

Navigation Act 1912  
Navigation (Marine Casualty) Regulations  
investigation into the capsizing of the  
landing barge

KEPPEL TRADER

and the subsequent fatality  
off the mouth of the Victoria River

Northern Territory

on

7 August 1995

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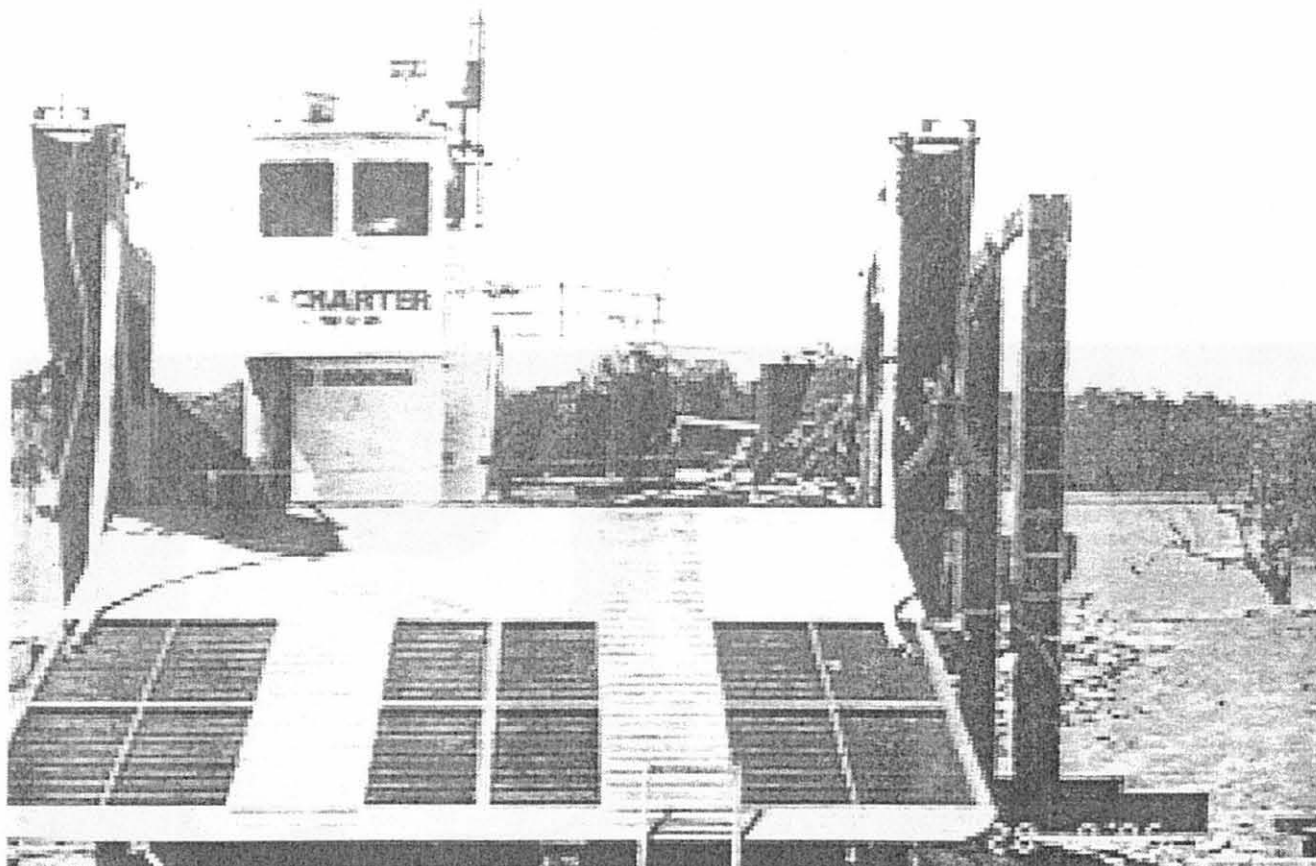
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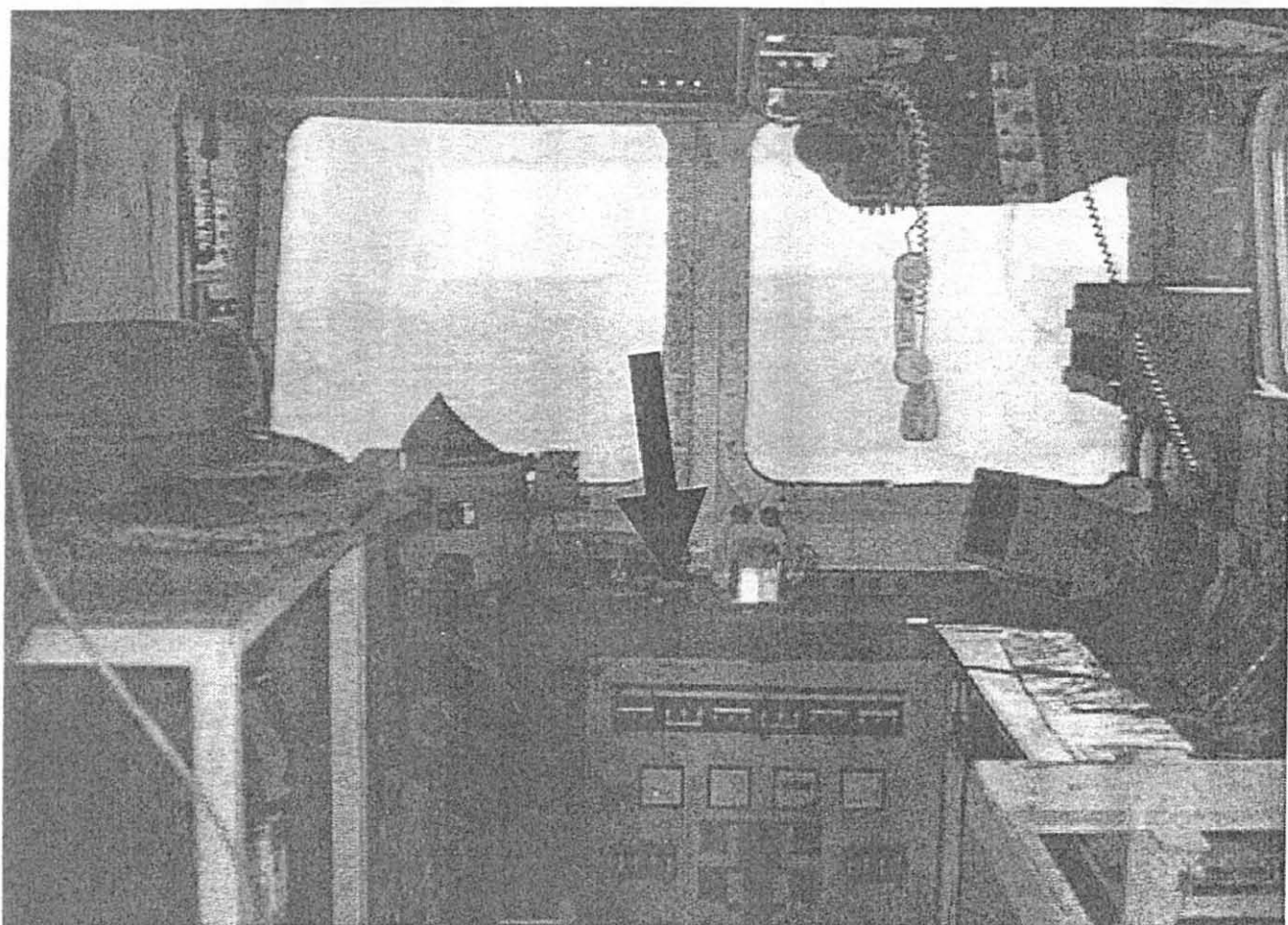
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'Keppel Trader' view from forward



On superstructure after action



Interior of wheelhouse after salvage  
Engine temperature gauges immediately to the left of the engine control  
levers (as marked)

# Summary

The 16 m landing barge Keppel Trader sailed from Darwin, Northern Territory in the early hours of the morning on 6 August 1995, bound for the port of Wyndham in Western Australia. On board were the Master and one deckhand.

On its deck, the barge was carrying a cargo of materials and equipment to enable it to be put on to a low-loader at Wyndham and transported overland to Lake Argyle. There it was contracted for thirteen weeks, to move equipment and stores during work on the Ord River hydro electric scheme.

The voyage plan was for the vessel to hug the coast, from Darwin to a position near Port Keats where, if necessary, it would anchor and wait for suitable weather conditions before making the crossing of the south-eastern corner of the Joseph Bonaparte Gulf at the mouth of the Victoria River. Strong south-easterly winds were forecast.

At about 0400 on 7 August, the vessel was south of Cape Hay when the Master handed the watch over to the deckhand instructing him to follow a course approximately one mile off the coast. The Master then turned in for a few hours sleep.

At some time before 0700, the Master was awakened by the motion of the vessel and found that it was in rough seas and approximately six miles off the coast, west of Pearce Point. The wind was blowing from the south-east

at 25-30 knots and an estimated 3.5 m sea was running. He decided to run with the weather for a while, but after a further twenty minutes turned on to a reciprocal course and headed back into the weather towards the lee of the coastline.

The vessel made no headway into the weather. After a while, the deckhand went down the engine room hatch, situated on the main deck, to carry out engine checks. He had been gone for about five minutes when the barge suddenly developed a loll. The Master left the wheelhouse and when he reached the deck, the barge appeared to be sinking by the stern. A few seconds later it rolled to port and capsized, settling in a stable, upside down, attitude. Both men were thrown into the water.

The Master twice managed to swim to the exhausted deckhand, who drifted away from the vessel, and twice dragged him back to the upturned barge. After several unsuccessful attempts to get the apparently lifeless deckhand up the sloping bow door, the Master, exhausted, let go of him and the deckhand drifted away.

By that afternoon, the owner of the barge, having not been able to make either radio or satellite phone contact with the vessel, flew his own aircraft down the vessel's intended route but did not find the barge. On the morning of 8 August, when Keppel Trader still had not arrived at Wyndham and there had been no communication with the vessel, the owner advised the Marine Branch of the Northern Territory Department of Transport and Works, which contacted the Maritime Rescue

Coordination Centre and a search and rescue (SAR) operation was initiated.

The Master was rescued late that afternoon by an army helicopter, after spending some 34 hours on the upturned hull and in the water.

Two weeks later Keppel Trader was towed back to Darwin having been salvaged and righted.

Although Keppel Trader is under survey by the Marine Branch of the Northern Territory Department of Transport and Works, it was on an inter-State voyage and thus came under the provisions of the Navigation Act 1912. As such, the incident was investigated by the Marine Incident Investigation Unit under the provisions of the Navigation (Marine Casualty) Regulations.

# Sources of information

The Master, Keppel Trader

Sandford Pty Ltd

Marine Branch, Department of  
Transport & Works, Northern Territory

Australian Maritime Safety Authority

Maritime Consultants (Australia)  
Pty Ltd

Maritime Rescue Coordination Centre,  
AMSA

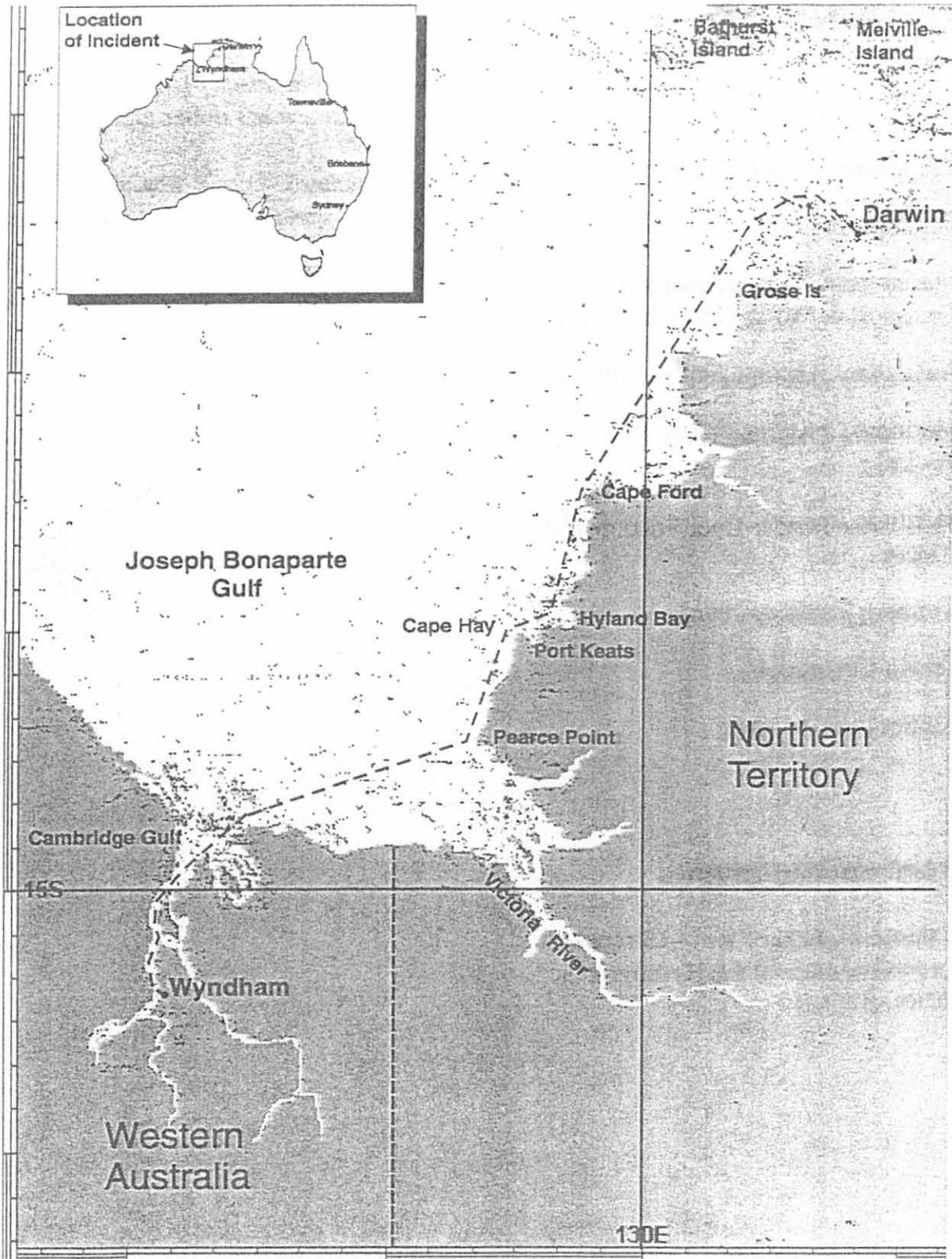
Northern Territory Police

Telstra Corporation

Air Services Australia

## Acknowledgments

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Portion of chart Aus 413 showing intended voyage of Keppel Trader, from Darwin to Wyndham

# Narrative

## Keppel Trader

Keppel Trader is a conventional single deck landing barge of 37.8 gross tonnes, with ramp bow door. It has a length between perpendiculars of 15.95 m, a beam of 5.1 m and a moulded depth of 1.68 m. It was built in 1976 at Yeppon, Queensland, originally to carry stores and vehicles from the mainland to Great Keppel Island. It was first registered in the Northern Territory in 1983 and has, since then, been under survey by the Marine Branch of the Northern Territory Department of Transport and Works as a class 2C vessel<sup>1</sup>.

The company operating Keppel Trader, Tiwi Barge Services, is a small company which usually employs about 10 workers and is situated at Hudson Creek near Darwin. It uses two vessels, Keppel Trader, which is entirely owned by Sandford Pty Ltd and Tiwi Trader, a larger barge of approximately 125 gross tonnes, which is part owned by Sandford Pty Ltd and part by Pirtunbulla, an Aboriginal cooperative and the trading arm of the Tiwi Land Council.

Keppel Trader was acquired by its present owners in 1977 and during the following years it was extensively modified to the point where little of the original structure remained. It was lengthened from its original length of 12.82 m, its beam and moulded depth were also increased, a new steel deckhouse, with wheelhouse on top, was added to the starboard side aft and

the vessel was re-engined. All of this work was carried out on the owner's slipway at Darwin and by May 1986, it had acquired its present configuration.

Keppel Trader was employed mainly around Darwin harbour doing a variety of work, such as ammunitioning naval patrol boats, salvage work and general contracting. It was also used on short voyages from Darwin to Bathurst and Melville Islands to supplement the operations of the company's larger barge, Tiwi Trader. On occasions, it has been used for longer voyages such as from Darwin to McArthur River and to Troughton Island.

Keppel Trader was powered by two, eight-cylinder, Perkins V8-510, 90 kW diesel engines driving, through Twin Disc reduction gearboxes, two 700 mm diameter contra-rotating propellers. Electrical power was provided by one 12 kVA, three phase, 415V Lister generator set and one 8 kVA, single phase, 240V Yanmar generator set.

In the wheelhouse, the barge was fitted with an autopilot, a 72 mile radar, digital depth sounder, HF radio with Cellcall, VHF radio and satellite telephone.

An external access to the machinery space is through a hatch on the main deck, with a 250 mm high coaming, adjacent to the deckhouse and slightly to starboard of the centre line. Another hatch to the machinery space is provided under the benchtop in the galley, giving internal access to the machinery space from within the deckhouse.

<sup>1</sup> Seagoing vessel for use in Northern Territory



**Access hatch to engine room from main deck**

The only access to the wheelhouse is external and is obtained via rungs welded to the aft bulkhead of the deckhouse and thence through an overhead hatch.

The barge was equipped with a 3.4 m aluminium dinghy powered by a 15 HP outboard motor. This dinghy was carried by a frame, in the form of davits, extending at an angle over the transom. Secured to the same frame, was a cradle for a 4-man RFD inflatable liferaft. The liferaft was secured in its cradle by a hydrostatic release and was attached to the vessel by a plaited nylon painter.

The normal complement for the vessel is two, Master and deckhand, the minimum safe manning level on the Northern Territory survey certificate. The maximum manning allowed by the certificate is four.

## **The voyage**

About three months before the incident, Keppel Trader was contracted to carry equipment and materials on Lake Argyle for the Ord River hydroelectric scheme. This contract was to employ Keppel Trader on Lake Argyle for thirteen weeks. The vessel's cargoes, such as pylons and conductors, were to be used for constructing a power line along the shores of Lake Argyle to supply electricity to the Lake Argyle diamond mine.

The plan was for Keppel Trader to sail to Wyndham in Western Australia, and from there, to be transported overland to Lake Argyle. On completion, the vessel was to be again loaded on to a low loader and transported overland back to Wyndham, from where it would return to Darwin. Before sailing from Darwin, Keppel Trader was

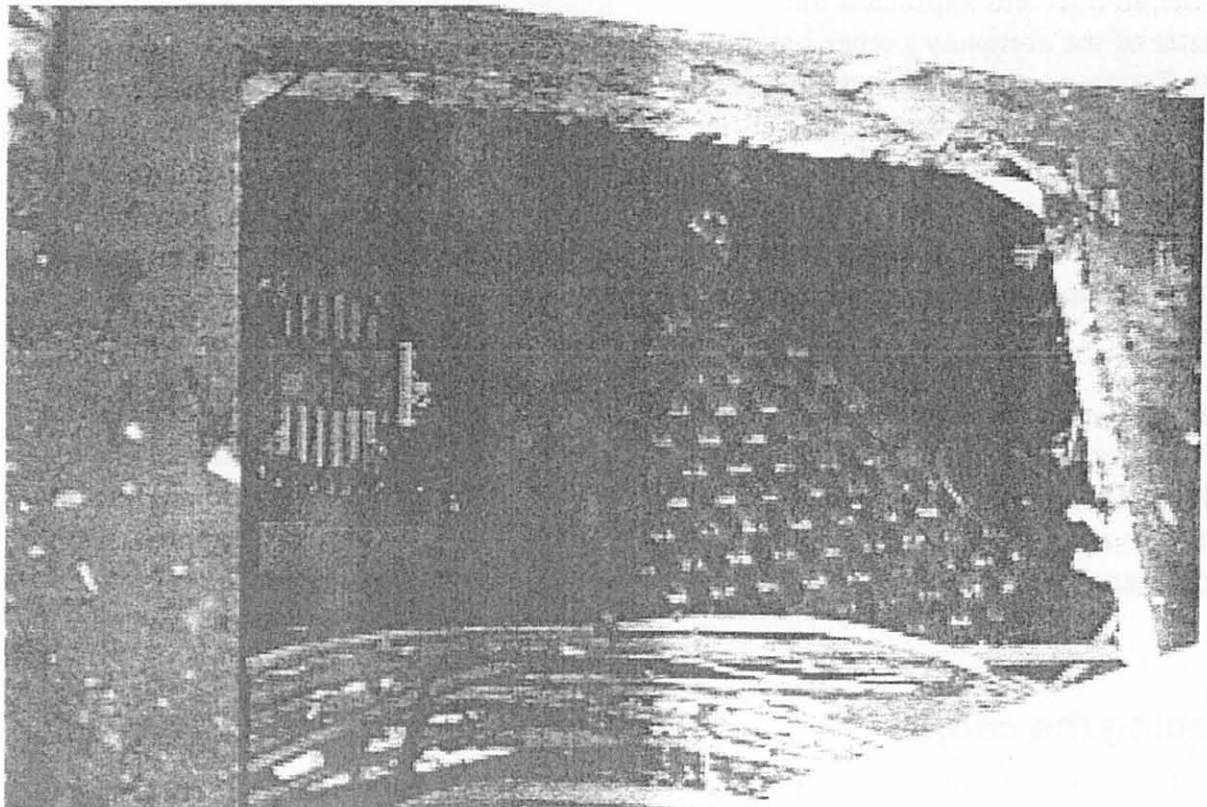
loaded with all the necessary equipment to enable it to be loaded on to the low-loader.

The planning for this operation engaged the owners for a period of about two months. For a while, the Victoria River was considered as a possible alternative to Wyndham, as perhaps being more suitable for loading the barge on to the low-loader, but it was eventually decided that Wyndham was the preferred option. This decision, therefore, meant that Keppel Trader would have to undertake an inter-State voyage.

It was intended that concrete blocks would be set up on the shore line and Keppel Trader would be floated over them at high tide and then lowered on



Internal access to engine room from under galley bench



Internal access to engine room showing compressor and cable runs

to them by the falling tide. At low tide, the low loader would be positioned underneath, and using a number of 50 tonne jacks, Keppel Trader would then be lowered on to it. At Lake Argyle, a similar procedure was to be followed, but utilising railway lines, sleepers and a slipway trolley to construct a makeshift slipway, there being no tide on the lake. Thirty empty oil drums were to be used to make a raft by means of which the underwater part of the slipway could be correctly positioned. On completion of the contract, the reverse procedure was to be followed to enable the barge to be transported back to Wyndham and then to Darwin.

It was customary for the owner to skipper Keppel Trader, but on this occasion as his aircraft was also required to be available during the course of the project. He decided to fly the aircraft and appointed the Master of the company's other barge, Tiwi Trader, to skipper Keppel Trader. The Master held a Master Class IV certificate and a Marine Engine Driver's certificate, both issued by the Marine Branch of the Northern Territory Department of Transport and Works.

The deckhand, who was a member of the usual crew, withdrew at a late stage in the planning of the voyage and his place was to be filled by the company's works manager.

## Loading the cargo

The afternoon of Saturday, 5 August, was spent loading Keppel Trader with the cargo of equipment and materials.

This cargo consisted of:

one 5.6 tonne Michigan 35R front-end loader fitted with forks;

one 1.2 tonne Toyota Hi-Lux twin-cab utility;

one 6.3 m long 'dog' trailer loaded with 50 m of railway lines and a slipway trailer, total weight approximately 7.3 tonnes;

four 1.5 tonne concrete blocks;

2 tonnes of steel railway sleepers;

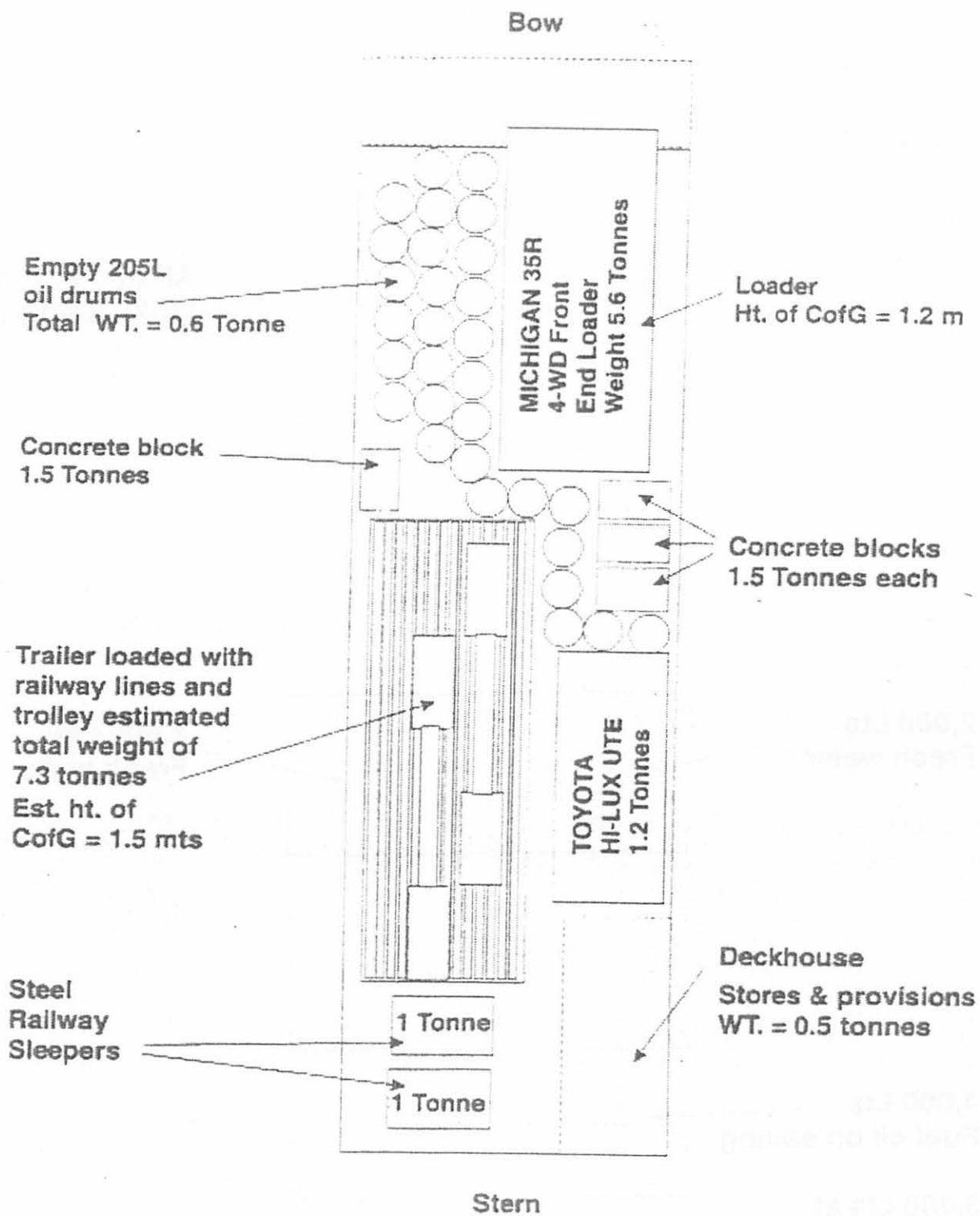
thirty empty 205 litre oil drums.

Provisions for the operations on Lake Argyle, including a number of cases of soft drinks, were loaded into the galley. The cases were stowed under the bench, on top of the internal engine room access hatch.

Because of the operations involved when loading the barge on to the low-loader at Wyndham, it was a requirement that there was no more fuel on board on sailing than was absolutely necessary. Approximately 3,000 litres had to be discharged back ashore before departure, leaving sufficient to get to Wyndham with two and a half days fuel to spare. The vessel's fuel consumption was about 600 litres per day.

It was planned to sail Keppel Trader from the company's yard at Hudson Creek, near Darwin, at approximately 0050 that morning on the high tide. The voyage was expected to take approximately 36 to 40 hours, depending on the weather.

At about 1900, when the loading was completed, the Master thought about his voyage plan, then went over to the



Cargo plan—7 August 1995

Bow

All unmarked tanks empty

2,000 Lts  
Fresh water

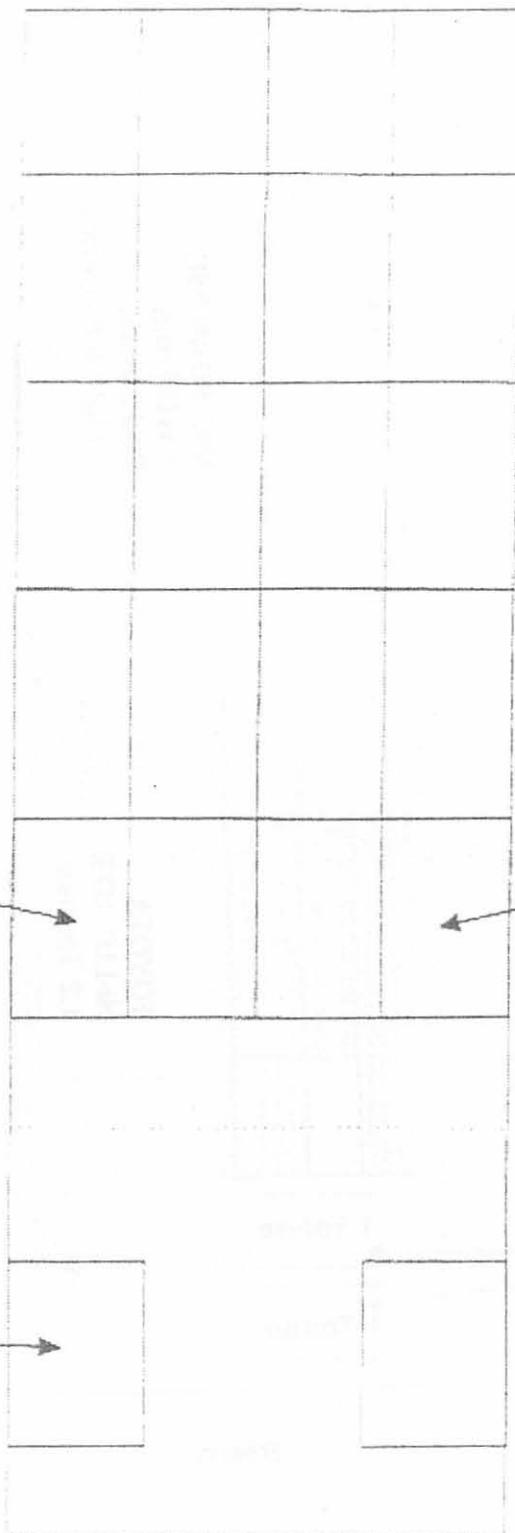
4,000 Lts  
Fresh water

4,000 Lts  
Fuel oil on sailing

3,400 Lts at  
time of capsize

Stern

Tank plan



company's other barge and had a shower before going to sleep. He awoke at 2300, returned to Keppel Trader and made some engine-room checks in preparation for the voyage and to reassure himself that all was well. Shortly afterwards, the owner and the deckhand (the works manager) arrived and preparations were made to sail.

## Sailing

As the vessel had recently come out of a refit and it had been some time since the Master had skippered this particular barge, the owner stayed on board and took the barge out into the creek, checked all the systems and the 'feel' of the vessel by carrying out some tight turns. Satisfied that all was well and that it was handling satisfactorily, he left the barge when it returned alongside and the Master and deckhand took Keppel Trader to sea at 0115 on Sunday, 6 August.

Keppel Trader did not follow the Ausrep<sup>2</sup> ship reporting procedure. However, as a matter of operational practice, the owner routinely maintained a regular contact with his vessels and it had become customary for contact to be established, either from ship to shore or from shore to ship, three times a day—morning, midday and evening. In the case of Keppel Trader, for the voyage to Wyndham, this was to be via the newly installed satellite telephone. If a call was missed, the owner would allow six hours then call every hour on the hour until contact was re-established.

About 45 minutes after sailing, the owner called the barge on the satellite phone to check that all was well and was told that they were passing mid-harbour at that time. Although conditions were fine with a calm sea, the Master was feeling somewhat tired and the deckhand stayed up with him at the wheel until they were clear of the harbour. At about 0800, once they were in open water off Grose Island on a south-westerly heading, the Master handed over the watch to the deckhand and turned in. At about the same time, he received the second satellite phone call of the voyage from the owners.

The deckhand continued at the wheel for the next five hours, until the vessel was four or five miles off Cape Ford, when he was relieved by the Master. The course set by the Master had kept Keppel Trader close in to the shore, providing shelter from the south-easterly winds.

The owner called the vessel again, at about 1300 that afternoon, once again trying out the newly installed satellite telephone, to find out how the voyage was progressing. The Master advised him of his intentions to make for Port Keats and, if necessary, to shelter in Hyland Bay until the weather was suitable for making the crossing of the mouth of the Victoria River.

The last scheduled call for that day was made by the owner at about 2100 that evening. The vessel was then on a course for Port Keats. At that time, the Master told him that there was a 1.5 to 2 m sea running and the wind was

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<sup>2</sup> A daily position report, made at a nominated time, to the Maritime Rescue Coordination Centre, required from vessels operating under the

about 20 to 25 knots from the south-east. He also mentioned that, although they had no real problems, the trailer had been moving back and forth with the pitching of the barge and it had been necessary to further secure it with some extra chain. It was very close to the Toyota utility but no damage had occurred and there was no cause for concern.

At about midnight, on the Sunday night, the barge arrived in Hyland Bay in a flat calm sea. The Master hove to and went below to carry out the daily checks around the engine room in accordance with the owner's instructions. He shut down one engine at a time to enable checks of the engine and transmission oil levels to be carried out more easily. He had noticed, just before arrival, that there was a slight quiver of the lines on the echo sounder which gave him an indication that one bank of batteries on the 12 volt system was getting low. He changed the battery charger over to charge that bank. The deckhand had gone to the engine room with him and watched him carry out the various checks.

According to the Master's account, on leaving the engine room he remarked to the deckhand that he was sure he had previously shut the engine room hatch. The deckhand replied "No, no, I left it open". The Master chided the deckhand advising him that he should keep it shut as it was the only means of keeping the engine room dry. The deckhand commented that he did not like the idea of keeping it shut, but the Master shut it and stood on it, screwing the dogs down tight.

Shortly afterwards, the deckhand turned in and the Master took the vessel out of Hyland Bay, past Port Keats, through the shoals and on to a south-south-westerly course past Cape Hay, with the intention of, once again, remaining within one mile of the coast. The weather at this stage was still calm as they were in the lee of the coastline and the wind had dropped during the evening. They had not, however, obtained a weather forecast.

At 0400, on Monday 7 August, the barge was approximately halfway between Cape Hay and Pearce Point when the Master handed the watch over to the deckhand. He had set the course on the chart and instructed the deckhand to remain within a mile of the coast. However, he also said that if the deckhand was intimidated by the proximity of the rocks, he could 'hang out a bit wider' as there was nothing further out which would give cause for concern. The Master then turned in on one of the bunks at the back of the wheelhouse.

About three hours later, the Master was awakened by the violent motion of the vessel. He jumped out of the bunk and, checking the vessel's position, found they were north-west of Pearce Point, approximately six miles out to sea. The vessel was being thrown around by the waves and there was a moderate swell running. He turned the barge on to a course of 300° with the intention of running with the weather for a while. He reduced the speed of the engines to an idle, but then had to increase the revs somewhat, so the autopilot could retain control of the vessel's heading.

His concern then centred on the fact that the barge was heading out to sea in what had become very unfavourable weather conditions. There was a sea, which he estimated at 3.5 m, running to the north west and the wind was blowing from the south-east at 25 to 30 knots. After about 20 minutes on that course and having considered all his options, the Master decided to turn on to a reciprocal course and to head back into the lee of the coastline, even though this meant heading the barge directly into the weather. By this time, the barge was 10 miles off the coast.

The barge rode the weather quite comfortably but made no headway at all over the next 15 to 20 minutes. The Master took a number of fixes, all of which confirmed that the vessel was not moving towards the coast. The vessel's heading was 130°, on which course the weather was coming from fine on the starboard bow. The Master became concerned that, in this situation, they should have no problems such as overheating engines and sent the deckhand down to the engine room to carry out checks on the header tanks and the engine temperatures. It was known that the engine temperature gauges on the bridge were always reading 'in the red' at the top end of the scale, even when the temperatures were actually normal, and so it had become an established routine to check the temperatures on the local gauges on the engines. The Master also asked him to make a cup of coffee while he was below.

The deckhand had been gone for around five minutes when the Master felt the barge take a loll to starboard.

As it settled with a loll of about 10°, he sensed that there must have been free surface water in the engine room, the only place such a free surface could develop. Shortly afterwards, the barge lolled to port, away from the weather and the Master brought the vessel head to wind. He made a slight alteration to the course setting on the autopilot to maintain that heading and started to make his way down from the wheelhouse to the engine room. As he left the wheelhouse, the engine room bilge alarm sounded.

He reached the bottom of the rungs only to find that the barge was settling by the stern and the aft end of the main deck was awash. As he stood with one leg on the bottom rung and the other on the top of the transom bulwark, he could see the deckhand sitting on the coaming of the engine room hatch with water swirling above his thighs, apparently exhausted and unable to climb clear of the hatch. The Master was conscious of the railway lines on the trailer and, with the angle and motion of the vessel, was afraid they were going to break loose at any second and slide aft, off the trailer, over the deckhand. He shouted repeatedly at the deckhand to get out. Thinking the deckhand's legs may have been trapped by the hatch lid under the swirling water, the Master was about to move towards the deckhand to help him out when he noticed that the hatch lid was already open and leaning back against the engine room vent. The deckhand was slowly dragging his legs clear of the hatch, when the barge took another loll, to port, and then capsized. The time was approximately 0755 on Monday, 7 August.

The barge settled upside down with the upturned bow considerably higher than the stern. Empty drums, timbers, pallets and other flotsam continued to bob to the surface all around the Master who could see the deckhand attempting to tread water about 25 m away behind the barge. The Master shouted to him to swim to the upturned barge and himself swam towards the bow. He could see their aluminium dinghy floating, upside down, to the west of the barge, but there was no sign of the vessel's inflatable liferaft.

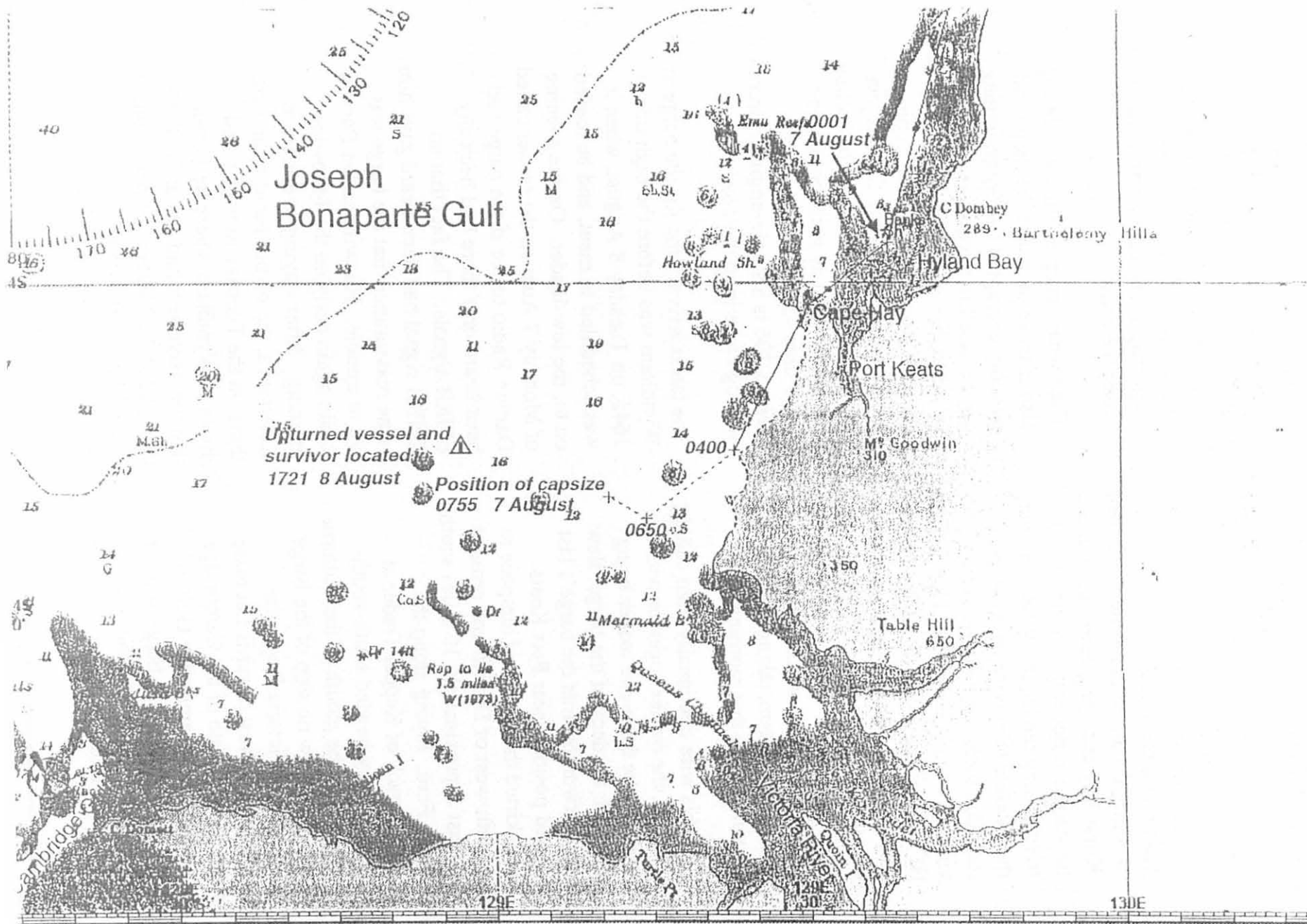
When he reached the bow, he found a plastic fuel hose for the dinghy's outboard motor floating nearby and, tying it to one of the brackets which hold the stowed anchors in position, made a bowline by means of which he could attach himself to the barge. Having done that, he climbed up the sloping bow on to the upturned hull from where he saw that the deckhand had not made it back to the barge. He started to make his way along the hull, which was being pounded by the heavy seas, but slipped and slithered aft along the hull, passing between the two propellers, the starboard one of which was still spinning.

Again back in the water, he dragged the deckhand towards the starboard side of the barge. As they reached the aft end of the barge, the deckhand broke free from him and swam to the starboard quarter, but the Master continued to swim forward, urging the deckhand to follow him forward as it was too dangerous aft just below the spinning propeller, with a 3 m sea still running. The deckhand, however, hung on to the aft end, being lifted into the air one moment and disappearing completely, under the swells, the next.

The Master, reaching the bow, put the bowline in the plastic tube around himself and looked aft again only to see the deckhand lose his grip on the hull and be swept away by the next wave. The Master swam to the deckhand again, reaching him when they were both 25 to 30 m from the barge and once more started to drag him back. The deckhand, lying on his back, started to help by paddling for a minute or two before becoming exhausted. The Master was also exhausted by the time they eventually reached the bow of the barge and he hung on to the side for a while before slamming the deckhand's hands on to the anchor brackets. There was, however, no response from the deckhand whose hands remained quite limp. Dragging him around to the bow door, the Master climbed up on to the bow door before trying, unsuccessfully, to pull the deckhand up after him. He tried three or four times to pull the deckhand up, but was himself rapidly getting weaker. Back in the water again, he tried to get some response from the deckhand by poking his eyes, shouting at him and punching him. There was no response at all, and the Master, powerless to do any more, let the apparently lifeless deckhand drift away.

## Search and rescue

The owner had estimated the barge would be making good a speed of 5.5 to 6 knots in the prevailing weather conditions and expected it would arrive in Wyndham on the evening of Monday 7 August, at the very earliest. His plan was to fly his aircraft, a Cessna 206, to Wyndham after lunch on that day to be there to meet the



Portion of chart AUS 413 showing approximate track of Keppel Trader

barge. There had been an arrangement, made on the Sunday evening, for a scheduled radio call from the barge to the owner at 0800 on the Monday morning. When this call was not received, the owner obtained a fax of the meteorological forecast. When he read that there was a strong wind warning for all coastal waters between Kurie Bay and the Queensland border, he started to become concerned and tried calling the barge. When he tried the satellite telephone he received a recorded message stating that the number was not available. He tried the HF radio using Cellcall<sup>3</sup>. The Cellcall indicated that the call had not been received by the vessel's HF receiver. He became more uneasy and brought forward the departure time for his flight to Wyndham, taking off from Darwin at 1130 that morning.

While his wife continually tried calling the barge, the owner, together with a driver for the front-end loader being carried on the deck of the barge, flew from Darwin towards the barge's last reported position near Port Keats. They skirted the restricted airspace to the south-west of Darwin and crossed the coast approximately 10 miles south of Cape Ford. Flying along the expected track of Keppel Trader at 4500 feet, they headed south-south-west towards the mouth of the Victoria River. They saw no sign of the barge. Reaching the Victoria River, the aircraft turned west towards Lacrosse Island at the mouth of the Cambridge Gulf then down Cambridge Gulf to Wyndham. Finding the barge was not at Wyndham by that evening, the owner flew on to Kununurra, where he

was to meet the low loader which had driven from Darwin. He called the Harbour Master at Wyndham who went to have a look at the harbour before last light. The Harbour Master reported that the barge had not arrived and suggested that it may have sheltered in one of the numerous inlets along the coast.

The owner accepted this, wondering also if those on board the barge had possibly corrupted the programming for the satellite telephone, as it was new and they were unfamiliar with its use. Although he had been hoping to see the barge during the flight down the coast, he had not been conducting an aerial search as such, coming no lower than 4500 feet and, as the Cessna 206 is a single-engined aircraft, staying close in to the coast.

The latest arrival time for the barge at Wyndham was before the high tide at 1645, on Tuesday 8 August, when it was scheduled to meet, and be loaded on to, the low-loader. On the evening of Monday 7 August, the owner called Darwin Radio to see if the barge had been heard or if there had been any EPIRB signals. The fact that no EPIRB signal had been heard gave him some reassurance that the barge was not in trouble. His wife called Darwin Radio again early on the following morning. After staying overnight at Kununurra, the owner hired a car, first thing on the Tuesday morning, and drove to Wyndham where he found that the barge still had not arrived. He then called the Nautical Superintendent of the Marine Branch at the Northern Territory Department of Transport and

Works and related the account of events up to that point. The Nautical Superintendent immediately called the Maritime Rescue Coordination Centre in Canberra and a search and rescue operation was initiated.

At 080200Z (1130 on Tuesday 8 August local time) the MRCC declared a marine distress and requested air assistance from the Army in conducting the search. At that time, a large military exercise, 'Kangaroo 95', was in progress in northern Australia. An urgent broadcast was made to all vessels in the area, requesting them to keep a lookout for Keppel Trader and to report hearings or sightings. In addition, the Northern Territory Police were requested to relay a description of the vessel to volunteers, port authorities and fishing operations between Darwin and Wyndham.

An army aircraft, after completing a sortie along a track from Wyndham to King Shoals, Turtle Point, Fossil Head and Port Keats, reported no sighting of Keppel Trader. The aircraft reported that the sea state at the mouth of the Victoria River was calm and the wind was south-easterly at 15 knots. Three other aircraft were tasked to join and intensify the search including a twin-engined Cessna 310 from a local air charter company and a police aircraft from Darwin.

The owner had returned to Kununurra to resume his own search, taking off from Kununurra and retracing his route of the previous day to Wyndham, then up the Cambridge Gulf. This time, his search was more intensive. After searching the islands and inlets along

the coast between Lacrosse Island and the Victoria River, he turned north towards Pearce Point. At about the time his aircraft reached Pearce Point, the Cessna 310 arrived in the area to continue the search, and the owner returned to Kununurra to refuel.

The upturned barge was being carried further out to sea by both the south-easterly winds and the current running from the mouth of the Victoria River. During the morning of Monday 7 August, the Master was battling to retain his hold on the upturned hull, frequently being submerged as the seas washed over him. In an attempt to gain body warmth without becoming totally exhausted, he alternated between being on top of the hull and being in the water, secured to the hull by his strop made from the plastic fuel pipe. He was wearing only a T-shirt and a pair of shorts. So quickly had the vessel capsized, he had no chance to grab either a life-jacket, warm clothes or the EPIRB, stowed in a bracket inside the wheelhouse.

The wind was blowing at 30 knots and he could feel his body core temperature falling. He curled himself into a ball while in the water in an attempt to retain his body heat. The routine of being on the hull then back in the water, when he became too cold, continued all day and all that night during the 7-8 August, although, in the late afternoon, the wind and the seas moderated and he was more easily able to retain his position when on top of the upturned hull.

When the sun rose the next morning on Tuesday 8 August, he retrieved a

length of rope from the water and was able to use that to help him retain his position on the hull. He stayed there, out of the water, for most of that day, attempting to conserve his energy. That afternoon, over 30 hours since the capsized, the weather moderated further and the seas dropped off to less than 2 m. He dived under the bow of barge and managed to retrieve a pallet and some more rope from beneath the upturned hull. He dragged the pallet up the ramp of the bow and lashed it in a position on top of the hull, feeling that he now had a chance of surviving another night (that of Tuesday 8 August).

He was aware that the EPIRB was still in its bracket in the wheelhouse and started to calculate his chances of successfully retrieving it by diving under the hull again. He was unsure whether the EPIRB would still be in working order. After considering the possibility that, if it did work, he may not have to spend another whole night in his freezing predicament, he decided he would attempt it, although it crossed his mind that he could be struck on the head by the motion of the vessel in the swells, or overcome by the cold.

He was also aware of the cartons of soft drinks, which were in the galley, and considered attempting to retrieve some.

Before doing so, however, he used a broken zip fastener and started to scratch a message on the upturned hull informing any would-be rescuers that the deckhand had died the previous day after the engine room flooded.

At 080751Z (1721 on 8 August, local time), the Cessna 310 search aircraft located the upturned barge, 25 miles off the coast, at a position 14° 15' S, 128° 57' E. It flew directly overhead, but the Master did not see it on its first run and only became aware of it on its second pass. After dropping flares, by means of which the aircrew were able to judge the wind and drift, the aircraft dropped a liferaft equipped with a radio beacon and survival equipment. It landed close by, with the painter falling over the hull. The Master was able to grab the painter and pull the liferaft to him. He secured the painter of the liferaft to the upturned hull and then climbed in.

Inside he found four bottles of mineral water. He rapidly drank two, but then vomited. The aircraft circled overhead and the Master, uncertain of what to do next, attempted to read the instructions in the liferaft, but 34 hours of exposure to salt and sunlight had affected his eyesight to the point where he was almost unable to read. With some difficulty he read the first direction, which was to cut the line securing the liferaft to the vessel. He pondered on this for some considerable time, unable to conceive why he should do this, there being no explanation with the instruction. All his concentration focused on this matter for a long time. He half expected it may be another day or two before a vessel could reach his position to pick him up. He was most reluctant to cut the line. He knew the barge would not sink but, as the aircraft was continuing to circle, he surmised that they were waiting for him to cut the line, which he eventually did.

Inside the liferaft was a strobe light, shrink-wrapped in plastic. He was unable to read the instructions through the plastic and attempted to tear it off. Being unable to tear it off with his numbed hands, he had to use his teeth. Once the plastic was removed, he was still unable to read the instructions which he thought were in a foreign language. However, he eventually worked out how to activate the strobe and tossed it out of the raft.

The pilot of the Cessna 310, meanwhile, had seen no strobe light activated from the liferaft and, aware that the light was fading rapidly, dropped another strobe light. It landed very close to the liferaft, was retrieved by the Master and soon afterwards was also activated.

Once a report was received that Keppel Trader had been located, the MRCC requested the assistance of a military helicopter to effect the rescue of the survivor on the upturned hull. HMAS Cessnock, an RAN patrol boat which was participating in exercise 'Kangaroo 95', was also despatched to the barge's position, but Cessnock's ETA was not before 2100 that evening.

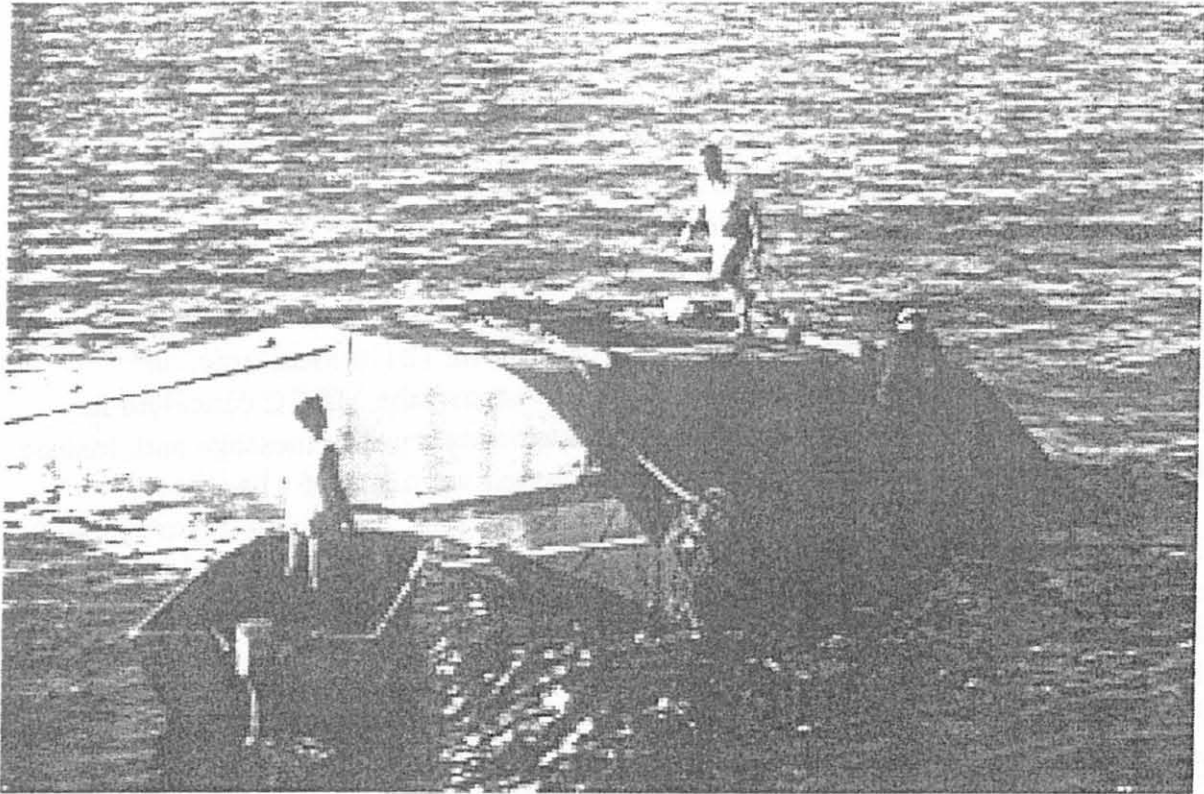
An army Iroquois helicopter, arrived over the capsized Keppel Trader at

1733, shortly before last light and lifted the Master to safety, before flying him to Kununurra where he was admitted to hospital suffering from exposure.

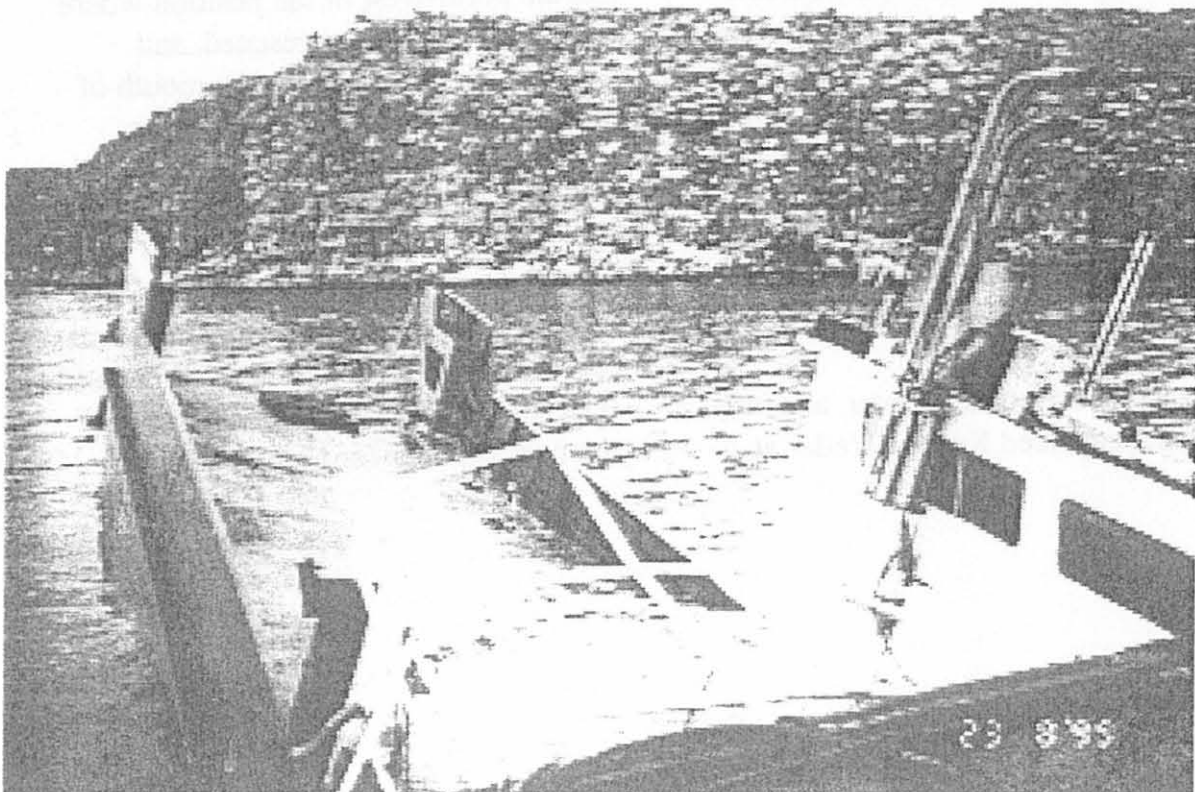
The air search for the missing deckhand continued until last light. At 081140Z (2110 local time, on 8 August) the MRCC cancelled its previous urgency message and, instead, issued warnings of a hazard to navigation. The following morning, the search for the body of the missing deckhand was resumed by the Air Wing of the Northern Territory Police, but it was never found.

On 11 August, the tug Valali left Wyndham to search for the upturned Keppel Trader and to attempt salvage. It located the barge on the morning of the following day (12 August), 43 miles to the north-west of the position where the Master had been rescued, and commenced towing it to the mouth of the King George River in Western Australia, this having been considered a suitable anchorage at which to attempt to right it.

About two weeks later, the barge was successfully righted and towed back to Darwin where it was returned to the owners slipway for repairs and refit.



Upturned Keppel Trader before salvage



Keppel Trader being righted during salvage

# Comments

The account of the events on board Keppel Trader, from the time the barge sailed from Darwin to the time the Master was rescued by helicopter, is, of necessity, drawn solely from the evidence provided to the investigation by the Master, he being the only survivor. The vessel's log book and charts were not recovered after the capsizing.

## Personnel

The Master had worked at sea for approximately 15 years in various types of small vessels, for most of those years he had been in the fishing industry but for three years he had run tours on river barges. He had obtained his Marine Engine Driver's (Grade II) certificate in 1986 and his Master Class IV certificate at Darwin in April 1992. As part of the requirements for obtaining his Master's certificate he had completed a sea survival course. At the time of the incident, he had been employed by Sandford Pty Ltd for 5½ years, of which 4½ were as master. His experience was mainly as master of Tiwi Trader, at 125 gross tonnes, a considerably larger vessel. During those 4½ years as master, however, he had skippered Keppel Trader a number of times on short passages around the Darwin area and to Melville and Bathurst Islands. He had not, however, skippered Keppel Trader in the previous 12 to 18 months, and he had not before taken it on a voyage of similar duration.

The Master had participated in water sports, swimming and diving, for many

years, felt quite comfortable in the sea and regarded himself a strong swimmer.

The 44-year-old deckhand had worked for the company for two years, as the works manager and office manager, and he had stood in as a member of the crew (on both barges) on a number of occasions as deckhand, loader driver, or cook. He was much liked and well regarded by others in the company, both for his general abilities and his personality. His experience as a seafarer, however, was limited and he held no seafaring qualification.

The owner of Keppel Trader had been involved in operating barges for 15 years. He holds a Master Class V certificate and a Marine Engine Driver (Grade II) certificate, both issued by the Marine Branch of the Northern Territory Department of Transport and Works. He has been a licensed aircraft pilot for 28 years and owns and flies a Cessna 206 aircraft. At the time of the incident, he had been a director of Tiwi Barge Services for five years and was full owner of Sandford Pty Ltd. Throughout the time he had owned Keppel Trader, it had been customary for him to skipper the barge himself. He maintains a 'no alcohol' policy for the crew on board both the company's barges and there was no indication during the investigation that this had been breached.

## Weather and sea conditions

The barge was to have arrived in Wyndham by the high tide on Tuesday 8 August, at the latest, in order to meet the low loader. The contract called for the barge to start work on Lake Argyle

on 10 August, and the programme was running a little behind schedule. The contractors on Lake Argyle were putting pressure on Sandford Pty Ltd to start work on the lake, however this pressure was not passed directly on to the Master and, to the contrary, he was advised to shelter from the weather at any time that it gave him concern. The Master, however, was aware of the schedule and the fact that pressure was being applied by the prime contractors. During the course of the voyage, the Master had no concerns about the weather.

Although the Master stated he had heard a general weather forecast on broadcast radio on the day the vessel sailed from Darwin, he had not obtained a detailed meteorological forecast for coastal waters along the vessel's intended route before departure. He felt that, at that stage, there was no need as they would be in the lee of the coastline all the way to Port Keats, and he knew from experience that those waters were always sheltered in the prevailing south-easterly winds. His intention was, once having reached Port Keats, to check the weather before proceeding across the southern end of the Joseph Bonaparte Gulf and, if necessary, to await suitable conditions.

Weather forecasts, issued by the Northern Territory regional office of the Bureau of Meteorology, predicted strong south-east winds for all coastal waters from Kuri Bay (in the north of Western Australia), to the Queensland border, and a strong wind warning was in force for these areas from 1100 on 3 August to 1700 on 8 August.

Specifically, for the area between Wyndham and the Daly River, the forecast issued at 0532 on 5 August was for south-easterly winds, 25 knots, easing to 15 to 20 knots temporarily during the evening and seas to 1.5 m. A similar forecast was issued on 6 August. By 0531 on 7 August, 2½ hours before Keppel Trader capsized, the forecast for sea state had increased to 2.2 m and the wind to 25 to 30 knots.

The weather forecast was sought by the vessel's owner who obtained a fax from the Bureau of Meteorology during the morning of 7 August, after Keppel Trader had failed to make its scheduled radio call at 0800 that day. It was only then that he learned of the strong wind warnings and started to be concerned.

When the Master awoke to find the barge so far off the coast, the deckhand offered no explanation for the vessel's position and the Master had not asked for one. Although it cannot be stated with certainty, it seems likely that the deckhand, having been advised by the Master that, if he wished, he could 'take it wide', set a course diverging from the coastline because he was concerned about being too close to the coast in the hours of darkness. Once on a diverging course, the barge would have gradually left the lee of the coast and the strong south-easterly wind would have further set it to the north west, possibly without the deckhand becoming aware of it. The tide at Port Keats had been ebbing for four hours at the time that the barge reached a position 6 miles out, off Pearce Point. As Keppel Trader approached that

position, both the tide and the outflow from the Victoria River would have combined to further set her to the north west.

The southern end of the Joseph Bonaparte Gulf, particularly at the mouth of the Victoria River and the entrance to Cambridge Gulf, is an area of some notoriety among local owners or masters of small vessels. In volume V of *Australia Pilot* published by the Hydrographic Office, there is a particular reference to overfalls:

*"The area west of Pearce Point consists of broken ground, in this vicinity overfalls, dangerous to small craft, have been observed up to 6 miles west of the point."*

At the time the Master was awakened by the violent motion of the barge, it is possible that it was being affected by the overfalls in this area. However, it seems unlikely that an overfall would have affected Keppel Trader at the time of its capsizing, as, by then, it was approximately four miles further to the north-west. Nevertheless, the overfalls are indicative of the hazardous conditions in the general area.

### **Engine room access**

Keppel Trader has two hatches providing access to the engine room. The internal hatch under the galley benchtop and the external hatch on the main deck outside the galley access door, fitted with a 250 mm high coaming. The aft edge of the deck hatch is approximately 2 m from the stern. Over the years, it had become customary to use the external hatch on deck, as it was much easier to get

through, and in addition, the internal hatch, apart from the inconvenience of its being under the galley bench, was partly obstructed in the engine room by a cable tray, an air compressor, fitted as a later modification, and the starboard gearbox. Nevertheless, the headroom below the external hatch in the engine room is very limited and, because of the sloping contour of the bottom of the vessel immediately below the hatch, a person has to perform some contortions, negotiating the bend on entering, to manoeuvre oneself through the hatch and over the vessel's frames. This hatch could only be dogged shut from the outside.

The internal hatch had no 'escape hatch-keep clear' label or other warning that it should be kept clear and had been covered with a number of cartons of soft drinks when the stores were loaded in Darwin. It appears that, so accustomed were the crew to using the external hatch, either when the ship was at sea or in port, the possibility of needing to use this hatch in heavy weather never occurred to them. The external hatch had become the normal means of accessing the engine room.

The vessel's Trim and Stability booklet (qv.), in section 4 - 'Information for the Master and persons responsible for loading the ship'. Section 4.1 states:

#### *GENERAL SAFETY INFORMATION*

*The following matters are of importance to the safety of this ship:*

##### *4.1.1 Angle of flooding*

*The angle of flooding is the angle of immersion of the sill or coaming of the opening on or above the freeboard deck (through which progressive down-flooding can occur) which first reaches water level as the ship heels.*

*For the purpose of Loading Condition Calculations, the righting lever (GZ) curve is assumed to stop at this angle of flooding. To ensure that in all conditions of loading the angle of flooding is greater than 40° angle of heel, the following is to be noted.*

*(A) THE W.T. MANHOLE ON THE FREEBOARD DECK IS TO BE KEPT CLOSED AND SECURED AT ALL TIMES WHILE THE SHIP IS AT SEA.*

*(B) THE W.T. DOORS GIVING ACCESS INTO THE ENGINE ROOM ARE TO BE KEPT CLOSED AND SECURED AT ALL TIMES WHEN THE SHIP IS UNDER WAY, EXCEPT THAT IN LIGHT OR MODERATE WEATHER, THESE DOORS MAY BE USED FOR ACCESS ESSENTIAL TO THE WORKING OF THE SHIP PROVIDED THEY ARE THEN IMMEDIATELY CLOSED AND SECURED.*

In spite of this warning with its emphasis in the Trim and Stability booklet, the external hatch on deck had no warning notice to this effect and there was no requirement for this notice by the Northern Territory administration. No use, however, should have been made of the external hatch with the vessel at sea and

especially under the weather conditions prevailing on 7 August.

It is clear from the incident at Hyland Bay, when the deckhand was reluctant to close the hatch, that he was averse to closing the hatch while he was in the engine room. This would be a natural reaction, it being very claustrophobic, noisy and full of diesel fumes.

The evidence indicates that, on the occasion when the Master instructed the deckhand to check the engine room before the capsizing, he had again left the hatch open while he was in the engine room. At that time the barge was pushing into the weather and pitching heavily in seas which were at least 2 m and possibly 3 m. It seems likely that, while he was in the engine room and the hatch was open, seas being shipped on to the cargo deck, entered the hatch and started to form a free surface in the large area of the engine room bilge. The Master believed that the deckhand may have remained in the engine room to attempt to deal with this situation by starting the bilge pump but, over the next five minutes, as the situation worsened and the barge started to both settle by the stern and to develop a loll due to the free surface, progressive flooding commenced and the deckhand would have had to fight his way up through the hatch against the incoming water in order to escape. When he was seen by the Master, sitting on the hatch coaming, he was saturated, and his face and hair were covered in oil. In the opinion of the Master, he was totally exhausted, in a state of shock and must have nearly drowned while attempting to escape from the engine room. The fact that he had very little

energy left with which to attempt to save himself, after the vessel capsized, would support this theory.

## Certificates

Keppel Trader was under survey by the Marine Branch of the Northern Territory Department of Transport and Works as a class 2C (commercial) vessel. As it is under 16 m in length, it is exempted under Part 1, Section 7 para.3.15 of the Uniform Shipping Laws Code (USLC), from the requirements of a loadline survey. An annual and hull survey, however, was carried out on 1 August 1995, just six days before it capsized.

The survey required two defective items to be rectified, a) the automatic light on the lifebuoy to be shown working and, b) two bilge suction to have non-return valves fitted. These items were corrected on 2 August, the day after the survey. A survey certificate (No. 3242) was issued on 8 August 1995, the day after the capsized. Although not in actual possession of the certificate when it sailed from Darwin on 6 August, Keppel Trader had met all the requirements of survey.

The manning requirement, on the survey certificate, states:-

### DETAILS OF MINIMUM SAFETY MANNING

1 X MASTER CLASS 5

1 X MARINE ENGINE DRIVER GRADE 2

*Note: Provided that if the Master holds a valid Marine Engine Driver Grade 2 Certificate, an additional General Purpose Hand may be carried in place of the Engine Driver. However, he/she must :-*

1. *hold a shipboard safety course certificate;*
2. *be trained to carry out basic engine room duties as may be required whilst the Master is in the wheelhouse.*

The Master held a certificate as Master Class 4, and a certificate as Marine Engine Driver Grade 2. This exempted the vessel from the requirement to carry an engineer. The deckhand, however, did not hold a shipboard safety course certificate as required by Note 1.

The survey certificate (and its manning requirement) was applicable to the vessel within the limits of Northern Territory waters and within a limit of 30 nautical miles to seaward, however, the Marine (Safety Manning) Regulations 1982 (No.14), made under the Marine Act of the Northern Territory of Australia include, at Part 1 Section 3, under the definition of the meaning of the word 'vessel' as used in the Regulations:

*'... 'Vessel' means a vessel other than a vessel that is -*

- c) *A commercial vessel that is proceeding on an inter-State or overseas voyage;*

(Bold lettering for Inspector's emphasis)

Keppel Trader is classed as a commercial vessel and was proceeding on an inter-State voyage, the consequence of which is that the Northern Territory Marine (Safety Manning) Regulations did not apply for that voyage.

### Inter-State voyages

As Keppel Trader was proceeding on an inter-State voyage, and hence temporarily coming under Commonwealth jurisdiction, it came within the provisions of the Navigation Act 1912 and, as such, required an exemption under Section 421 of the Act, from certain provisions of the Act which it would be unable to meet. This exemption is issued by the Australian Maritime Safety Authority (AMSA) when departure from the requirements of the Act would not compromise the safety of the vessel. There is an onus on the owner or operator of the vessel to apply in writing and to obtain the exemption before the vessel departs on its inter-State voyage.

The owner of Keppel Trader stated that he had enquired of AMSA some weeks before the voyage, asking what was required of him before the voyage, and that he was told to contact AMSA again when the vessel was ready to leave. On Friday 4 August, two days before the departure date, he was in the company of the Nautical Superintendent of the Marine Branch of the Northern Territory Department of Transport & Works, when he commented that he needed to contact AMSA again and left the company of the Nautical Superintendent to make this contact. The Inspector was told

that he had attempted to contact the local AMSA surveyor in Darwin, but was unable to obtain a reply from the AMSA office or from the surveyor's mobile telephone. Attempts by one of the Marine Branch surveyors to contact the local AMSA surveyor on the same afternoon, but on a different matter, were also unsuccessful. No contact was made with the regional office in Adelaide or AMSA in Canberra. Inquires of AMSA failed to establish a record of the initial contact some weeks before and, in the event, the vessel sailed from Darwin without the required certificate of exemption having been obtained.

The owner stated that, as Keppel Trader was not carrying a commercial cargo—all the cargo on board consisted of his own company's equipment and was not being carried on behalf of, or paid for, by another shipper—he considered it was not a commercial voyage and he was not required to go through the routine of obtaining an official exemption under the Navigation Act 1912.

Nevertheless, the Act applies as follows, in Part 1, para.2 under 'Application of the Act':

2. (1) *Except in so far as the application of this section is expressly excluded by a provision of this Act, this Act does not apply in relation to:*
  - (a) *a trading ship proceeding on a voyage other than an overseas voyage or an inter-State voyage;*
  - (2) *A ship shall, for the purposes of this section, be deemed to be proceeding on the voyage from the time when it is got under way for*

*the purpose of proceeding on the voyage until the time when it is got under way for the purpose of proceeding on another voyage.*

A trading ship is further defined in the Act under Part 1, para 6, Interpretation as:

*“a ship that is used, or, being a ship in the course of construction, is intended to be used, for, or in connection with, any business or commercial activity and, without limiting the generality of the foregoing, includes a ship that is used, or, being a ship in the course of construction, is intended to be used, wholly or principally for:*

- (a) the carriage of passengers or cargo for hire or reward; or*
- (b) the provision of services to ships or shipping, whether for reward or otherwise;*

*but does not include a Commonwealth ship, a fishing vessel, an off-shore industry mobile unit, an off-shore industry vessel to which this Act applies, an inland waterways vessel or a pleasure craft;”*

Keppel Trader was undertaking an inter-State voyage and, under the definition of the Act, is classed as a ‘trading ship’. As such, an exemption from certain provisions of the Act should have been sought.

For the issue of an exemption, a number of conditions are listed in AMSA’s *Instructions to Surveyors*. Among these in paragraph 2.14.4.1 it states:

*The number and qualifications of the crew shall be in accordance with the sea-going manning scales contained in Section 3 of the Uniform Shipping Laws Code. . .*

Section 3 of the Uniform Shipping Laws Code covers the manning requirements for fishing vessels only, not trading vessels. There is, however, provision in section 2.14.4.2 of the *Instructions to Surveyors*, for AMSA to determine the manning level in instances where

*“the length or nature of the proposed voyage differs considerably from the normal voyages of the ship and the surveyor considers that, for reasons of safety, more highly qualified or additional crew are necessary than are provided for in the USL Code, . . . ”*

It should be noted, however, that the relevant section of AMSA’s *Instructions to Surveyors*, section 2.14., together with its appendix 5, is the subject of an amendment which, at the time of the incident, was still in draft format but which is more specific in its requirements for the manning of vessels on both inter-State and overseas voyages.

The Inspector considers a voyage of some 250 nautical miles, of up to 48 hours in duration, and which included an open-water crossing of the southern end of Joseph Bonaparte Gulf, was one that did differ considerably from the normal voyages of the vessel and is a factor which would have been considered by AMSA had the required exemption been sought. With the manning as it was on

the voyage to Wyndham, only the Master had any qualifications or significant sea experience. On those occasions when the Master needed sleep, which was inevitable on a passage of nearly two days duration, the watch was taken over by the deckhand who had little sea or navigational experience and no navigational, or engineering, qualifications. The manning is therefore considered to have been inappropriate for this length of voyage, with insufficient qualified bridge watchkeepers having been carried.

### **Loading and stability**

As Keppel Trader is under 16 m in measured length, it is not required to have a load line. The load line regulations provide for a minimum freeboard and a standard of watertight integrity. Without a load line, there was no limiting draught or minimum freeboard to which Keppel Trader could be loaded provided the reserves of stability of the vessel met the transverse stability criteria laid down in the USL code. The vessel could load to a draught with its main deck awash, provided the transverse stability criteria are complied with.

In early 1994, the owners commissioned a firm of naval architects to prepare a trim and stability booklet, being part of the Territory survey requirements, for Keppel Trader. This booklet was approved by the Marine Branch of the Northern Territory Department of Transport and Works on 23 February 1994 and placed on board the vessel.

The Trim and Stability booklet was drawn up on the basis that all conditions of loading were to meet the stability requirements of the USL Code Section 8, sub-sect C16 (Landing Barges) which states :

*C.16.2 The area under the righting lever curve shall be :*

- (a) not less than 6.30 metre-degrees up to an angle of heel of 15° when the maximum righting lever occurs at 15°;*
- (b) not less than 4.3 metre-degrees up to an angle of 20° when the maximum righting lever occurs at 20°, or ;*
- (c) not less than 3.15 metre-degrees up to an angle of 30° when the maximum righting lever occurs at 30° or an angle greater than 30°, or;*
- (d) an area, when the maximum righting lever occurs at angles between 15° and 20° or 20° and 30°, up to the angle of maximum righting lever, obtained by linear interpolation; and*
- (e) not less than 1.72 metre-degrees between the angles of heel of 30° and 40° or between 30° and the angle of flooding if less than 40°*

*Note:*

*The angle of flooding is the angle of heel at which openings in the hull , superstructures or deckhouses which cannot be closed weathertight commence to immerse. In applying this criterion, small openings*

*through which progressive flooding cannot take place need not be considered as open.*

*C.16.3 The maximum righting lever which shall occur at an angle of heel not less than 15° shall be at least 0.2 metres.*

*C.16.4 The initial transverse metacentric height shall be not less than 0.15 metres.*

It became apparent to the investigation, however, that although the presence of the booklet on board the vessel satisfied the survey requirements, it received no practical use when loading cargoes or considering stability (on either of the company's barges) and there was little knowledge of the practicalities of the application of the Trim and Stability booklet among any of those involved. No stability calculations were made during the loading on 5 August, or before Keppel Trader sailed for Wyndham on 6 August 1995.

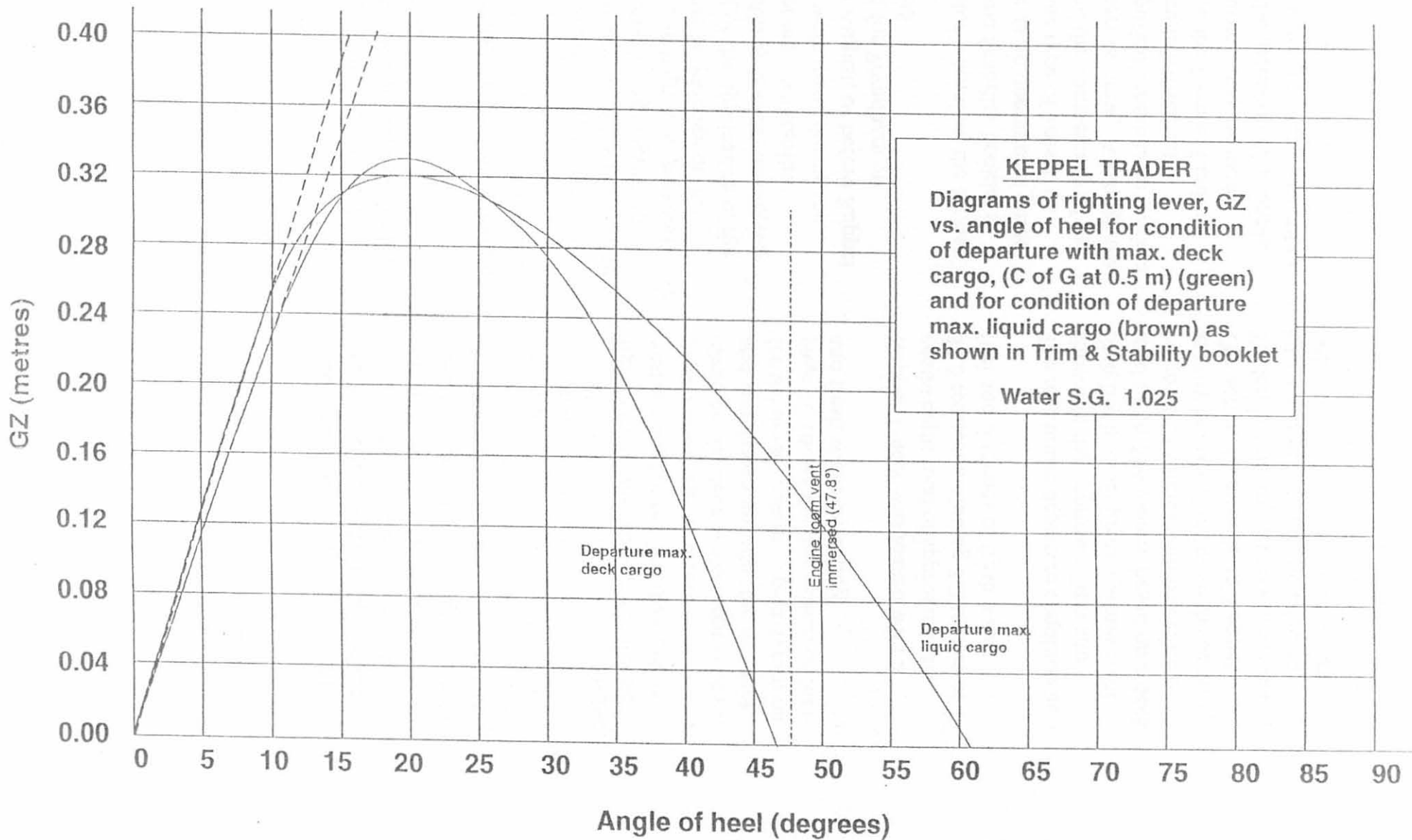
In the Inspector's opinion, the format of the Trim and Stability booklet is inappropriate as an operational guide, considering the type of vessel, its operations and the competency of the masters, owners or crew. Although the book is 'simplified', there is no worked example. Simplified stability information, in the form of Limiting KG or GM curves, may be more suitable and the inclusion of a simple proforma with step-by-step instructions for carrying out the necessary calculations, may facilitate this task for the master.

The Inspector understands that, before the investigation was concluded, both the company's barges were to be provided with pre-programmed calculators to enable the masters to more easily perform their stability calculations.

The figures given, and used in this report, including the heights of the centres of gravity of the deck cargo, are an estimate only because no loading plan was drawn up before the vessel loaded its cargo in Darwin on 5 August. Similarly, no stowage plan was drawn up on completion of loading. The owner assessed the vessel's stability by carrying out some tight turns in the harbour before the vessel's departure. The diagram on page 9 showing the disposition of cargo on the deck is also approximate and was drawn up, after the incident, for the investigation. The diagram on page 10 shows the disposition of fuel and fresh water on sailing.

Keppel Trader was loaded with a deadweight total of approximately 32.6 tonnes, including 3.2 tonnes of fuel and 6 tonnes of fresh water.

The maximum departure condition as shown in the approved Trim and Stability booklet gives a deadweight total of 26.594 tonnes, based on a deck cargo of 22 tonnes with its centre of gravity being 0.5 m above the deck. The actual deadweight of Keppel Trader, before any ingress of the sea into the engine room, included an estimated 23.4 tonnes of deck cargo with the centres of gravity of the heaviest items of cargo, the front-end



loader and the loaded trailer, being considerably higher than 0.5 m.

Keppel Trader, in common with many landing barges, had comparatively little freeboard in the fully loaded condition. The draught was not taken before sailing but calculations made from the loading plan, drawn up after the incident, indicate that it would have been approximately 1.012 m forward and 1.393 m aft. This would have given a freeboard of 668 mm forward, 287 mm aft and an angle of heel for deck-edge immersion of 10.42 degrees. The freeboard amidships would therefore have been 477.5 mm. The minimum freeboard, at the maximum loading condition as shown in the Trim and Stability booklet, is 380 mm. However, regardless of the value of freeboard, a vessel is overloaded when it can no longer meet the transverse stability criteria.

The maximum value of the righting lever GZ, in the condition of loading when Keppel Trader sailed from Darwin, was 0.216 m and occurred at an angle of heel of 16.332°. With the engine room hatch in the deck closed, the angle of flooding (immersion of the engine room vent) was 41.5°, approximately 4.5° past the angle of zero righting lever. With the engine room hatch on the main deck open, the angle of flooding (immersion of the engine room hatch) was reduced to 27.89°.

The vessel in the departure condition met all the requirements with the exception of the area under the GZ curve where it was significantly deficient. This area is the most important of all the criteria. It is an

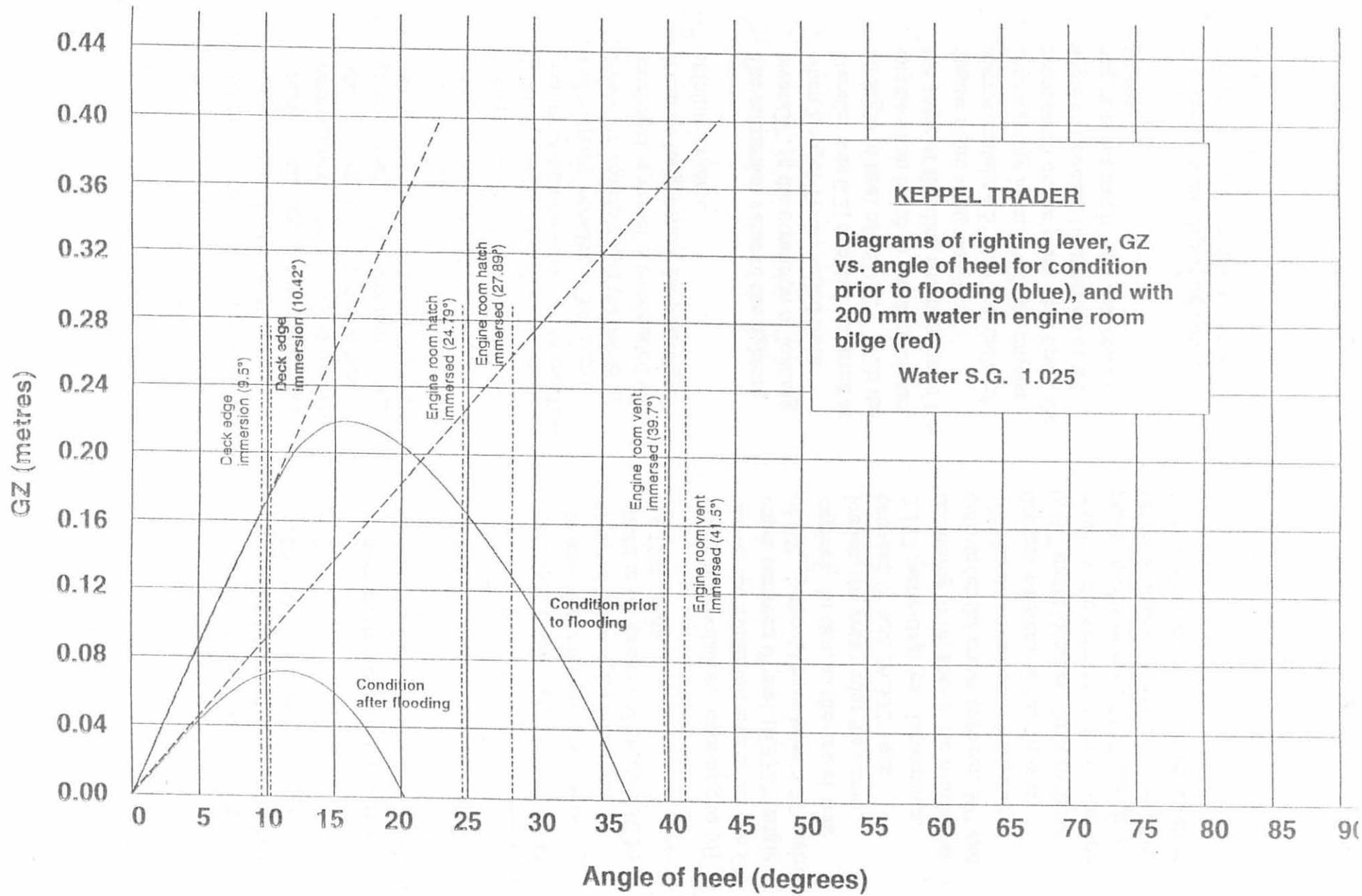
indication of the buoyancy reserve stored in the vessel to withstand the upsetting forces of wind, sea and swell, not to mention the additional effect of free surface in the engine room bilge.

A diagram showing the GZ curve for the condition of departure with maximum deck cargo, from the Trim and Stability booklet, is shown opposite.

A diagram showing the GZ curve applicable to the vessel in the situation which existed prior to any flooding of the engine room, is shown on page 32 (blue curve). Because the maximum value of GZ for the departure condition of Keppel Trader occurred at 16.332°, the area under the GZ curve was required to meet the minimums as stated in (d) and (e) of Section 8C16 of the USL Code.

Using interpolation, according to (d) above, the minimum area under the GZ curve between 0° and 16.332° (angle of  $GZ_{max}$ ) should have been 5.77 metre-degrees. In fact, as the vessel was loaded, the area under the curve between 0° and 16.332° was 2.157 metre-degrees. In addition, according to (e) above, the minimum area under the curve between 30° and 40° should have been 1.72 metre-degrees whereas, in fact, it was 0.407 metre-degrees. In both these respects, the stability did not meet the requirements of the USL Code. If a vessel is unable to meet any one of the criteria, then the minimum requirement for stability is not met.

It is significant, and should be noted, that the maximum GZ was required by the Code to have a minimum value of 0.200 m and, in the condition as



loaded, Keppel Trader met this requirement with a value of 0.216 m. The relationship between the value of  $GZ_{max}$  and the area under the GZ curve can, however, be misleading. The minimum value of  $GZ_{max}$  of 0.200 m is based on the  $GZ_{max}$  occurring at an angle of heel of between 25 and 30 degrees. This minimum value of  $GZ_{max}$  criteria becomes irrelevant where the angle of heel of  $GZ_{max}$  occurs below 25 degrees. In fact, meeting this criteria of 0.200 m will present a false sense of security.

The engine room of Keppel Trader is approximately 5 m in width, hence any flooding of the engine room bilge will cause a large free-surface effect. The bilge high-level alarms are 100 mm above the bottom of the bilge and one of these alarms was activated while the Master was leaving the wheelhouse. When he reached the deck and first saw the deckhand sitting on the hatch coaming, the engine room was free-flooding past the deckhand's legs which were dangling in the 500 mm square hatch.

Further stability calculations were carried out on the basis of a depth of 200 mm of water in the engine room bilge. This would represent 3.216 tonnes of water. In this situation, the aft draught would have increased to 1.467 m, and the forward draught increased to 1.015 m.

A diagram showing the GZ curve applicable to the vessel after flooding of the engine room had commenced (with 200 mm of water in the bilge) is shown opposite (red curve).

The area under the GZ curve between 30° and 39.68° (the angle of flooding)

reduces to 0.00 metre-degrees and the maximum value of GZ, which occurs at 10.742 degrees of list, reduces to 0.071 m. The area under the curve to this angle of  $GZ_{max}$  reduces to 0.460 metre-degrees.

At a list of 20.19°, the righting lever GZ becomes negative and the vessel would capsize.

It needs to be emphasised that all the above comments on the stability of the vessel are based on calculations made for conditions of still water. The effects of a 2-3 m sea would be to further decrease the stability, as there would be a frequent loss of waterplane area as the barge is lifted by swells.

## Freeing ports

In addition to effects of the swell, it is necessary also to consider the free surface effect of any water on the vessel's deck. Keppel Trader was experiencing rough weather at the time of the capsize and the area of the freeing ports, in relation to the deck area, is not large.

There is a requirement in the USL Code at Section 5, sub-section D29.1, for the total area of freeing ports on each side of a vessel in excess of 12.5 m measured length, to be of a minimum total area A:

$$A = (1+3.5 \times h) \times m \times h / 100$$

where  $h$ =bulwark height in metres  
 $m$ =length of 'well' in metres

The formula is stated to apply to a situation where '*...the bulwarks in the weather portion of the weather deck form wells*'. In the case of Keppel Trader, the whole weather deck forms a well surrounded by bulwarks.

The height of the bulwarks along the sides of the vessel is 1.04 m, while the height of that across the stern is 0.44 m. The total area of the freeing ports along the port side is 0.296 m<sup>2</sup>, and along the starboard side it is 0.301 m<sup>2</sup>. The area of freeing ports across the stern is 0.053 m<sup>2</sup>.

Using the formula above, if the height of the bulwark 'h' is taken as 1.04 m, the required area of freeing ports on each side is 0.77 m<sup>2</sup> and Keppel Trader fails the requirement. If a separate calculation is made for the stern, using a bulwark height of 0.44 m, then the required area for freeing ports across the stern becomes 0.057 m<sup>2</sup>, and the area is, again, less than the minimum required. Despite this, however, the modifications to the vessel in 1986 were approved and it has passed all subsequent surveys.

It appears, however, that the requirement in the USL Code is inappropriate for a vessel such as a landing barge, as the height of the bulwark is irrelevant to the need for the fast clearing of free surface water on the large area of deck. The surface area of the deck may be a more appropriate parameter. The loss of GM (metacentric height) is proportional to the product of the length of the 'well' and the cube of its breadth. Keppel

Trader has a length to breadth ratio of approximately 3:1.

It is not possible to accurately assess the loss of GM due to the free surface effect of any flooding of the main deck, on account of the number of 'obstructions' in the form of deck cargo. These would effectively reduce the deck area but, at the same time, they would also inhibit the free draining of water from the deck. However, without any obstructions on the deck the GM would be reduced by approximately 1.8 m and the vessel would lose all stability if the deck, with a slight list, was just covered with water. The main factor causing loss of GM is the breadth of the free surface, the depth of water having little significance.

### Trailer centre of gravity

During later stages of the investigation, it was suggested that the height of the centre of gravity of the 6 m trailer, loaded with railway lines and the slipway trolley, was considerably less than the estimated 1.5 m as used in the calculations for this report. The calculations were redone accordingly, using a new estimated height for the C of G of the loaded trailer of 0.9 m. The differences in the results of the stability calculations are not significant and are summarised below.

#### Summary of stability calculations with height of C of G of loaded trailer at 0.9 m.

	<u>Minimum</u>	<u>Actual</u>
Area under GZ curve between 30° and 40° of heel (metre-degrees)	1.720	0.607
Area under GZ curve up to angle of maximum GZ (metre-degrees)	5.771	2.345
Maximum value of GZ (metres)	0.200	0.235
Angle of heel at which max. value of GZ occurs	15°	16.25°

Using this amended figure for the height of the C of G of the trailer, the vessel still failed to meet the requirements of the USL Code upon sailing from Darwin.

## **Exemptions under section 421 of the Navigation Act 1912**

In AMSA's *Instructions to Surveyors*, under 2.14.2, *Load line matters*, at 2.14.2.1 it states:

### ***Stability Data***

*It must be established to the satisfaction of the surveyor that the stability in the proposed departure and arrival conditions will be sufficient to comply with the applicable criteria in 6.8 of Marine Orders Part 13 Appendix 1. Full details of the vessel and proposed loading conditions should immediately be forwarded to AS/SSB<sup>4</sup> where this cannot be established:*

- (a) using the vessel's stability data approved by a State Marine Authority or this Department, or*
- (b) due to the vessel having no approved stability data.*

*SSB may then require an inclining experiment or a rolling period test to be conducted in the departure condition to provide guidance on the adequacy of the vessel's stability. Evaluation of the arrival condition would also be based on such a test, if undertaken.*

### **2.14.2.2 Conditions of assignment**

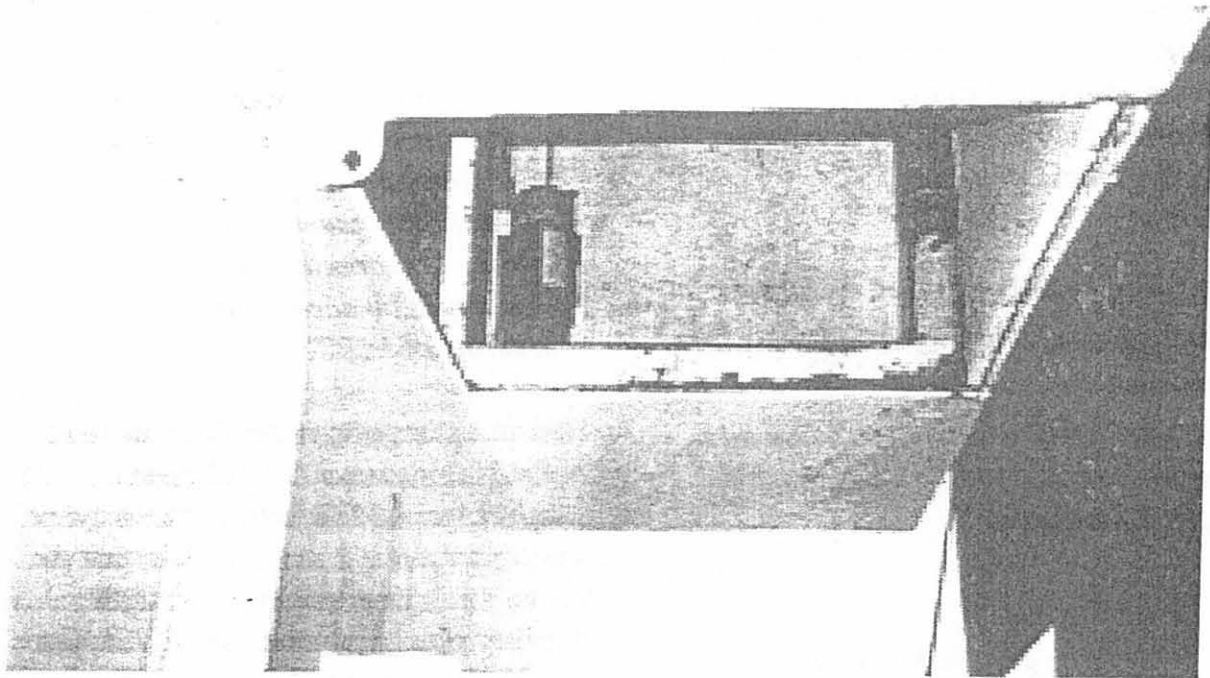
*The closing appliances, freeing ports and protection of crew arrangements shall be inspected to ensure that they are sufficient for the particular voyage and are not such that the ship could be deemed unseaworthy in terms of s.207.*

Had an exemption under Section 421 of the Navigation Act 1912 been sought from AMSA before the voyage was undertaken, it is probable that the vessel's failure to comply with the stability requirements of the USL Code would have come to light. At the very least, the fact that no stability calculations had been undertaken should have been revealed, as there is an obligation on the surveyor, in AMSA's *Instructions to Surveyors*, to ascertain that the relevant criteria are met. It is also possible that an inspection, carried out under 2.14.2.2 may have indicated the need for a warning notice on the engine room hatch in the deck, concerning the need for it to be kept closed at sea.

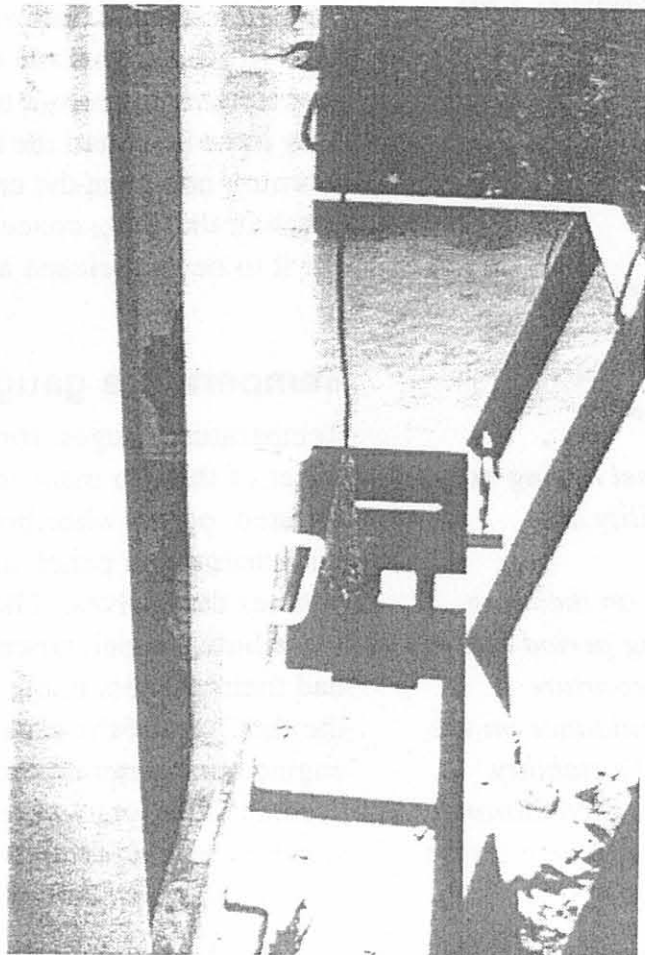
### **Temperature gauges**

Temperature gauges, for the cooling water of the two main engines, were situated on the wheelhouse instrumentation panel, as well as on the engines themselves. The gauges on the wheelhouse panel, however, always had their pointers in the red sector, at the 'hot' end of the scale, when the engine temperatures were, in fact, quite normal. This was a defect of long standing which required the deckhand to make regular comparisons of the

<sup>4</sup> Assistant Secretary/Ship Safety Branch, now



Wheelhouse access showing stowed EPIRB



temperature readings on the wheelhouse instruments with the temperatures on the engine local gauges. This was a major consideration in the Master's decision to send the deckhand below to check the engines when he found the vessel was making no headway into the weather just before the capsizing. The fact that the inaccurate gauges had not been replaced is, in the opinion of the Inspector, a contributory factor to the incident.

### **Lifesaving equipment**

Keppel Trader carried a four-man liferaft which should have been automatically released by a hydrostatic mechanism upon immersion to a depth of 2 to 3 m. On 3 July 1995, this inflatable liferaft had been serviced by the local agents for the manufacturer and issued with a re-inspection certificate.

The liferaft, which had been stowed on a cradle fitted to the davit for the aluminium dinghy, did not appear on the surface after the capsizing of the vessel. When Keppel Trader was located, several days after the rescue of the Master, and towed to the mouth of the King George River for righting, the plaited nylon painter of the liferaft was found to be entangled, along with a mooring line, around the starboard propeller. The inboard end of the painter was still secured to the vessel, but the outboard end, which should have remained attached to the liferaft, was found to have on its end the lug, and rubber doubler, where it had been attached with adhesive to the buoyancy chamber of the liferaft. The

indications are that the liferaft had been released by the hydrostatic release but, as the vessel capsized, the painter had become entangled by the still spinning starboard propeller and the end had been wrenched free of the liferaft, damaging the raft in the process. The starboard engine was still running, with the barge upside down, after the Master had climbed on to the upturned hull.

Keppel Trader carried one GME-EPIRB, programmed to transmit on 121.5 MHz. The EPIRB was not of the 'float-free' type and required manual removal in the case of emergency. The bracket holding the EPIRB was in the wheelhouse and in the circumstances in which Keppel Trader capsized, there was no opportunity for the vessel's crew to grab it after the capsizing. The EPIRB remained in its bracket beneath the upturned hull.

The barge's satellite telephone was also programmed to transmit a distress call by simply pressing 000 and 'send'. Once again, however, because of the rapidity of the capsizing the Master could not send a call.

### **SAR survival equipment**

Included in the equipment dropped from the search aircraft was a 'Sea Blitz' strobe light. The Inspector notes with concern that this light was wrapped in shrink-wrap plastic packaging and the Master found that, after thirty four hours of exposure to wind and water, his hands were unable to open the wrapping and he only managed it by using his teeth. There is

a knife in the liferaft which, had he not been so affected by exposure, he may have thought of using. However, this form of packaging, although effective in keeping the strobe light dry in the marine environment, does present problems for a survivor whose faculties may be partly incapacitated and who may not notice the notch in one edge of the plastic sealing strip by means of which it may be torn open. It is considered that a large coloured arrow pointing to the notch with 'tear here' printed on the plastic may help to prevent this situation recurring. This problem was receiving attention at the time of the investigation.

Although the Master was, due to the deterioration of his eyesight, under the impression that the instructions were in a foreign language, they are in fact, in English. A clearer and larger text on a separate card in the packaging would assist a person with impaired eyesight to read it.

The light itself is manufactured primarily for military use, and is extremely effective. It was reported that, once the Master had worked out how to activate it, the helicopter pilot was able to see the strobe from a distance of approximately 17 miles.

### **Reporting-in radio procedure**

If Keppel Trader had been sailing under the provisions of the Navigation Act, there would have been a requirement for a report on a daily basis. Because of the system, however, it is unlikely this would have resulted in a search being initiated any earlier. Although Keppel Trader did

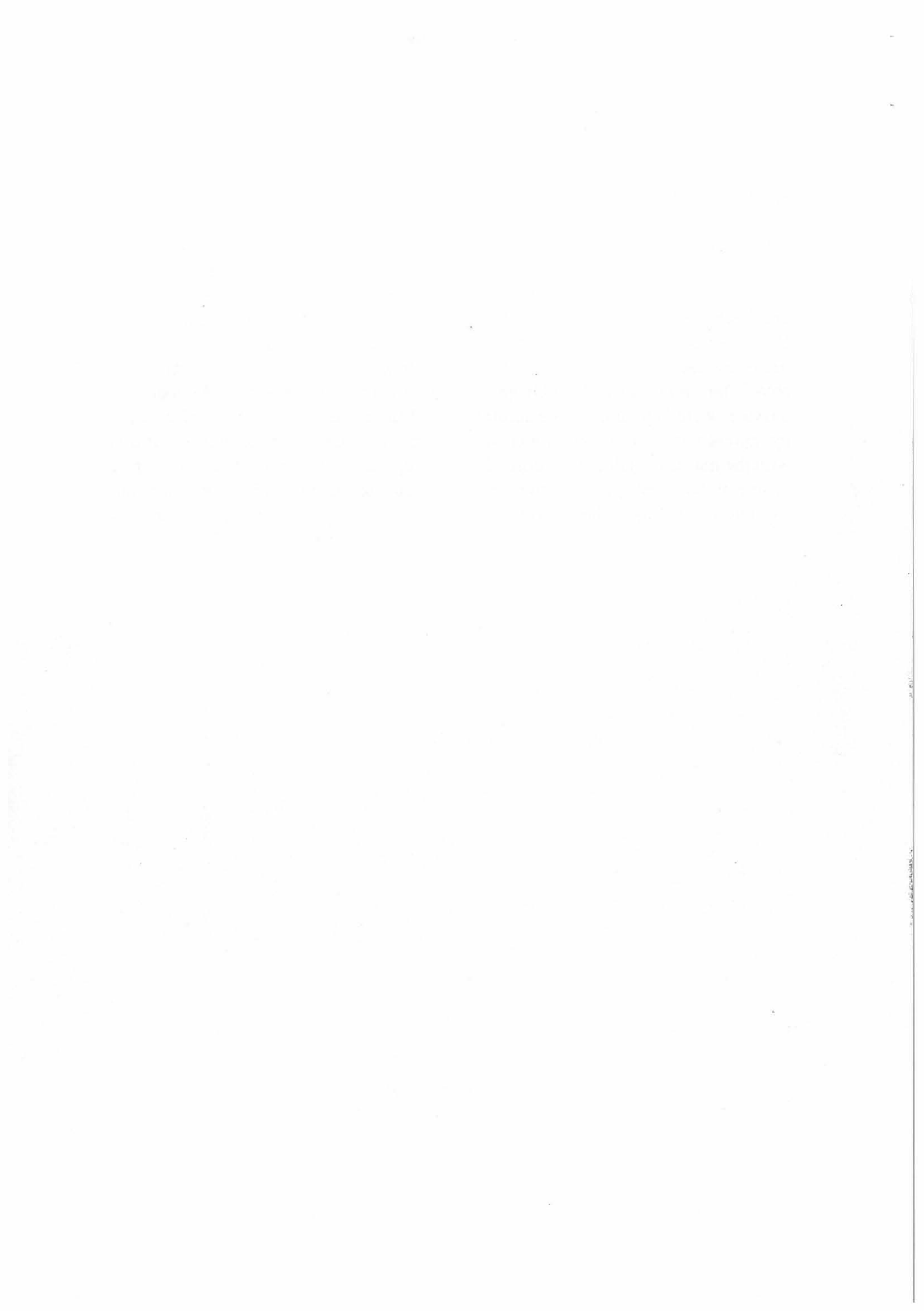
not follow a mandatory reporting-in procedure, the owner always maintained a regular contact with his vessels and it had become customary for contact to be established, either from ship to shore or from shore to ship, three times a day, morning, midday and evening. If a call was missed, the owner would allow six hours then call every hour on the hour until contact was re-established. This routine proved effective in that, when the call scheduled for 0800 on the morning of 7 August was not received, the owner commenced calling the barge on HF radio and the satellite telephone. He started to become concerned after he had received a weather fax containing a strong wind warning for the area. His concern intensified when he was unable to get acknowledgment of his HF and satellite phone calls, during that morning, and he brought forward his planned flight from Darwin to Wyndham. In the opinion of the Inspector, it would have been prudent for the Northern Territory Police to have been informed of the situation following this flight to Wyndham which had revealed no sign of the vessel.

Once the MRCC had been informed, at 1049 EST on Tuesday 8 August, of the concern for the safety of Keppel Trader as contact had been lost with the vessel for over 24 hours, the MRCC assumed SAR responsibility. The subsequent SAR operations were rapidly initiated and were efficient in as much as the upturned vessel was located, and the Master rescued, within six hours from the time of the declaration of a marine distress.

## **Other evidence presented**

Tiwi Barge Services has always been a non-unionised company. As such, there has, for several years, been some animosity between the owners of Tiwi Barge Services and employees of other unionised companies in the Darwin area. The operations of Tiwi Barge Services were kept under close scrutiny by representatives of unions connected with the maritime industry. During the course of the investigation, evidence was put forward by various parties

concerning certain safety aspects of the operations of Tiwi Barge Services and the standard of surveys conducted on the company's other barge, Tiwi Trader, by the Marine Branch of the Northern Territory Department of Transport and Works. The evidence presented, however, did not relate directly to the capsizing of Keppel Trader and, in view of this fact, was not considered for the purpose of this report, but was instead passed to the relevant administration for evaluation and any appropriate follow-up action.



# Conclusions

These conclusions identify the different factors contributing to the circumstances and the causes of the incident and should not be read as apportioning liability or blame to any particular organisation or individual.

The Inspector concludes that Keppel Trader capsized due to the ingress of seas shipped into the engine room after the hatch in the weather deck was left open while the deckhand was carrying out engine checks. The following factors are considered to have contributed directly to the incident.

1. Keppel Trader was loaded at Darwin in such a manner that the vessel's stability did not meet the criteria of the USL Code Section 8, Sub section C.16 (for landing barges). The effect of the free-surface formed in the engine room bilge was exacerbated by this reduced stability which existed before the flooding began.
2. No stability calculations were undertaken before sailing from Darwin and the investigation revealed a lack of understanding of the principles of stability as applied in the Trim and Stability booklet.
3. The weather deck hatch was not marked 'To be kept closed at sea' and the practice had arisen of always using this hatch, in spite of the emphasised warning contained in the Trim and Stability booklet.
4. The internal hatch, which should have been used for access to the engine room under the prevailing conditions, had been stacked with cartons of soft drinks when the vessel was stored with provisions, indicative of the fact that this hatch had fallen into disuse, even in heavy weather.
5. It is considered that the long-standing defects in the wheelhouse panel temperature gauges contributed to the incident, in as much as the Master felt compelled to check the engine temperatures on the local gauges at a time when the vessel was in difficulties.
6. Keppel Trader was proceeding on an inter-State voyage and as such came under the provisions of the Navigation Act 1912. No exemption under section 421 from certain provisions of the Act was obtained, or applied for in writing, from the Australian Maritime Safety Authority prior to Keppel Trader sailing from Darwin.
7. In the opinion of the Inspector, the manning of the vessel was inappropriate for a voyage of the duration of that being undertaken and Keppel Trader should have carried two qualified bridge watchkeepers.
8. The Inspector considers that insufficient attention was paid to the weather forecasts issued by the Bureau of Meteorology, both before the start of the voyage and after departure from Darwin, in particular the strong wind warning which was current for three days before the vessel's departure.

In addition, the Inspector considers that:

It would have been prudent to have alerted the Northern Territory Police to the loss of contact with the barge after the owner had overflowed the vessel's intended route on the afternoon of

Monday 7 August and it had not been sighted.

The Master made commendable efforts to save the deckhand following the capsize and the Inspector considers he did everything possible under the circumstances.

# Details of Vessel

<b>Name</b>	Keppel Trader
<b>Flag</b>	Australian
<b>Vessel Type</b>	Landing Craft
<b>Owner</b>	Sandford Pty Ltd, Berrimah, Northern Territory
<b>Year of Build</b>	1976
<b>Place of Build</b>	Yeppon, Queensland (rebuilt Darwin, Northern Territory)
<b>Gross tonnage</b>	37.8
<b>Net tonnage</b>	29.5
<b>Length b.p.</b>	15.95 m
<b>Moulded breadth</b>	5.1 m
<b>Engine</b>	2 Perkins diesel, 8cy
<b>Engine Power</b>	208 kW
<b>Crew</b>	2 Australian

# Stability terminology and principles

The *centre of gravity* of a body, or vessel, is the point through which the force of gravity is considered to act vertically downwards with a force equal to the weight of the vessel.

The *centre of buoyancy* is the point through which the force of buoyancy is considered to act vertically upwards with a force equal to the weight of the water that the vessel displaces. It is the centre of gravity of the underwater volume of the body.

To float at rest in still water, a vessel must displace a volume of water which is equal in weight to the weight of the vessel, and the centre of gravity must be in the same vertical line as the centre of buoyancy.

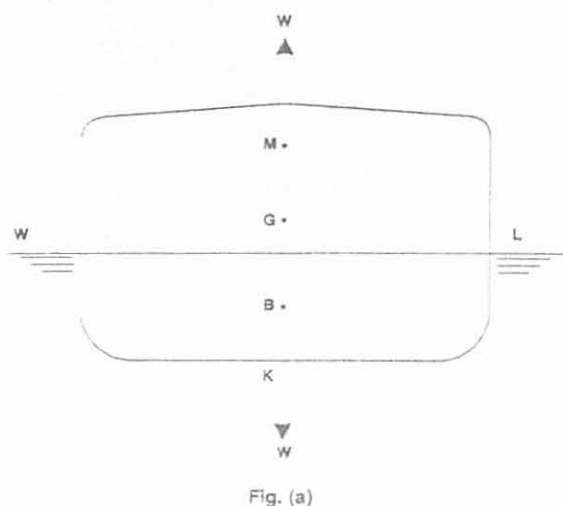


Figure (a) represents a vessel floating upright in still water. The centre of

centre of buoyancy is at point 'B'. The letter 'K' denotes the keel.

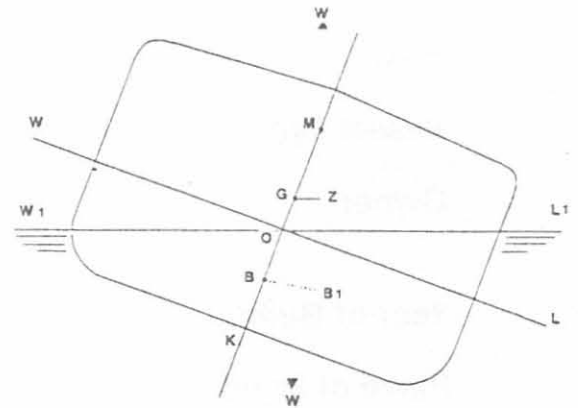


Fig. (b)

If the vessel is inclined by an external force to a small angle as shown in Figure (b) the centre of gravity  $G$  will remain static and the weight of the vessel 'W' is considered to act vertically through this point. The centre of buoyancy, being the centre of gravity of the underwater volume, will move from  $B$  to  $B_1$ .

For angles of heel up to about  $15^\circ$ , the vertical through the centre of buoyancy may be considered to cut the centre line at a fixed point. This point is known as the initial metacentre 'M'.

The height of the initial metacentre above the keel depends on the vessel's underwater form and the surface water plane area.

The vertical distance between  $G$  and  $M$  is referred to as the *metacentric height*. As long as  $G$  remains below  $M$  the vessel has a positive metacentric height.

A ship is in stable equilibrium if, when

position. For this to occur G must remain below M.

Figure (b) shows the vessel inclined at a small angle. The centre of buoyancy moves from B to B1 to take up a new centre of gravity of the underwater volume and the force of buoyancy is considered to act vertically upwards through B1 and the metacentre M. If the forces acting around G are summed, then there is a force or moment acting so as to return the ship to the upright position. This force or moment is referred to as the *moment of statical stability* and is equal to the product of the force W and the length of the imaginary lever GZ.

When a ship, which was inclined to a small angle of heel tends to heel still further, it is in *unstable equilibrium* where the centre of gravity is above the metacentre and has a negative 'GM'. The ship will not stop inclining until G and M coincide.

Figure (c) shows a vessel in unstable equilibrium. While G stays above M the imaginary lever GZ forms a capsizing lever.

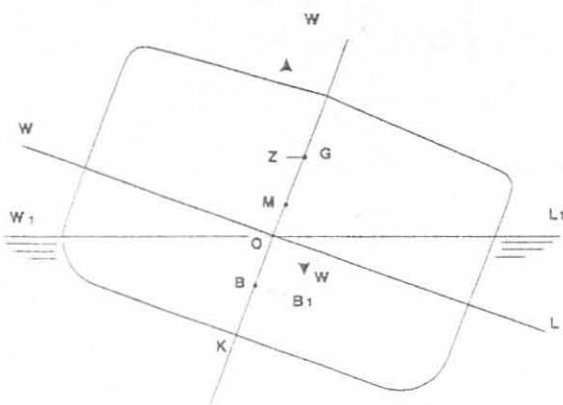


Fig. (c)

The distance GM or metacentric height is sometimes referred to as a measure of a vessel's stability but this will only apply to small angles of heel when GM can be considered constant. A better

measure of stability is the GZ lever. For small angles of heel  $\theta$ ,  $GZ = GM \sin \theta$  and GZ is thus zero when the heel is zero. GZ increases as the heel increases (as long as the formula holds good) showing that the vessel's stability varies with angle of heel. GM, however, remains constant.

This measure of a vessel's stability can be represented by plotting a graph of the value of GZ, the righting lever, in metres, against various angles of heel, in degrees. This plot is known as the *GZ curve* and the area under the curve, in metre-degrees, is used in various regulations as a parameter by which to specify requirements for a vessel's stability.

From the GZ curve can be determined:

- The range of stability and angle of vanishing stability
- The maximum value of GZ, the angle of heel at which it occurs and the righting moment.
- The GZ and righting moment at any angle.
- The angle of deck-edge immersion.
- The initial value of GM.

The range of stability is the range over which the ship has positive righting levers. The angle of vanishing stability is the angle of heel at which the sign of the righting lever changes from positive to negative.

The angle of heel at which the deck-edge becomes immersed provides a point of inflexion on the GZ curve. This is where the rate of increase, or slope, of the curve reaches its maximum value, i.e. where the slope (gradient or tangent) reaches its steepest

