EXPEDITION ‘JOB 74’

Summary of Expedition ‘Job 74’ which carried Explorers Club Flag #118 to the wrecks of HMS Prince of Wales and HMS Repulse, South China Sea, May 13th – May 25th 2007.

Report written and submitted by expedition member and flag applicant Kevin Denlay, Fellow International 1998.

“They shall not grow old, as we that are left grow old. Age shall not weary them, nor the years condemn. At the going down of the sun and in the morning we shall remember them.”
EXPEDITION ‘JOB 74’

PREAMBLE

The two British capital ships of Force Z, HMS Prince of Wales and HMS Repulse – a battleship and a battle cruiser respectively - were sunk by Japanese aircraft in the South China Sea off the east coast of Malaysia on December 10, 1941, just days after the Japanese attack on Pearl Harbour. Notably, they were the first capital ships to be sunk solely by air attack whilst underway at sea and fully prepared for action. Their dramatic sinking with significant loss of life spelled the end of the battleship era and ascendancy of air power, which subsequently lead to the aircraft carrier dominating the war at sea.

Job 74, from which the expedition took its name, were a series of exhaustive underwater explosive tests carried out during the mid 1930's by the British Royal Navy to determine (and supposedly ‘confirm’) that the protective design system to be incorporated into the hull of their most modern class of battleship soon to begin construction (the King George V Class) – of which Prince of Wales was one – was impervious to torpedo damage. However, in the very first ‘real life’ test, the anti-torpedo protection system incorporated into the hull of Prince of Wales as a result of Job 74 proved woefully inadequate.

Both wrecks now lay upside down, or virtually upside down, Prince of Wales even more so than Repulse, and in 68m/223ft and 54m/177ft of water respectively. Over the years since their sinking there has been much conjecture and debate as to exactly how many torpedoes actually hit the two ships, from the overly optimistic claims of the Japanese air crews, to the more moderate and generally accepted reports of the British survivors themselves. My intention, and my main task on the expedition, was to concentrate on recording video footage along the hulls of both Prince of Wales and Repulse so as to ascertain exactly how many torpedo holes there actually are in both hulls and exactly where they are located. The resultant video footage would then be provided to historians, etc, as ‘physical evidence’ of the hits themselves, and to ‘back-up’ any discrepancies the expedition might find as to what’s contained in the historical record with regards the overall number of torpedo hits and the actual damage sustained.

A total of eight Closed Circuit Rebreather (CCR) divers would take part in the overall expedition, although only three of those, expedition leader Dr Andrew Fock, his dive partner retired Royal Navy officer Graham Sharpe Paul, and I, would actually participate in the hull survey itself. All divers would however participate in two associated medical tests conducted by Dr Fock, a hyperbaric physician from The Alfred Hospital, Melbourne, Australia.

All expedition members traveled from Australia to Singapore in mid May 2007 where we boarded the dive vessel MV Empress which we had charted for our expedition to the wrecks. We then spent a total of ten days out in the South China Sea, which allowed for four days of diving on each of the two wrecks, with a day needed to travel up to the wrecks from Singapore and a day of travel to return to Singapore. All dives were conducted using helium based breathing mixtures and required extensive decompression, the final stages of which were conducted on a purpose built ‘decompression station’ suspended under the dive vessel with surface supplied oxygen available from 6m/20ft.
EXPEDITION ‘JOB 74’

EXPEDITION OBJECTIVES

1) Survey the hulls of both vessels using video cameras to ascertain exactly how many torpedo holes are actually in each ship and exactly where they are located. It was also hoped that besides providing the subsequent footage to interested historians, information garnered from viewing this footage could be used to definitively illustrate 3D models of the upturned vessels showing exactly where the hits are on the hulls, rather than where there are ‘thought to have been’.

2) Use a ‘look down, shoot down’ video filming technique – with a video camera mounted vertically on the front of a diver propulsion vehicle (i.e. scooter) - to gather footage of the wrecks, ‘from above’ as it were, that would be then used to make a photographic mosaic of both ships as they now lay.

3) Daily testing/recording of all divers on the expedition, even those not directly involved with the hull survey itself, for symptoms of Hyperoxia Induced Myopia (HIM) by Dr Andrew Fock using a Snellen chart and various strength dioptr lenses. (As stated previously, all divers were diving using Closed Circuit Rebreathers which hold a constant partial pressure of oxygen during the dive, and were decompressing on 100% oxygen from 6m/20ft and above, both factors which are known to contribute to HIM, especially when conducting long deep dives over multi day periods as the divers on this expedition were doing.)

4) Daily testing/recording of all divers on the expedition, even those not directly involved with the hull survey itself (again by Dr Andrew Fock and using a Spirometer) for symptoms of Pulmonary Oxygen Toxicity, another side effect when diving using constant partial pressure CCR’s and decompressing on 100% oxygen over a multi dive/day period as the divers on this expedition were doing.

<table>
<thead>
<tr>
<th>Expedition members</th>
<th>Rebreather model used</th>
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<tbody>
<tr>
<td>Andrew Fock</td>
<td>Inspiration CCR</td>
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<tr>
<td>Les Rothbart</td>
<td>Inspiration CCR</td>
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<td>Andrew McIntosh</td>
<td>Inspiration CCR</td>
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<td>Ian Brice</td>
<td>Inspiration CCR</td>
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<tr>
<td>Jim Moroukis</td>
<td>Inspiration CCR</td>
</tr>
<tr>
<td>Graham Sharpe Paul</td>
<td>Evolution CCR</td>
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<tr>
<td>Mike Campbell</td>
<td>Prism CCR</td>
</tr>
<tr>
<td>Kevin Denlay</td>
<td>Mk15.5 CCR</td>
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</tbody>
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After arriving ‘on site’ we spent the first four days diving on HMS Repulse and the subsequent four days diving on HMS Prince of Wales, which lays approximately nine nautical miles southeast from the wreck of Repulse. Disappointingly, while the surface conditions were literally perfect for our whole time at sea, with calm ‘glassy’ conditions each day, the visibility on Repulse was poor to begin with and it continued to deteriorate, literally on a daily basis, as the expedition progressed and we moved over to Prince of Wales. Given the depth of the dives, the poor visibility, the strong currents at times and the sheer magnitude of the wrecks themselves (Repulse is 242m/794ft overall and Prince of Wales is 227m/745ft overall), it made for ‘challenging’ conditions to say the least.
EXPEDITION ‘JOB 74’

Results of Objective 1 on HMS Repulse

Repulse is the shallower of the two wrecks, resting almost upside down in 54m/177ft of water, although the starboard deck edge itself is ‘held up’ well off the seabed by parts of Repulse’s forward superstructure protruding from under the wreck out across the seabed, with the elevation of the deck edge (or the ‘tilt’ of the deck off the seabed as it were) tapering off gradually until the stern of the ship is basically flush with the seabed. Hence this ‘elevation’ along much of the starboard side of the wreck has tended to have pushed – for want of a better word – or ‘orientated’ Repulse’s port side hull down into the seabed, especially in the amidships area. As a result the sand has built up to such an extent that much of the port hull amidships is now completely hidden/buried beneath the seabed itself. (This, as it turned out, seriously hindered part of our survey.)

British accounts state that HMS Repulse was thought to have been hit by five torpedoes, with four hits in various places along the port side and one hit amidships on the starboard side. Our expedition could only confirm the hit amidships to starboard and one of the hits to port (beneath the port inner propeller) but could not locate any of the other three reported hits to port even though I did ‘video runs’ along the port side hull on separate dives specifically looking for these hits/holes.

However part of the reason for not seeing two of the hits/holes could be that where these two hits were reported to have been, port amidships, the sand/seabed has built up to such an extent against the hull in this area as to have covered any actual torpedo holes that may be there. There was some evidence in two areas along the port hull amidships, right on the seabed, where there was what appeared to be some ‘dimpling’ or crumpling of the hull, but no evidence of actual jagged penetrating holes, as can be seen say starboard amidships. There could be times however when the ocean currents scour the sand out ‘deeper’ along the port side hull, resulting in exposing a greater expanse of the hull side itself for investigation around these ‘dimpled’ areas, but while we were on site there was only about 2.5m/8ft of hull showing between the port bilge keel and the seabed amidships. Therefore any torpedo holes that may have been higher on the port hull itself in this area would have been buried (hidden) under the actual seabed itself.

It should be noted however that the other, or fourth ‘reported’ torpedo hit to port towards the stern, supposedly abreast Y turret - an area where the seabed/sand has not built up against the hull to any great extent and hence which should have left any hole clearly visible - was simply not seen to be there.

We spent four days diving on Repulse, with the visibility steadily deteriorating on a daily basis, which did not bode well for - and subsequently proved to be the case - on our next target, HMS Prince of Wales. (On both wrecks two dives a day were conducted by most members of the expedition, with each divers bottom time - i.e. the time spent actually on the wreck - ranging from thirty to fifty minutes, which resulted in total in-water time - or ‘run times’ including decompression - of between one and half and three hours per dive.)
Arrows indicate where Japanese aircrews thought 13 of the 35 torpedoes launched at HMS Repulse hit. (Above diagram as reported by Japanese sources.)

British sources record only five torpedo hits, as shown above.
Black solid circle on hull = Suspected starboard side torpedo hit.
Black outline circles on hull = Suspected port side torpedo hits.

Expedition ‘Job 74’ could confirm only two hits as shown, although as stated previously the two port side amidships hits may have been buried beneath the seabed at the time the expedition was conducted. However, the suspected hit abreast the rear turret is not there.
Black solid circle on hull = Confirmed starboard side torpedo hit.
Black outline circle on hull = Confirmed port side torpedo hit.
EXPEDITION ‘JOB 74’

Results of Objective 1 on HMS Prince Of Wales

Prince of Wales also rests upside down (even more so than Repulse) in 68m/223ft of water with, again, the starboard deck edge held up off the seabed but in this case by only about 4m/13ft in the amidships area - which is much less ‘elevation’ than seen on Repulse. Subsequently the port hull amidships is only partly buried, with the deck edge down to about two thirds the original waterline under the seabed, leaving the lower portion of the armour belt through port amidships clearly visible (unlike on Repulse). The port deck edge forward of A turret remains held up off the seabed a little, while the very stern is basically flush with the seabed, or only ‘just’ buried. Therefore, given this relatively ‘favourable’ orientation of the hull, all the areas where torpedoes were reported to have hit Prince of Wales would be expected to be clearly visible above the seabed.

British accounts state that HMS Prince of Wales was hit by at least six torpedoes, four on the starboard side and two to port. Our survey results differ in the fact that we found ‘only’ three large jagged holes to starboard and ‘only’ one to port and can categorically state that there are no ‘jagged holes’ where (two) torpedoes were reported to have hit on the starboard and port hull beneath the mainmast and the rear funnel respectively. The hull both fore and aft of this area is however ‘dished in’ longitudinally – from about frame 274 to about frame 168 on the starboard hull and about frame 270 to about frame 150 on the port hull - and is ‘split’ longitudinally along the base of the armour belt for quite some distance in those areas, and is ‘crumpled’ in places along there also. The damage observed along these two sections differs dramatically though from the gapping jagged holes in the four other areas where torpedoes have actually ‘blown open’ the hull.

Video survey footage shot along the entire starboard hull therefore confirms only three large jagged penetration holes at; 1) The very bow itself – so close to the bow stem that the stem itself is broken/cracked and the hole actually penetrates right through the ship from starboard to port; 2) Beneath B turret just forward of the bridge; 3) At the very stern centered around the area of the outer propeller shaft ‘A’ bracket. Video survey footage shot along the port hull confirms only one large jagged penetration hole, which is at the stern between the port outer propeller shaft ‘A’ bracket and where the port outer propeller shaft enters the hull. The same video footage however shows no jagged penetration holes - as specifically seen in the above four areas - anywhere else along the port or starboard hulls and specifically not in the general area of the mainmast or rear funnel where the same gapping jagged holes were expected to have been found.

We spent a total of four days diving on Prince of Wales, with the visibility continuing to steadily deteriorate on a daily basis, until on the last day it was only about 3m/10ft.

Footnote: Video footage of the hull of Prince of Wales has since been forwarded to British naval historians and we eagerly await their assessment, especially of the damage documented between frames 274 and 168 starboard and between frames 270 and 150 port. As stated above, even though two distinct but separate torpedo hits were reported along those areas there were none of the jagged torpedo ‘holes’ that we found elsewhere. What we have documented (on both wrecks) certainly appears at odds with the historical record.
EXPEDITION ‘JOB 74’

Arrows indicate where Japanese aircrews thought 7 of the 14 torpedoes launched at HMS *Prince of Wales* hit. (Above diagram as reported by Japanese sources.)

British sources record six torpedo hits, as shown above.
Black solid circles on hull = Suspected starboard side torpedo hits.
Black outline circles on hull = Suspected port side torpedo hits.

Expedition ‘Job 74’ could confirm only four hits, in the areas as shown above. If the hits reported beneath the mainmast and rear funnel actually struck the ship they have not penetrated the hull like the others have. However considerable indentation exists on both sides of the ship along the entire length of the shaded grey area - shown above - with longitudinal splitting in some parts in this area, right beneath/along the armour belt base.
Black solid circles on hull = Confirmed starboard side torpedo hits.
Black outline circle on hull = Confirmed port side torpedo hit.
**EXPEDITION ‘JOB 74’**

**Results of Objective 2.**
Because of the poor visibility (and low ambient light) encountered on both wrecks, which at the start of the expedition when we first dived on *Repulse* was at most about 8m/25ft on the seabed, and which continued to deteriorate until the last days on *Prince of Wales* when it was only about 3m/10ft or less in parts, it was not possible to shoot the type of video footage necessary for making a photo mosaic.

**Results of Objective 3**
Dr Andrew Fock conducted daily visual acuity tests on all divers using a Snellen chart and various strength diopter lenses to quantify any refractive change in vision that may be attributed to Hyperoxia Induced Myopia, and a summary by Dr Fock is attached as an appendix to this report.

**Results of Objective 4**
Dr Andrew Fock conducted daily pulmonary tests using a Spirometer to ascertain any changes in pulmonary functionality that may be attributed to the high levels of oxygen that the divers were exposed to, and the subsequent oxygen ‘loading’ that was ‘accruing’ in their bodies on a daily basis over the period of the expedition, and a summary by Dr Fock is attached as an appendix to this report.
EXPEDITION ‘JOB 74’

Appendix A:

Medical Aspects to Expedition ‘Job 74’

The toxic effects of oxygen on the lungs was first described by Lorraine-Smith[1] in the late part of the 19th Century. This was further quantified by the Royal Navy[2] during the second world war and the United States Navy[3] post war. However, these studies were conducted using single exposures. In the 1980’s Hamilton et al [4]developed the REPEX (repetitive exposure) tables for dealing with repeated exposures to high levels of oxygen encountered in deep sea habitats. This has been extrapolated to estimate pulmonary oxygen toxicity for sequential oxygen exposures in recreational diving, but, to the researchers knowledge, has never been validated in recreation technical divers. Technical divers using CCR SCUBA (Closed Circuit Rebreather Self Contained Underwater Breathing Apparatus) are particularly at risk of oxygen toxicity from repeated exposure. This is because the apparatus maintains a high level of oxygen (usually 1.3 ATA) for the duration of the dive. Additionally, technical divers will often use pure (100%) oxygen for the final part of the dive to reduce decompression times. During a recent self reporting health survey of this group of divers during an 8 day technical diving expedition, we detected symptoms suggestive of pulmonary oxygen toxicity in 50% of the divers. These symptoms commenced between day 4 and day 6. This study aims to quantify pulmonary oxygen toxicity in a similar group of technical divers performing a series dives during several diving expeditions conducted in 2007.

Serial basic respiratory function tests are performed on a daily basis (including pre and post expedition) to assess any decrement in pulmonary function. These tests are of a non invasive nature involving basic spirometry with the results stored onto a laptop computer in a suitable data base. Tests are performed at approximately 4 hours post dive. Oxygen exposure are derived by interrogation of the divers dive computers to calculate the partial pressure of oxygen multiplied by the time of exposure in minutes as described by Bardin et al[5]. All participants are also asked to complete a health survey at the completion of each days diving. As divers have also reported changes in Visual Acuity when exposed to repeated high oxygen levels (Hyperoxic Induced Myopia), each diver is asked to record changes in their eye sight using a Snellen visual acuity chart and a series of corrective lenses. This test is performed each morning prior to diving with the observer recording the lens value (in dioptres correction) which produced the clearest vision for each diver and each eye. Results will be published in an appropriate Hyperbaric and Diving journal (probably Diving and Hyperbaric Medicine). It is hypothesised that information gained from this research will enable us to make suitable recommendations about limiting oxygen exposure in this group of divers as well as recovery times from repeated oxygen exposure.

Statistical Analysis
All analysis will be performed using SAS version 8.2 (SAS Institute Inc., Cary, NC, USA.). Univariate analysis will be conducted using paired t-tests for normally distributed outcomes and Wilcoxon sign rank tests should the outcomes be found to follow non-parametric distributions. Multivariate analysis will be performed using generalized linear modeling adjusting for repeat measures and potential covariates. Results will be further validated by considering changes from baseline.
EXPEDITION ‘JOB 74’

Sample size
Whilst the exploratory and descriptive nature of this study should reduce the need for formal power calculations, with a minimum of 8 subjects this study will have an 80% power to detect an effect size of 1.4 standard deviations with a two-sided p-value of 0.05.


Appendix B:

Medical results from Expedition ‘Job 74’:

The results for this expedition are part of the overall study which involves 30 divers and three expeditions. As such formal analysis of the results from this part of the study have not yet been conducted. However, the following observations were made:

- Despite symptoms consistent with pulmonary oxygen toxicity, no consistent decrement in pulmonary function was observed (subject to statistical confirmation).
- Symptoms were worse if the divers were using open circuit surface supplied oxygen at the final decompression stops rather than remaining on their CCR units.
  - This may have been due to the dry gas breathed when using open circuit?
- No significant decrement in visual acuity was noted using the methods described in appendix A. However, due to the restrictions of the vessel, a modified Snellen chart at 3 metres instead of 6 metres was used. This may have confounded the results as several divers still complained of symptoms of HIM.
- Despite several divers exceeding the REPEX limits and the NOAA daily Oxygen limits, no Central Nervous System toxicity symptoms were observed.
- Despite repeated dives in the “Extreme Exposure” range of the diving tables, very few symptoms of decompression sickness were observed and those that were seen were treated with in-water recompression with excellent results.

Dr. Andrew Fock MB;BS FANZCA Dip DHM
July 2007
Dr Andrew Fock (left) and Explorers Club member Kevin Denlay with their respective Closed Circuit Rebreathers and EC Flag 118 at the completion of Expedition ‘Job 74’.

**Naval References:**


