HYDROGRAPHIC SURVEY WORK TO ASSIST THE SALVAGE OPERATION

Refloating the Pasha Bulker

On Friday 8 June 2007, the bulk carrierPasha Bulkerran aground in heavy storm conditions on one of Newcastleâ€™s most famous surfing beaches, Nobbys, near the entrance to Newcastle Harbour in New South Wales, Australia. As part of the large-scale salvage operation, the Survey Section of Newcastle Port Corporation and the Coastal Unit of the Department of Environment and Climate Change were called on to use their high-tech survey systems to provide bathymetry, navigation support and other services to the salvors. In the end, both departments made significant contributions to the success of the salvage operation. This article looks at the equipment and techniques used in testing conditions and the remarkable results achieved.<P>

Survey tasks were initially broken down into four categories: location of any existing relevant information; shore surveys; single-beam surveys; and multi-beam surveys. Although the Newcastle Port Corporation (NPC) was equipped with a multi-beam system and had single-beam equipment available, the Department of Environment and Climate Change (DECC) Coastal Unit were called in at the initial planning stage because of their unique system for surveys in the surf zone.

Initial Survey Support
Searches were made for readily available information that may have shown bathymetry around the grounding site. The only definitive information that could be found, however, was from old charts prepared in the 1950s and 1970s. These were single-beam surveys that depicted rock shelves only in general terms. However, an extensive survey conducted by the DECC in 2002, consisting of shore-normal survey lines at 50m intervals, provided a good general overview.
The first field task was to accurately locate the position and orientation of the casualty. Directly boarding the casualty at that stage was difficult and hectic as preparation for the salvage work was being undertaken and the only access was by helicopter. It was decided that the most efficient and convenient method was to simply intersect the fore and aft navigation lights from three shore control points. The general arrangement for the Pasha Bulker was obtained and the precise ship outline was plotted digitally against a background of the available information. When used in conjunction with aerial photography, this allowed the salvage master to map out his intended operation, and an area 500 by 800m was identified as requiring intensive multi-beam survey.

Multi-beam Surveys
A risk assessment was carried out for the survey work. From this, it was decided that an extra crewman would accompany the survey team to act as observer for rogue swells, while the pilot cutter would shadow the survey vessel to act as a rescue team in case of an incident. Swell and sea conditions were regularly monitored. While conditions prevented sounding, the survey team was kept busy with pre-survey planning and chart preparation in the office. As a result of the storm, the worst flood in 30 years had reached the harbour area. The normal work for the port had to continue and surveys needed to be done to gauge what loss of depth was being experienced so that the pilots could monitor loading drafts accordingly.
By the afternoon of Tuesday 12 June, seas and swell had abated a little. With time critical, the NPC survey team of Bass Randall, Dave Connors, Fred Eckford and Darren Stocker set off to commence the multi-beam survey, despite swell conditions still about 3 to 4m. Poor conditions persisted, forcing the survey to be carried out over five sessions on separate days and into the second week. All sessions had swell of around 3m or more. While the multi-beam survey was finished on Thursday 21 June, conditions had been unsuitable to undertake any survey in the surf zone.
Using the multi-beam data supplemented by the single-beam data from 2002, the salvage master formulated a preliminary salvage plan. This involved the laying of three sea anchors to allow the casualty to assist in towing itself off the rocks using its own winches. The anchors needed to be located as close to the ideal positions as possible. It was then necessary to extend the multi-beam survey 300m further into deeper water to allow the seabed to be investigated.
Eventually, an area 800 by 1,400m had been surveyed with 200% coverage, from 200 to 800m off the casualty. The high resolution available from the multi-beam system was very useful to the salvage attempt, allowing sun-illuminated images to be formed that clearly showed areas of rock and sand, and allowed precise planning of the escape route.

Multi-beam Equipment
The NPC first commissioned the multi-beam echosounder system on its 9m survey launch, John Shortland , in October 2004. The survey team is now quite experienced and confident in its use, an obvious advantage in an emergency situation. The system comprises:
- RESON SeaBat 8125 high-resolution multi-beam echosounder
- Applanix POS MV 320 version 4 with Real-Time Kinematic (RTK) option, high-accuracy motion sensor and inertial navigation system
- Sea-Bird MicroCAT sound velocity probe
- data collection and navigation PC with two Neovo flat-panel monitors (one surveyor, one helmsman)
- QINSy version 8 data collection (launch) and processing (office) software
- Trimble 5700 RTK-GPS base station for 1cm performance of the POS MV
- Pacific Crest base and rover data-link radios

- Qloud 3D processing software.

Coastal Unit of DECC

The survey in the surf zone required the specialist system developed by Stephen Holtznagel from the Coastal Unit of the DECC. DECC made available a rigid-hull 4.7m inflatable boat set up with RTK and single-beam echosounder to survey as much of the area within 200m of the casualty as possible. Shoal areas and areas requiring tight manoeuvring near the casualty were then filled in with a jet ski also mounted with RTK and single-beam echosounder. These surveys involved some risk to the survey personnel, with high turbulence created in the surf zone from the backwash off the vessel.

The Coastal Unit of the DECC has a 30-year history of conducting near-shore bathymetric surveys. The requirement to 'close the gap' between offshore, large-vessel surveys and onshore terrestrial surveys of the sub-aerial beach has driven the development of a succession of survey techniques.

The development of compact digital echosounders, rugged notebook computers and low-latency RTK-GPS equipment has provided an opportunity to deploy a full single-beam survey system in small light-weight vessels that can safely operate in the surf zone.

Single-beam Equipment

Both systems are built around a rugged laptop running HYPACK. In the case of the jet ski, the computer is controlled via a wireless (WiFi) touch screen, which is mounted in a waterproof housing in front of the driver.

The core of the hydrographic system is a Ceeducer, comprising a Ceestar echosounder, an Ashtech Z-EURO GPS card and a Wood & Douglas Very High Frequency (VHF) radio modem. Echosounder transducers are mounted in the sea chest on both vessels and fire though the hull. Both vessels can be equipped with interchangeable, 200kHz (2.75° beam), 200kHz (8° beam) and 30kHz (19° beam) transducer systems. The lower frequency transducers provide improved immunity to problems associated with entrained air and sediment commonly encountered in high-energy environments. Bed penetration is minimal in these environments. Smoothing due to the wide beam angle is negligible for shallow water use. For the current surveys, the 30kHz was used in the jet ski and 200kHz (8°) transducer was used in the inflatable. The inflatable is equipped with a TSS DMS2-10 heave compensator, mounted directly above the echosounder transducer. At this stage, the jet ski system relies on unaided RTK heighting.

On both vessels, the GPS antenna was mounted directly above the echosounder transducer. The final component is the GPS RTK base station, which consists of an Ashtech Z12 receiver and Wood & Douglas VHF radio modem.

Single-beam Surveys

It was more than two weeks after the grounding that the sea conditions had moderated sufficiently to deploy the inflatable. It was decided to run survey lines normal to the casualty, partly to minimise the interference due to the 44mm wire cables, which by this time had been deployed to attach the ship to offshore ground tackle. Most of the target area was successfully covered with 10m line spacing. The exception was Inner Nobbys Reef, which was amidships of and about 50m off the casualty, where seas were still breaking heavily.

On the following day, the jet ski was deployed in an attempt to fill in the gaps. Seven lines, this time parallel to the casualty, were run. However, on the eighth line, the operator was caught between an incident and reflected wave. The estimated 3 to 4m fall disabled the jet ski. The support crew on the inflatable was able to take the jet ski in tow without further incident.

Each survey utilised an RTK base station set up at Fort Scratchley, overlooking the survey area. This provided excellent line-of-sight radio transmission to the survey vessels with a range of little over 500m.

Supplementary Services

The laying of the sea anchors was carried out by the Pacific Responder, a 64-m anchor-handling tug from Cairns. The survey team set up a navigation computer on board running Geonav software. This is specialist survey navigation software that allows real-time GPS and gyro input, and shows the accurate position of the ship against a background coloured according to depth. With the input waypoints, the Pacific Responder was able to navigate to the required anchor position. Anchors were laid as close to the design location as possible, with a coordinate taken at the drop point.

Each position was later confirmed and the anchor cables tracked using the multi-beam system and plotted on the survey chart for inspection by the salvage master. While the cables were only 44mm in diameter, with the known drop point of each anchor, sufficient hits on each cable were obtained to be able to track each route. This clearly showed that two of the cables had snagged around rocks, which probably resulted in one of the cables parting during the first attempt to turn the casualty bow around towards open sea.

Following the success of using the survey navigation software for the anchor laying, the salvage master requested that similar systems be set up on the other two towing tugs, Keera and Woona . This gave a real-time display of each tug's position against a background of coloured depths taken from the bathymetry collected in the weeks leading up to the re-floating. A similar system was placed on the casualty itself to allow monitoring of movement and to allow it to navigate out along the chosen escape route once it had been towed clear of the rock shelves.

Data Results

Despite the expected significant errors in heave (up to 0.4m) due to the heavy swell conditions for most of the survey, the data in all multi-beam overlap areas was remarkably consistent. Rock shelves and isolated rock peaks were clearly and accurately shown.

The heave data for the inflatable vessel surveys proved to be unreliable and were discarded. The single-beam surveys were therefore based entirely on unaided RTK heighting.

A comparison was made between the multi-beam data and the single-beam data where the two surveys crossed. Results were surprisingly good with the general difference between the two surveys in the order of 0.2m. This gave confidence in both systems as not only had different styles of echosounder been used, but the DECC had used GPS RTK heights to determine seabed bathymetry, while the NPC had used tide data from the in-harbour tide gauge. In addition, most of the multi-beam data had been collected in 3 to 4m swell conditions.

A final chart was prepared from all available data collected in all sessions of the multi-beam and single-beam surveys. The chart showed all bathymetric data collected, the precise location of the Pasha Bulker and the anchor cable routes. It was supplemented with the single-beam data from the 2002 DECC survey.

The single-beam survey was also overlain on ortho-rectified aerial photography. This gave a good overview of the extent of rock shelves surrounding the casualty. In the end, the lack of coverage on Nobbys Reef was not critical to the salvage effort. The salvors had devised a strategy of pulling the bow of the casualty to face the open sea, pivoting it on its stern. Ballast manipulation meant that the vessel would be drawing less than 2m as it passed over the high point of the reef. The critical area for the tow out was that offshore of the stern of the casualty. It was well covered by the DECC and NPC surveys.

Rudder Search

During the initial salvage operation of turning the casualty to face the open sea, a section of the rudder broke off. The NPC was again called on to assist.
There was some irony in that, on the morning of Tuesday 3 July, the morning after the successful re-floating, seas were dead calm, with Nobbys Beach resembling a lake more than a surfing beach. This allowed the survey launch to get right into where the casualty had grounded and scan the area using the multi-beam system. One disadvantage with the SeaBat 8125 is the narrow swath in shallow water. This meant that the survey team had to do a number of passes over the investigation area to ensure 100% coverage was obtained.
Using Qloud 3D processing software and a lot of careful attention, the surveyor was able to eventually discern a rectangular shape of about the correct dimensions but only about 0.3m high, instead of the expected 1m. Having no other possibilities, the salvage tug was given the coordinates of the likely object and the missing section of rudder was found in that location and later salvaged.

Conclusion
The information supplied by the surveys was invaluable to the planning of the salvage, allowing previously uncharted rocks to be identified in critical positions that, in turn, led to a change in the planned escape route. The supply of accurate, spatially referenced data had significant impact on the success of the salvage and this highlights the major role that surveyors and state-of-the-art technology can take in emergency operations.
The salvors took full advantage of the high-tech knowledge of surveyors, not only for traditional hydrographic surveys but also to guide the tugs and the casualty itself during the salvage operation and to locate the missing section of rudder.
This project also provided the opportunity to test the DECC shallow-water survey systems in very severe conditions. The results demonstrated not only the robustness of the systems but also that the safety procedures developed to protect the operator are adequate.

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