Australian Government
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MARINE SAFETY INVESTIGATION
No. 190

Independent investigation into the grounding of the
Maltese registered cargo ship

Tauranga Chief

at Bradleys Head, New South Wales
17 January 2003

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Helmsman error leads to grounding

An execution error by the helmsman of a ship led to a ship running aground in Sydney Harbour. The Maltese registered general cargo ship *Tauranga Chief* ran aground on a mud/sand patch just south of Bradleys Head light in the middle of Sydney Harbour at 0339 in the morning of 17 January 2003.

The Australian Transport Safety Bureau (ATSB) investigation report released today states that the ship arrived at Sydney Heads at 0300 on 17 January 2003 and a harbour pilot boarded. The pilot took charge of the conduct of the ship and it continued into the harbour toward its White Bay berth. During a series of wheel orders when the ship was rounding Bradleys Head, the helmsman put the helm the wrong way. This was the first step toward the grounding.

The report concludes that the helmsman's error was possibly due to fatigue effects caused by his long flight from Russia to join the ship a day and a half earlier. The concentration and reaction time of the master and officer of the watch, who also joined the ship on 15 January, may have also been affected.

The fact that the pilot did not order 'midships' before ordering counter rudder during the turn may also have been a contributing factor.

The ship was refloated using tugs, the ship's anchor and main engine after being aground about half an hour. *Tauranga Chief* continued to its berth where divers checked the ship's hull externally for any damage, while it was alongside the wharf for cargo operations.

Only slight, localised scratching of the underwater paintwork on the bottom of the hull under the bulbous bow and around the forward end of the hull was reported after the divers inspection.

No injuries or pollution resulted from the grounding.

Copies of the report can be downloaded from the internet site at www.atsb.gov.au, or obtained from the ATSB by telephoning (02) 6274 6425 or 1800 020 616

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1 SUMMARY

Tauranga Chief arrived at Sydney from Port Kembla on 17 January 2003 on its normal liner route. It had sailed from Port Kembla the previous evening and arrived at the Sydney pilot boarding ground on schedule at 0300 local time. The pilot boarded as planned and the ship continued inwards toward the booked berth at White Bay container terminal.

When the ship came to an intended course alteration position in the harbour, east of Bradleys Head, the pilot initiated the turn to starboard to round the headland. He firstly ordered 5° starboard rudder and, when the ship did not respond quickly enough, he increased the order to starboard 10°. The rate of swing increased markedly and so the pilot ordered port 20° to slow the swing. The seaman on the wheel made an error executing this last wheel order and instead applied starboard 20° wheel. Before the consequences of this error could be corrected, the ship ran aground on a mud/sand patch just south of the light on the southern end of the headland.

Two harbour tugs, which were waiting to assist the berthing operations for the ship, were called to the location and the ship was refloated using the tugs, the ship's anchor and main engine after being aground for about half an hour. *Tauranga Chief* continued to its berth where divers checked the ship's hull externally for any damage, while it was alongside the wharf for cargo operations.

Only slight, localised scratching of the underwater paintwork on the bottom of the hull under the bulbous bow and around the forward end of the hull was reported after the divers inspection and video report so the ship was released by AMSA to continue its voyage to New Zealand.

The report concludes that the grounding was caused by an error in the execution of wheel orders during a routine course alteration. Contributing factors identified included:

- The grounding was initiated by an error in the execution of wheel orders during a routine course alteration.
- The pilot did not order midships before ordering counter rudder. This may have contributed to the helmsman's failure to recognise and act upon the change in rudder direction.
- The seaman on the wheel was possibly affected by fatigue, predominantly caused by the circadian low at the time of the incident and compounded by the effects of circadian dysrhythmia (jet lag). The concentration and reaction time of the master and OOW may also have been affected by these effects.
- The handling characteristics of the ship, due to its load and trim at the time of the incident, made the handling of the ship more difficult than usual. The following flood tide and wind on the passage down the harbour would have accelerated the rate of turn which reduced the likelihood of success of the attempted corrective actions.

The report makes recommendations relating to pilotage and crew change practices.

2 SOURCES OF INFORMATION

The master, officers and crew of *Tauranga Chief* and ship's records.

Sydney Ports Corporation and the Harbour Master

The pilot of *Tauranga Chief* and Sydney Pilot Service

New South Wales Department of Transport

The diver's reports

Acknowledgment

The Inspector is grateful to the Sydney Harbour Master for the use of his system for replaying and copying the outputs from the Sydney port Integrated Vessel Surveillance System.

The inspector would like to thank Mr R Lorraine for the use of his photographs in this report.

FIGURE 1:
Tauranga Chief

3 NARRATIVE

Tauranga Chief

Tauranga Chief, ex *Socol 5*, (figure 1) is a Maltese flag general cargo/container ship owned by Mezen Navigation Company, Malta and bareboat chartered to AKP Sovcomflot. The ship is managed and operated by Unicorn Management Services (Cypress) and is currently classed ✠100A1 and ✠LMC by Lloyds Register of Shipping (LR).

Tauranga Chief has a deadweight of 9 598 tonnes at a summer draught of 8.541 m. It has an overall length of 113.12 m and a moulded breadth of 18.90 m. The distance from bow to bridge is 98.12 m and from bridge to aft is 15.00 m. The ship was built in 1992 by Miho Zosensho in Shimizu, Japan. The main engine is a Hanshin 6LF58, 2 stroke, slow speed diesel of 4 413 kW which drives a single, right hand turning, four bladed, four metre diameter, controllable pitch propeller to give the vessel a service speed of 14.0 knots. The steering gear is a Tokimec PR 8259-L. The rudder is a standard, single, 'mariner type', semi-balanced spade rudder in an 'open water' type stern frame.

The ship can carry about 287 TEU[1] on deck and general cargo and/or containers in the two holds under the main deck. *Tauranga Chief* has two of its own cargo handling cranes located on the starboard side of the main deck. These have a maximum safe working load of 50 tonnes each.

The bridge (figure 2) on *Tauranga Chief* is equipped with a Global Positioning System (GPS), an echo sounder and other navigational aids including two radars, a JMA-627-6 to port of the helmsman's position and, to starboard, a Kelvin Hughes Nucleus 3 6000 set. The only rudder angle indicator visible within the wheelhouse is a deckhead mounted, multi-faced type. This display is mounted above the walkway immediately inside the bridgefront windows, on the centreline. One display faces aft towards the helmsman for use during pilotage and other hand steering operations and two others face port and starboard respectively. It is illuminated for night use. At the time of the incident, all of the ship's navigation equipment was operating normally.

Tauranga Chief is on a regular liner, container and general cargo service between several ports in Australia and various ports in New Zealand and other Pacific Islands. In the two years prior to the incident, the ship had visited the port of Sydney 19 times, during which no incidents or pilot's comments had been recorded.

At the time of the incident, *Tauranga Chief*'s crew of 15 were all Russian nationals. All the watch-keeping officers were appropriately qualified. The master had been with the management company and *Tauranga Chief* for six contracts (since 1997) and had been at sea since 1968. This was the first time the second mate (Officer of the Watch - OOW) had been on the ship or on a container ship but had been at sea since 1998. The seaman on the wheel had been serving at sea since 1991 and had been on the ship on six month contracts for the previous four years.

[1] TEU is Twenty foot Equivalent Unit (a standard 20 foot shipping container).

FIGURE 2:
Wheelhouse

Pilotage

Pilotage is compulsory for *Tauranga Chief* whilst transiting Sydney Harbour. Pilots for the port of Sydney are employed by Sydney Pilot Service, a part of Sydney Ports Corporation. The same pilot service also provides pilots for Port Botany, to the south of Sydney Harbour. All Sydney pilots operate on a four week duty roster. The roster includes a period of work in the pilot's office as duty pilot, as well as periods of operational ship piloting. Broadly, pilots undertake a week of day duties (0600–1800), followed by a week off then two weeks of varied night duties (1800–0600). This cycle consists of a duty rotation that was formulated with the assistance of the Sleep Research Centre of the University of South Australia to help minimise the possibility of fatigue effects on individual pilots.

The pilot

The pilot assigned to *Tauranga Chief* began his seagoing career in 1970 and has had experience on a wide variety of ships and ship types. Prior to joining the pilot service, he had gained ten pilotage exemptions for various ports in Australia and New Zealand while serving as master. At the time of the incident he held an Australian Class 1 Masters certificate and was qualified as a level 3, unlimited, pilot for the port of Sydney. This permits him to pilot any size or type of ship in Sydney.

Tauranga Chief's pilot had been a licensed Sydney pilot for the previous nine years. He had handled the ship, with different masters and crews, in Sydney on previous voyages and also sister ships which are also frequent visitors to Sydney. He was in the last week of his duty cycle and so was working night duties.

The evening before starting the inward pilotage aboard *Tauranga Chief*, the pilot had completed one passage into Port Botany, finishing at about 2000. During the early hours of 17 January, he had taken a ship out of Glebe Island container terminal in Sydney immediately prior to the trip in on *Tauranga Chief*.

The incident

Tauranga Chief arrived in Melbourne, its first Australian port, on 12 January 2003. After departing Melbourne, the ship sailed to Port Kembla where a scheduled crew change (all crew members) took place during an otherwise routine port visit. Some of the crew were joining the ship for the first time and some were rejoining after a period of leave. All of the joining crew had flown to Australia from Saint Petersburg in Russia. The ship spent about one and a half days alongside in Port Kembla and sailed at 2230 on 16 January.

At about 0300 local time, 17 January, *Tauranga Chief* arrived at the Sydney pilot boarding ground on schedule. At this time, a helmsman was assigned to steering duties and control was changed to hand steering mode. The master also took the conduct of the vessel from the OOW. They had previously advised their estimated arrival time and other details required by the port, including the ship's arrival draughts.

There was a set (current flow) to the south off the Sydney Heads so Sydney Harbour Control asked *Tauranga Chief* to stay well to the north of the line of the entrance leading lights on approach.

The pilot, who had just conducted another vessel out of Sydney, transferred to the pilot boat near Sydney Heads. He was then taken across to *Tauranga Chief* as planned, boarding at 0315, about two miles from the entrance to the harbour, but slightly to the south of the entrance leading lights. He informed Harbour Control that he had boarded *Tauranga Chief* and was given permission to enter the port and take the vessel to its berth at White Bay container terminal.

Before proceeding inward, the pilot and master discussed the planned passage. The pilot described the proposed route and provided details about the tugs and berthing procedure. The master provided a pilot card with all the ship's arrival information and reported the arrival draughts[2] as 7.97 m forward and 8.03 m aft (virtually even keel). During the information exchange, no mention was made of any handling difficulties. The wind was from the north-east at about force four (11 to 16 knots[3]) and the tide was flooding (flowing from approximately astern at a maximum rate of about 0.5 knots). The next high water was predicted for 0821 that morning. There was no other shipping traffic moving in or out of the harbour at the time.

Tauranga Chief then continued inwards under the direction of the pilot, via the Western Channel, toward the berth. The pilot initially ordered a course to bring the ship back onto the leads as it passed through Sydney Heads. The ship was on full manoeuvring speed at about 12 knots. After regaining a position and course on the approach leads, the first required course alteration was a turn of about 74° to port (from 293° to 219°) to round Junction Buoy (the Sea Buoy) and enter the Western Channel. The pilot initiated this turn at about 0326, at the planned wheel-over position for a ship of this size. He noticed during this manoeuvre that the ship took more rudder, and a longer time than he expected, to start the turn. His initial order to start the turn was for 5° port rudder and the order was repeated and actioned correctly by the helmsman.

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2 Draught is the distance between the keel of the ship and the waterline at any position.

3 A knot is a nautical mile per hour (1852 metres per hour).

When there was no perceived reaction from the ship, he increased this to port 10° to initiate the turn. This had the desired effect.

To stop the ship's swing and steady the heading for the passage down the Western Channel, the pilot initially reduced the amount of port rudder then ordered midships. The ship continued to swing to port. The pilot then ordered starboard wheel. The ship eventually required a significant amount of counter rudder (hard-a-starboard) to steady it on course for the passage down the Western Channel. The pilot was a little concerned about the handling characteristics of the ship and, suspecting that the ship might be trimmed by the head, confirmed with the master the declared draughts reported earlier to Harbour Control.

Tauranga Chief steered reasonably well once settled on course and, when exiting the Western Channel, the pilot, as a precaution and bearing in mind the ship's earlier response, requested a course of 214°(G). This was slightly to the east of the usual track and would allow a little more distance (and hence a more gentle turn) off the headland for the next planned turn at Bradleys Head.

At 0335, when the ship came to the wheel over position about 2.1 cables (0.21 nmiles) east of Bradleys Head, with the Bradleys Head safe water buoy fine on the starboard bow, the pilot ordered starboard rudder to round the headland.

During this manoeuvre, both the master and the pilot positioned themselves to the starboard side of the centreline at the bridgefront windows in front of the control console. This position allowed them to gain a clear view ahead and to be able to see the rudder angle indicator on the deckhead. The first helm order for the turn was 'starboard 5°'. The seaman on the wheel repeated the order and correctly applied the wheel. Again, the ship was slow to respond and, after a short time, the pilot ordered 'starboard 10°'. This order was repeated to the pilot and actioned correctly by the helmsman. The ship started to swing to starboard. Shortly after the helm was applied, the pilot judged the rate of change of heading to starboard to be too great so he ordered counter rudder of 'port 20°' to slow the swing. The seaman on the wheel repeated back 'port 20' but then applied 20° of starboard rudder.

Both the pilot and master, who were looking ahead using the ship's foremast to visually judge the rate of turn, noticed that the rate did not decrease as expected and looked up to check the rudder angle indicator. Simultaneously, they noticed that the indicator was showing that the rudder was just stopping at 20° starboard. The OOW was at this time at the starboard radar checking the distance off the headland. All three men realised the helmsman's error and the master reissued the previous order (port 20), this time also in Russian. Both the master and the second mate physically assisted the man on the wheel, who appeared slightly confused, to reverse the error and the rudder was set to port 20° and then almost immediately to hard-a-port.

Meanwhile the pilot assessed that the ship's rate of turn was still too rapid to be checked in time to prevent a grounding. He ordered the propeller pitch to zero, to reduce the speed at grounding. Next, judging that the rate of turn with full counter rudder might be sufficient to prevent the grounding, the pilot ordered ahead pitch. Very soon the pilot judged that this attempt would not be successful so it was abandoned and the propeller pitch put full astern. When the speed reduced a little, they let go the starboard anchor and paid out four shackles[4] of anchor cable. This had little retarding effect and, at 0339, the ship slid to a stop in the sand and mud about 0.5 cables to the south of the light at the end of Bradleys Head on a heading of about 299°(T).

[4] One shackle of anchor chain is 90 feet or 27.4 metres long.

The pilot was sure, from the ship's position and heading, that only the forward end of the vessel was aground. He checked with the master with regard to the disposition of fuel, ballast etc and then called harbour control to report the incident.

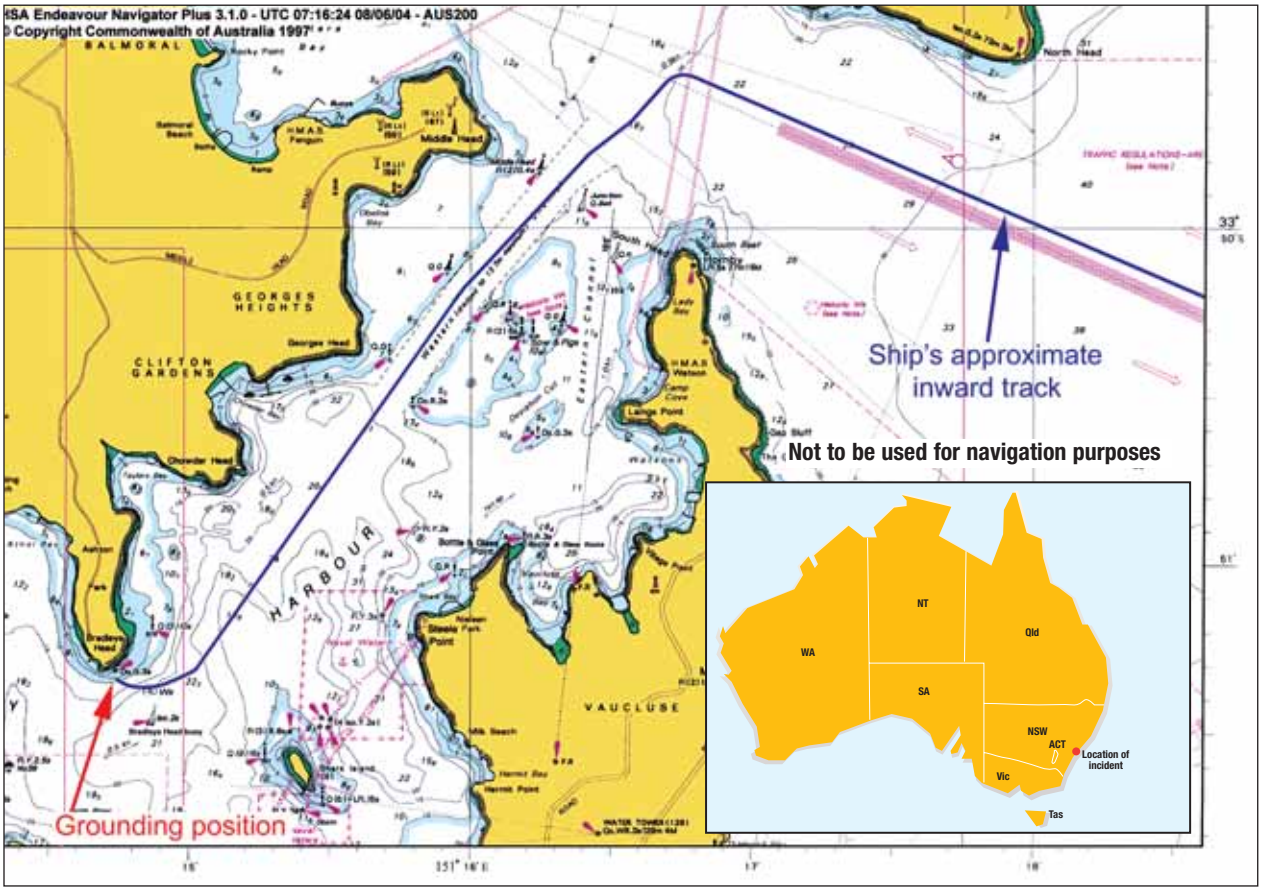
The ship's crew checked all compartments on board for damage or water ingress and found the hull to be sound.

The two harbour tugs, *Wonga* and *Watagan*, which were waiting near Fort Denison to assist the berthing operations for *Tauranga Chief*, were called to the assistance of the ship. When they arrived, the tugs checked for any loss of draught forward and then one was set on a long line from the ship's stern and the other on a line on the port shoulder[5]. The tug masters were briefed by the pilot on the plan to refloat the ship.

At 0407, *Tauranga Chief* was refloated using the tugs, the ship's main engine and anchor. It had been aground for about half an hour on the rising tide. The ship continued to its berth and made fast at 0508 with no further incident. While it was alongside the wharf for cargo operations, divers checked the ship's hull externally for any damage. A port authority representative visually confirmed the ship drafts just after berthing.

The divers found only slight, localised damage to the underwater paintwork on the bottom of the hull under the bulbous bow and around the forward end of the hull. On receipt of the diver's inspection reports, the Australian Maritime Safety Authority released the ship from the detention order issued at the time of the grounding so that it could continue its voyage to New Zealand.

FIGURE 3:
***Tauranga Chief*'s approximate track**



5 Shoulder is where a ship's hull form changes from the bow shape to the parallel mid body of the ship.

4 COMMENT AND ANALYSIS

Evidence

Interviews were conducted with the master, officers and relevant crew members onboard *Tauranga Chief*. The pilot was interviewed later at the pilot station.

Copies of ship's documents including their voyage plan and the official statements from the relevant people were reviewed. Copies of the ship's stability information were examined. A copy of the ship's course recorder trace was made and examined. This trace recorded the ship's heading against time (the time scale was about 10 minutes 30 seconds to eleven minutes fast of ship's time). There was no record of rudder angle.

The ship was equipped with an automatic engine telegraph logger but this was not operational at the time of the incident.

Records of the working hours and travel schedule of the master, second mate, seaman on the wheel and pilot were obtained and examined to assess the possibility of fatigue.

Documents and replays from the Sydney port Integrated Vessel Surveillance System (IVSS) were reviewed to assist in the analysis. A transcript of radio conversations between *Tauranga Chief* and Harbour Control between 0303 and 0436 on 17 January 2003 made by Sydney Ports was reviewed. A review of Sydney Ports records did not show any adverse comments about the ship or it's handling characteristics in the past. Pilots at some other Australian ports were also canvassed for opinions about the ship's handling characteristics.

A report and video of the damage, compiled by the divers, was inspected.

On 17 February 2003, when the ship next returned to Sydney, an investigator from ATSB boarded the ship with its pilot and observed the conduct of the inward pilotage in order to observe the handling characteristics and the procedures and practices employed on board during pilotage.

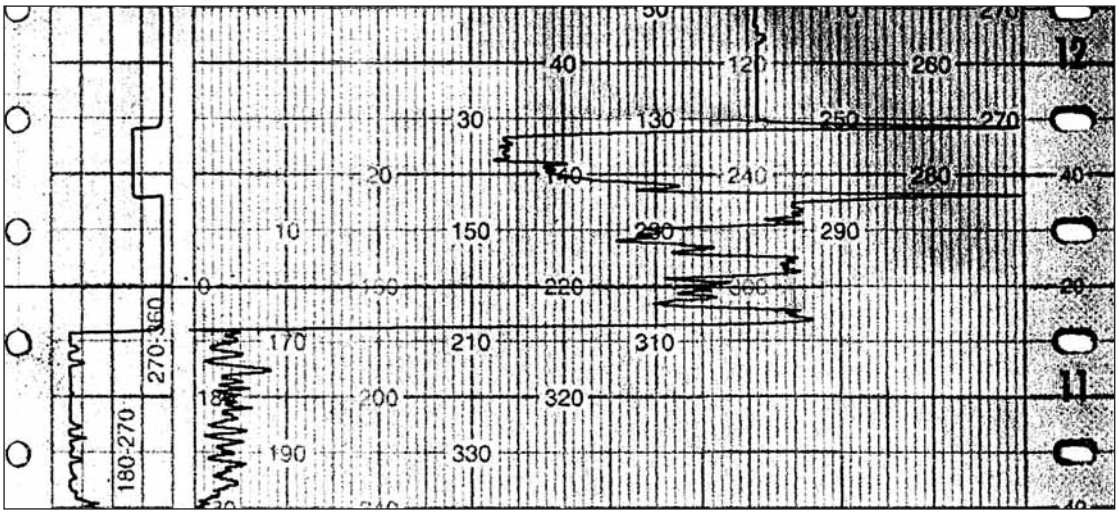
The incident

On the morning of 17 January, *Tauranga Chief*'s passage into the port of Sydney was proceeding routinely up to the time of the turn around Bradleys Head. The vessel was a regular caller at the port, the pilot on board had handled the vessel several times in the past and the crew on the bridge were fully briefed on the planned passage to the berth. The weather conditions in the outer harbour were good and the ship was making a speed of about 12 knots. The pilot had noted during the turn into the Western Channel that the vessel was reacting as though it was trimmed by the head (difficult to start turning and difficult to stop turning once started) and had decided to slightly modify his approach to Bradleys Head. His plan was to now put the Bradleys Head buoy[6] slightly to starboard (rather than to port) to make a more gentle turn around the headland.

[6] Bradleys Head buoy is a safe water type buoy and is used in Sydney primarily as a turning mark to separate in and outbound ships rounding the headland. It is also a guide for small craft in the harbour as to the movements of larger ships which usually leave it to port. The necessity for the buoy and its siting were reviewed as part of the investigation. The buoy was not considered to be a factor in this incident.

Tauranga Chief's course recorder trace shows for the northern section of the Western Channel, the ship steered about 219°(G) for two minutes. The next course was about 214°(G) for the 4½ minutes as the ship approached the wheel over position east of Bradleys Head. The next heading was to be about 277° (T), towards Kirribilli Head, an alteration of 63 degrees to starboard.

Figure 4:
***Tauranga Chief*'s course recorder trace**



A little before 0336 the pilot ordered 5° of starboard rudder. The ship did not respond as the pilot wanted and he ordered an increase of rudder to 10° starboard rudder.

Analysis of the course recorder trace shows that the ship began to turn at 0336 at an initial rate of 6°/min. About 60 seconds after the ship began to turn to starboard the course recorder trace shows an increase in rate of turn to 30°/min. About 30 seconds later the course recorder indicates reaching a maximum of 40°/min. The ship reached a heading of 277° (G) at 0337:30, 90 seconds after starting to turn. At some stage in the turn the pilot ordered 20° port counter rudder without, apparently, first ordering 'midships'. Despite repeating the order for counter rudder correctly the helmsman increased the rudder angle to starboard.

There is insufficient evidence to determine with confidence when the pilot ordered counter rudder, or how long the rudder was at 20° to starboard before the error was realised, or how long it took to rectify the error. The statements of those on the bridge were that the error was realised very quickly and that it was rectified after a short period of confusion. The course recorder trace would suggest that the order to increase to 10° starboard rudder resulted in the increase to 30°/min. It is possible that the increase to 40°/min resulted from the helmsman applying 20° of starboard rudder.

The elapsed time between *Tauranga Chief*'s initial movement to starboard off Bradley Head to the time of grounding was 3½ minutes.

When it was realised that *Tauranga Chief* may ground, the pilot ordered a series of ahead and astern propeller settings to try and avoid grounding and then to mitigate the consequences. These were made with the full agreement of the master. The propeller settings were not recorded, either manually or automatically. Given, however, the steering characteristics of the ship and the situation facing the bridge team at the time, the pilot had few options other than those attempted. The fact that the anchor was dropped before taking the ground and that it was later able to be used in the refloating operation also suggests that appropriate actions were taken to mitigate the effect of the grounding.

The error made by the helmsman was the 'active', unsafe act that led to the grounding. Such an error is what is known as an action slip, occurring at the skill-based level of performance. Slips are errors resulting from some failure in the execution of an action sequence and are due to a failure to monitor one's own current intention. The evidence suggests that the pilot's command was noted and recorded at the fringes of the helmsman's consciousness, and correctly acknowledged but was not acted on because his attention was not focussed on the job at hand. The main questions are therefore, what led to the helmsman's error and whether the vessel's handling was a factor in the grounding.

Bridge team

At interview, the master demonstrated that he had a very good command of English.

The second mate (OOW) likewise had no trouble with the English language. The helmsman's understanding and comprehension of English at interview, whilst not at the same standard as the senior officers, suggested a good command of maritime English and particularly steering instructions.

None of the bridge team suggested that he did not understand the helm orders given. There were no indications of excess noise levels or aural disturbances to distract the helmsman at or about the time of the steering error.

It is a common convention that, before ordering counter helm, a pilot would order the rudder be put amidships. This practice increases the salience of a potential change of rudder direction by directing the attention of the individual towards it. Therefore, without this cue, the possibility that a change of rudder direction was potentially imminent, was reduced. This strategy is implemented as a means of reducing the risk of the type of error that occurred in this incident. It would be reasonable for a helmsman to anticipate such an order before applying the rudder in the opposite direction, especially given that the pilot had used this order before. An increase in rudder angle in the same direction is usually not preceded by any other special phrase (a reduction in rudder angle is normally either preceded by 'port' or 'starboard' as appropriate or by the phrase 'ease to . . .').

The pilot, as a matter of routine, normally ordered the wheel amidships before ordering a rudder angle in the opposite direction. On this occasion it seems that he did not, due to some slip or lapse in his mental processing. Although the pilot could not recall whether or not he had ordered 'midships' prior to the order for counter rudder the ship's crew stated that there had been no order of 'midships' between the order to increase the rudder angle to 10° to starboard and the order for 20° of port rudder. The helmsman's error may therefore have been further influenced by his expectation. The expectation may have existed that prior to any counter helm orders, he (the helmsman) would be instructed to return the helm to midships. Conversely, if this order is not given it is reasonable to assume that the helmsman would not expect a counter rudder order to follow. In its absence, the helmsman may have expected orders that either increased or decreased the rate of turn in the one direction (i.e., all orders to starboard direction), not an absolute change in rudder angle (i.e., from starboard to port). Consequently, when the order for counter helm was given (port 20°), without the expected cue 'midships', the second routine may have held greater salience and given the natural increment from 5°–10° to 20° (which potentially agreed with expectation) there was little to challenge the helmsman's mind set. The role of expectation therefore may have further exacerbated the potential for error.

Until the time of the incident, the helmsman had repeated every wheel order he was given properly and applied it correctly. It seems that the helmsman was operating at different levels

simultaneously. While he had acknowledged the order of '20° port wheel', he had actually turned the wheel to starboard 20°. The lack of the normal prompt or cue of 'midships', together with issues such as time of day and his pre-existing level of fatigue probably contributed to his mis-application of the helm.

At the time the helmsman made the misapplication of the pilot's order for 'port 20' the other members of the bridge team were not directly monitoring his actions. Both the pilot and the master were looking forward, watching the foremast move in relation to the land, to assess the vessel's rate of turn. The second mate was busy at the radar on the starboard side of the helm taking a range. While all three men quickly realised the helmsman's error and responded rapidly to correct it, the vessel's proximity to Bradleys Head, its handling characteristics and rate of turn were such that the grounding was possibly inevitable at this point.

It is the practice on most ships, and reflects good seamanship and Bridge Resource Management, for the OOW to cross-check the helmsman's execution of helm orders during a pilotage. Many pilots also perform this check and may also use hand signals in addition to verbal orders to provide the helmsman with a visual cue. The International Chamber of Shipping's Bridge Procedures Guide states under the heading '3.3.3.4 Monitoring the Pilotage':

> Verbal orders from the pilot also need to be checked to confirm that they have been correctly carried out. This will include monitoring both the rudder angle and rpm indicators when helm and engine orders are given.

These practices serve as a defence against 'one-man errors' - the possible ambiguity of the pilot's order and the subsequent execution error made by *Tauranga Chief*'s helmsman - and reduce the likelihood and/or consequences of an incorrect helm setting, an error which is not uncommon.

Fatigue

The grounding occurred at about 0339 in the morning. This is a time in the day when most individuals undergo a 'dip' in their circadian rhythm which results in a feeling of sleepiness or fatigue. To compound the time of day effect, all of *Tauranga Chief*'s crew had travelled by air from St Petersburg, Russia to Sydney two days prior to joining the ship in Port Kembla on the morning of 15 January. This repositioning for duty involved travel across eight time zones. Travelling rapidly across time zones can disrupt a person's circadian rhythms, leading to circadian dysrhythmia or 'jet lag'. The symptoms of jet lag can include:

- Fatigue and sleepiness
- Impaired judgement and decision making
- Memory lapses
- Detrimental effects on concentration and reaction time.

Consideration was given to whether the three crew members on the bridge at the time of the incident had been allowed sufficient rest time after repositioning to ensure that their fitness for duty was not compromised by the effects of jet lag. The master and second mate travelled from St Petersburg to Sydney with a stopover of about 12 hours in London en route. The helmsman travelled from St Petersburg to Sydney at about the same time but went via Frankfurt and Singapore. The travel time from St Petersburg to Sydney was approximately 29 hours for the master and second mate and 42 hours for the helmsman. After that time, the three crew members departed Sydney at approximately 0700 on 15 January 2003 to join the vessel alongside the cargo wharf at Port Kembla at about 0900. The grounding occurred approximately 39 hours later.

The adequacy of the rest period afforded to the master, second mate and helmsman was assessed by applying a formula derived by the International Civil Aviation Organization (ICAO), and by using a fatigue model developed by the University of South Australia Centre for Sleep Research that includes an allowance for transmeridional flight. The variables that are available for computation in these analyses do not include factors like age, health, individual tolerance or change of activity (from being on leave to returning to work), nor do they make allowance for environmental factors like weather, noise, ship movement or vibration.

Neither analysis conclusively indicated that the performance of the three crew members was likely to have been significantly influenced by the effects of fatigue or jet lag at the time of the grounding. Intuitively, however, it seems probable that the actions of the helmsman in particular (who stated that he had not had a good rest immediately before coming on watch), were nonetheless symptomatic of these effects.

Many ship managers and manning companies, like *Tauranga Chief*'s, have a policy of changing entire crews in at one time. Joining crews are often flown over long distances, through a significant change in local time. While it is generally impractical to allow these crews a rest period after arriving at their destination sufficient to overcome all of the effects of jet lag, a staggered crew change would often be a practical possibility. Changing part of the crew at any single time would reduce the chance of all of the crew being affected by fatigue or jet lag at the same time and may also improve the operational continuity of the vessel.

Analysis of the pilot's hours of work and rest and his work routine and personal circumstances did not indicate that fatigue was a contributing factor for him.

Ship handling

From the pilot boarding position to the first significant wheel-over position *Tauranga Chief* was, with some minor adjustments, on a steady course of 294°. At a position about 0.5 miles north-east of the Junction buoy (the Sea buoy) the ship made a 74° alteration to port. The radar plot recorded on the Vessel Traffic System shows that *Tauranga Chief* executed a turn that would have brought the ship close to the Sea buoy and some adjustments were made to position the ship towards the centre of the Western Channel. During this turn the under keel clearance was in excess of 10 m, the tidal stream was following and the wind was north-east at force four (11–16 knots). The ship's length/beam ratio is approximately 5.98.

The pilot noted that the ship seemed to be slow to respond to the helm, but once the turn was established the ship turned quickly and required large angles of counter rudder to steady the ship. The helmsman, who was familiar with the ship, also stated that he felt that the steering was 'heavy'. The pilot had conducted the ship on previous occasions and, from the steering characteristics, suspected that the ship was trimmed by the head. The master, however, confirmed the arrival draught as 7.97 m forward and 8.03 m aft, giving a very slight stern trim of 6 cm.

Neither the pilot nor the master were unduly concerned but agreed that an allowance should be made for a more gentle turn at the next major course alteration of about 60° off Bradley Head.

'Behaviour and Handling of Ships'[7] contains a useful description of the 'Effect of Trim on Steering' and with respect to a ship trimmed by the head it states:

> When moving sideways through the water, (ie., turning), the ship down by the head has relatively more of the underwater area forward of the pivot point[8], which will meet more lateral resistance. A stronger transverse force on the foreship pushes the pivot point farther back and shortens the steering lever…
>
> When a swing is on, there is a larger rotational momentum of the foreship which has to be met by a smaller steering moment. The more the ship is down by the head, the more difficult it is to steer the ship. It takes time to start the swing, and it takes even more time to stop the swing.

While *Tauranga Chief* was in fact on a nearly (static) even keel at the time of the incident, the vessel's response to helm orders was symptomatic of a head trim. Other factors including the vessel's stability[9] were investigated and were found to be unlikely to have contributed to the vessel's handling characteristics.

Several other Sydney pilots and pilots at other ports that the ship had recently visited were questioned about the ship's handling characteristics. The pilots did not offer any specific negative comments but did remark that large amounts of helm and counter rudder were required even though the ship's trim during some of their movements was substantially different to that at the time of the incident. Over the previous 36 movements of the ship in Sydney harbour (a period of about two years) it had only ever once been trimmed with a near even-keel. In the past, the ship has been trimmed at least 0.5 m by the stern.

While there is no reason that the ship should not be sailed at even keel, it may have exacerbated the ship's inherently slow response to the rudder and is a factor in the grounding. It resulted in the vessel reacting to rudder commands in an excessive way. The following flood tide and wind from astern on the track down towards the last turn combined with the ship's pivot point being well forward of midships would also have accelerated the rate of turn at Bradleys Head. These factors reduced the likelihood of success of the pilot's corrective actions following the incorrect rudder movement.

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7 Behaviour and Handling of Ships, page 31, Henry H. Hooyer, Cornell Maritime Press, 1983.

8 The itinerant vertical axis about which a ship rotates during a turn.

9 The ship's stability calculations indicated an initial GM (metacentric height) of 0.81 m and with an area under the GZ curve of 0.134 m for angles of heel between 0 and 30 degrees. These figures are well within the IMO criteria and do not indicate that there was anything unusual about the ship's loading which would cause any handling difficulties. An accepted ratio for the introduction of shallow water effects is 1.5. The water depth in this case exceeds 1.5 times the ship's draught, so shallow water effects on the ship's handling characteristics are not considered to be a factor.

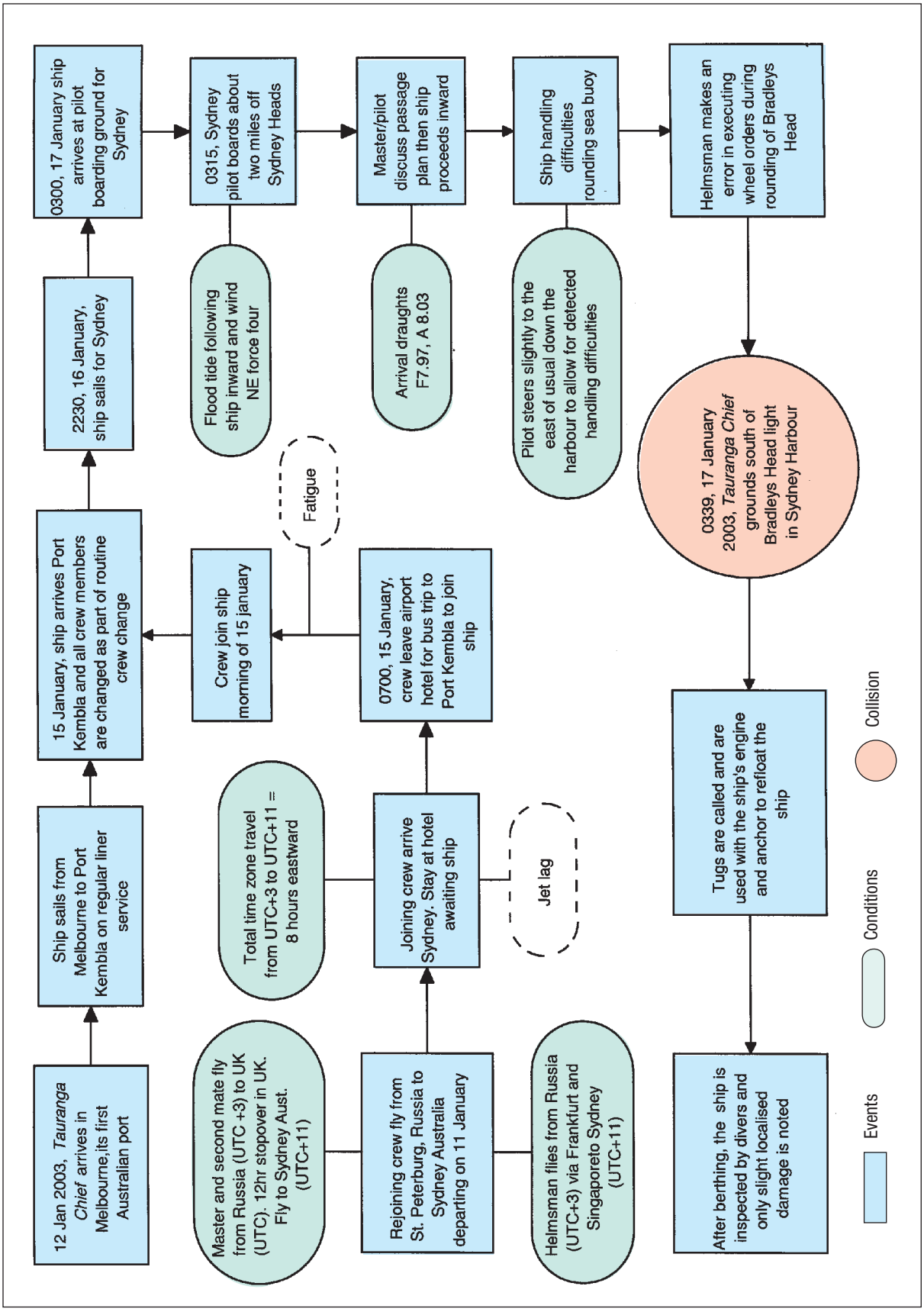
5 CONCLUSIONS

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

Based on the evidence available, the following factors are considered to have contributed to the grounding of *Tauranga Chief* on 17 January 2003:

- The grounding was initiated by an error in the execution of wheel orders during a routine course alteration.
- The pilot did not order midships before ordering counter rudder. This may have contributed to the helmsman's failure to recognise and act upon the change in rudder direction.
- The seaman on the wheel was possibly affected by fatigue, predominantly caused by the circadian low at the time of the incident and compounded by the effects of circadian dysrhythmia (jet lag). The concentration and reaction time of the master and OOW may also have been affected by these effects.
- The handling characteristics of the ship, due to its load and trim at the time of the incident, made the handling of the ship more difficult than usual. The following flood tide and wind on the passage down the harbour would have accelerated the rate of turn which reduced the likelihood of success of the attempted corrective actions.

FIGURE 5:
***Tauranga Chief*: Events and causal factor chart**



6 RECOMMENDATIONS

MR20040037

Pilots and bridge teams should ensure the conventions governing helm orders are observed, particularly the use of 'midships' when changing rudder direction and also consider the use of hand signals to supplement verbal steering orders.

MR20040038

Shipping companies should review their crew change practices and give consideration to staggering crew changes to minimise the risk of all of the crew suffering travel related fatigue at the same time.

7 SUBMISSIONS

Under sub-regulation 16(3) of the Navigation (Marine Casualty) Regulations, if a report, or part of a report, relates to a person's affairs to a material extent, the Inspector must, if it is reasonable to do so, give that person a copy of the report or the relevant part of the report. Sub-regulation 16(4) provides that such a person may provide written comments or information relating to the report.

The final draft of the report, or relevant parts thereof, was sent to the master and ship managers, the pilot, Sydney Pilot Service and Sydney Ports corporation.

Where appropriate the text has been change to correct the draft or reflect the submission.

8 TAURANGA CHIEF

IMO Number	9004504
Flag	Malta
Port of Registry	Valletta
Classification Society	Lloyds Register (LR)
Ship Type	General cargo/container ship
Builder	Miho Zosensho K.K Shimizu, Japan
Year Built	1992
Owners	Mezen Navigation, Malta
Ship Managers	Unicom Management Services, Cyprus
Bareboat Charterer	Sovcomflot
Gross Tonnage	6 030
Net Tonnage	3 602
Deadweight (summer)	9 597 tonnes
Summer draught	8.541 m
Length overall	113.12 m
Breadth	19.221 m
Moulded depth	11.28 m
Engine	1 x Hanshin 6LF58
Total power	4 413 kW
Crew	15 (Russian)

Independent investigation into the grounding of the Maltese registered cargo ship Tauranga Chief at Bradleys Head, New South Wales 0n 17 January 2003

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