Report 97-211

jet boat *K-Jet 3*

rolled on a shingle bar

Lower Shotover River, Queenstown

26 December 1997

Abstract

At about 1545 on Friday, 26 December 1997, a jet boat carrying 10 passengers plus the driver, ventured into a shallow tributary of the Lower Shotover River. The driver turned hard left in an attempt to regain the main channel but the boat skidded sideways along a shingle bar for some 10 m before it rolled and came to rest upside down. Several of the passengers and the driver received minor to serious injuries in the accident.

Safety issues identified included the fitting of roll bars and passenger lap belts on commercial jet boats operating in braided rivers, and the recording of the number of passengers carried on each trip. Safety recommendations were made to the Director of Maritime Safety, the chairman of the Commercial Jet Boat Association and the management of Kawarau Jet Limited to address the above safety issues.

K-Jet 3

Transport Accident Investigation Commission

Marine Accident Report 97-211

Boat particulars:

Type:	Mackraft commercial jet boat
Class:	Passenger (under 6 m)
Limits:	Lake Wakatipu, Kawarau River and the Lower Shotover River
Allowable occupants:	14 (including driver)
Length:	5.95 m
Built:	In 1995 at Bluff, by Mackraft
Construction:	Aluminium mono-hull
Propulsion:	One 350 cubic inch (5735 cc) 261 kW Chevrolet petrol engine driving a single stage Hamilton 212 jet unit
Normal operating speed:	70 km/h
Owner/operator:	Kawarau Jet Limited

Location: Lower Shotover River, Queenstown

Date and time: Friday, 26 December 1997, at about 1545[1]

Persons on board:

Crew:	1
Passengers:	10

Injuries:

Crew:	1 (serious)
Passengers:	8 (minor to moderate)

Nature of damage: Moderate indenting and scraping on aluminium hull and topsides

Inspector-in-Charge: Captain Tim Burfoot

[1] All times in this report are NZDT (UTC + 13 hours) and are expressed in 24 hour mode

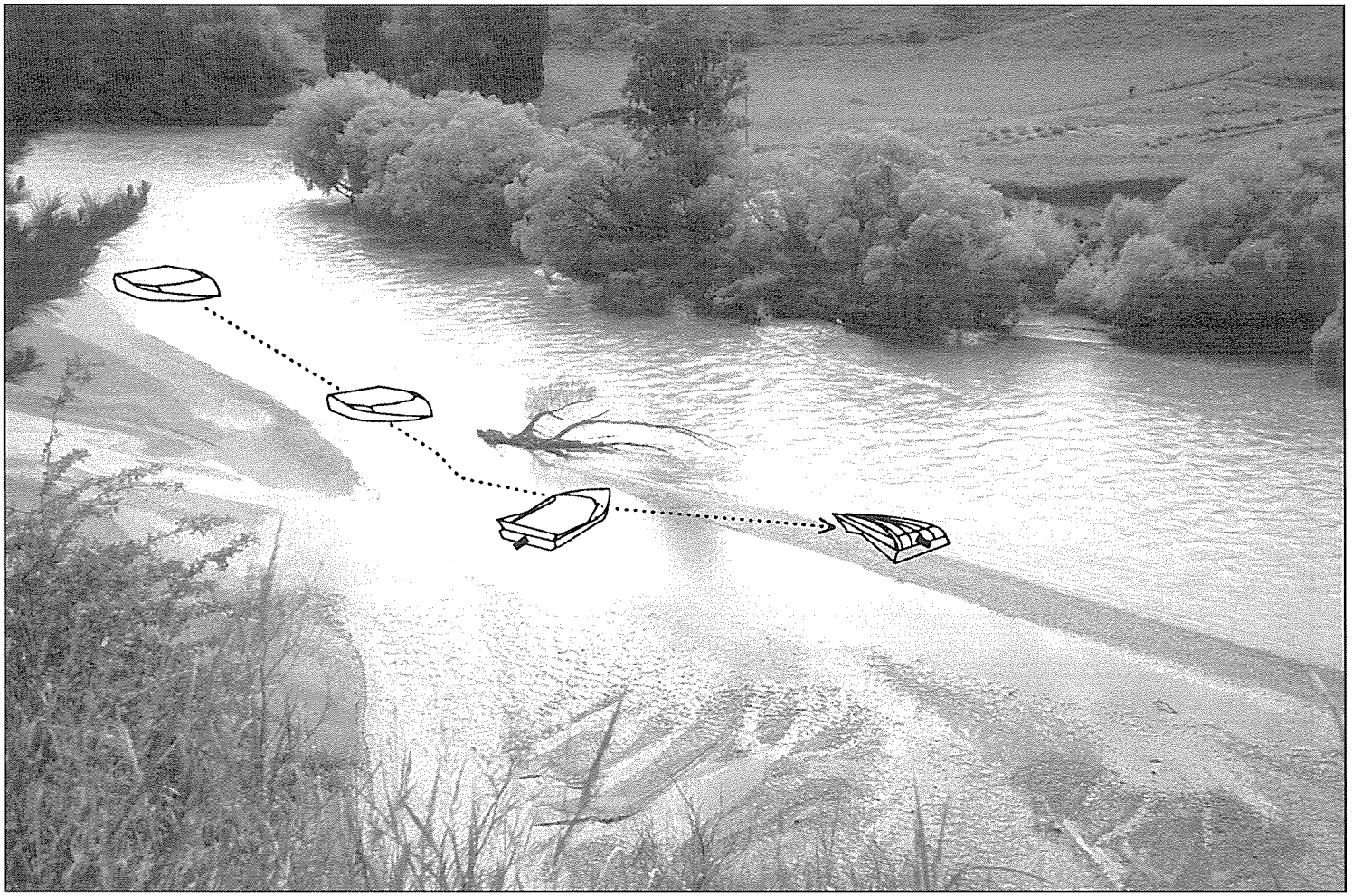

Figure 1
Approximate track of *K-Jet 3* to the right of the tree

1. Factual Information

1.1 History of the trip

1.1.1 Shortly before 1500 on Friday, 26 December 1997, 10 tourists gathered at the Town Pier in Queenstown to embark on a one hour scenic/thrill jet boat trip down the Kawarau and up the Lower Shotover Rivers.

1.1.2 The driver ensured each passenger was fitted with a life-jacket, and allocated them a seat in the jet boat *K-Jet 3*. Before departing the wharf, the driver gave the passengers a briefing on the trip, and explained the hand signal he would use to indicate when he was going to execute a spin[2]. He also told them to hold on to the hand rail in front of them at all times.

1.1.3 *K-Jet 3* departed the wharf at about 1500, traversed the Frankton Arm of Lake Wakatipu and entered the head waters of the Kawarau River. The driver followed the Kawarau River down to the junction where the Shotover River flowed into it, turned up the Shotover and picked his way up river to a place called Tuckers Beach.

1.1.4 The driver executed a number of spins on the way near points of interest, and used these opportunities to give brief historical accounts of the area.

1.1.5 At about 1530, *K-Jet 3* left Tuckers Beach heading back down the Shotover River to return to Queenstown. Just above the Shotover River road bridge, *K-Jet 3* came around a wide sweeping right hand bend in the river and was running parallel and close to the right hand side of the main channel. The driver lined the boat up heading for a large dead tree that had grounded on a shingle bar near the right hand side of the main river flow (see Figure 1).

1.1.6 To the right of the tree, the river fanned into a small tributary which became progressively shallower, ending in a shingle bank over which the river flow was just visible. *K-Jet 3* entered the small tributary at about 70 km/h and began a left turn close to the tree. As the boat drew level with the tree, the driver exclaimed, "Oh [**][3]" and some passengers observed the driver turn *K-Jet 3* to the right slightly before executing a hard left turn. The driver later recalled releasing the accelerator at that time.

1.1.7 As the boat entered the hard left turn, the foot of the bow struck a shingle bar behind the tree and the boat skidded sideways along the shingle bar for about 10 m, before rolling over to the right and coming to rest up side down, half in and out of the water.

1.1.8 Most of the momentum of the boat was dissipated during the sideways slide along the shingle bar before it rolled over. The rate of the roll was described by the passengers as, "slow".

1.1.9 In its final resting position, the stern of *K-Jet 3* was supported off the ground by an aluminium antenna arch that spanned the engine bay, allowing the passengers in the rear and middle seats enough room to escape from under the boat.

1.1.10 The two passengers in the front seat were more cramped for space and could escape only after the other passengers had removed the seat bottoms. The driver was pinned under the boat, so the passengers lifted the boat off him and managed to right it again.

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[2] A spectacular manoeuvre, unique to jet boats, where the boat is turned at relatively high speed, almost within its own length. The manoeuvre is normally used when a rapid stop, or change in direction, is required in narrow sections of the river. It is often used by commercial jet boat drivers to enhance the degree of excitement for the trip.

[3] Expletive deleted.

1.1.11 Meanwhile, one of the passengers, who was a trained nurse, used the contents of a first aid kit from the boat to dress the various wounds that the passengers had suffered. The driver, despite having broken his shoulder, made a check of the passengers and, seeing that they were being attended to by the nurse, used the boat radio to make a distress call to the base.

1.1.12 Meanwhile, at about the time of the accident, a second Kawarau jet boat had reached the junction of the Shotover and Kawarau Rivers. The driver of the second jet boat radioed *K-Jet 3* to inform the driver that he was on his way up the Shotover River. This was a normal safety procedure to ensure each driver was aware of any possible conflicting traffic.

1.1.13 Receiving no reply, the driver of the second jet boat proceeded with caution up the Shotover River. On his way up the river, the driver heard the *K-Jet 3* driver's distress call, and relayed the message back to the base, who alerted the emergency services. The second boat arrived at the scene some four minutes after the accident.

1.1.14 The driver of the second jet boat made another first aid check of the passengers and, having ascertained that none of their injuries were life-threatening, arranged another jet boat to ferry them down river to the closest road access where ambulances were waiting.

1.1.15 Because Kawarau Jet Limited did not record the final numbers and names of passengers on each trip, there was initially some confusion between them and rescue services as to how many passengers were on board, and whether they had all been accounted for.

1.2 Additional trip information

1.2.1 The driver was on his fifth trip that day when the accident occurred. He had passed the tree, and the shingle bar that the tree had grounded on, five times heading up river, and four times heading back down.

1.2.2 The river water was relatively clear and the driver acknowledged that in spite of the receding river level, the main flow was passing to the left (approaching from up river) of the tree all day, and still was at the time of the accident. On the previous four down-river runs, the driver had passed close left of the tree, with the main river flow.

1.2.3 The driver later stated that he had kept *K-Jet 3* closer to the right hand side of the main channel than he had on the previous runs that day. His statement included comments such as ". . . I had taken my line of drive where assumably there was water behind the tree and found myself in an eddy, a near dead end of shallow water, heading towards the cliff . . . so when I realised that the water didn't exist behind the tree as much as I thought it had . . ."

1.2.4 When pressed for a reason why he chose to go to the right of the tree, out of the main flow, the driver responded "I didn't want to go in there. . .but found myself in there and reacted". The driver's recollection of his actions after passing the tree were vague. He recalled ". . . seeing the cliffs ahead . . . turning to the left . . . taking the foot off the gas . . . the boat being on top of me".

1.2.5 All of the passengers spoken to commented that, to them, the driver appeared to make a deliberate approach to the right of the tree. All of them stated that, until the time of the accident, the driver was not acting recklessly and appeared to have good control of the boat.

1.3 Boat information

1.3.1 *K-Jet 3* was a 5.95 m mono-hull jet boat constructed in aluminium. Propulsion was by one 350 cubic inch Chevrolet petrol engine driving a single stage, 212 Hamilton water-jet unit. The engine developed a maximum of 261 kW, which gave a normal operating speed of about 70 km/h.

1.3.2 The engine was located behind the passengers, near the rear of the boat, under an aluminium hatch. Built onto the hatch cover was an antenna arch which spanned the engine bay. The hatch cover was hinged at the back to allow access to the engine. The arch had the look of a combined roll bar and air foil; however, its intended role was purely for aesthetics. The hatch was not fastened down at the front and was free to open if the boat was inverted or rolled.

1.3.3 Speed and reverse thrust were achieved by the combination of throttle setting and a cable operated reverse duct[4]. When the reverse duct was fully open, the water efflux was rearwards, thrusting the vessel forward. As the reverse duct was closed, an increasing amount of the water efflux was deflected forward, progressively changing the resultant thrust from forward to reverse. The engine throttle was adjusted independently of the duct setting. At full reverse thrust, and with the throttle fully open, the stopping capability of a jet boat is often likened to that of a car.

1.3.4 Steering was achieved by a cable operated deflector plate in the jet unit which deflected the water efflux left or right, depending on which direction the wheel was turned. If a steering cable failed, the water efflux would usually centre the deflector and the heading of the boat stabilise in a relatively straight line. If the boat suffered a power loss, it would drop off the plane rapidly and continue in the direction the bow was pointing regardless of the direction and amount of wheel the driver was applying at the time.

1.3.5 *K-Jet 3* was constructed with a long shallow-vee bow, progressively transforming into a relatively flat bottom stern. The resultant operating shallow draft made it ideal for the Lower Shotover River, where the river often fanned into several shallow tributaries, particularly when the river level was low.

1.3.6 Planing strakes were fitted along the hull to reduce side-slipping in turns, thereby improving tracking and turning performance. When lightly loaded (six occupants or less) the boat was considered "quite zippy" in turns. When heavy, the driver had to allow for a certain degree of side-slip in each turn, this requiring the driver to start each turn earlier.

1.3.7 The boat was inspected by the Queenstown Lakes District Council (QLDC) Harbourmaster and licensed by him to carry up to 13 passengers plus the driver.

1.4 River information

1.4.1 The gradient of the Lower Shotover River is less than that of the Upper Shotover River which causes the river to slow, widen and, depending on the river level, branch out into several tributaries within its banks.

1.4.2 As the water slows, much of the gravel and silt it carries in suspension is deposited in the river bed forming new banks and changing the nature of the river. The main channel of flow can change dramatically in a short space of time. Drivers of jet boats operating on the Lower Shotover need to constantly "read" the water ahead to judge the best tributary to follow. Consequently, the route a driver takes may vary from trip to trip, especially in the period immediately after floods.

[4] A scoop which is closed into the water efflux to deflect some or all of the water forward.

1.6 Toxicology and human performance information

1.6.1 The driver had made five trips the day before the accident, and then gone out that night for Christmas dinner, during which he consumed three small bottles of beer. He had slept for about 5.5 hours the night before the accident and about 7 hours the night previous to that.

1.6.2 Although he felt, ". . . a little slow out of bed" the morning of the accident, he felt particularly good for the rest of the day. "It was a great day to be on the water, the river was great, as far as I was concerned I was having an excellent days' boating."

1.6.3 After the accident, the driver of *K-Jet 3* submitted to a voluntary blood test for the purposes of drug and alcohol analysis. No presence of drugs or alcohol was detected in his blood.

2. Analysis

2.1 River conditions were considered to be good for jet boating on the day of the accident. Although the river was receding throughout the day, the water was clear, making it easier for drivers to pick the main channels. At the accident site, there was no doubt that the main river flow was to the left of the tree when approaching from up river. This was evident to the driver and passengers at the time, and to the Investigator-in-Charge, four days after the accident.

2.2 If the driver had, ". . . found himself in there" (the small tributary to the right of the tree), the safest option for the driver would have been to keep *K-Jet 3* straight, switch off the engine, and let it slide into the shingle in the shallows at the end of the tributary.

2.3 The marks left on the shingle bar by the jet boat as it slid across it, started almost at the head of the dry shingle bar, directly behind the tree. If the driver had entered the tributary inadvertently, with *K-Jet 3* travelling at about 70 km/h, and then decided to turn away from the cliffs, the initial point of contact would have been further down the shingle bar than it was.

2.4 The evidence indicated that the driver intended to pass close to the right of the tree and then cross behind it into the main channel again, all the while assuming there was adequate water behind the tree to effect the manoeuvre. By the time the driver realised there was too little water behind the tree, he would have been committed to the manoeuvre and the option of running *K-Jet 3* into the shallows would probably not have been available to him.

2.5 The driver approached the tree from further right than on previous runs, probably to give him a better angle of approach to pass behind the tree. He began the left turn to pass behind the tree early to allow for the side slip in the turn due to *K-Jet 3* being heavily laden. As he saw that there was not enough water for *K-Jet 3* to pass behind the tree, he exclaimed, and made an instinctive small turn to the right, away from the shingle bar, before deciding to go hard left in an attempt to regain the main channel by jumping the shingle bar.

2.6 The above scenario would have taken between one and two seconds. The driver releasing the engine throttle while *K-Jet 3* was entering a tight left hand turn would have caused the vessel to begin to settle off the plane, and would have induced a spin. The foot of the bow struck the shingle bar and the momentum of the spin carried the stern around resulting in *K-Jet 3* side slipping along the shingle bar and rolling over as it came to rest. If the driver had kept the power on, he would have retained better control of *K-Jet 3* and may have succeeded in skipping over the bar without the boat rolling.

2.7 The driver was familiar with the topography surrounding the accident site and would have been aware that the cliffs off to the right were some distance away. He had passed the tree nine times that day and had checked on each occasion and later said that he thought there was ". . . assumably water behind the tree". The trickle of water between the tree and the shingle bar would have been wider at the start of the day, but reduced as the river receded. There was not enough water behind the tree at the time of the accident for *K-Jet 3* to have remained afloat and passed in safety.

2.8 The four previous trips the driver had made that day were without incident. The passengers on the accident trip reported that, prior to the accident, the driver was not taking any risks and appeared to have good control of *K-Jet 3*. The driver was in a good frame of mind before the accident. On the previous four trips he had passed to the left of the tree, with the main river flow. His decision to try and take *K-Jet 3* behind the tree on the accident trip was probably made out of the desire to vary the trip, which to him would have held a certain degree of monotony.

2.9 Professional opinion in the jet boat industry indicates that, while some drivers will be better than others, it will normally take up to one year of driving jet boats frequently, before drivers ". . . become part of their boat" and can read the water and manoeuvre their boat naturally.

2.10 The driver of *K-Jet 3* had been driving jet boats for almost one year. He appeared to have a high level of confidence, perhaps higher than his level of experience accounted for. The Commission has investigated two other jet boat accidents which involved a certain degree of error in judgement by the drivers. On both occasions, the drivers had been driving jet boats commercially for about one year. The trend indicates that this period of a driver's career is when they can be vulnerable to mishap.

2.11 The management of Kawarau Jet Limited recognised that the driver of *K-Jet 3* was performing manoeuvres beyond the scope of his experience, as evidenced by the increased incidence of damage to his boat. In spite of several warnings from them about keeping to the main channels, the driver made a detour down what was conspicuously a secondary channel and manoeuvred around the tree without fully appreciating the form of the river behind it.

2.12 Although the antenna arch was on the boat purely for aesthetics, its effectiveness as a roll bar almost certainly prevented serious injury to the passengers when *K-Jet 3* rolled; however, had the roll been more severe, the engine cover with the antenna arch could have flown open, and its effectiveness as a roll bar lost. Although the recorded incidence of commercial jet boats rolling is rare, the accident highlights that the potential is always there, particularly when operating in shallow or braided rivers.

2.13 The confusion between the rescue services and Kawarau Jet Limited management over the number of passengers that were on board and accounted for, raises some concern. In the event of a mishap, rescuers need to know how many persons to account for. An occupant could easily be thrown into the water and float away from the scene unnoticed which, if other occupants were more seriously injured and unable to speak with the rescue services, could result in a significant delay in rescue of that person.

3. Findings

Findings and any safety recommendations are listed in order of development and not in order of priority.

3.1 The driver of *K-Jet 3* was licensed as required by the QLDC.

3.2 *K-Jet 3* met the requirements of the QLDC and was appropriately loaded on the accident trip.

3.3 The accident was not caused by mechanical failure or equipment malfunction.

3.4 *K-Jet 3* struck a shingle bar when the driver attempted a manoeuvre for which there was not adequate room or depth of water.

3.5 The driver's attempt to recover the situation resulted in him losing control of *K-Jet 3* and caused the boat to roll on the shingle bar.

3.6 The driver of *K-Jet 3* appeared to be at a vulnerable point in his commercial jet boat career, when confidence was higher than experience.

3.7 Kawarau Jet Limited management recognising that the driver was performing manoeuvres above his level of experience, and warning him on more than one occasion to be more cautious with his driving, did little to change his driving habits.

3.8 To attempt the manoeuvre, the driver proceeded down a shallow tributary, in spite of the repeated warnings from management to keep to the main channels.

3.9 Although not designed for that purpose, the antenna arch spanning the back of *K-Jet 3* prevented more serious injury to the passengers, and possibly prevented loss of life.

4. Safety Recommendations

4.1 On 8 June 1998 the Commission recommended to the Director of Maritime Safety that he include in the Maritime Rules, Part 80 (Marine Craft used in Adventure Tourism):

4.1.1 the requirement for all commercial jet boats operating in braided rivers to be fitted with a roll bar, or similar device, of sufficient height and strength to afford passengers adequate occupiable space under the boat in the event of it rolling across terrain. (027/98)

4.1.2 the requirement for all commercial jet boats to be fitted with quick-release lap belts, one for each passenger the craft is licensed to carry. (028/98)

4.1.3 the requirement for operators to include in their safe operational plan, a system of recording the number of passengers carried on each trip, at the base, and on the boat, before the boats depart, to assist rescue services in accounting for all boat occupants in the event of a mishap. (029/98)

4.2 On 19 June 1998 the Director of Maritime Safety responded as follows:

4.2.1 With regard to recommendation 029/98 concerning the recording of passenger numbers, we are arranging for this to be included as a requirement of the safe operational plan in Part 80 of the maritime rules.

4.2.2 On recommendation 027/98 and 028/98 concerning the requirements for fitting of roll bars and quick-release lap belts, we intend to consult with the industry and investigate fully the implementation of these recommendations in relation to -

(a) other operational safety issues that may arise; and

(b) the costs involved

before we could incorporate these provisions in the rules.

The retro-fitting of roll bars or similar devices may require changes to boat's design or structure. Additionally we have some concern over the use of seat belts should the boat sink.

4.2.3 As you know, the Maritime Transport Act 1994 requires that the Minister promote maritime safety at reasonable cost. Any rules submitted for the Minister's signature must indicate the probable costs and benefits of its implementation and, additionally, be subject to industry consultation.

4.3 On 8 June 1998 the Commission recommended to the chairman of the Commercial Jet Boat Association that he:

4.3.1 Liaise with members of the association and support the requirement for:

4.3.1.1 all commercial jet boats operating in braided rivers to be fitted with a roll bar, or similar device, of sufficient height and strength to afford passengers adequate occupiable space under the boat in the event of it rolling across terrain. (030/98)

4.3.1.2 all commercial jet boats to be fitted with quick-release lap belts, one for each passenger the craft is licensed to carry. (031/98)

4.4 On 8 June 1998 the Commission recommended to the management of Kawarau Jet Limited that it:

4.4.1 Modifies the engine cover securing arrangement on all their boats so that the cover remains closed in the event of the craft rolling, to improve the effectiveness of the antenna arch as a roll bar. (032/98)

4.4.2 Devises a system whereby the number of passengers carried on each trip is recorded at the base, and on the boat before the boats depart on each trip. (033/98)

4.5 The chairman of the Commercial Jet Boat Association, and the management of Kawarau Jet Limited advised the Commission that safety recommendations 030 - 033/98 will be considered at the annual general meeting of the Commercial Jet Boat Association on 11 July 1998.

Report approved for publication 10 June 1998

Hon. W P Jeffries
Chief Commissioner

Glossary of marine abbreviations and terms

aft	rear of the vessel
beam	width of a vessel
bilge	space for the collection of surplus liquid
bridge	structure from where a vessel is navigated and directed
bulkhead	nautical term for wall
cable	0.1 of a nautical mile
chart datum	zero height referred to on a marine chart
command	take over-all responsibility for the vessel
conduct	in control of the vessel
conning	another term for "has conduct" or "in control"
deckhead	nautical term for ceiling
dog	cleat or device for securing water-tight openings
draught	depth of the vessel in the water
EPIRB	emergency position indicating radio beacon
even keel	draught forward equals the draught aft
freeboard	distance from the waterline to the deck edge
free surface	effect where liquids are free to flow within its compartment
focsle	forecastle (raised structure on the bow of a vessel)
GM	metacentric height (measure of a vessel's statical stability)
GoM	fluid metacentric height (taking account the effect of free surface)
GPS	global positioning system
heel	angle of tilt caused by external forces
hove-to	when a vessel is slowed or stopped and lying at an angle to the sea which affords the safest and most comfortable ride
Hz	hertz (cycles)
IMO	International Maritime Organisation
ISO	International Standards Organisation
kW	kilowatt
list	angle of tilt caused by internal distribution of weights
m	metres
MSA	Maritime Safety Authority
NRCC	National Rescue Co-ordination Centre
point	measure of direction (one point = 11¼ degrees of arc)
press	force a tank to overflow by using a pump
45 Nm^{-1}	Newton - meters

SAR	Search and rescue
SOLAS	Safety Of Life At Sea convention
sounding	measure of the depth of a liquid
SSB	single-side-band radio
statical stability	measure of a vessel's stability in still water
supernumerary	non-fare-paying passenger
telegraph	device used to relay engine commands from bridge to engine room
ullage	distance from the top of a tank to the surface of the liquid in the tank
VHF	very high frequency
windlass	winch used to raise a vessels anchor