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POINT & CLICK ON BOLD LINKS

Equipment *in the news*

Lightmonkey

Back in the day, cave divers would buy a canoeing helmet and promptly snoopy loop their lights onto each side. And then helmets fell out of favour in certain quarters because it was perceived that the diver had rotten buoyancy. Enter stage left, Light Monkey. They understood that accidentally bashing your head whilst scootering in an overhead environment really doesn't make for a happy dive. Available in 'Monkey Brown', the helmet is an injection molded high density polyethylene (HDPE) suspended over an adjustable inner cradle. It has nine ventilation holes on the top and sides to release trapped air and has no foam lining that would make it overly buoyant, and comes complete with an adjustable chin strap and quick disconnect buckle. This comes in one size only, so won't fit everyone, so we recommend that you measure your head to ensure a good fit. **Lightmonkey.us**

D6i White

This Suunto instrument features an integrated tilt-compensated 3D digital compass and comes with an optional wireless air integration showing current cylinder pressure, remaining air time. There are four dive modes: Air, Nitrox, Freedive, Gauge. It has gas-switching capability and full continuous decompression algorithm omes with scratch-resistant sapphire crystal glass and is available with silicone-rubber or steel bracelet, or with black or white wrist strap. **Suunto.com**

Transpac

The new T3300 TransPac XT is designed like a backpack design with an integrated hip belt and ergonomic shoulder pads. Dual density foam pads provides lumbar support and snugly hugs the lower back and promises chafe free comfort around the shoulders. The weight is evenly balanced across the hips and back, when diving either with singles or doubles. Dive Rite also claims that the easy customization options of the TransPac XT at the shoulder and waist plate makes it fit any size diver, including children. Neutrally buoyant, the TransPac XT weighs less than 2.29kg (5lbs) and packs flat for travel. **Diverite.com**

F2

Travelling divers should have a look at this pair of fins. Not only is the F2 lightweight, it uses a shorter blade that packs easily as well. The blade is designed to increase efficiency on both the down stroke and the upstroke, supposedly with any type of kick and eases maneuverability in tight areas. The material is Monoprene and comes with adjustable stainless steel spring straps as standard. **Hollisgear.com**

LED 15

LED15 canister system combines the power of HID with the reliability, durability and efficiency of LED technology. The result is the concentrated beam preferred for exploration diving. The Lithium-ion Polymer battery is rechargeable; the LED15 burns at over 1,000 lumens of brightness for six hours. The single LED offers the advantage of a long 20,000-hour life and the 8 degree beam width is much tighter than multi-LED arrays. A 90 degree version is available where rear mounting a canister is necessary. **Hollisgear.com**

Gara

French divers quite like the Gara fin, so much so that they asked Cressi for a reinforced blade. Cressi's response has been to sensibly play the long game, and they've designed a future proof fin called the Gara Modular. This newly launched freediving fin has an interchangeable blade. Simply undo two clips and unscrew the blade and replace it with another. We believe that Cressi is looking to manufacturer up to three blades of differing strengths, thus giving end users more choice. It's hoped these blades will be available within the next 24 months. **www.cressi.com**

Poseidon Tech

The Tech is the world's first rebreather with a fully automatic bailout system, Poseidon writes. It features a redundant back-up rebreather with fully automatic switching—almost two rebreathers in one. In the event of a malfunction, the Poseidon Tech's safety system switches from the primary to secondary rebreather. With a secondary dive computer, no data is lost during the switch. The diver can then make manual additions to the system, or leave the system in automatic mode. **www.poseidon.com**

D7PRO ISS

Waterproof's D7PRO ISS Cordura drysuit is as equipped as its best-selling D7PRO ISS brethren, but enhanced with a full Cordura outer shell and new blue color accents. The D7PRO's all Cordura exterior offers unsurpassed durability and tear resistance and is an ideal choice for technical divers and divers who appreciate quality construction and performance. Available in standard sizes from S-2XL and 3XLT , the suit comes stock with replacement silicone seals, a H1 5/7mm hood and drybag. **Waterproof.eu**

Bonex Ecos

As the underwater scooter races around wrecks grow in popularity, another great use for scooters is found. Although Bonex Exploration Systems clearly didn't have that in mind when they produced Ecos. The mind was set for long explorations, and despite its compact demeanor, the driving time on this handsome puppy is 150 minutes in cruising mode. The total weight, including the battery, is 15kg. Performance contra the low weight is great. If you belong to the more impatient drivers, the scooter will last you circa 90 minutes. Operating depth down to 120 meter. **Bonex-systeme.de**

Antares Dry Glove System

A new improved Dry Glove System has left the drawing board at Si-Tech. The new ergonomically designed modular quick-change solution comes with oval rings with minimal volume. This gives the diver a slim, comfortable and ergonomic dry glove system. The design follows the arm, wrist and hand anatomy and is built for maximum comfort. **Si-Tech.se**

A view from Rebreather Forum 3

Improving Rebreather Safety

How can rebreather diving be made safer? That was the question at the core of the numerous presentations and discussions at Rebreather Forum 3 (RF3) held in Orlando, Florida, this May. Powered by the American Academy of Underwater Scientists (AAUS), PADI Inc., and Diver's Alert Network, the international conclave brought together just under 400 industry-insiders from the sport diving communities, scientific, media, military and various international government agencies diving communities along with other training agencies, manufacturers, instructor/trainers and divers who came to talk rebreathers, learn, share experiences, network, ogle the latest gear and hopefully help steer the community forward.

Text by Michael Menduno
Photos by Peter Symes (EXCEPT WHERE OTHERWISE CREDITED)

IN THE LOOP
RF3
REBREATHER FORUM 3

The last forum, Rebreather Forum 2.0, which I organized with rebreather builder Tracy Robinette, was held 16 years earlier in 1996, at a time when rebreathers were just being introduced to the sport diving market.
In his opening remarks, PADI CEO, Drew Richardson, proposed that the number one goal of RF3 was contributing to rebreather diving safety and reducing incidents.

Some controversy

The issue is of critical importance today when manufacturers like Poseidon Diving Systems Ltd. and Hollis Inc., in conjunction with PADI and other training agencies, are now actively promoting rebreathers for use by recreational divers, which is a source of some controversy.

Until recently, rebreather use was limited primarily to tech divers because of their complexity, operational requirements and cost.

The concern is that rebreathers may be too complex and time consuming for a typical open water diver who is still mastering their basic diving skills.

A matter of protocol

However, PADI has developed a simplified diving protocol using rebreathers designed specifically for recreational use, which it believes will prove efficacious.

Though no one knows the actual risks, there have been more than 200 reported rebreather fatalities worldwide since 1998, which have averaged approximately ten fatalities per year prior to 2005 and about 20 per year since. To put these numbers in perspective, on average there are about 100-120 scuba diving fatalities annually in the United States, Canada, United Kingdom and Europe combined,

"Men in Black" aka Jan Jørgensen (left) and X-ray Mag editor Peter Symes during CCR training in the Red Sea anno 2000

which represents the majority of the worldwide market. Given that there are millions of open-circuit divers compared to, at most, tens of thousands of rebreather divers, the fatality rate for rebreather diving is evidently much higher than its open-circuit counterpart, as industry-insiders are all too well aware.

Unacceptable record

During one of the opening sessions, Dr Andrew Fock, head of hyperbaric medicine at The Albert Hospital in Melbourne, Australia, asked for a show of hands from the audience: "How many people in this room believe that the current rebreather safety record is acceptable?"

No one raised a hand.

Concieved centuries ago

First conceived in the 17th century by Giovanni Borelli, closed-circuit rebreathers (CCR) remained an elusive invention until the advent of galvanic oxygen sensors in the early 1960s made their construction possible. Like simple, non-electronic oxygen rebreathers before them, the technology was primarily limited to military divers until the late 1980s when pioneers like Dr Bill Stone, Olivier Isler, Stuart Clough and Rob Palmer began experimenting with rebreathers for cave exploration, just as technical diving was emerging.

Though the early tech community immediately seized upon their potential for extending bottom times and optimizing decompression, it took until the late 1990s for the first production units like the Cis-Lunar Mk-IV, Ambient Pressure Diving's Inspiration and the KISS Classic to become available.

Fastest growing segment

Today, rebreather diving represents one of the fastest growing areas of sport diving. Poseidon reported at the Forum that they sold more of their recreational Mk-VI rebreathers in the last four and half months than in the prior two and half years, and PADI is certifying new recreational rebreather instructors to meet the demand. In certain countries, such as the United Kingdom, which is regarded as rebreather "ground zero", it's considered "normal" that everyone on a dive boat is diving a rebreather.

Industry insiders estimate there are as many as 10,000 to 15,000 active rebreather divers worldwide, and there are more than a dozen rebreather manufacturers.

At one of the forum sessions, the three oldest technical training agencies, ANDI, IANTD and TDI,

How can rebreather diving be made safer?

Associate Professor Simon Mitchell gives a presentation on CCR physiology

380 delegates from 26 different countries attended RF3.

Giovanni Alfonso Borelli (28 January 1608, Naples - 31 December 1679, Rome) was a Renaissance Italian physiologist, biomechanist, physicist, and mathematician. He contributed to the modern principle of scientific investigation by continuing Galileo's custom of testing hypotheses against observation. Trained in mathematics, Borelli also made extensive studies of Jupiter's moons, the mechanics of animal locomotion and, in microscopy, of the constituents of blood. He also used microscopy to investigate the stomatal movement of plants, and undertook studies in medicine and geology.

Borelli is also considered to be the first man to consider a self-contained underwater breathing apparatus along with his early submarine design. The exhaled gas was cooled by sea water after passing through copper tubing. The helmet was brass with a glass window and 0.6 m (2 ft) in diameter. The apparatus was never likely to be used or tested.

— EXCERPTS FROM WIKIPEDIA

which have been responsible for the majority rebreather training to date, estimated that collectively they issued 30,000 basic, intermediate and advanced rebreather certifications from 1990-2011, and are currently trending at about 2,500-3,000 certs a year. (Data from the British Sub-Aqua Club, PSA International, and Rebreather Association of International Divers was not included).

These numbers are likely to grow significantly as PADI recreational rebreather courses proliferate.

Though the number of users is still small, rebreather technology has greatly expanded tech divers' underwater envelope, and has also been a boon to photographers/videographers as well as the early adopters among scientific and recreational divers as evidenced by the community's sessions chaired by explorer and instructor trainer Martin Robson.

Poseidon reported at RF3 that they sold more of their recreational Mk-VI rebreathers in the last four and half months, than in the prior two and half years

Pushing the envelope (again)

Dives that would be logistically difficult or even impossible on open-circuit are routinely done with rebreathers, and some explorers like Robson, Richard Harris and others are now pushing limits of human physiology. During a Friday afternoon session, Harris detailed his team's exploration dives to 207m (680-feet) at the Pearse River Resurgence (caves) in the South Island of New Zealand, where divers are hitting up against the limits of "respiratory sufficiency" (and arguably surface-based diving).

Industry insiders estimate there as many as 10,000 to 15,000 active rebreather divers worldwide

However, as David Conlin, Chief of Submerged Resources Center for the National Park Service, explained to the assembly, "The real value of rebreathers is not deep diving at all, but staying longer at 21-30m (70-100 feet). You can work at those depths nearly all day long when the conditions are good." Conlin reported that rebreathers have increased Park Service divers productivity by nearly 40 percent. "We gain nearly one day for every three days we're in the field."

Killing them softly

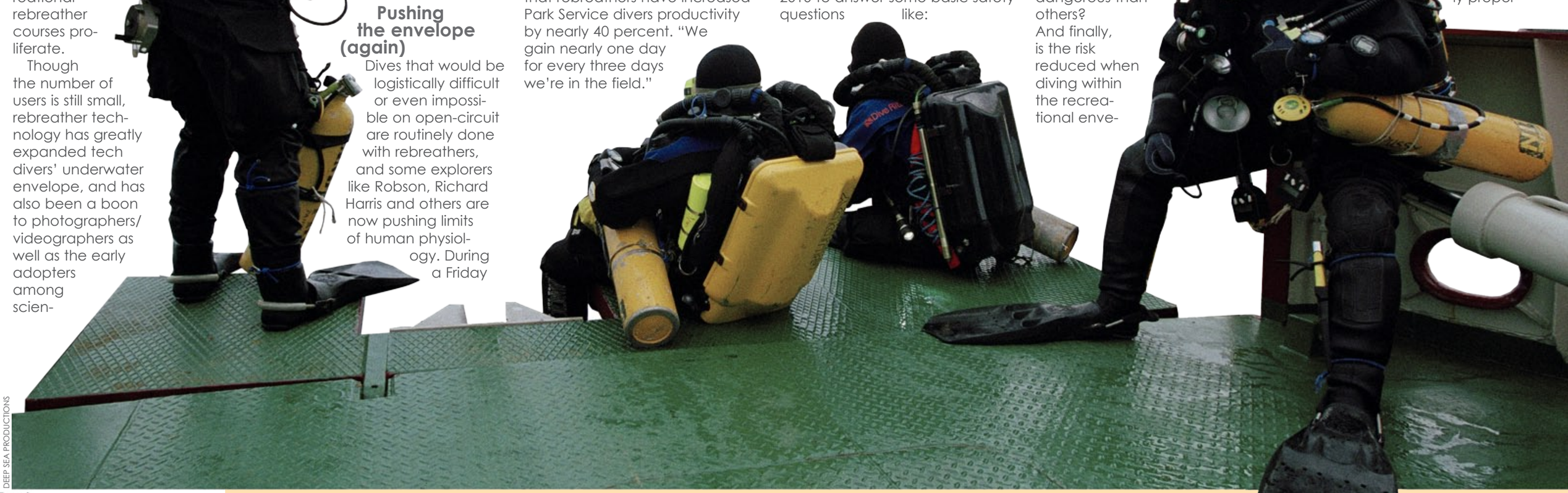
Fock, who himself is a very accomplished rebreather diver, took the stage on Saturday morning with an important and sobering presentation on the risks of rebreather diving, titled, *Killing Them Softly*. One of the problems in the industry is the lack of an accident reporting system that records and details the cause of diver fatalities and near misses, in order to inform and improve diver safety. In many cases, information about specific fatalities is sequestered for fear of litigation. As a result, existing accident data is incomplete, and in many cases, inaccurate.

Fock analyzed available data from multiple sources from 1998-2010 to answer some basic safety questions like:

... there was no difference in fatality rates among manual or electronic units, or specific brands of rebreathers; accidents were roughly proportional to market share

How dangerous is rebreather diving? What causes fatalities? Are manual units (that depend on the diver to manually add oxygen)—like the KISS Classic, which represent about 15 percent of the installed base of rebreathers—safer to dive than their electronic counterparts? Are there any specific brands of rebreathers more dangerous than others? And finally, is the risk reduced when diving within the recreational envelope (i.e. no-stop diving to 40m or 130ft)?

With the caveat that they are "best guess numbers", Fock concluded that rebreather diving is probably 5-10 times as risky as open circuit scuba diving, accounting for about 4-5 deaths per 100,000 dives, compared to approximately 0.4 to 0.5 deaths per 100,000 dives for open-circuit scuba. This makes rebreather diving more risky than sky diving at 0.99 per 100,000 jumps, but far less risky than base-jumping at 43 deaths per 100,000. He found that there was no difference in fatality rates among manual or electronic units, or specific brands of rebreathers; accidents were roughly proportional to market share



DEEP SEA PRODUCTIONS

Jeff Bozanic (left) in debate with Dr Siman Mitchell during the concluding session

Rebreather

tional to market share. Fock also pointed out that while the data suggests that deeper dives carry greater risks, a large number of rebreather fatalities occur in shallow depths within the recreational envelope.

"Pilot error"

As far as the causes or "triggers" that precipitated accidents, Fock concluded that the source of most problems was the human-machine interface, or so-called "pilot error", involving assembly and pre-dive preparation, maintenance, training and high risk behaviors like ignoring checklists, carrying insufficient bailout and diving beyond one's limits. "The question," posed Fock, "is whether the risk can best be mitigated by training [reinforced by dive culture] or engineering out potential problems or both."

Creating a safety culture

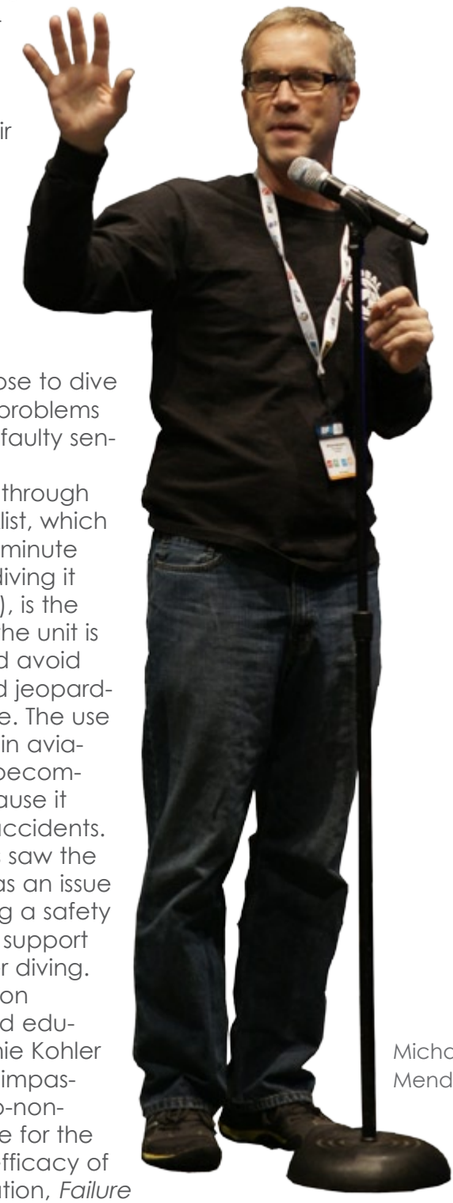
Though veteran explorers and educators Jill Heinerth and Terrence Tysell chaired an open-discussion session on training, enabling Forum participants to present views on a host of training related topics, the majority of the discussion on improving safety centered around diving culture—what happens after training.

Currently, one of the biggest safety issues surrounding rebreathers is the fact that divers become complacent and don't rigorously adhere to a pre-dive checklist in assembling and preparing their unit for diving as they (presumably) learned in class, and also neglect required post-dive maintenance. (Some experienced rebreather divers don't follow checklists either.) Even worse, some divers choose to dive knowing that there are problems with their unit such as a faulty sensor or small leaks.

Methodically working through your rebreather's checklist, which typically includes a five-minute pre-breathe (and only diving it if everything checks out), is the best way to insure that the unit is functioning properly and avoid any problems that could jeopardize safety during the dive. The use of checklists is standard in aviation and is increasingly becoming so in medicine, because it reduces accidents. Presenters saw the problem as an issue of creating a safety culture to support rebreather diving.

"The real value of rebreathers is not deep diving at all, but staying longer at 21-30m (70-100 feet.) You can work at those depths nearly all day long when the conditions are good."

Expedition leader and educator Richie Kohler made an impassioned, no-nonsense case for the use and efficacy of checklists in his presentation, *Failure Is NOT an option: The importance of checklists.* During the presentation, Kohler put up a picture of eight close friends and mentors including



Michael Menduno

his rebreather instructor, who lost their lives as a result of pilot error. "They were not fools," explained Kohler, "but each of them made foolish mistakes and died as a result." Checklists are designed to prevent such mistakes from occurring.

In another session, Heinerth presented her "Five Golden Rules" for rebreather diving which included: 1) be properly trained and current for the dive you are about to conduct; 2) follow your checklist; 3) pre-breathe your unit; 4) make the decision to dive (responsibly); and 5) be prepared to abort the dive safely (with sufficient bailout gas!). Heinerth told a story of being on a dive boat with five rebreather veterans. During her pre-breathe, she detected a small problem with her rebreather and told the assembly she would be sitting out the dive, only to be pressured by the others divers to make the dive anyway. "It's only a minor problem," some opined, "You can still fly the unit manually." To her credit, Heinerth didn't back down. How do we, as a community, encourage divers to do checklists and support their adoption within the culture?

"Industry leaders need to become role models," offered Heinerth. "We need to make it cool to do checklists." Heinerth along with industry pioneers Dr Richard Pyle, Database Coordinator for Natural Sciences at Bishop Museum, Kevin Gurr, CEO of VR Technology, and others are now spearheading an effort to create a set of best practices for rebreather diving dubbed, *Blueprint For Survival 3.0*. This refers to the original set of ten safety principles for cave diving developed by legendary cave explorer Sheck Exley in his monograph, *Basic cave diving: A blueprint for survival*. The early tech community created a similar set consensus-standards for open-circuit mix diving, *Blueprint for Survival 2.0*, which was published in the now defunct *aquaCORPS Journal*. Watch this space.

The question is whether the risk can best be mitigated by training [reinforced by dive culture] or engineering out potential problems or both

Jill Heinerth presenting her "Five Golden Rules" for rebreather diving

Engineering the CCR blues away

In addition to training and creating a culture that reinforces safe diving practices, experts agree that a number of safety issues might be resolved through better engineering. Indeed, this is the basis behind PADI's so-called "Type R" rebreathers that are suitable for recreational divers. For example, a Type R rebreather will turn itself on if the user forgets and jumps in the water, and it won't operate without the scrubber canister correctly in place or if the cylinders are turned off.

What became clear at the Forum, however, is that better engineering solutions are needed for one of the most fundamental aspects of rebreathers: knowing precisely the composition of the breathing gas in the loop at any point in the dive. Unlike open-circuit, of course, where the fraction of gas is constant and known with certainty, the gas mix in a diver's breathing loop dynamically changes with every breath and gas addition.

"We need to make it cool to do checklists."

Ten to 15 years from now

Ten years from now, or 15, we will likely look back at our current technology and regard it as primitive, or what explorer and engineer Dr Bill Stone, CEO of Stone Aerospace, refers to as "test pilot era" technology. "You actually dived those units without knowing exactly what you were breathing? OMG!" It'll be like us looking back at early cave divers using J-values (reserve) and empty Clorox bottles for buoyancy, and going, "***Really?***"

Bruce Partridge, CEO of Shearwater Electronics, summed up the current state of the art in his presentation on information systems this way, "Divers must interpret the readouts from three roaming O_2 sensors, which are known to be unreliable. They dive with no CO_2 gauge, and they don't have good data on the risks or what is most likely to go wrong."

The trouble with O_2 sensors

Most experts agree that current O_2 sensing systems are the weakest links on a rebreather and also the most critical. If the PO_2 in the loop is too low, the diver will suffer hypoxia and go unconscious and drown; too high and the diver risks hyperoxia, convulsions and drowning.

Explorer and engineer Dr Bill Stone, CEO of Stone Aerospace

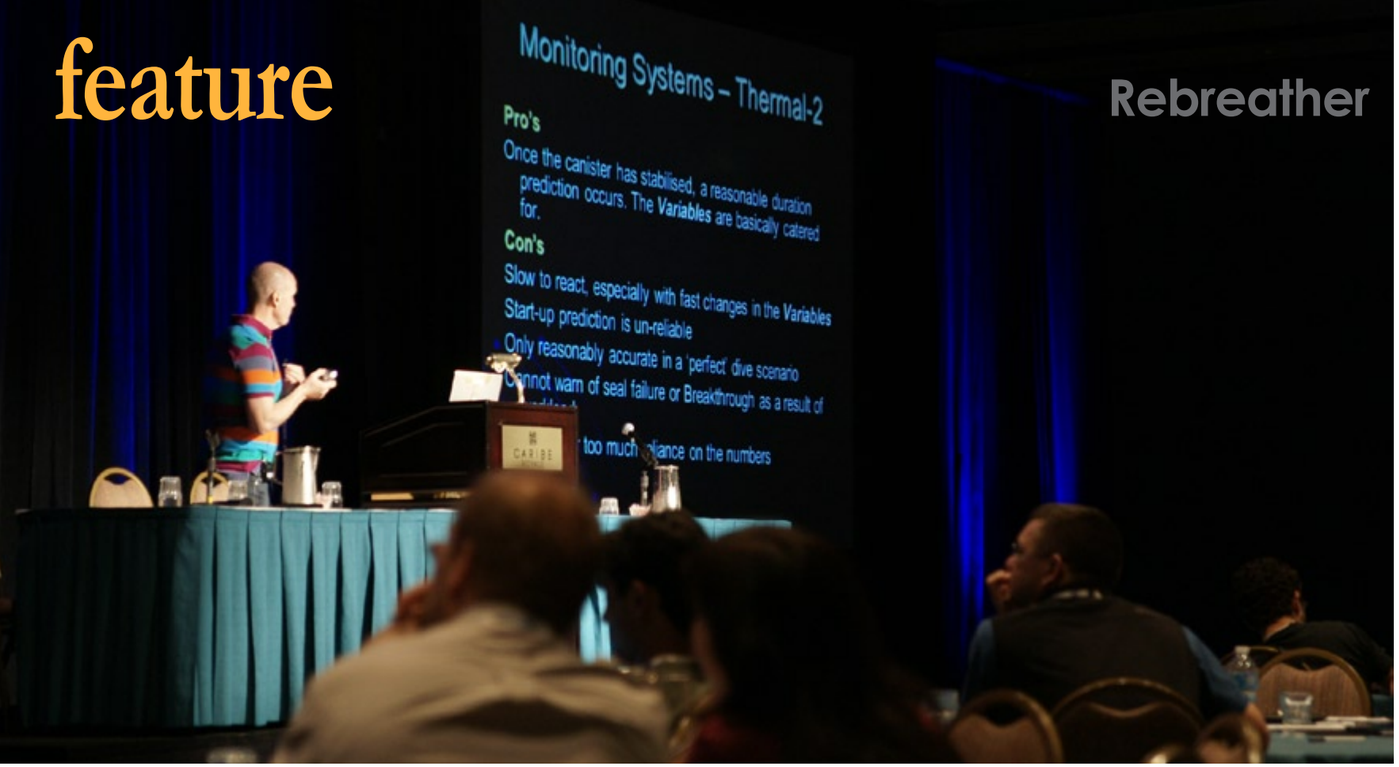
Limits

But what most divers might not appreciate are the limitations of current O_2 sensing systems on the market, which was made clear in a pair of presentations by biomedical instrumentation engineer Dr Arne Sieber, CEO of Seabear Diving Technology who built his own rebreather, and Nigel Jones, principal at RMB Consulting who works with Stone Aerospace.

Sensors were not designed with diving in mind

Sieber began by explaining that the galvanic O_2 sensors made for the biomedical industry were never designed to be used in diving and are, in fact, being used outside manufacturer's specs. To wit: sensors are meant to be calibrated under the same conditions that they will be used for in measurement, in the same measurement range and temperature. That's not how it's done in diving.

"Divers do all the wrong things," explained Sieber. "We calibrate the sensors at 0.2 bar (air) and 1.0 bar (O_2) at ambient pressure and temperature, and then use the sensors at up to 1.6 bar at much



Kevin Gurr, CEO of VR Technology Ltd. went over the challenges with developing CO_2 sensing and how the issue could be solved thanks to recent advances in technology

hotter temperatures." Sieber said that this leads to increased sensor errors as well as a decreased lifespan.

Sensors can fail high or low as a result of the gradual consumption of their reactive material and aging and also fall out of calibration. In addition, they commonly fail from condensation on the sensor. Worse is that "transient failures" from a loose electrical connection, or more commonly condensation, causes the sensor to generate erroneous data and then go back to working correctly when the condition abates. Jones believes that these "transient failures" are insidious and likely the cause or trigger of many unexplained rebreather diver fatalities.

Voting logic

Because of the known unreliability of these sensors, early designers like Walter Stark in the late 60's who invented the "Electrolung" built the first closed-circuit rebreathers with three O_2 sensors and a voting logic algorithm—the computer averages the readings from the two sensors whose readings are closest and uses that average for its O_2 calculations.

Their idea was that the redundancy of three voting sensors would greatly reduce the risk of sensor failure, and the concept stuck. Today, virtually all rebreathers, except the Poseidon, use this 50-year-old sensing technology. The problem, explained Jones, is that it is simply not as reliable as once thought.

Reducing the benefits

First, Jones showed using probability theory that the voting logic algorithm itself actually reduces the benefits of redundancy. For example, instead of having a system that is "hundreds" of times more reliable (e.g. with pure triple redundancy), a voting logic system can reduce the improvement to single digits.

Questionable assumption

Second, voting logic is based on the assumption that sensors fail independently i.e. the failure of one sensor does not change the likelihood that others will fail, too. Unfortunately, that is ***not*** the case with the O_2 sensors in a rebreather. The sensors are dependent because they share a common history; they may have come from the same manufacturers lot, they experience similar use, they share a common environment, suffer common abuse and use shared measurement and calibration gas. The lack of independence greatly decreases the reliability. "Having three sensors is barely better than one in some circumstances," emphasized Jones.

Erosion of risk reduction

Third, risk reduction is eroded even further, by the fact that there are more than two outcomes to the system i.e. heads: a correct reading, or

tails: an incorrect reading. The third outcome is the case when the diver doesn't know if the reading is correct or incorrect, which Jones equated to having the coin land on its edge.

Case story

He offered a real-world example reported by Rich Pyle where during a dive, his PO_2 sensors read .4, 1.0 and 1.3 and asked the audience to make the call, "What is the correct PO_2?" (The computer's voting logic would average the 1.0 and 1.3 reading and call it 1.15).

Leon Scamahorn, CEO of Inner Space Systems manufacturers of the Megalodon and Pathfinders rebreather

Unfortunately, the majority of the audience got it wrong! The correct answer was 0.4; the system had experienced a double sensor failure. Fortunately, Pyle got it right. If he had ascended at that point in the dive thinking his PO_2 was 1.15, he would have risked hypoxia and possible drowning.

Calculations under duress

An animated discussion ensued prompted by Leon Scamahorn, CEO of Inner Space Systems and manfacturer of the Megalodon and Pathfinder rebreathers, who pointed out that "Meg" users could go the "millivolt screen" on their handset, which shows actually sensor voltage (a linear function of $_PO_2$) and with some simple math determine that the low sensor was correct. This assumes of course that the diver was alerted to the problem in time. [Scamahorn's arguments, however, did not address the limitations of voting logic systems].

I'm sure Pyle, who has thousands of hours on his rebreather, wouldn't have a problem with Scamahorn's procedure (Pyle was tipped off to the faulty sensors by the lack of voltage fluctuations). But I couldn't help wondering if I'd have the calm presence of mind do "millivolt math" at 100 meters with the stress of a possible alarm and knowing one or more of my sensors were crapping out. Definitely a test pilot-esque notion! Couldn't a computer do this better than me?

Probability theory demonstrated that the voting logic algorithm itself actually reduces the benefits of redundancy.

Active validation

Both Sieber and Jones urged the industry to develop and adopt "active validation" type systems, such as used in the Poseidon MK-VI, which calibrates and tests the validity of the oxygen sensors (the MK-VI uses two sensors) throughout the dive using onboard diluent and oxygen. Sieber added that solid-state sensors, which are currently in prototype form, also hold promise for the future.

However, several rebreather builders I spoke to disagreed with Sieber and Jones' assessment and said that they overstated the O_2 sensing problem given improvements in sensor manufacturing, testing and voting logic software. As one manufacturer said, "There's more than one way to skin the cat."

Nevertheless, in its consensus recommendations, the Forum strongly endorsed industry initiatives to improve oxygen measurement technologies and advocated consideration for new approaches like "active validation" and alternatives to galvanic fuel cells.

$ppCO_2$: The dark matter of rebreather diving

Divers face similar sensing problems with respect to pCO_2, which has been dubbed the "dark matter of rebreather diving". High $ppCO_2$'s (0.03 bar and above) can cause hyperventilation,

Dr Richard Vann, Duke University and DAN, was a key driving force behind Rebreather Forum 3

confusion, mental impairment, unconsciousness and death, may lower CNS O_2 toxicity thresholds and is believed to be a factor in unexplained rebreather fatalities, hence the moniker "dark matter". Worse, the diver may not be aware of the problem before a full onset of symptoms occurs.

Searching for 25 years

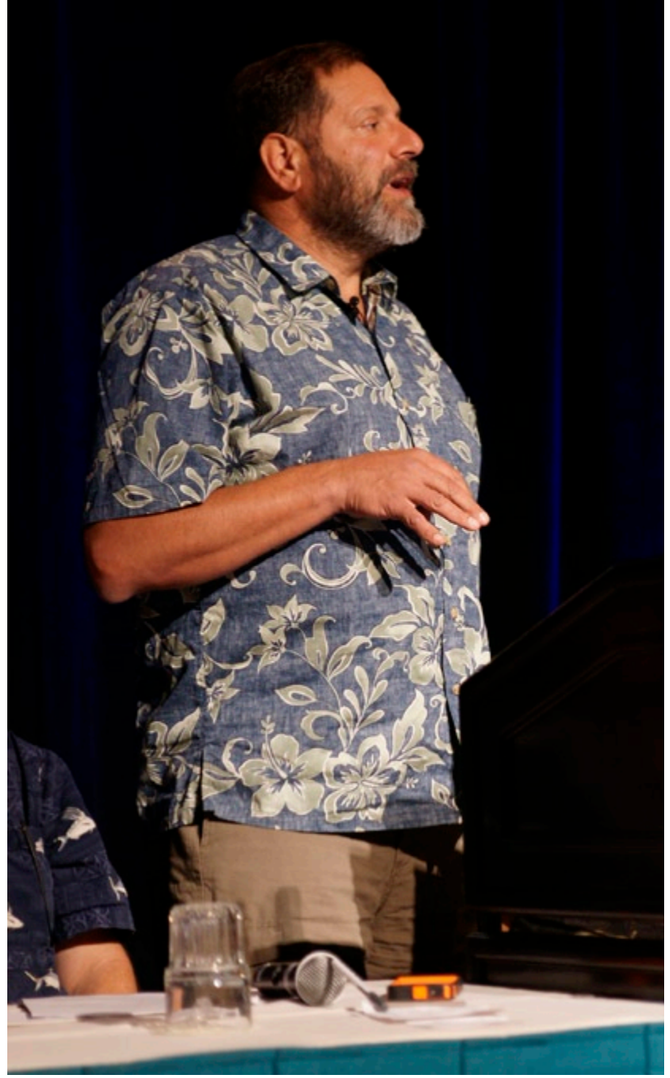
According to Dr John Clarke, Scientific Director of the U.S. Navy Experimental Diving Unit (NEDU), the Navy has been searching for solutions to problem of CO_2 sensing for more than 25 years. The need for CO_2 sensing was also identified in the findings of Rebreather Forum 2.0.

Divers have two information needs: first, to monitor the duration of the scrubber canister, which varies with workload, depth, and temperature; second, to detect a CO_2 breakthrough as a result of a spent canister, mechanical failure or channelling.

Ignorant divers

Kevin Gurr, who is regarded as one of the gurus on CO_2 sensing, began his session by sharing data from a recent Internet survey of 323 rebreather divers representing 25 different models of rebreathers. The results were surprising. Twenty-three percent of the divers did not know the maximum operating depth of their unit, and another 19 percent did not know the manufacturer's stated scrubber duration. Forty-two percent of divers said that they experienced symptoms of hypercapnia for a total of some 297 incidents (some divers had more than one incident), however, 64 percent said that they didn't bailout; 19 percent said they bailed out sometimes. The results suggest better training and a cultural shift are needed!

Gurr next recounted the current methods used to monitor scrubber duration which are: 1) a duration timer based on manufacturer's test data (usually conducted at two depths at 4ºC at a specified CO_2 production rate); 2) a timer system based on the diver's oxygen consumption (divers produce about 0.8 liters of CO_2 for every liter of O_2 consumed) which takes account of workload but not depth or temperature; and 3) thermal sensing, also referred to as the "Temp Stik", which measures how the scrubber's thermal reaction front moves through the canister. Gurr explained that the Stik, which is used in the Ambient Pressure, VR technology and rEVO rebreathers, is a reasonable predictor of duration, but is slow to react to fast changing variables like work rate. However, none of these methods are able to detect CO_2 breakthrough!



Forty-two percent of divers said that they experienced symptoms of hypercapnia for a total of some 297 incidents (some divers had more than one incident), however 64% said that they didn't bailout, 19% said they bailed out sometimes.

Steve Lewis, author and technical trainer

Phil Short, IANTD UK

Jeff Bozanic

Rebreather

Following Gurr, Dr Dan Warkander, from the Navy Experimental Diving Unit (NEDU) who holds a patent on thermal sensing, compared to the days of early scuba when divers didn't have a pressure gauge but instead dived with a J-valve. "Wouldn't it be nice to have a gauge for your scrubber to tell you how much time you had left?" he offered.

Warkander went on to explain how factors such as workload, depth and temperature effect scrubber duration and how difficult it is to predict. For example, hard work can reduce duration by 50 percent, while light work can double duration. He said that scrubber duration can vary by a factor of 5-20 through combined effects of workload, temperature and depth. What's worse, when a scrubber is spent, the threshold between no CO_2 and too

much, can happen in a matter of minutes.

As far as detecting scrubber breakthrough or a seal failure, VR Technology Sentinel is currently the only production unit with a gaseous infrared CO_2 sensor (The Sentinel uses all four methods mentioned above in its CO_2 monitoring package). Gurr said that we are 80 percent there in fully characterizing a CO_2 absorption system properly.

Holy grail

The last piece is a mouthpiece sensor that can measure end-tidal CO_2, which is regarded as the "Holy Grail" of CO_2 monitoring. Gurr estimated that this is still at least three years away.

The Forum acknowledged the poor of understanding of operational limits with regards to depth and scrubber duration among trained rebreather divers and recommended that training agencies do more to emphasize these issues, and manufacturers make data more readily available.

Dive-by-Wire?

The diving press and interested Forum participants were treated to a preview of Poseidon and Stone's latest lovechild, the Poseidon TECH rebreather, which is scheduled to ship this November and features the latest in diving automation. "Our goal," explained Poseidon CEO Peter Swartling at the press briefing, "is to increase the level of automation by using smart systems that monitor every breath, make adjustments accordingly and interact with the user only when they need to know what's going on."

When a scrubber is spent, the threshold between no CO_2 and too much, can happen in a matter of minutes.

In addition to the many automated features in Poseidon's Mk-VI recreational rebreather such as a wet switch, an auto-checklist that verifies that cylinders have the correct gases and their values are open, and auto-oxygen sensor calibration and validation, the new TECH offers a "Dive-by-Wire" handset that is truly breaking new ground.

The device, which is smaller than an iPhone, provides system information to the user and enables them to control the rebreather to the extent of doing a loop flush or adding oxygen at the touch of a virtual button. The computer of course would warn and or prevent the diver from taking an action, like adding O_2 if it was ill advised.

The new Poseidon TECH offers a "Dive-by-Wire" handset

POSEIDON

This level of automation gave heebeegeebees to many of the tech divers I spoke with at the bar following Poseidon's press conference, but I couldn't help wondering if this is indeed the future of dive automation. Granted, 15 percent or so of rebreather divers prefer a strictly manual unit (sans solenoid) and other groups such as the DIR community don't even trust dive computers, well not the kind that you strap to your arm anyway. Ironically, I'm sure that most of these people have no trouble trusting their ABS brakes in their cars (versus feathering the brakes on their own). In fact, their vehicles depend on computer automation, as do the commercial aircraft that flew them to RF3.

Can we trust automation?

Stone, whose company builds autonomous vehicles for space exploration, addressed the issue head on in his talk, *Hazard Analysis and Human Factors*, posing the question, "Can we trust automation?" As an example, he recounted the development of the autonomous car that can navigate city streets sans driver and showed video of prototypes in action. Stone said that within five years, you'll be able to buy a car that will drive you home if you had a bit too much to drink, and it will do it as safe or safer than a human driver.

15% or so of rebreather divers prefer a strictly manual unit (sans solenoid)

Could rebreathers be far behind?

One of the major problems in rebreather (read car, train, plane, spacecraft, etc.) safety is humans' ability, or rather inability, to manage and operate complex machines without incident. Stone's solution, along with others such as Gurr's soon-to-be released Hollis Explorer, is to simplify the human machine interface by reducing the ways that people interact with these systems, letting the computer do more of the work. "We have to move out of the test pilot era to a new paradigm," he said.

Given that Stone's vision of more than 25 years ago helped drive the creation of a consumer rebreather market (he could arguably be considered the godfather of modern rebreathers) his ideas should not lightly be dismissed.

Dr Michael Gernhardt, NASA astronaut, manager of the Environmental Physiology Laboratory and principal investigator of the Prebreathe Reduction Program at the Lyndon B. Johnson Space Center, compared decompression issues in space with those in diving

Gavin Anthony, a recognised expert in military and com-mercial diving equipment and operations and QinetiQ's technical lead for independent diving equipment testing and incident investigation. He provided highly-valued constructive feedback and suggestions to the consensus statements

At the closing session of the forum, just before Dr Simon Mitchell, who heads the department of anaesthesiology at the University of Auckland, New Zealand, brilliantly facilitated and crafted a series of community-consensus statements from the assembled Forum participants (no small task!), audience members were encouraged to speak out and share their views. Andrew Fock walked up to the mic and put the following question to the community, "Given that the fatality rates are five to ten times that of open-circuit scuba, should we morally offer this technology to the recreational diving community, before putting our house in order?"

There was silence as if no one wanted to tackle the question, then another participant took the stand and changed the topic. Eventually, Mark Caney, PADI's Vice President of Rebreather Technologies, worked his way to the microohone and addressed his comments to Fock.

How to prevent drowning

Though it's not the trigger, the primary cause of death in most rebreather fatalities is drowning. Some of these fatalities might have been prevented by use of a retainer strap to hold in the diver's mouthpiece. Full-face masks and retainer straps have long been the standard in military diving and they were also a key recommendation from Rebreather Forum 2 (1996). While full masks introduce other problems for our diving applications and are not very suitable to sport diving, retaining straps arguably have the potential of saving lives. Rebreather instructor Paul Haynes who is former military diver and business development director and trainer for DIVEX Ltd., made a strong case for retainer straps at the Forum, which recommended that the efficacy of using straps be taken up as a research question. "We might all consider experimenting on ourselves."

Special thanks Rosemary E. Lunn and the Rebreather Forum 3 team!

"Yes we should," he said. "Within certain parameters." ■

Writer and technologist Michael Menduno published and edited aqua-Corps: The Journal for Technical Diving *(1990-1996), which helped usher tech diving into the mainstream of sports diving, and coined the term "technical diving". He also organized the first Tek, EuroTek and AsiaTek conferences, and Rebreather Forums 1.0 and 2.0. Menduno, who is based in Berkeley, California, USA, remains an avid diver.*

Rebreather

"Given that the fatality rates are 5-10 times that of open circuit scuba, should we morally offer this technology to the recreational diving community, before putting our house in order?"

"Yes we should! Within certain parameters."

Additional resources

RF3 included several discussions of how rebreather incident reporting and analysis could be improved resulting in several Forum recommendations.

DAN reporting system

In addition, DAN announced its new non-fatality online diving incident reporting system for rebreathers, which was endorsed by the Forum. See: https://DAN.org/IncidentReport/. The hope is that the DAN system will provide valuable information for the community.

Rebreather Forum 2 Conference precedings:

http://archive.rubicon-foundation.org/7555

Rebreather Forum 3 Consensus Statements:

http://rubicon-foundation.org/News/rf3-consensus/

Together with an assistant, Hubert Chretien (far left), founder of Freedom At Depth, helps a disabled diver after a dive

Freedom At • Depth

Hubert Chretien

Text and photos
by Robert Osborne

What you need to know about Hubert Chretien is that he had the opportunity to do anything he wanted with his life. He was born the son of one of the most powerful people in Canada—former Prime Minister Jean Chretien. Which means that Hubert was brought up in the company of the most influential people in this country. With those kinds of connections, he could have become virtually anything he wanted—a captain of industry, a power player among the political elite. He could, quite frankly, have even chosen to do nothing. Instead, Hubert set out on a singular and humble path, a path that would lead him to found an organization that would devote itself to helping hundreds of disabled people learn how to dive—Freedom at Depth.

For Hubert, the dream began when he was only 11. It was 1976. Local divers in Ottawa, Ontario, were giving kids at a pool a chance to experience scuba diving. Hubert tried it out and was hooked. That summer, a diver asked to use the dock at the Chretien summer home. According to Hubert, his father gave permission on one condition: that the man would give Hubert some lessons. Under the Christmas tree that year, Hubert found a tank and regulator. Immediately, he excused himself to fill up the bath, then spent a good chunk of the day submerged.

From that point on, every summer Hubert would spend as much time as he could diving in the lake beside his family home. His mother's condition, he had to tie a rope around his wrist. She would stand patiently on the dock holding the other end—an early safety precaution.

"As I was growing up, I never really knew what I wanted to do. But I knew that whatever it would be, it would be underwater."

Finally, at age 15 Hubert completed his PADI Open Water certification. And over the years, he's accumulated one impressive credential after another: more than 4,000 dives, PADI Master Instructor with ten specialties, National Association of Cave Divers Instructor, Technical Divers International Instructor for deco procedure and advanced Nitrox. But it was the certification he received from the Handicapped Scuba Association that would turn out to be the most meaningful. His position as a Course Director would ultimately inspire the Prime Minister's son to found Freedom At Depth

Freedom At Depth

In a fitting parallel to his earlier life, just as Hubert's mother Aline stood lovingly on the dock holding the rope that enabled her son to explore the world under the dock at their summer cottage, Hubert chose to extend a sort of enabling rope to others.

Hubert had been working with the Handicapped Scuba Association (based in California and operating around the world). In fact, he was the Canadian President of the organization. But Hubert decided that he could do more than just teach—so much more. He decided to found a charity that would devote itself to giving people with disabilities the opportunity to dive—whatever that entailed.

In the 12 years since Freedom At Depth was established, the dream has demanded a lot. It has meant certifying the disabled, providing the opportunities, means and support for them to travel and dive. Sometimes, it has meant

CLOCKWISE FROM RIGHT: Disabled diver, Monique, gets suit on; gets mask on; being geared up; just prior to going under

just being a dive buddy for someone with a disability. Often, it has meant just being a friend.

For Hubert, it is all about giving handicapped people a chance to experience a moment of independence under the water. He said, "I started this group because I don't believe people should be told there are limits to what they can do." He has, himself, certified well over 100 disabled divers, and his organization has worked with over 500.

And working with disabled divers isn't always the easiest task. For a start, there is a lot of lifting involved. Many don't have a great deal of mobility. They have to be put into their gear, carried to the water, carried from the water. The realities of lifting a 200lb man who has little muscle control can be daunting. Another challenge—assuming responsibility for someone underwater who, in some cases, is physically unable to respond to the most basic emergency.

And then there are the special challenges. Ask Hubert about his most difficult challenge and his biggest reward when it comes to working with disabled divers, and he'll respond with one word, "Isabelle."

Isabelle is a 20-something woman from Ottawa with cerebral palsy (CP). She wanted to learn how to dive, but she had problems (as many people with CP do) with muscle spasms—In particular, with her jaw muscles. Which meant that even keeping a regulator in her mouth was a challenge. "I spent 42 hours in the pool working with Isabelle on that," said Hubert. "I even gave her a snorkel to practice on when she was away from the pool."

At any given time, Isabelle could be found diligently sitting in front of the television mouthing a snorkel and practicing muscle control. Ultimately, working together, they managed to control the spasms and perfect her diving skills. Today, Isabelle has more than 60 dives under her belt, and Hubert said she's "one hell of a diver".

But at the end of the day, regardless of the significant challenges, Hubert said there is an enormous reward when it comes to working with disabled divers. "Whenever someone becomes a diver, I get a huge thrill," said Hubert. "I get an even bigger thrill from students who stick with it, who continue to put in 20 dives a year."

The work has demanded so much of Hubert's time that in 2005, he finally admitted to himself it was a full time job—and his chosen life's work. He gave up a promising career in the high tech world and became a

THIS PAGE: Disabled diver, Monique, being assisted down and propelled through the water. Quadrapeligic diver floating in water (bottom left)

full time director and instructor at Freedom At Depth. Although he drew a salary for the first few years, he's since decided that the money can be better spent on the work of the charity.

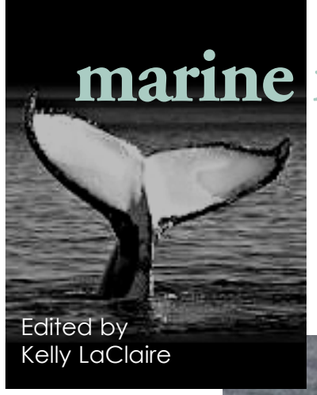
He's able to do this because of the support of his family—in particular, his father. The former Prime Minister does much of the fundraising for the charity and has set up a trust fund that provides Hubert with a modest income, which enables him to devote his energy full time to teaching and managing the charity. Hubert has also received a lot of help from his sister, France.

Since turning the work into a full time job, Hubert has set his sights on some impressive goals. While he's realistic about some of the physical restrictions that disabled divers face, Hubert believes that with the right support, there are no boundaries. "You can manage most of their needs and make them into really good divers within their restrictions," he said.

To prove it, Hubert is working with two determined divers—Tim Inglis, who is an amputee, and Bob Brown, who is quadrepalegic—on a project that will see the men train to ice dive, train to cave dive and, then, ultimately, join the exclusive group of only a few people in the world to have dived inside an iceberg.

Hubert has recruited world famous cave diver, Jill Heinreith, to help him with the project. He's also trying to find a broadcaster in Canada that will help him film the entire experience. He wants to call the project, *Boundless*, and he's starting on the first phase of the training in Canada and Florida this winter.

Successful or not, one thing is certain, project Boundless won't be the last project he initiates. In his own words, Hubert "plans on working with disabled divers until my back gives out". He's hoping he'll be working with students well into his 60's as much for himself, one suspects, as for the disabled. It's what he's chosen—it's what he lives for. "I push to enable people to dive," he said. They provide the grit; he provides the vision—and keeps a gentle but firm hand on the imaginary rope. ■



Call him Ishmael: A passing whale sinks California man's sail boat

Max Young, a 67-year-old retired Sacramento high school teacher has a whale of a tale to tell his friends and family.

While cruising the waters off the coast of Laplaya, Mexico on his 55-foot sail boat, *Reflections*, a whale rammed the back of his vessel, disabled the rudder and tore open a gash in the hull.

The boat immediately began taking on water and Young radioed the Coast Guard before scrambling to stuff a mattress in the hole and began turning on pumps in an attempt to slow the water that had begun to sink the small ship.

To make matters worse, Mr. Young was on the last leg of round-the-world voyage that he had begun 12 years earlier.

The Coast Guard District Command Center in Alameda received Young's distress signal and dispatched a plane, establishing radio contact at nearly 2:00 a.m. They found Young "trying to bail out water as fast as he could, because he wasn't sure how long it was going to take to be rescued," his wife, Debra, told The Associated Press.

The Coast Guard requested rescue assistance from the Panamanian freighter, the *Ocean Virgo*, that was 60 miles away and the cargo ship arrived at 4:00 a.m. He was taken aboard via a rope ladder that was thrown down by the larger ship's crew just after sunrise—about nine hours after the whale hit his boat.

Young has been sailing for at least 30 years, and having worked on boats with his father, who was a commercial fisherman, he's been on the ocean most of his life, his wife said. His experience and well designed communications systems no doubt saved his life.

"The safety equipment he had on board allowed us to find him very quickly," said Petty Officer 2nd Class Pamela J. Boehland. "It was a big reason why we were able to rescue him."

Young said it was too dark to see just what kind of cetacean hit him but he guessed the length of the whale that ultimately sank his boat at nearly 60 feet. ■

KAREN MUNRO / SEA WATCH

Killer whales hunting dolphins caught on camera

In late May, whale watchers and a Sea Watch Foundation official observed a group of a half a dozen killer whales hunting five white beaked dolphins near Duncansby Head in Caithness, Scotland.

Karen Munro, who regularly reports sightings to Sea Watch (a non-profit conservation group that monitors sea life in the United Kingdom), photographed the hunt.

"I saw three dolphins breaching right out the water as they were chased," Munro said. "Then it all went quiet and six orca fins rose together but did not appear to be moving.

"A minute or two later they all rose together in the same place which made us think they had caught one of the dolphins. Finally, in true killer whale fashion, they disappeared with us not knowing which direction they went in."

At least one of the dolphins was thought to have been caught and killed.

Orca hunting their smaller cousins is not unheard of, and a quick search around the Internet will yield a few results, but it isn't all that common either, especially to get such an event on film.

Sea Watch members say it is extremely rare to witness and photograph a hunt of this nature. Danielle Gibas, a sightings officer with the research group stated: "Killer whales are collaborative hunters and many people will have seen them in action in wildlife documentaries filmed in other parts of the world.

"The fact that we can witness such behavior from the U.K. coastline is a reminder of how important our coastal waters are for marine mammals."

The killer whales involved in the dolphin hunt are believed to be part of a small pod of about 30 whales frequently seen off Dunnet Head and Duncansby Head in northern Scotland and are thought to be a part of a larger community of orcas that follow spawning Icelandic herring. ■

SOURCE: BBC NEWS

Unsold: Three-quarters of Japan's NW Pacific whale hunt

Despite repeated attempts to auction it off, three-quarters of over a ton of whale meat resulting from Japan's controversial whale hunt last year was not sold, according to officials.

The Institute of Cetacean Research, which is a partly-public organization that coordinates the nation's whaling activities, reported that buyers could not be found for about 75 percent of nearly 1,200 tons of whale meat from minke, Bryde's and sei whales caught during the deep-sea mission.

There are still buyers for smaller coastal whaling programmes in northern Japan. This is most likely due to the fact that the whale meat is sold in areas with strong whale-eating traditions and that the whale meat sold is fresh, not frozen.

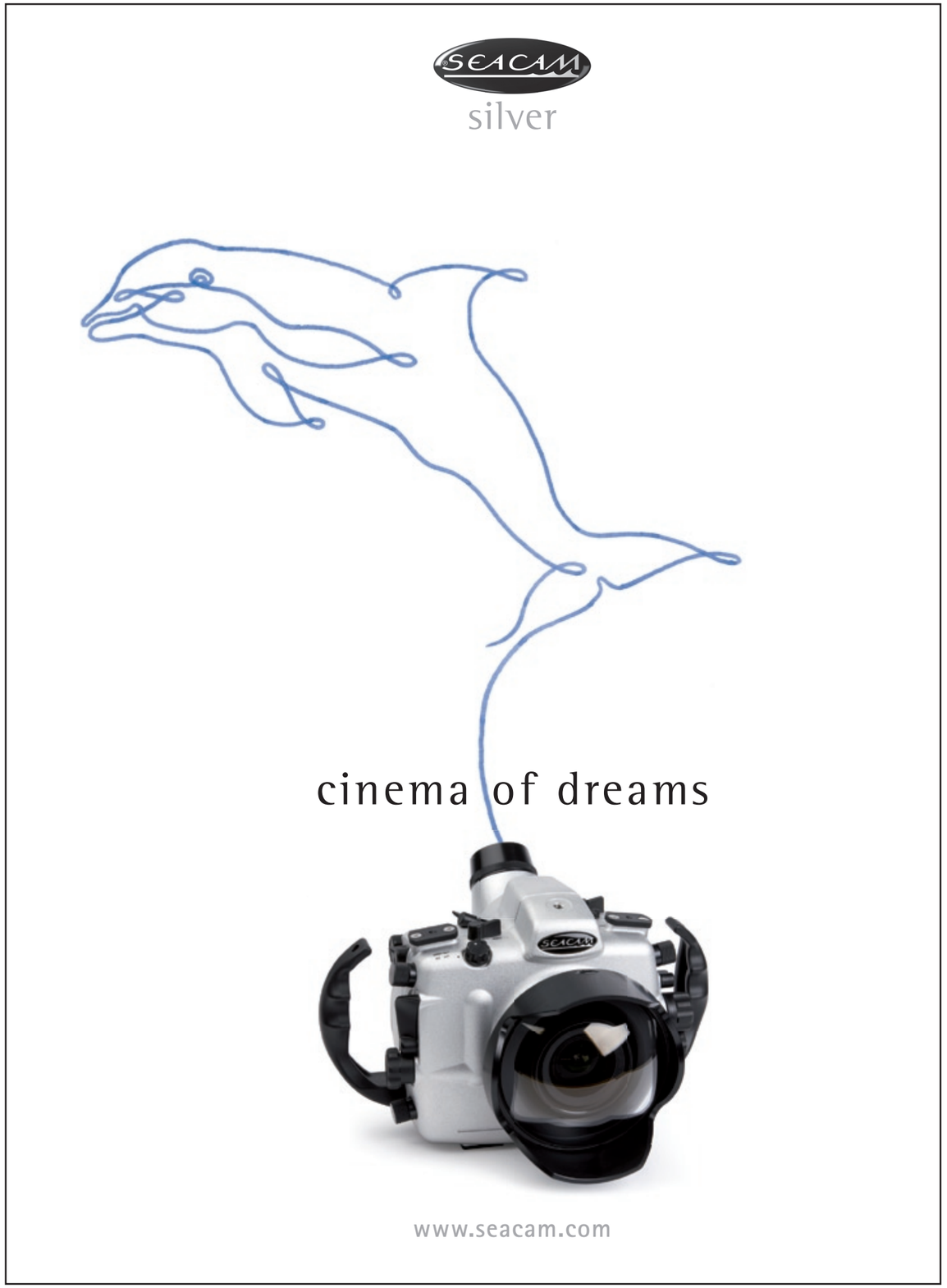
Auctions to sell frozen whale meat from whales caught in Northwestern Pacific waters last summer by the institute were held between November and March. It was the intention of the institute to promote whale consumption and generate more income through auctions.

Apparently, food sellers want to avoid trouble with anti-whaling activists, according to an institute spokesman who names this reason as the cause for the "disappointing" auction results. "We have to think about new ways to market whale meat," he told AFP.

There is a loophole in the international moratorium on whaling that allows for lethal research, which Japan exploits. Environmentalists, conservationists and activists from anti-whaling nations say that commercial whaling threatens whale populations worldwide and continue to condemn the missions of the institute. They believe that Japan uses the loophole as a cover for whaling activities. However, Japan says that the research is needed to support its view that a robust whale population exists in the world today.

The country also claims that whaling is part of Japanese tradition and accuses Western nations of cultural insensitivity. No compromise is the motto of Japan's powerful fishing industry and right-wing activists. However, Japanese anti-whaling activists said in a report that the poor auction results confirmed that whale meat is no longer popular with Japanese consumers. The low demand is leading to oversupply, which is making Japan's whaling programme unsustainable, according to freelance journalist, Junko Sakuma, released by the Iruka and Kujira (Dolphin and Whale) Action Network. ■ SOURCE: THE KOREA HERALD

CREATIVE COMMONS / GNUFDL



New sensory organ found in whales

Scientists have discovered a sensory organ in rorqual whales that coordinates its signature lunge-feeding behaviour and may help explain their enormous size.

The new sensory organ has been found within the chin of rorqual whales, lodged in the ligamentous tissue that connects their two jaws. It is responsible for coordinating the biomechanics of their extreme lunge-feeding strategy.

Lunge feeding is an extreme feeding method in which the whale accelerates from below a bait ball to a high velocity and then opens its mouth to a large gape angle. This generates the water pressure required to expand its mouth and engulf and filter a huge amount of water and fish. Lunge feeding by the huge rorqual whales is said to be the largest biomechanical event on Earth. Blue whales can swallow almost 2,000,000kJ (almost 480,000 kcalories) in a single mouthful of krill, and eat 90 times as much energy as they burn during a dive.

The study, to be featured on the cover of the journal *Nature*, details how scanning of the whale's chin revealed a grape fruit-sized sensory organ, located between the tips of the two lower jaw bones. The organ, composed of connective tissue with papillae (protrusions) that contain nerves, is suspended in a gel-like material. Vascular and nervous tissue from an ancestral front tooth socket still remains in today's whales and connect to the sensory organ. Evidence indicates that the sensory organ responds to jaw rotation when the whale opens and closes its mouth and when the whale's throat pleats expand as it takes in water.

In terms of evolution, the innovation of this sensory organ has a fundamental role in one of the most extreme feeding methods of aquatic creatures.

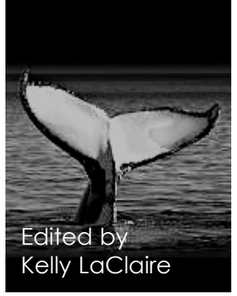
—UBC Zoology Prof. Bob Shadwick

Fossil records show that the bottom jaw of baleen whales has been unfused, or separated, at its tip since the late Oligocene epoch (23-28 million years ago). Despite the long expanse of time to the present, this organ represents an evolutionary novelty for rorqual whales, based on its absence in all other modern species of baleen whale, such as gray and right whales. ■

SOURCE: DISCOVERY OF A SENSORY ORGAN THAT COORDINATES LUNGE FEEDING IN RORQUAL WHALES, NATURE 485, 498-501 DOI:10.1038/NATURE11135

GEORGIA EVELYN STANTS VIA WIKIMEDIA COMMONS.

A group of humpback whales lunge through the centre of their bubble net



Nat Geo photographer captures first ever photo of humpbacks mating

National Geographic photographer Jason Edwards has done what no photographer in the history of the world has ever been able to do.

In August 2010, Edwards took the first still image of humpback whales mating after a "heat run" the photographer and several other researchers witnessed.

The heat run—when adult males compete with each other to see who is going to get the female—apparently went for several hours. "It was amazing," Edwards said. "There were four or five males vying for her attention and while the larger ones were busy jostling each other, the smallest one swam away with the female. Their coupling lasted less than 30 seconds, which might explain why it's never been captured on film before."

Edwards and his colleagues spent over two hours following the heat run, jumping in the water whenever possible to capture footage of the giant mammals. Edwards told reporters that he was stunned by the brief but tender moment.

Heat chase

"When the successful male mated with the female, he came in from above and behind her. He clasped her between his pectoral fins, and whilst they floated along together, he was stroking her flanks with his pectoral fins."

The photos and video taken of the heat chase and the actual mating itself may shed tremendous light for scientists on the behaviors of these mysterious animals. Currently, more is known about the gestation period of the species—roughly 11 months—than is known about their sexual activities.

Already for example, a few details are coming to the forefront. Despite humpback whales being known for their songs, Edwards says absolutely no sound was heard during the mating act, although it's possible that noises may have been emitted from the whales above or below the audible frequencies of humans.

Blowing bubbles

The female however, was heard and seen blowing bubbles from her mouth following the copulation but just why this was done scientists can only speculate.

"The purpose of this bubble release is still unclear, however it may have signaled to the male that the reproductive act was over. Further research is still needed to confirm whether this is a common sexual practice or simply a random occurrence," Edwards said.

"When we came upon the heat run, it was the last day of my shoot. I didn't have a single frame of these animals from the whole trip. All I kept thinking was 'don't mess it up'. I was just supremely lucky to even be there, let alone capture this incredibly intimate moment on camera."

According to National Geographic, the pictures Edwards took were kept secret for nearly two years but a gallery of the images is scheduled to make their first public appearance at Auckland Museum this month. ■

SOURCE: THE DAILY TELEGRAPH

JASON EDWARDS

PROTECTED RESOURCES DIVISION, SOUTHWEST FISHERIES SCIENCE CENTER, LA JOLLA, CALIFORNIA, USA

False killer whale

False killer whales able to focus their echolocation beams on targets

Toothed whales and dolphins (odontocetes) rely on echolocation to locate food with incredible precision. These marine mammals produce their distinctive echolocation clicks in nasal structures in the forehead and broadcast them through a fat-filled acoustic lens, called the melon. It has been known for a while that dontocetes have the ability to control the shape of the echolocation beam, and it was assumed that they are using the melon to focus the sound.

However, it was up to Laura Kloepper from the University of Hawaii, USA, and her PhD supervisor, Paul Nachtigall, to discover how false killer whales are able to focus their echolocation beams on targets. Their findings are described in a recent issue of *The Journal of Experimental Biology*.

The false killer whale (*Pseudorca crassidens*) is a cetacean, and the third largest member of the oceanic dolphin family (*Delphinidae*). It lives in temperate and tropical waters throughout the world. As its name implies, the false killer whale shares characteristics, such as appearance, with the more widely known orca (killer whale).

The challenge

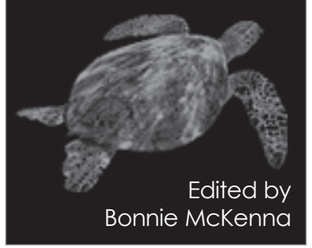
The width of an acoustic beam is determined by the frequency of the sound. But how could the team tell whether a change in beam width was due to the killer whales focusing the sound or simply due to the physics of acoustics? Using statistical analysis, it was established that a relationship exists between beam area and frequency.

"Squint"

Training a false killer whale to discern between cylinders of the only marginally different diameters of 6.553mm and 6.35mm presented at mammals at random at various distances, it was discovered that the false killer whale was effectively 'squinting' and adjusting the size of her echolocation beam in response to the more difficult tasks. ■

SOURCE: ACTIVE ECHOLOCATION BEAM FOCUSING IN THE FALSE KILLER WHALE, *PSEUDORCA CRASSIDENS*. *JOURNAL OF EXPERIMENTAL BIOLOGY*, 2012 DOI: 10.1242/%U200BJEB.066605

turtle tales



Edited by
Bonnie McKenna

The leatherback sea turtle is virtually extinct in Malaysia

It is too late for the Malaysian leatherback, but there is hope for the three remaining sea turtle species. The decline of the leatherback was set in motion before anyone truly understood the gravity of the situation.

Universiti Malaysia Terenggau marine biologist Juanita Joseph has spent the last decade researching Malaysian turtles and does not believe the leatherbacks are ever going to recover.

"This is because sea turtles return to breed at their natal beaches. They may travel thousands of miles to reach foraging grounds, crossing transnational borders, but all turtles return to the area where they were born to breed and nest," said Joseph.

PUBLIC DOMAIN

It took hard data to convince the Terengganu state government, once one of the most significant leatherback hosts, of the need to ban leatherback turtle egg consumption. Communicating the situation's urgency, especially to the older generation of Malaysians in the states of Kalantan and Terengganu, where turtle eggs are considered a delicacy, remains notoriously difficult.Because turtles lay so many eggs, in Malaysia turtle eggs are still allowed to be sold in markets in Kuala Terengganu.

Joseph likes to retell the tale of how the leatherback has disappeared from their shores. She reiterated that it is a story that should not be forgotten because it illustrates why it is in everyone's interest that we start saving the other turtle species.

Thousands of leatherbacks used to frequent the sleepy shores of Rantau Abang, a small fishing village on the coast of Terengganu. Eggs were aplenty. Hundreds of thousands were buried in scattered clutches across the shore, far more than egg collectors could carry, and plenty for the locals to eat. With road expansion, turtle eggs were soon transported to new markets as far afield as Kuala Lumpur. The eggs became a commodity, prices rose and more collectors started digging them up as egg sales became a lucrative source of income for the under-developed state.

In Rantau Abang, scenes of large groups of tourists crowding around a single nesting female were commonplace in the 70's and 80's. When the tourists left, the eggs were scooped up for sale. At the same time, a rapidly developing fishing industry led to leatherbacks being caught in nets.

Leatherback eggs laid in Terengganu dropped from 10,000 clutches in 1955 to about 3,000 in 1965. In 1999, only two percent of that number was found, and by 2002, only three female leatherbacks came to the beach.

Once it was realized that the numbers were dropping, conservationists and the state initiated efforts to protect the turtles. The first leatherback hatcheries were established in the 1960s, but only four percent of the eggs were protected. Considering that only 0.001 percent of hatchlings will make it to adulthood, that figure was not enough to preserve the leatherback population.

Joseph explained the situation, "Only a handful of female leatherbacks have returned to Rantau Abang to nest in the last few years, but none of the clutches hatched." Joseph believes that could be a symptom of man-made distortions in the sex ratio of Malaysian leatherbacks because reptiles will lay eggs even if they are not fertilized. To make things worse, lights from resorts along the coast and vehicles ridden by sanctuary personnel patrolling the beach have disoriented the nesting females and hatchlings.

Efforts to save the other species of marine turtles

According to the International Union for Conservation of Nature (IUCN) Red List, green turtles are endangered, Olive Ridley's are vulnerable, and hawksbills are critically endangered. In Peninsular Malaysia, none of these turtle eggs are banned from consumption. In addition, turtles are being picked off by poachers.

Earlier this year, World Wildlife Fund Malaysia has made fresh calls for the government to amend the Fisheries Act of 1958 to ban the eating of all turtle eggs. Sabah instituted a ban on commercial egg collection 30 years ago, and there has been a threefold increase in its breeding population of green turtles despite the ongoing poaching in Borneo.

Conservationists have this message: Turtle egg consumption is no longer a sustainable practice. Unless action is taken now, seeing turtles on Peninsular Malaysia will eventually become only a memory. ■

India reports millions of Olive Ridley hatchlings head to sea

The beaches along Gahirmatha beach have brought cheers to conservationists as they watched millions of hatchlings head for the sea. Approximately 1.68 lakh (1 lakh=100,000) Olive Ridley sea turtles arrived at the nesting beach between March 20 and March 28 to lay their eggs.

On the first Saturday of May, in the late evening, hatchlings began to emerge. The wildlife officials who are stationed on Nasi-2 Island were witness to this natural occurrence.

Tourists and researchers were denied access to the island to witness the hatchings because the islands are located close to a defense test range, a prohibited territory. During the week of the hatch-out, the one kilometer beach was virtually littered with hatchlings. The babies literally jostled for space to move about the beach before heading to the sea. It is estimated that nearly two-million hatchlings emerged in a 24-hour period. ■

THE HIGH FIN SPERM WHALE AT EN.WIKIPEDIA

Promoting Conservation Policies in Albania

Three year research by The Mediterranean Association to Save the Sea Turtles (MEDASSET) has confirmed that Drini Bay, on the northern coast of Albania, is an important habitat for sea turtles in the Mediterranean. Turtles use the bay for foraging, as a refuge and are part of a key migratory corridor between the Ionian and Adriatic Seas.

Information on the sea turtle population visiting Albania's waters had been scarce and research fragmented until 2008. Based at the Patok Lagoon area of Drini Bay, the project's researchers systematically collected data during the summer months by monitoring the sea turtles captured incidentally.

A remarkable 407 sea turtles were studied and released back into the wild: 402 loggerhead turtles (*Caretta Caretta*) and five green turtles (*Chelonia mydas*), confirming that Albania is a range state for green turtles.

Of the captured sea turtles, 27.5 percent were males (35 adults, 77 subadults). In contrast to females, males never return to land, and therefore, scientists' understanding of the distribution and marine ecology of males is very limited. "This discovery has increased importance due the impact of global climate change, as sand temperature during incubation is the sex determinant of hatchlings and an increase of just one or two degrees could lead to more female than male hatchlings being produced," said Dr. Michael White, Project Lead Researcher.

The project revealed Drini Bay is used by both adult and subadult loggerheads, and occasionally by green turtles for foraging or migration. Juvenile loggerhead and possibly green turtles are using the area as a developmental habitat. There are indications that loggerheads may be staying in the bay during the winter months. This conclusion is also supported by the preliminary results of the first satellite tracking program of sea turtles in Albania that was launched through MEDASSET's project.

MIKE GONZALEZ / CREATIVE COMMONS GNUFDL

Tracking continued until September 2011 and has confirmed the timing of the return of two out of the three tracked turtles to Drini Bay for feeding.

A waste pollution survey was conducted in the coastal zone of Drini Bay and upstream in five rivers. It was noted that there is widespread presence of marine litter in Drini Bay, in conjunction with the omnivorous nature of loggerheads means the consumption of plastic and other debris is highly probable. The illegal use of dynamite for explosive-fishing was monitored, and the first ever systematically recorded evidence was provided to the authorities.

MEDASSET's second project was to train 11 Albanian university students as research assistants, enabling them to monitor the sea turtle population. The project also offered a unique opportunity to over 250 Albanian university students to attend workshops at the project field station. MEDASSET worked with Prof. Idriz Haxhiu, Director of the Herpetofauna Albanian Society and sea turtle researcher, to raise awareness locally and nationwide through local and national media. The researchers worked with the local fishermen, demonstrating good animal-handling skills and advocating conservation practices.

The sea turtle population in Drini Bay has yet to be completely understood. However, the findings and conclusions of MEDASSET'S three-year project led to the formulation of recommendations and a "National Sea Turtle Management Strategy". The long-term aim of this project is for Drini Bay to be recognized as a nationally and regionally important foraging and developmental habitat for sea turtles in the Mediterranean and that these endangered species are fully protected under Albanian national law. ■

Baby loggerhead sea turtle

USNPS

Uncontrolled development on Specially Protected nesting beach in Fethiye Turkey, taking its toll

MEDASSET's complaint submission to the Secretariat of the Bern Convention stated that unplanned construction and developments to accommodate tourism are threatening Fethiye, one of the most important nesting sites for loggerhead turtles in Turkey, even though the whole bay area is designated as FethiyeGöcek Specially Protected Area.

Wetlands have been bulldozed for the construction of hotel complexes; snack bars and cafés are situated right on the nesting beach; motorized water sport activities are taking place in the bay; wooden walkways have been built on the sand; and dense rows of beach furniture remain on the beach on a 24-hour basis.

Strong lighting is used during the night and visitors freely roam the beaches until the small hours. Artificial plastic carpeting covers part of Çalış nesting beach, and huge stones have been placed to delineate this area. Fourteen rows of acacia trees, an introduced species known for their extensive rooting, were densely planted along a 150 meter stretch of this beach. Quads and trucks pass freely through the beaches, and there is car access to virtually every beach. The garbage problem is entirely unsolved; there has been sand removal and fishing occurs directly off all three of Fethiye's nesting beaches. It is not to wonder why the number of nests has been notably declining since the early 1990s as tourism developed. ■

Zakynthos, Greece…the problems continue

In mid-July 2011, following a delay of nine months, the Greek Ministry of Environment, Energy and Climate Change finally released the operational funds to the Zakynthos national Marine Park (ZNMP). The funds covered salaries owed to the staff since November 2010 and should cover management costs of the park for the next five years. The delayed disbursement caused numerous problems to the management team during the summer nesting season. Some of the problems encountered are insufficient patrolling of the marine park, construction of an illegal parking lot, construction of an illegal underwater stone breakwater in front of the Marathonissi islet, a decrease in the number of nests and a highest ever recorded number of turtle deaths.

Despite the European Com-mission's intervention on illegal landfills in Greece, they continue to operate within the ZNMP and have expanded construction of two illegal additions. Nesting in the summer was reduced to 786 nests. The high number of dead turtles (45) was indicative of the numerous violations in Laganas Bay. MADASSET continues to monitor and assess conservation activities at the ZNMP, but they are concerned that the loss of the large number of adult turtles may irreversibly affect the loggerhead population that reproduces in Zakynthos. ■

BRIAN GRATWICKE / CREATIVE COMMONS

Loggerhead sea turtle resting