

## **Bubble Trouble, an incident analysis in the first person**

*Christian Stimson*

This trip report is in two parts – the first recounting the dive day as per usual, but ending with a trip to the Whangarei Base hospital with suspected DCI. The second part is something of an analysis of the events leading up to that. The conclusions drawn are personal ones, based on my current experience, training and knowledge and information gathered during the day. This has not been ‘peer reviewed’ and does not constitute a formal incident analysis in any way, shape or form. Regard it as a long winded pub chat, but with diagrams!

### **PART 1 – TRIP REPORT**

Mike Smith has a golden rule – “Skive Dives have to be on primo days”. And what a day we had before us! Swell map was showing 50cm or less for Bream Head, sunshine and light winds were forecast. I’d not dived for over three months, so it wasn’t difficult to make the call to skip off work and drive up for a survey session on HMNZS Waikato. Mike picked me up from the north shore at 0530 and we arrived at Tuts just before 0800. Kate was jumping around the D!T counter itching to tell us about the conditions on the wreck but not wanting to jinx it by doing so. We elicited that 20m vis. was the expectation based on yesterday’s dives. This was going to be great!

Kit was duly carried aboard the Hendrik J, and a mix of recreational divers and D!T staff joined us for what was lining up to be a cracking day. Mike and I high-fived on the way out, as we estimated the swell to be a mere 20cm. We discussed the plan, and rapidly pushed the interior surveying dives to the back of the queue to focus on an exterior examination in the (hopefully) excellent vis., and allow Mike the chance to take some pictures of exterior deck features for reference.

### **DIVE 1**

I had not dived the props and rudders, so we made that our first objective, followed by a multilevel swim round the superstructure on the port (low) side. As we were both on 21% our profiles should be similar, and we agreed that on reaching 5min no-deco remaining we’d lift 5m or so and continue. Both of us were on twin 12’s, so gas was not going to be the constraint. We planned our dive, and dived our plan accordingly. On descent I could clearly see the white growth on the starboard (high side) deck-edge of the helicopter deck from 3m! Then I could see the sand from 15m – the vis. was as predicted at 15-20m!



From a tour of the props at 30m we nipped in to the junior ratings mess aft on the starboard side swam forward and out on the no.2 deck exit port side in the sand at 31.5m. This was primarily because it is the shortest route from where we were to the port side exterior, but to be honest the option for a little penetration was not to be missed! Then a loop around the bridge at 26m where we hit 5min no-deco. So we lifted and headed back to the hangar, cruising at a nominal 20m. Mike snapped a pic of a crab being munched that Laurent had spotted aft of the bridge. We reached the line at about 28min and started to ascend with

5min no-deco showing on both our computers. At this point we got a bit of vertical separation as I was running a GUE 9m/min to 15m, whereas Mike was on a slower constant rate of ascent, guided by his computer. So I dropped back to clarify the signals, and we headed to 6m for a 3min hang under the back of the boat, and broke surface at 40mins having gone from 6m to 3m in 40secs or so.

That was a spectacular dive, and the best conditions I'd ever had on the wreck. Mike said the anchor recovery dives in 2009 were better vis., but we agreed we preferred this to the pea-souper of a dive we'd both done on a previous occasion! I pinged the TDNZ Facebook wall with a message citing the dive as "20x20x20" in deference to Jamie's most excellent 10x10x10 series of dives – but twice as good with 20cm swell, 20deg temperature and 20m vis. – a primo day, without doubt!

## DIVE 2

Following nearly a 2 hour surface interval, refilling, re-fuelling and re-watering ashore, we headed back out with what Mike counted to be 4 guests and 8 D!T staff on board! The word had spread! Again opting for an exterior swim, but focusing on the bow section, we observed the same fundamental procedures of 5min no-deco and multi-levelling from there.



We dropped down the line, leaving it at 20m to scoot forward along the starboard superstructure, and out into the bow break area, arriving at the 'middle' of the bow on the #3 deck opening at 26m. We then dropped to sand and examined the magazine and the shell carriers at around 30m before going in through the big opening amidships on #3 deck. We made our way forward and up, taking a peek into side compartments and building a picture of the layout. We exited on

the hull side in the middle of the bow section and headed aft and down to immediately below the gun at 30m. At this point we hit 5min of no-deco and swam up and over the gun mount on #1 deck, out into the main corridor, and out the aft end the way we had originally come in at 26m. We made our way over the gap to the main section, scooted into the control rooms on #2 deck and out the high side. With 5mins no-deco upon us again we nipped back into #01 deck aft of the bridge at 20m and back to the line.

The ascent was much tidier this time, with both in sync. I had a wobble on arrival at 6m as a gaggle of divers from another operator were something of a distraction as they jostled for position on the line at their 5m safety stop. So we left the line to park by the hang tank. I reset at 5.5m and got the computer ticking off my own 3min hang then a slow lift to 3m. Mike and I broke surface at 38mins. We headed back to Tuts for a refill, and discussed the option of third dive. Mike was showing subdued enthusiasm for a third dive, but didn't object when the option was discussed. My shoulder was giving me a bit of gyp but I shrugged it off as an old sailing injury complaining about lugging twinsets up and back for fills! Evan checked it out with Kate, and 2hours later we headed out with the boat to ourselves!

## DIVE 3

This time we had no excuse but to complete the interior survey work! We again left the line early and swooped forward to the break. Heading to the port side #3 deck opening Mike nipped in with the laminated plans and a chinagraph pencil to sketch the details we were looking to confirm. I hung at the break, eyes on Mike's fins hanging out of the doorway at 28m, and practicing my back-kicks. At 9mins or so we headed up to #2 deck to check some deck hatch/ceiling hatch locations that didn't tally on the plans. Mike went low and I went high of a midships longitudinal bulkhead, reconvening in the mess area on the low side at 28m about 20mins in to the dive, at which point we hit the 5mins no-deco mark, and headed up and aft at 20m. Coming up to the aft end of the hangar at 26mins I had 7mins of no deco showing, so we opted for a quick tour inside the hangar to check out the overhead there. A minute after that I pinged Mike with 3min no-deco and we headed out and up. The 6m hang was uneventful this time and we broke surface at 37mins, again after a 40sec lift to 3m - mission accomplished!

#### FIRST RESPONSE

On the way back in I started to feel a touch nauseous, but shook it off as we came alongside. We lifted the gear off, and thanked Evan for a great day out there. As we broke our kit down in the carpark I really started to feel unwell, slightly dizzy and unsteady on my feet. The nausea wasn't the metallic taste in the mouth 'I am going to puke' sensation, more the upset tummy sort of feeling. I sat on my crate and took a couple of breaths but I couldn't shake it off. Mike spotted me and asked if I was OK, and I just said I was a touch woozy and maybe some O2 would fix it! As I headed back the Hendrik J to see if the option existed, Evan was coming up the ramp carrying the O2. I asked if I could have a sniff just to sort my head out, and although he looked at me quizzically when I said I wasn't feeling at all good, he didn't waste time but promptly sat me on the wall and started to administer the O2.

At this point my recollection gets a little unclear, but as I remember it Laurent was also on the way up, and seeing the situation checked in on me and conferred with Evan. He then headed over to the D!T shop, leaving me with Mike and Evan and returned shortly with Kate. Kate immediately called for the boat's dive log and checked our profiles and found them to be nothing unusual. I offered up my D9, and Mike checked his Stinger, and we confirmed 2hrs 13mins was the surface interval on 2nd and 3rd dives for us both (spookily). She then sat beside me and logged the time of O2 being administered and my symptoms of nausea and dizziness. She asked how much I'd had to drink, and I told her 1litre before leaving the house this morning, 75cl in the car on the way up, which refilled and drank on the way out and back from dive 1, followed by an orange juice and soda on both surface intervals.

After about 15mins on O2 I developed a tingling in my right forefinger and thumb. It felt like pins and needles, but prodding the skin I detected it was also completely numb – which I reported to Kate. Laurent had returned with a large bottle of water and I had been taking occasional swigs from it in my right hand, but on the next swig I missed my mouth! So while the nausea had subsided and some colour had returned to my face being on O2, my lower arm was no longer under my control! Kate muttered words to the effect "right, that's really not good!" and headed back to the shop to call the Whangarei Base hospital. She returned with the news that the first responders would be here in a few minutes. By this time the tingling in my hand had gone, but a dull ache had begun inside my right elbow – more upper forearm than crook of my arm. Kate and I had some





exchanges about these developments, but her bedside (dockside) manner was a fairly perfunctory “stop talking and breathe the O2!” (which was sound advice, and I have no complaint!)

First responders Tony and Paula arrived on scene approx. 30mins after I’d started on the O2, plugged me into an IV saline drip, ECG and switched the O2 to a free-flow regulator rather than the demand reg I had been on. They discussed Kate’s notes, and confirmed an ambulance was on the way. At this point, with a hospital trip on the cards, the anxiety levels stepped up a touch! Mike called Sian (my other half) to update her, and I kept asking Mike what was to be done with Jamie’s tanks that he’d hauled up here – maybe best to drop them at D!T shop, or on Mazurka..... at which point Kate interjected again with “shut up and breathe!”

The ambulance arrived, I’m guessing, 40minutes after I was first on O2. I reported to the crew that my inner elbow/lower bicep was still aching a touch, but my shoulder was now the point of most intense aching. While not painful (I’d give it a 3 on 10, with 5 being “Ow!” and 10 being “Sh#! that hurts”) it was most definitely ‘there’ and was absent elsewhere in my body by way of comparison. I made some poor joke about the fact that at this rate of migration the bubble was going to come out of my ear, but it was to mask the more concerning thought that it might find somewhere far less convenient to park up. Kate chipped in with the now familiar “shut up and breathe” – which I obediently did.

The ambulance ride was uneventful – no “blues and two’s” so I couldn’t be that bad! The driver very skilfully got us there without a hint of car sickness, which considering the head down attitude I had going round those twists and turns is impressive! I was monitored the whole way. My blood pressure dropped initially and my extremities got too cold for the crew’s liking, so a blanket was wrapped around me. Wheeled into ED on a stretcher, I found the passing of overhead flouro strip lights, and the upside down heads of various medical staff coming to have a look at a casualty to be exactly as portrayed on TV!

Initially I counted 5 or 6 anxious-looking medical staff in the room with me, but that soon whittled down to 2 - I guess once they realised I was breathing and talking (without Kate to tell me not to) and evidently not at death’s door. I was plugged into the ECG and kept on O2 with another 2litre saline IV plugged in. I was asked to describe the day’s events, my diving experience and qualifications, and any other relevant medical information. They visually checked me out for skin bends or other signs of barotrauma – but found none.

Gradually the ache in my shoulder faded, the nausea was long gone and I was feeling ‘alright’ – a fact which I passed on to the nurse. The nice doctor came back to carry out tests to check for impairment of motor and visual co-ordination – ‘follow my finger with your eyes’, ‘touch my finger with your finger’. Then came the rubber mallet on my knees, ankles, wrists and soles of my feet, to which I apparently provided the correct responses.

Then she poked a cotton bud in my eyes, making me blink and my eyes water – again the correct response! A couple of other pokes and prods on my tummy and she left the room telling me “I’m just going to confer with a colleague....” She returned and asked me to perform a sobriety test – at which point I remarked that they must be running out of tests and have to start making them up! The old “stand on one leg, arms out, shut your eyes and touch your nose” plus a couple of variations on that were carried out and passed. 4hours on O2 and 4litres of saline had done the trick.

Mike appeared at this point, having dropped Jamie’s tanks off at Kev’s, and he sat and chatted to me while they conferred at the front desk. A few moments later I was told, pending blood work results, I was good to go. Which we did at 20:00 - via Burger King - and made it home for 22:00.

## PART 2 - ANALYSIS

Why did I get a DCI hit? What follows is my own interpretation of what led to me being admitted to Whangarei Base. For those readers thinking 'sawtooth profiles' or some variation on that theme, I'd urge you to read Mark Powell's 'Deco for Divers' - especially the chapter on reverse profiles, which debunks that particular myth.

Mike and I carried out three 40minute no-deco air dives to a max depth of c.30m. We both had Suunto computers (mine a D9, Mike's a Stinger) running the same RGBM algorithm, both with personal settings of P0 (the 'ideal' or least conservative of the three options). The D9 has an additional setting to attenuate the RGBM algorithm, which was set to 50% - the least conservative of the two options, described as applicable to 'experienced divers'. Both computers gave no-deco time remaining within a minute of each other at any point in the dives that we conferred. My settings have been that way since I bought it and have not given rise to any incidents of DCI over 100+ dives in that time. The profile summaries read as follows:

Mike Dive#	Max Depth	Dive Time	Av. Depth	Surface Interval
1	31.7	40	20.4	--
2	30.4	38	19.8	2:13
3	28.9	37	20.1	2:13

Christian Dive#	Max Depth	Dive Time	Av. Depth	Surface Interval
1	31.6	40	19.8	--
2	30.2	38	19.1	2:13
3	29.1	37	19.1	2:13

From this it can be seen we both dived pretty much the same profiles, with mine consistently shallower on max and average depths apart from Dive#3 where I was 0.2m deeper on max depth. As for the P0 settings, the Suunto manual describes the factors affecting the selection of the setting as follows: *"The personal factors which tend to increase the possibility of DCI include, but are not limited to: - cold exposure - water temperature less than 20 °C [68 °F] - the diver is below average physical fitness level - diver fatigue - diver dehydration - previous history of DCI - stress – obesity."*

Taking these in turn and applying them to me and Mike. Cold: 20deg was recorded at 20m, and we were both in drysuits – N/A. Fitness: What is 'average'? I'm 46years old non-smoker and I run a few km's 2-3 times a week. Mike is 55 yrs old, also a non-smoker and in good health, but does not describe himself as fit, avoiding current and long surface swims if possible. Fatigue: I have a 6month old son, a full night's sleep is a distant memory, but I'm not falling asleep during the day. Mike as far as I'm aware had a good night's sleep, and says he was not fatigued that day. Dehydration: I drank plenty at the start of the day, and continued to drink, but did not maintain the same rate of intake through the day. Mike had a couple of cokes and a coffee during the day ashore, both diuretics, but drank heaps of water and has a pee-valve for that reason. Previous DCI: None formerly diagnosed as such. Stress: For me, these were three of the least stressful dives I've done. Mike was struggling with buoyancy on dive 3 and says he was a little stressed as a result. Obesity: I am 1.75m and 88kg, a higher BMI than the 'normal' zone, but not obese. I'm 8kg (1stone) heavier than my best ever 'fighting weight' during my mid-twenties. Mike is 1.86m tall and 86 kg – what I would call lean build.

On the face of that info the P0 setting was not inappropriate, and while my personal circumstances have changed (new arrival, increased age etc) it is possibly the combination of exercise and dehydration that tells a



story. The 50% RGBM setting would seem to have had no impact on the no-deco times as Mike and I clocked the same numbers at each check.

Mike and I both have c.250 dives, and I have TDI Extended Range and Normoxic Trimix certifications which qualify me to dive to 60m using accelerated decompression, plus I have training for overhead environments. The majority of my recent dives were on 21% or 32% Nitrox, rarely deeper than 35m but occasionally to 45m. While the question of what constitutes 'experienced' when you dive in the company of those exploring caves at 60m+ is one for the pub, in the context of not being regarded as 'a novice' I feel the 50% setting was appropriate. DCI is a complicated topic and I don't pretend to understand it all. While not proffering a formal diagnosis, the doctor suggested the following scenario might be a plausible explanation.

The nausea in the car park was probably the result of dehydration and heat stress caused by wearing dark thermals and drysuits all day long and breathing compressed (dry) gas at depth for 3 dives. The fact that I run regularly might have put me on a lower hydration base to start with, and although I loaded up at the start of the day I failed to maintain the rate of fluid intake as the day progressed and the dehydrating effects of the day took hold.

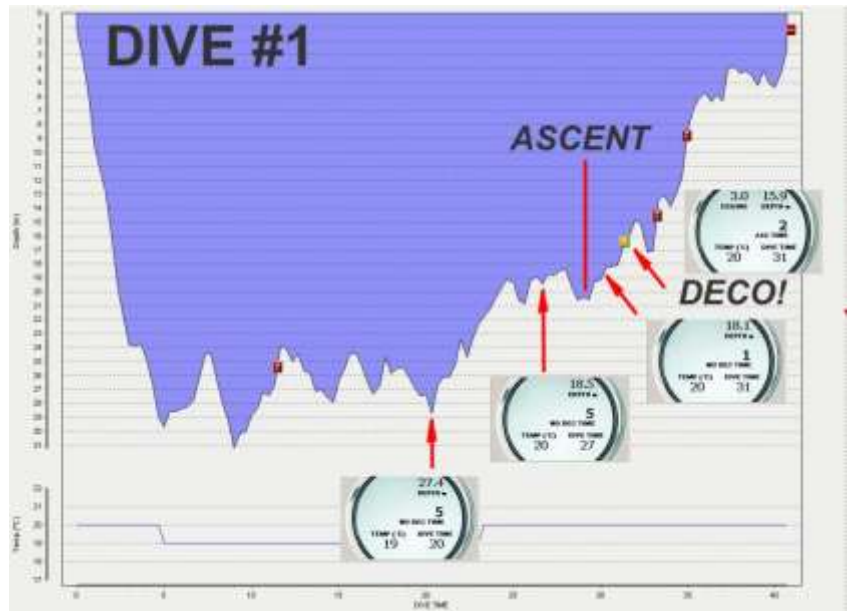
The numbness in my hand and aches in my arm and shoulder may stem from an old sailing injury. I damaged my shoulder and tore some muscles resulting in scar tissue forming. That scar tissue is not as well supplied with blood vessels as the surrounding healthy tissue, and so cannot off-gas as effectively. Lower hydration would negatively influence that further. The three dives, all of equal nominal max depth, average depth and duration, caused tissue loadings that the impaired blood supply was unable to clear. The 4hrs of O2 successfully created a pressure gradient that allowed the nitrogen to be removed from the scar tissue and out into the blood stream, thence to my lungs and away.

#### DIVE PROFILES

As described above, we performed three similar dives that might individually be described as 'normal' Waikato dives. With the ability to download and analyse my dive profiles, I have looked into the 'chasing' the 5min of no-deco limit and I have found that the snap-shot you take of your computer display at intervals throughout a multi-level dive can lead to a misinterpretation of the reality of the situation.

#### DIVE 1

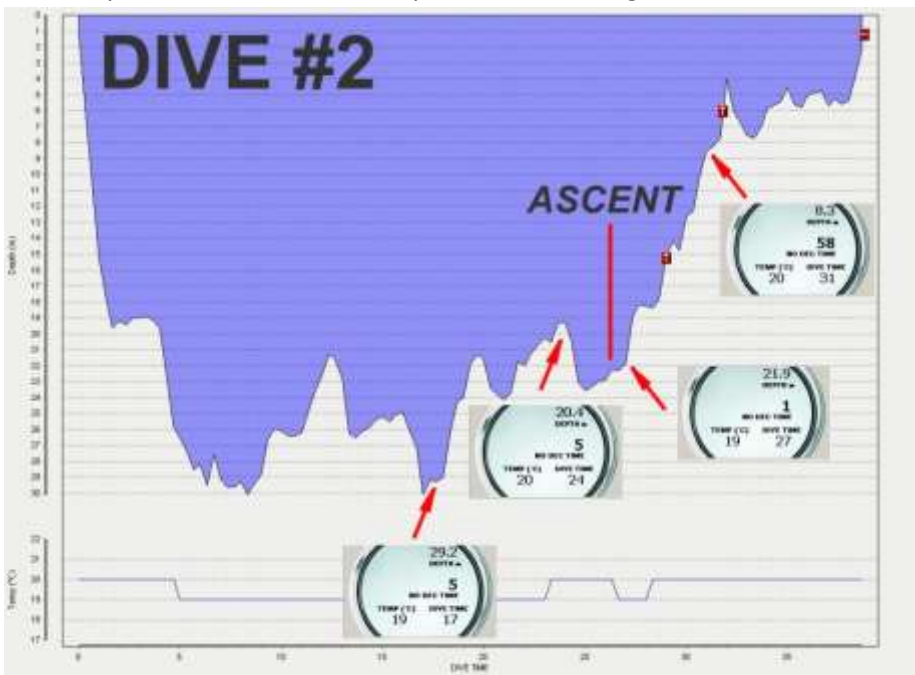
From the screen shot below it can be seen that I got three ascent warnings at 11mins, 33mins and 35mins. These are generated when ascent rates exceed 10m/min – which is close to the GUE recreational rate of 9m/min for up to the half average depth (which I selected to be 15m in this case) so quite tricky to avoid tripping these (but that's half the 18m/min that PADI suggests as a safe maximum rate).



From the data logged at 20sec sample rate I got:

Time 1	Depth 1	Time 2	Depth 2	Rate
11:10	27.4m	11:40	23.9m	7m/min (!)
33:00	17.1m	33:20	13.4m	11m/min
34:40	11.9m	35:00	8.3m	10.8m/min

The computer displays show the 5min-no-deco at 20 and 27mins, at each point we initiated a lift. The 2m dip at 28/29min was me returning to Mike to signal 5mins, and the dip at 32mins was me dropping back down the line to re-affirm the signals for the ascent stops so we would ascend together. However, the DECO indication at 31mins went unnoticed because I was running the ascent on my right wrist UWATEC bottom timer. On my left wrist my D9 called for a 2min stop with a 3m ceiling, which had cleared itself on the ascent and was showing a 3min 'safety stop' on arrival at 6m.



### DIVE 2

Like Dive #1 I was pinged for ascent rates momentarily exceeding the D9's 10m/min rate (although, and as for Dive #1 based on the data one of those is slower than 10m/min). No DECO was flagged this time, but at 27min, a minute into the ascent my no-deco time was at 1min remaining – again unnoticed due to my UWATEC being the instrument of interest at that time. 4mins into the ascent my D9 was showing 58mins no-deco.

Time 1	Depth 1	Time 2	Depth 2	Rate
28:40	17.8m	29:00	15.1m	8.1m/min (!)
31:40	7.7m	32:00	4.4m	11.1m/min

### DIVE 3

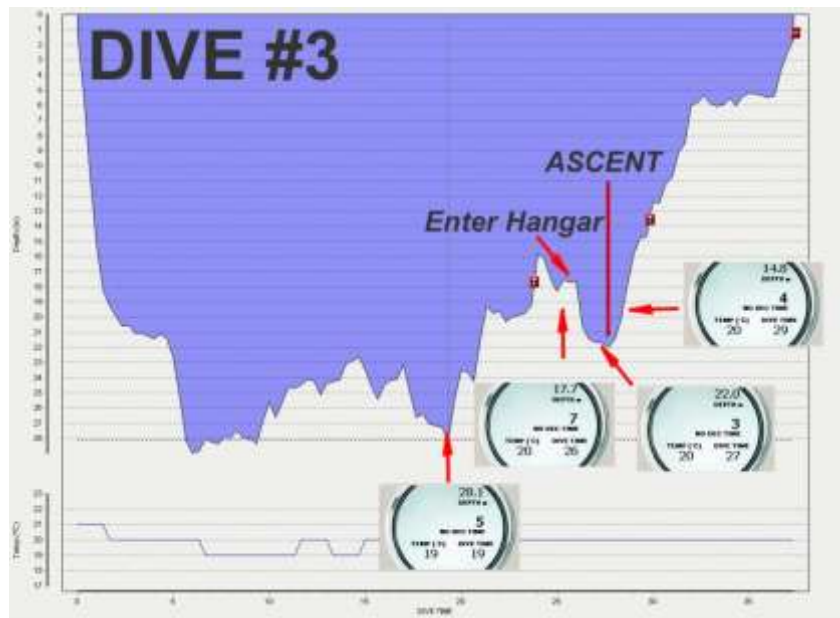
Same as Dive #1 and #2 I had momentary ascent violations, but one within the D9's stated threshold, and one marginally beyond it. With 7min no-deco called at 26mins Mike and I re-entered the hangar, and within 1 minute the margin had dropped to 3mins remaining! Mike, who was 2m deeper than me actually signed 1min remaining – at which point we made a prompt exit and ascent.

Time 1	Depth 1	Time 2	Depth 2	Rate
23:40	19.2m	24:00	15.8m	10.2m/min
29:40	14.7	30:00	12.4m	7m/min (!)

## CONCLUSIONS

I'd not been in the water for 3 months and was certainly not "dive fit". My profiles show wobbly ascents on the first two dives, with the third looking a bit tidier, but even then a faster than ideal rate of ascent throughout.

That we did three 40min, 30m air dives back to back, with no deco gas, was probably adventurous. That we 'chased' the no-deco limit is probably acceptable on one, possibly two of those dives. But to chase it on all three, and go beyond it was (certainly in retrospect) ill-advised. That we didn't use Nitrox to extend our no deco limits is also a trick missed. I had an O2 deco bottle sitting at home with 150bar in it but I didn't take it for these 'easy' dives.



We were lured into a third dive by the prospect of great conditions rarely seen at the wreck, and Mike's lack of comfort on the third dive was possibly due to the cumulative effects of sun, heat, dehydration and tissue loading starting to take their toll. My shoulder playing up after dive 2 may well have been an indicator of something brewing. We ignored those signs.

That shoulder injury potentially predisposes me to DCI, I was dehydrated, starting from a low hydration base, with a decreasing rate of hydration during a day of increasing dehydration. We sat in thermals and drysuits all day in the sunshine (albeit seeking shade where possible and with hats and sunscreen on), and probably incurred a degree of heat stress.

The 5min no-deco limit is only of any use if observed –as in both read and then adhered to. Ascending 5m or so to gain a few minutes is acceptable, but penetrating the wreck in that shallower phase was potentially hazardous as an entanglement would have led to incurring unplanned deco there and then.

I know from my training that ascending to a shallower depth does not prevent on-gassing. In these three dives the slower compartments were on gassing all the time at depth, and our pushing the 5min no deco limit, and unknowingly going beyond it, reduced the no-deco time in a non-linear manner.

Did the momentary ascent violations have an effect on micro-bubble formation – my knowledge runs out at this point. Technically it's possible, but the instances were both short lived and not excessive rates. For an injured shoulder muscle block, maybe they had some impact....?

There is nothing in these conclusions that I did not already know. Like many incidents it is the combination of factors (each of which in isolation would not lead to an incident) that is the root cause. What I draw from this is how easy it is to let such a combination form:



#### CONDITIONS

- Lack of dive-fitness
- A hot, sunny day
- 21% rather than 32% Nitrox
- Lack of proper hydration
- Existing shoulder injury
- P-valve fitted, but not used
- O2 stage left at home
- Perfect diving conditions leading to....

#### ACTIONS

- Multiple aggressive profiles with....
- Unplanned/unnoticed(!) deco and....
- Multiple ascent violations
- Faster than optimum overall ascent rate
- ....and multiple warning signs ignored!

You wouldn't find that combo listed in a book on good ideas, would you? The engineer in me (and maybe Mike too?) set out to observe the letter of the law with the 5min no deco limit, rather than the spirit – which is don't push too hard, as it is not something worked to a 3 decimal place level of accuracy.

I am grateful for the swift and professional actions of Kate, Evan and Laurent at Dive!Tutukaka, the patience and support of Mike Smith and the care given by the first responders, St. John's and Whangarei ED.

Dive safe!