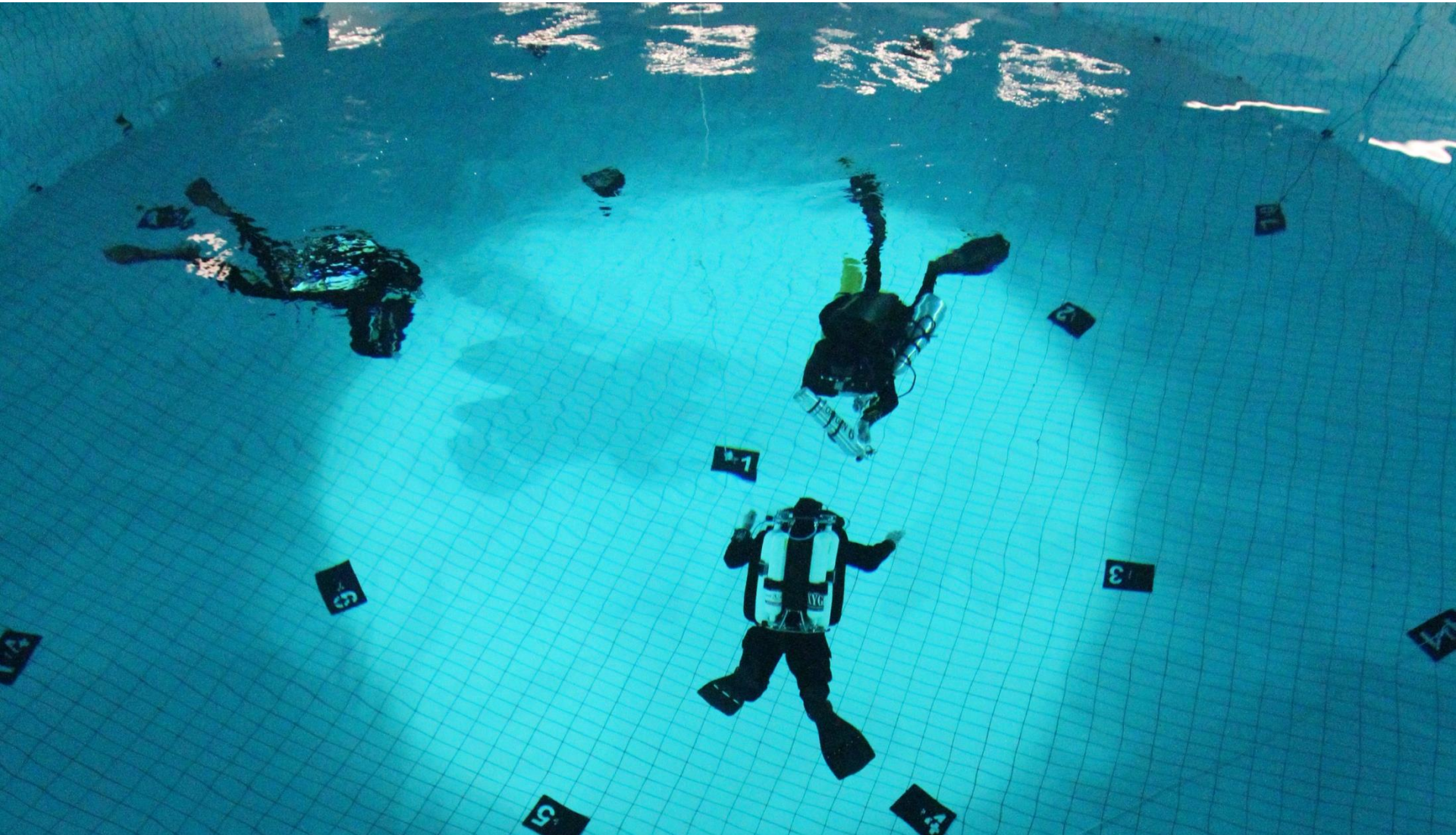

Present

Mine clearance rebreather - ISMIX

Present

Cold diving performance

Present

Cold diving performance

The New York Times
INTERNATIONAL EDITION | WEDNESDAY, APRIL 17, 2019

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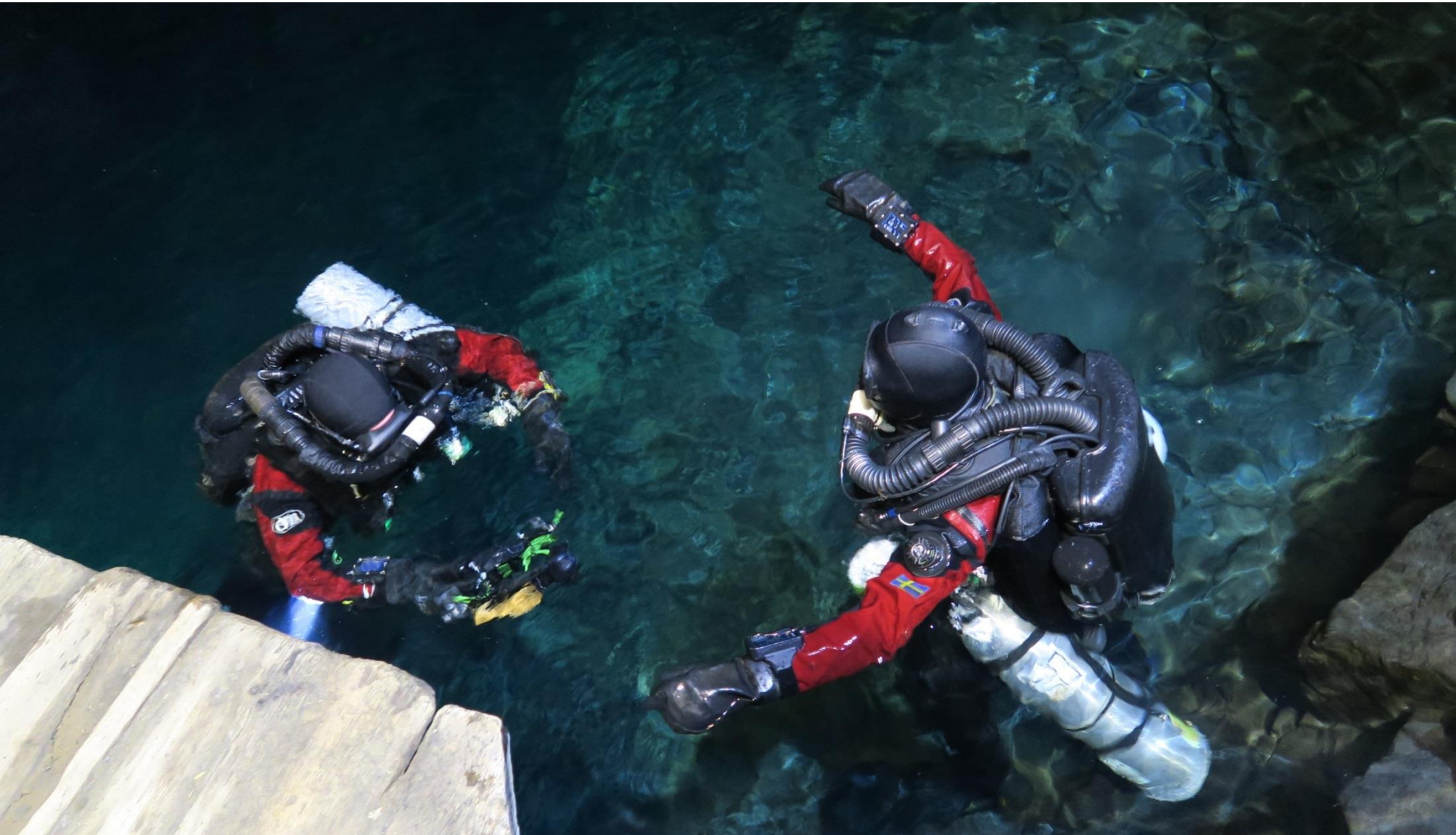
Present

Autonomous deep diving methods



Present

Composite gas cylinder behavior

Present

Soda lime performance

Diving and Hyperbaric Medicine Volume 49 No. 1 March 2019 48

Technical report

The performance of 'temperature stick' carbon dioxide absorbent monitors in diving rebreathers

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Key words
Hypercapnia; Monitoring; Technical diving; Soda lime; Equipment

Abstract
(Silvanius M, Mitchell SJ, Pollock NW, Frånberg O, Gennser M, Lindén J, Mesley P, Gant N. The performance of 'temperature stick' carbon dioxide absorbent monitors in diving rebreathers. Diving and Hyperbaric Medicine. 2019 March 31;49(1):48–56. doi: 10.28920/dhm49.1.48-56. PMID: ?????.)

Introduction: Diving rebreathers use canisters containing soda lime to remove carbon dioxide (CO_2) from expired gas. Soda lime has a finite ability to absorb CO_2. Temperature sticks monitor the exothermic reaction between CO_2 and soda lime to predict remaining absorptive capacity. We investigated the accuracy of these predictions in two rebreathers that utilise temperature sticks.

Methods: Inspiration and rEvo rebreathers filled with new soda lime were immersed in water at 19°C and operated on mechanical circuits whose ventilation and CO_2 addition parameters simulated dives involving either moderate exercise (6 MET) throughout (mod-ex), or 90 minutes of 6 MET exercise followed by 2 MET exercise (low-ex) until breakthrough (inspired PCO_2 [P_ICO_2] = 1 kPa). Simulated dives were conducted at surface pressure (sea-level) (low-ex: Inspiration n = 5, rEvo n = 5; mod-ex Inspiration n = 7, rEvo n = 5) and at 3–6 metres' sea water (msw) depth (mod-ex protocol only, Inspiration n = 8, rEvo n = 5).

Results: Operated at surface pressure, both rebreathers warned appropriately in 4 of 5 low-ex tests but failed to do so in the 12 mod-ex tests. At 3–6 msw depth, warnings preceded breakthrough in 11 of 13 mod-ex tests. The rEvo warned conservatively in all five tests (approximately 60 minutes prior). Inspiration warnings immediately preceded breakthrough in six of eight tests, but were marginally late in one test and 13 minutes late in another.

Conclusion: When operated at even shallow depth, temperature sticks provided timely warning of significant CO_2 breakthrough in the scenarios examined. They are much less accurate during simulated exercise at surface pressure.

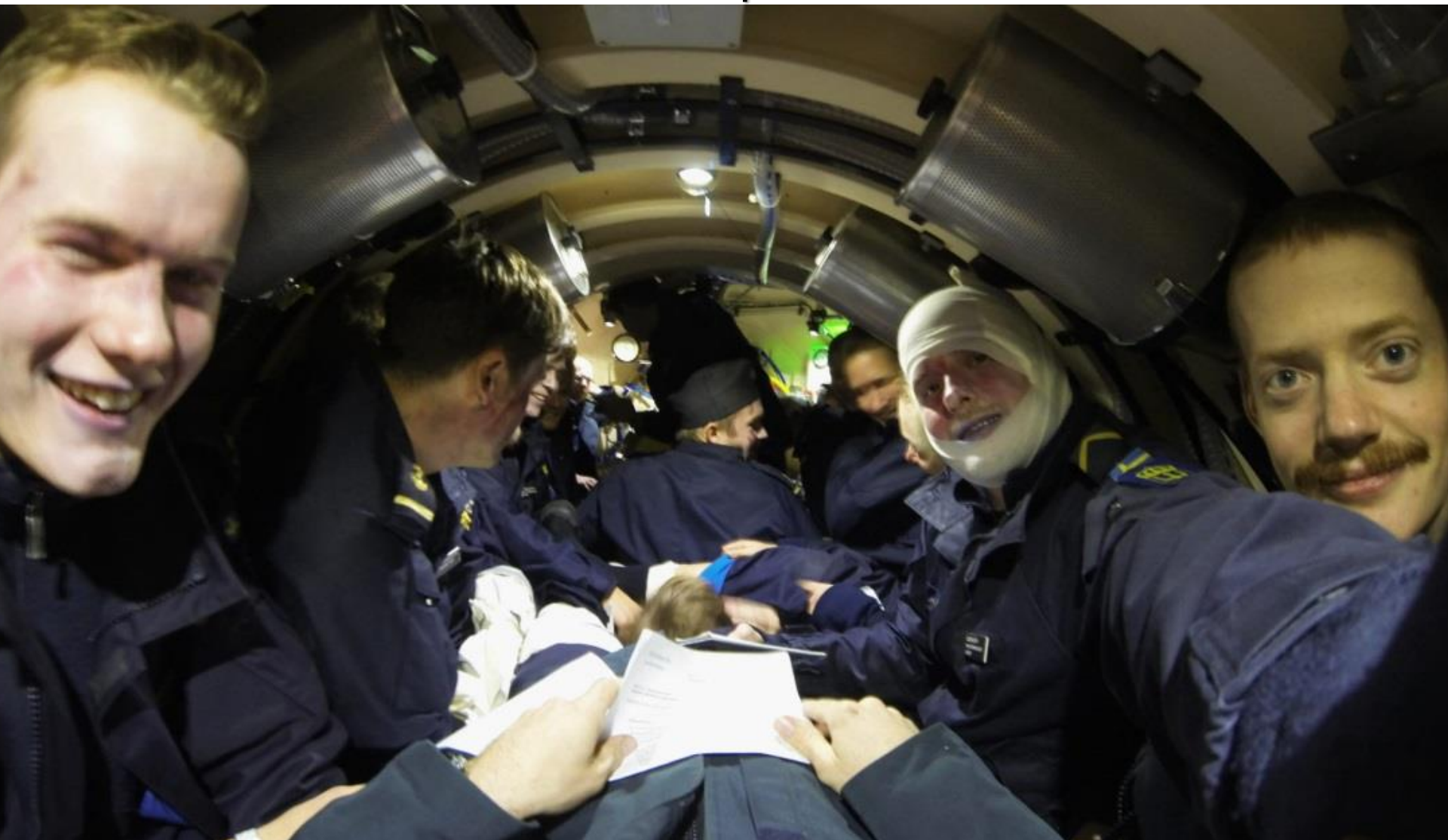
Introduction

A closed circuit rebreather is a type of underwater breathing apparatus that recycles expired gas through a carbon dioxide (CO_2) absorbent and incorporates a gas addition system designed to maintain both a safe inspired pressure of oxygen (P_IO_2) and an appropriate mix of diluent gases. They are popular with so-called 'technical divers' and scientific divers performing deep and/or long dives because the recycling of expired breath markedly reduces use of expensive gases such as helium, and maintenance of a constant optimal P_IO_2 increases decompression efficiency.[1]

There are several forms of CO_2 absorbent, but the most commonly used is soda lime; a granular compound containing calcium hydroxide, water and sodium hydroxide. This is packed in a canister (often referred to as a 'scrubber') through which the exhaled gas is passed. Soda lime has a finite capacity for absorbing CO_2 and, if this capacity is exceeded, CO_2 will 'break through' the scrubber and its re-

Present

Submarine rescue decompression tables <30msw



Present

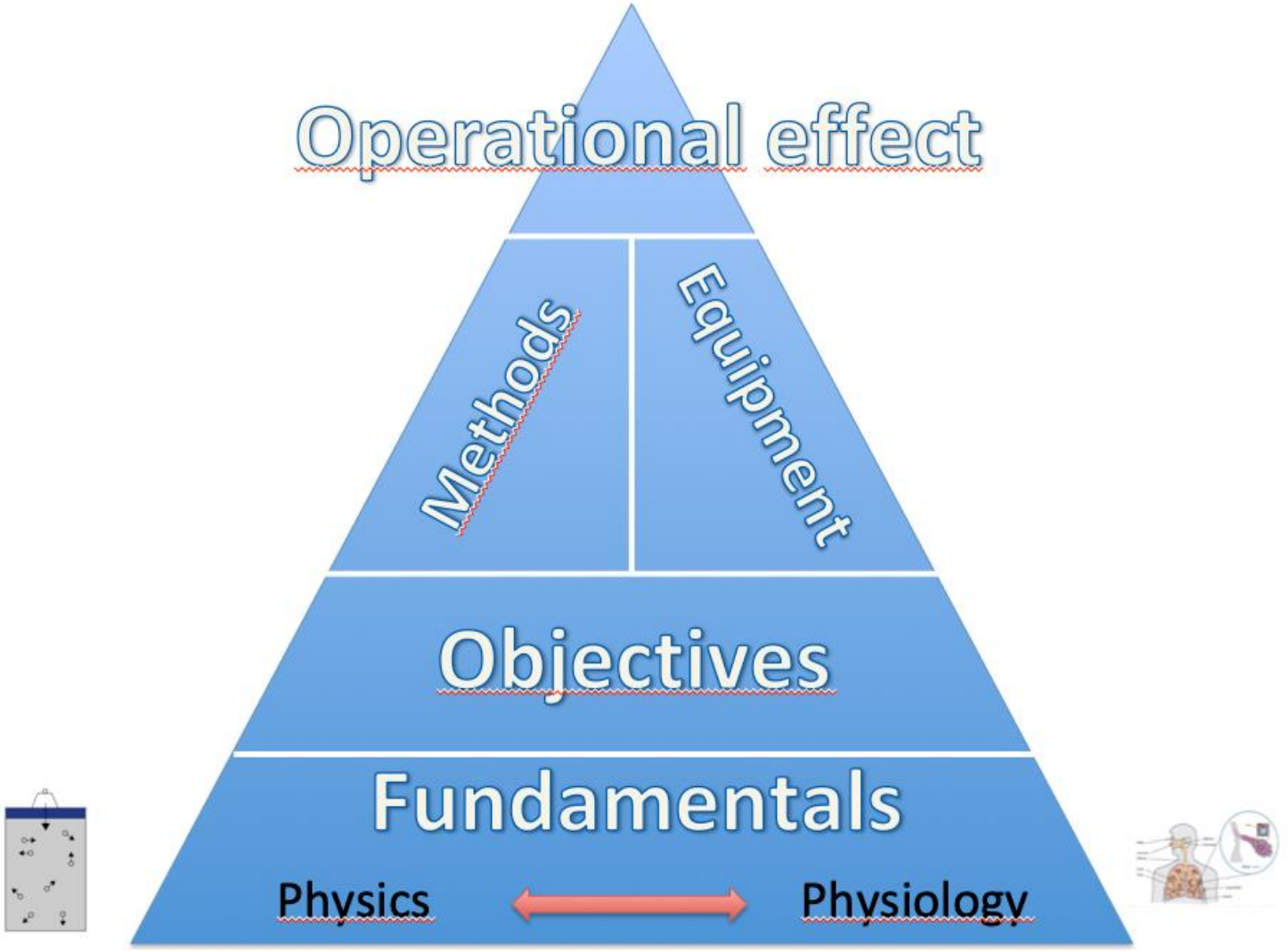
Hosting researchers, conferences, meetings and workshop

Present

National Underwater technological Centre

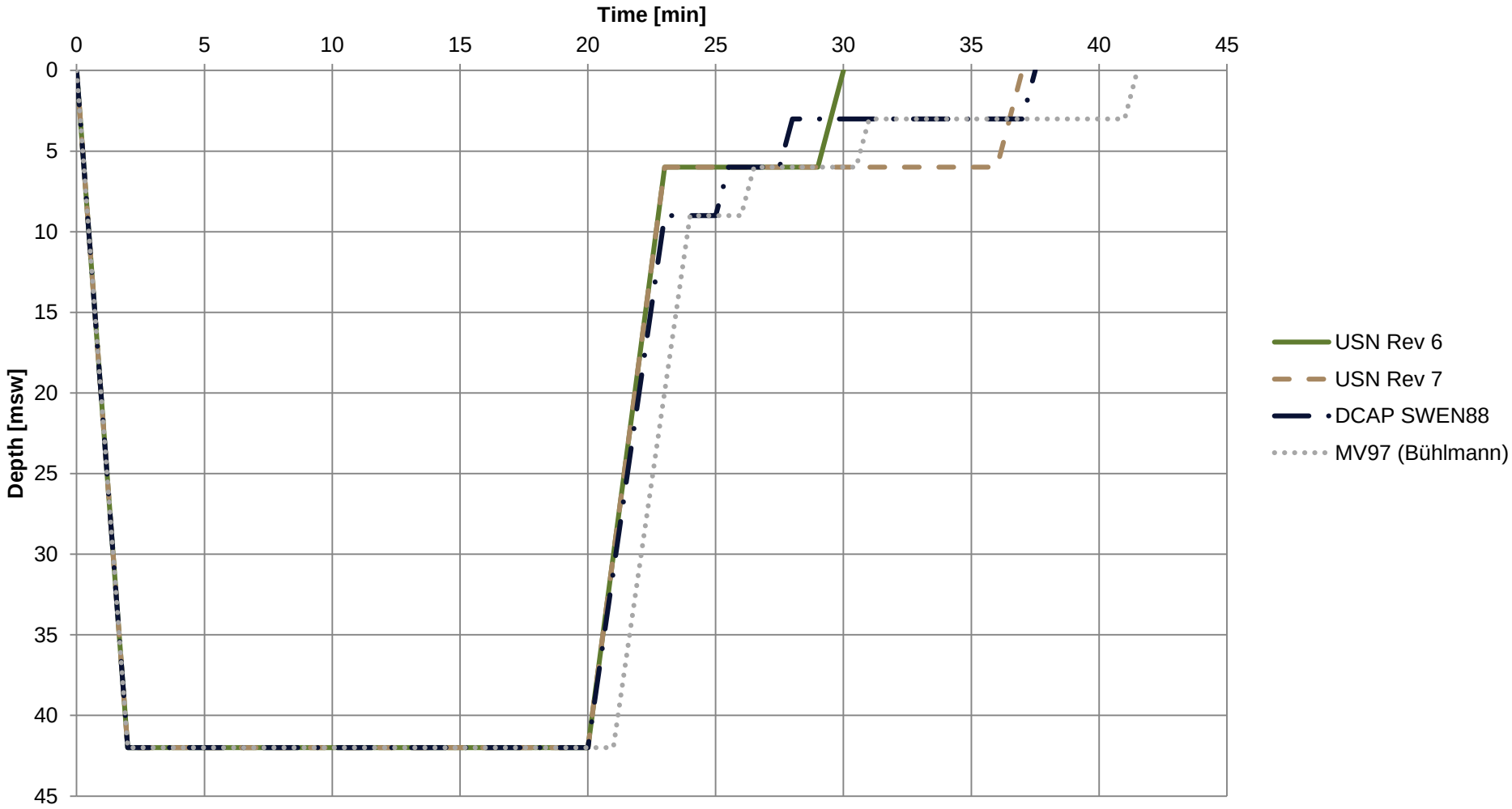
Future

Strategy



Future

Fundamentals – Physiology – Decompression



Future

Fundamentals – Physiology – Trimix tables

Dekompressionstabell för dykning med TRIMIX avsedd för OMD 10

21% Oxygen, 35% Helium, 44% Nitrogen i andningskretsen.

Total aktionstid (utan extern gastillförsel) för OMD 10 är c:a 80 minuter.

Expositionstider markerade med orange färg och fet text innebär längre total dyktid än apparatens totala akti

Nöddekompression med luft på öppet system är markerat med ljusgrön färg. Gasskifte till luft görs innan uppstigning påbörjas. Planerad dykning med luft som dekompressionsgas är förbjudet.

Tabellområde märkt med röd färg ligger utanför utprovat område. Planerad dykning inom detta område räknas som extrem exposition.

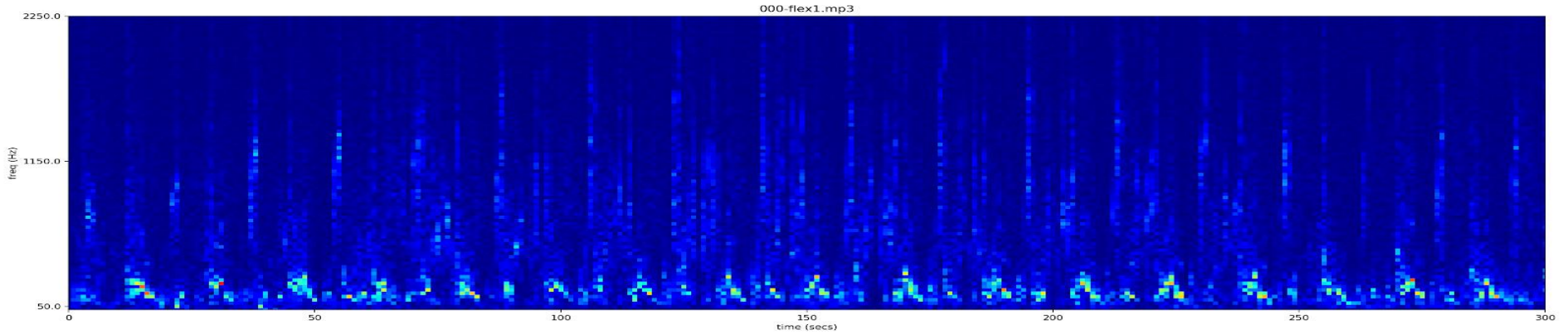
Expositions-tid	Uppstignings-tid till 1:a etapp (min:sek)	Dekomp-ressions-gas	Nedstigningshastighet max: 20 meter/minut Uppstigningshastighet: 9 meter/minut Etappdjup (m) Tid (min) på etappdjup 24	21	18	15	12	9	6	3	Total dekomp-ressions-tid (min:sek)	Total dyktid (vid max. exp.tid) (min)
42 meter												
Etappuppstigning												
10	4:20	Trimix								1	5:40	16
		Luft								1	5:40	16
15	4:00	Trimix							1	6	11:40	27
		Luft							1	5	10:40	26
20	3:40	Trimix						1	4	26	35:40	56
		Luft						1	3	19	27:40	48
25	3:20	Trimix					1	2	9	36	52:40	78
	3:40	Luft						3	7	29	43:40	69
30	3:20	**Trimix**					**2**	**6**	**20**	**48**	**80:40**	**111**
		Luft					2	5	14	33	58:40	89

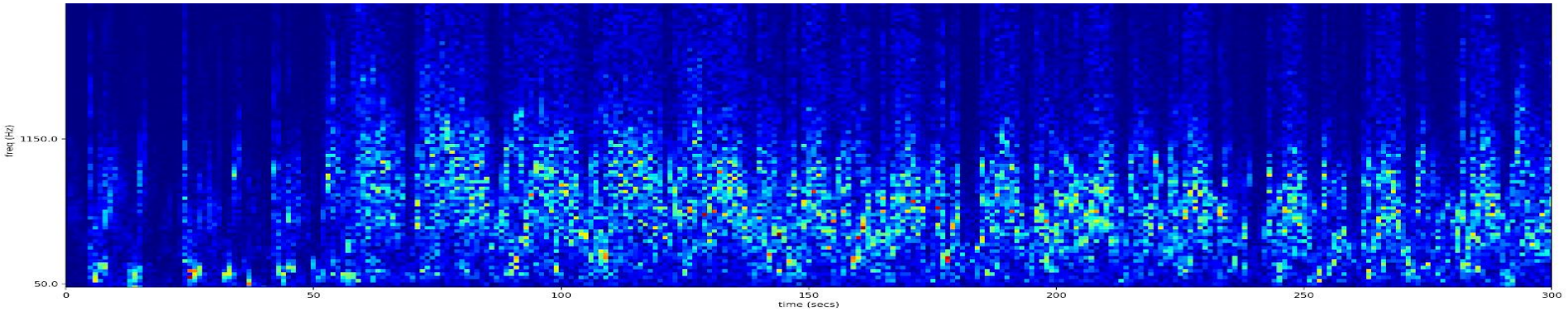
Future

Fundamentals – Physiology – Oxygen after dive

Future

Fundamentals/Equipment - Doppler AI



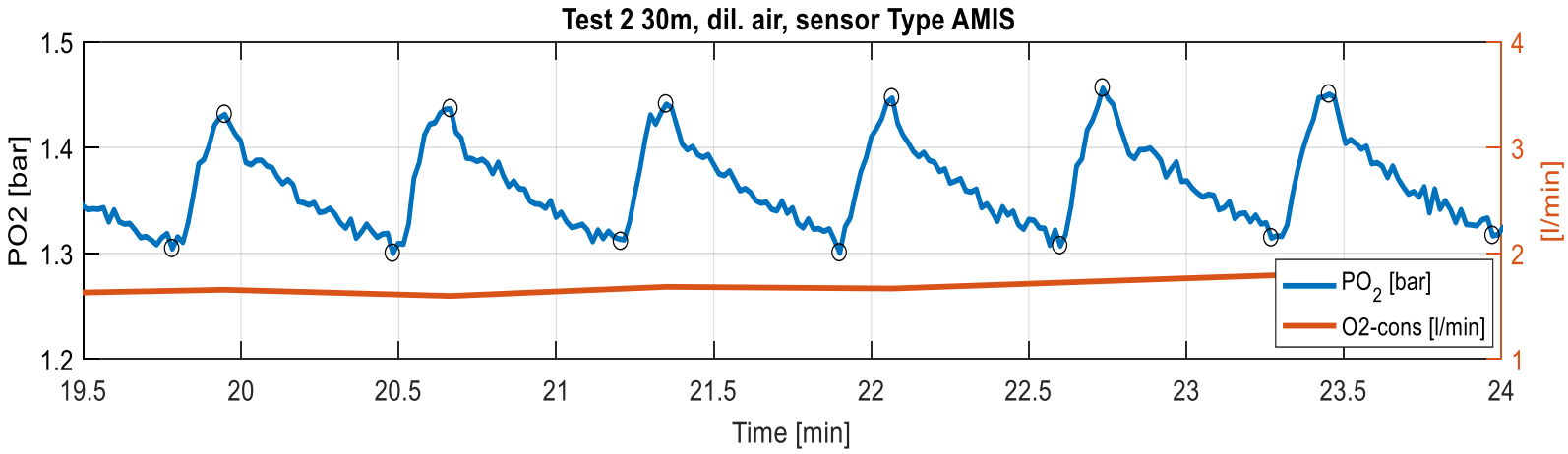


Future

Equipment - eISMIX

Future

Equipment – sensor algorithm



Summary