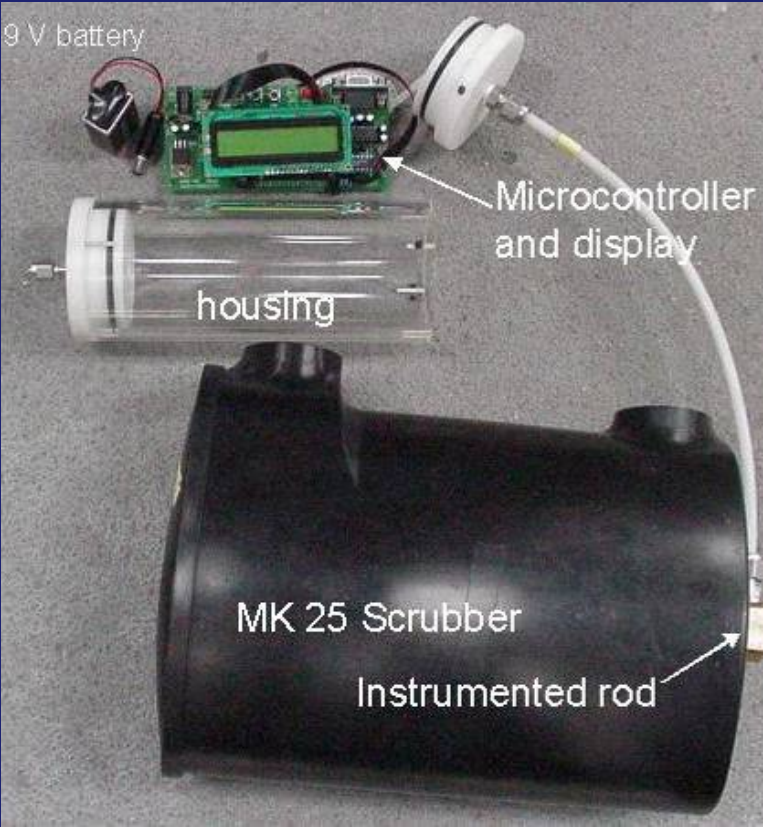




Introduction

Carbon dioxide (CO₂) is a by product of respiration and a potential hazard for divers. CO₂ canister tracking technology has recently become available within the recreational and technical diving community. Current designs involve tracking the time a canister has been used with known data on canister time limitations. Another method involves the use of a thermistor that is integrated into the canister itself to measure the exothermic reaction.¹ Some systems also integrate alarms that are tied to the measurements. Our aim was to evaluate comprehension and use of existing CO₂ tracking technology by recreational and technical divers.



Pictured to the left is an example of the thermistor based measurement equipment. Above are examples of the gauge readout that would be seen by the divers during operations.²

Method

Rebreather owners were asked to utilize REDCap (Nashville, TN <http://project-redcap.org/>), a web-based questionnaire software, to provide information on their current understanding of unit specifications and CO₂ events for their rebreather. The questionnaire was set up with conditional branching whereby follow-up questions would be asked when applicable.

All information collected was done in a way that removes the identity of the respondents for privacy protection. Duke and US Navy Experimental Diving Unit (NEDU) Institutional Review Board approval was obtained prior to data collection. Data was collected from December 16th, 2011 to January 31st, 2012.

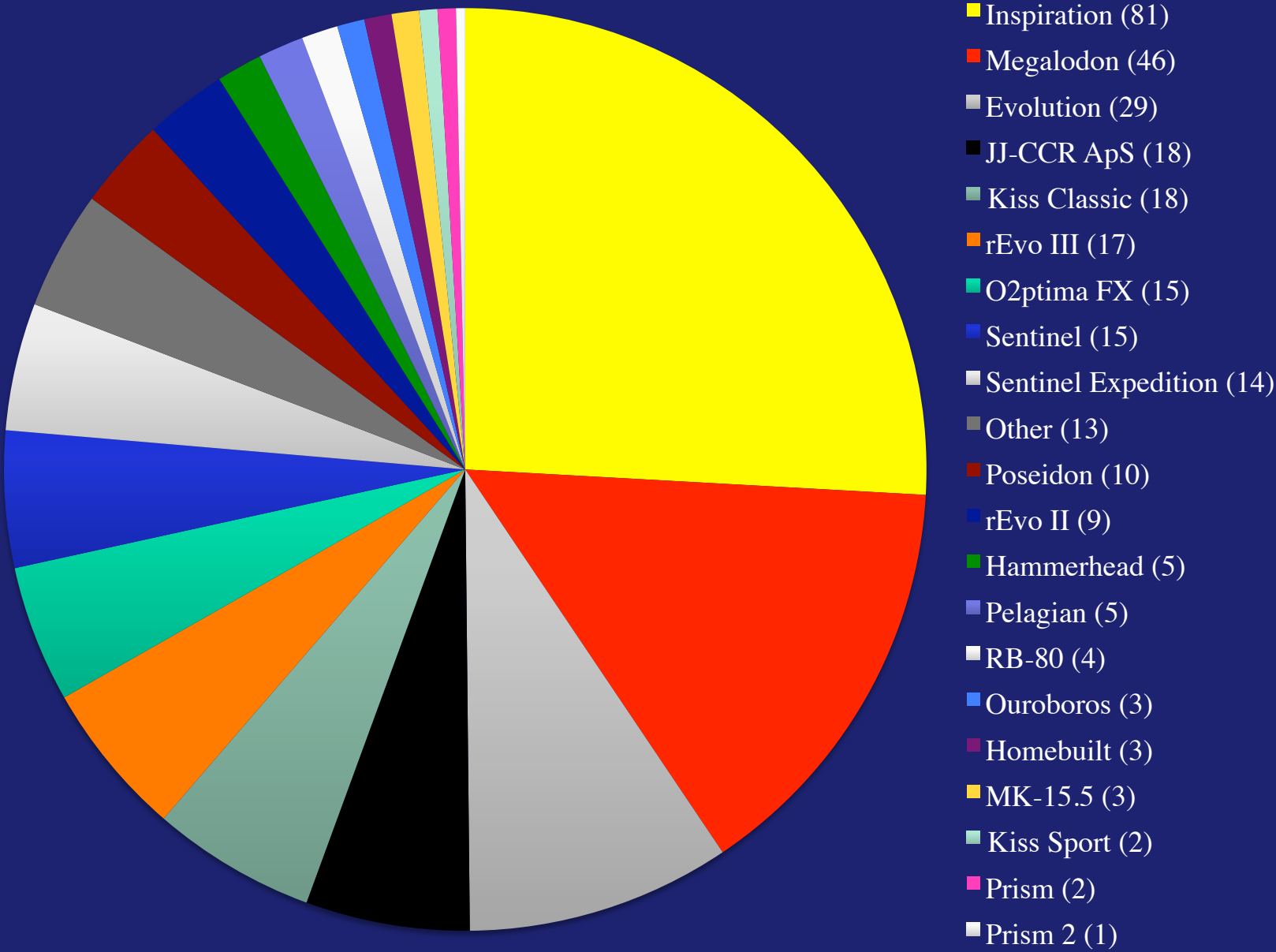
Results

Rebreather divers completed 505 survey responses with 328 of these considered ‘complete’. Results were obtained from divers with 20 different commercially available units and 13 units listed as "other". Divers owning multiple units were asked to answer using the unit they use most often.

	Yes	No	Blank
Does your unit have a timer designated to monitor canister duration?	88	229	6
Does your unit have a thermal monitor for canister duration?	120	198	5
Experienced symptoms of hypercapnia?	147	176	n/a



Symptoms of Hypercapnia									
Increased breathing rate	Shortness of breath, sensation of difficult breathing or suffocation (dyspnea)	Confusion or feeling of euphoria	Inability to concentrate	Increased sweating	Drowsiness	Headache	Loss of consciousness	Convulsions	
127	61	31	23	5	3	49	5	3	



	Knows	Doesn't know	Knows where to find	No Response
Do you know the recommended maximum operating depth (MOD) of the rebreather unit you dive most often?	243	31	44	5
Do you know the maximum recommended carbon dioxide (CO ₂) canister duration for your configuration?	263	9	49	2

Discussion

Most divers claim to know the MOD and the maximum CO₂ canister duration for their unit. Majority of rebreather owners included in this survey do not have a monitor for canister breakthrough available on their unit. The most often reported symptom of hypercapnia was an increased breathing rate (86.4%) however divers did not always report the need to bailout. This may be due to their awareness that ceasing hard work will often return CO₂ to normal levels.

Data from this survey has been utilized in formation of the Rebreather Forum 3 consensus statements.³

References

1. Warkander, DE. Temperature-based estimation of remaining absorptive capacity of a gas absorber. United States Patent Number US006618687B2. Sep 9, 2003 <http://www.google.com/patents/US6618687.pdf>
2. Warkander, DE. CO₂ Scrubber Technology: why, how and how long. Rebreather Forum 3. May 18-20, 2012 Orlando, Florida, USA
3. Rebreather Forum 3 Consensus Statements. June 12, 2012 <http://rubicon-foundation.org/News/rf3-consensus/>

Acknowledgements

The authors would like to thank Dan Warkander of the Navy Experimental Diving Unit for the MK 25 photos, Kevin Gurr of VR Technology for his assistance in this project.
DUHS IRB Pro#00034562