Isle of Man Marine Administration
Oaseirys Lhuingys

Casualty Investigation Report CA 89

"Mirabella V"

Grounding

16th September 2004

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ABBREVIATIONS AND DEFINITIONS

Anchor Fluke	Side portion of anchor head (see Annex II)
Anchor Shank	Long bar section of the anchor (see Annex II)
Chain stopper	Clamp that secures the chain in place and takes the load when anchored (see Figure No. 4)
CPP	Controllable Pitch Propeller. The propeller turns at a constant rate and the thrust developed is varied by the amount of pitch applied to the blades
Designated Person Ashore	Person who provides the link between the Management Company and the yacht as required by the ISM Code
DNV	Det Norski Veritas, Classification Society
Dynema Line	Rope made of special material, using carbon fibre technology, which is very strong (see Annex V)
ECDIS	Electronic Chart Display Information System – Electronic navigation chart system, integrated with the GPS (Global Positioning System) which marks the position of the yacht automatically on the electronic chart display
Flotsam	Floating debris in the sea
Gypsy	Cog keyed on to a windlass shaft, the shape of which grips the chain for lifting/lowering purposes
HHP	High Holding Power. Anchors of this type do not act just by weight but dig into the seabed for grip
Hawse Pipe	Pipe through which anchor chain goes from deck down to sea, also known as a ‘cassette’ on this yacht (see Annex II)

IACS	International Association of Classification Societies
ISM Code	International Safety Management Code
LR	Lloyd’s Register, Classification Society
NAVTEX	The NAVTEX system is used for the automatic broadcast of localised Maritime Safety Information (MSI) using Radio Telex
RINA	Registro Italiano Navale, Classification Society
Shear	Lateral movement
STCW 95	International Convention on Standards of Training Certification and Watchkeeping for Seafarers, 1978, as amended in 1995 and 1997
Stud Link Anchor Chain	Standard marine anchor chain with oval links fitted with studs (see Figure No. 6)
UHF Radio	Ultra High Frequency Radio, the portable versions of which are used for communication around the yacht. These have a limited range compared to the VHF Radio
U2(a)	Grade of higher tensile steel according to Lloyd’s Register Rules
Yaw	Rotation about the x-axis, ie a change in heading for a yacht

SUMMARY

The 'Mirabella V' is a luxury sailing yacht, certified for chartering. She is 75.22m long, with a displacement of 728 Tonnes. She has a single 88.5m mast. She is certified for the carriage of 27 persons, including 12 guests.

On the 13th September 2004 she anchored just outside the port of Saint Jean, Cap Ferrat, on the French Riviera, in position 43^{o} 41.8'N 007^{o}20.4'E. The water depth was 17-18m. The yacht is equipped with 2 anchors, one 400kg and one 600kg. The 600kg anchor was deployed and 65m of chain (24mm diameter stud-link) paid out. There were no guests on board. The wind was light and variable and there was negligible tidal current.

Three days later on the 16th September 2004, from 0800Hrs onwards the wind and sea state steadily increased until at approximately 1300Hrs the yacht's anchor suddenly dragged and within a matter of minutes the yacht drifted onto the rocks at Pte Rompa de Talon. The wind was SE 20-22 Knots (onshore) and sea state Beaufort 4. The crew attempted to start the engines but did not manage to do so before the yacht grounded. The initial grounding broke the securing mechanism for the lifting keel (150 Tonnes), which then dropped to the seabed and secured the yacht in position. The yacht was subsequently re-floated in more favourable weather conditions, when the keel lifting mechanism was temporarily repaired and the keel lifted off the seabed.

There were no injuries, nor loss of life. Pollution of the environment was insignificant. The yacht sustained structural damage to the keel, keel box, keel lifting mechanism, starboard rudder and transom flap.

Figure No. 1 Mirabella V alongside wharf at La Coitat under repair

1 NARRATIVE OF EVENTS

1.1 Monday 13th September 2004

At 1900Hrs Mirabella V anchored at just off the port of Saint Jean, Cap Ferrat in position 43^{o} 41.8’N 007^{o}20.4’E. The water depth was 17-18m. The wind was SE 5 Knots with calm sea conditions. The yacht is equipped with 2 anchors, one 400kg and one 600kg. The 600kg anchor was deployed and 65m of chain paid out. This anchorage was familiar to the crew as they had used it several times earlier in the summer. There were no guests on board.

1.2 Tuesday 14th & Wednesday 15th September 2004

The crew were preparing for a private trip with the owner’s daughter and her friends. They were expecting to pick them up at 1400Hrs Thursday 16th September 2004, from the quay at Saint Jean, Cap Ferrat, using a tender.

They deployed the ‘Hinckley’ tender (see Annex III) which is normally stowed in the aft garage and secured it, ready for use, to the ‘Mirabella V’s’ aft starboard quarter. This tender was used frequently by the crew for runs ashore for supplies and general errands.

The weather during this period was fine with a gentle 3-8 Knot breeze, generally from the South East (‘on shore’). Sea conditions were calm. The rise and fall in tide in this area is negligible and tidal currents were small.

With the prevailing weather conditions the crew worked day work shifts preparing the yacht to receive guests. No formal anchor watch was kept. The position of the yacht was monitored by the crew intermittently, using the GPS trace on the ECDIS display. At night all crew slept with no watches maintained.

The company Designated Person Ashore attended on board from 0930Hrs Tuesday 14th September 2004 until 1145Hrs Wednesday 15th September 2004. He conducted an ISM Internal Audit of the yacht’s Safety Management System, an Internal Safety and Environmental Protection Inspection and an Internal Security Audit. The internal audit was very thorough. One of the items raised was that the NAVTEX (an automated radio receiver which can receive navigational warnings and weather forecasts. It can display them both on screen and on a printed record) was switched off and was out of paper.

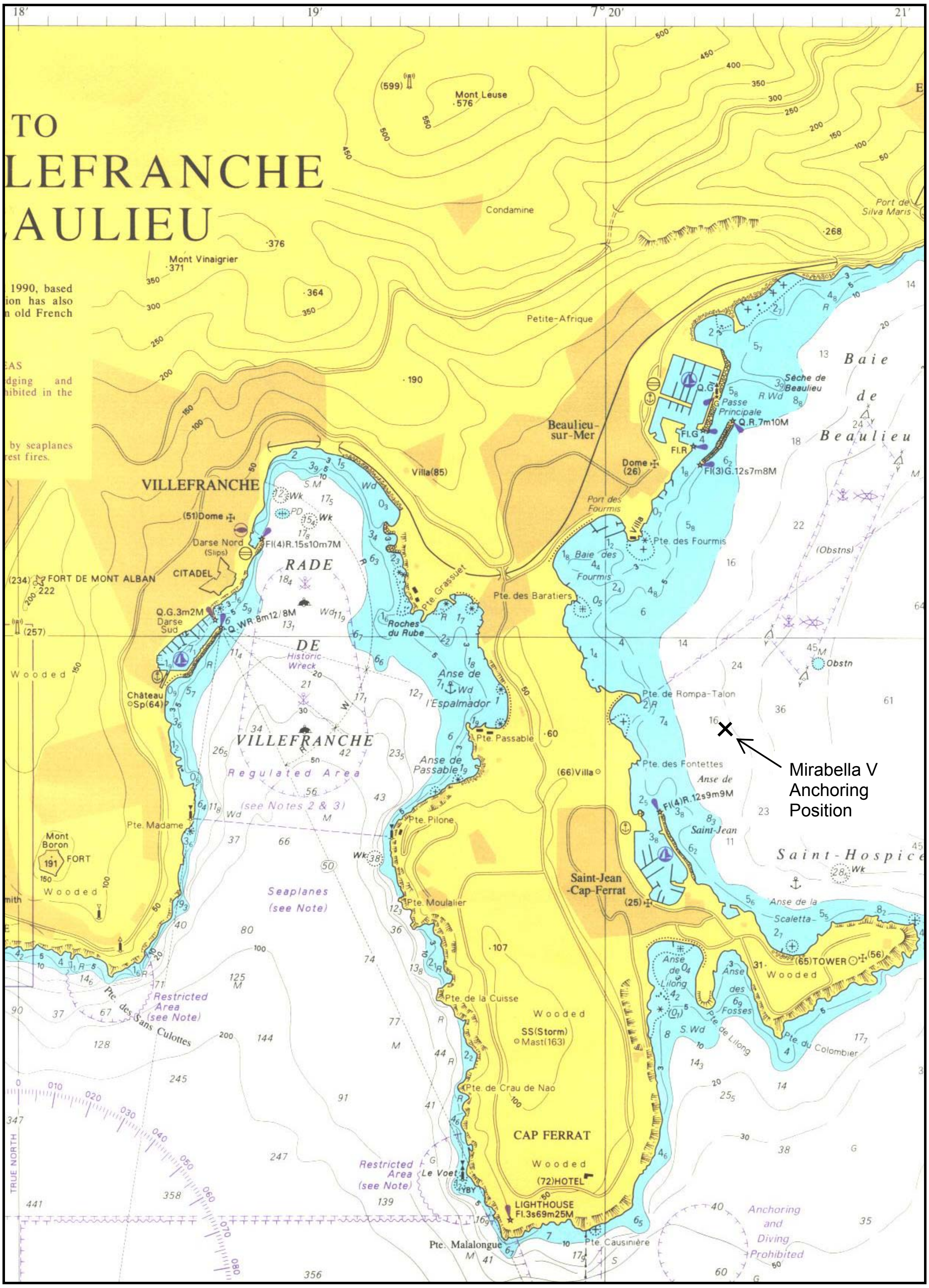


Figure No. 2
Extract from Admiralty Chart No.149 ‘NICE AND MONACO’
(reproduced under licence from the UK Hydrographic Office)

1.3 Thursday 16th September 2004

1.3.1 **0800Hrs**
The wind was South East 15 Knots (Force 4, moderate breeze), sea state Beaufort 2 (small wavelets, crests do not break), sunny with good visibility. All the crew were on board with the exception of the Head Chef. The crew were looking forward to an afternoons sailing with this breeze after the recent calm conditions.

1.3.2 **1115Hrs**
The wind had increased to South East 18 Knots (Force 5, fresh breeze). The guest party contacted the yacht and informed the crew that there had been some delays with their travel arrangements and they would not be at the quay for collection until 1600Hrs.

1.3.3 **1130Hrs**
Chief Engineer and the Mate are taken ashore by 2 Deckhands in the tender, to go shopping for supplies.

1.3.4 **1140Hrs**
2 Deckhands returned in the tender with the Head Chef who had spent the night ashore.

1.3.5 **1145Hrs**
2 Deckhands returned to shore in the tender to pick up the Chief Engineer and Mate.

1.3.6 **1200Hrs**
The wind was still South East 17 Knots (Force 5, fresh breeze), sea state Beaufort 4 (small waves with fairly frequent white horses). The Deck Crew were on deck working. The Chief Engineer was ashore getting supplies. The Master was in the wheelhouse aware that the weather was deteriorating and that the yacht was anchored on a lee shore. Lunch was served and the deck crew ate in shifts. Lunch as usual was a quick affair.

1.3.7 **1215Hrs**
The Chief Engineer and Mate returned from shore in the tender.

1.3.8 The Chief Engineer had a quick lunch and then went to the Engine Room, cleaning floor plates. There was no engine maintenance going on. The propulsion plant was all ready for departure, save the final engine starting sequence.

1.3.9 **1255Hrs**
The wind had increased to South East 20-22 Knots (Force 5/6 fresh/strong breeze), and the sea state was still Beaufort 4. The Deck Crew were on deck working. The Master was in the wheelhouse now very concerned about the building wind.

1.3.10 **1300Hrs**

1.3.10.1 The Mate entered the wheelhouse. The Master made the decision to weigh anchor and proceed to a safer anchorage at Villefranche and informed the Mate accordingly.

1.3.10.2 The Mate agreed and went back on deck, immediately using his portable UHF radio to contact the Bosun, who was also on deck. The Mate requested the Bosun to proceed to the bow and weigh anchor using the local windlass controls.

1.3.10.3 At the same time the Master used his portable UHF radio to try to contact the Chief Engineer to start the engines.

1.3.11 **1301Hrs**

1.3.11.1 At this moment the anchor suddenly began to drag. The Master observed the bow ‘falling away’ to starboard towards the shore, until the heading of the yacht was beyond broadside to the wind. The Master realised immediately that the anchor was no longer holding.

1.3.11.2 The Master moved to the starboard flybridge and using his portable UHF radio, he urgently requested the Chief Engineer to start the engines.

1.3.11.3 The Chief Engineer was in the Engine Room and heard raised voices on his portable UHF radio. He could not make out what was happening over the noise of the machinery that was running (generators etc.). He ran to the Engine Control Room and shut the door. He received the Master’s request to immediately start the engines because the anchor was dragging.

1.3.11.4 The Chief Engineer ran back into the Engine Room. He turned on the local main engine ignition switches on both engines. He turned on the local Kamewa controllable pitch propeller controls. He then ran back to the Engine Control Room. He started both main engines and the steering gear pumps, using the computerised engine management platform system.

1.3.12 **1303Hrs**

1.3.12.1 A crew member entered the Engine Room to confirm that the Chief Engineer had started the main engines.

1.3.12.2 The Chief Engineer ran up to the flybridge to confirm this to the Master, not trusting his portable UHF radio. When he got there he noted the Master was in the process of clutching in the propeller shafts using the control station on the starboard flybridge console.

1.3.12.3 The Mate jumped into the ‘Hinckley’ tender and cast off, realising that the tender could get trapped between the yacht and the rocks.

1.3.13 **1304Hrs**

As soon as the clutches were engaged the Master went full astern and put the steering gear hard to port. At this moment the yacht grounded. The yacht bounced several times along the rocks and then came to a halt with the wind and sea on the port beam.

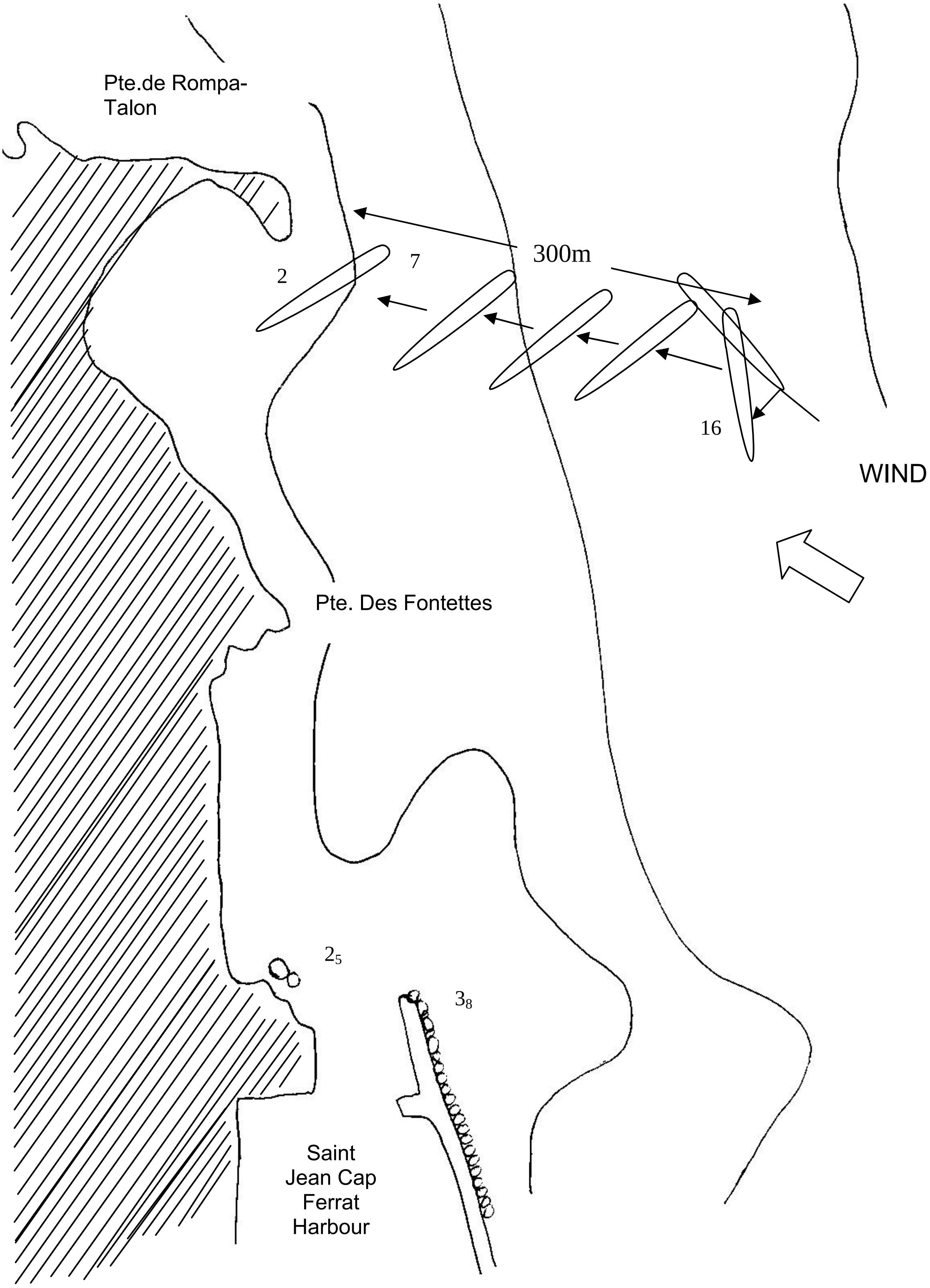


Figure No. 3
The course and heading of Mirabella V as she dragged her anchor

1.3.14 **1305Hrs**
The Master entered the wheelhouse and activated the general alarm. He then called Cap Ferrat Signal Station using VHF Channel 12. They acknowledged and requested he stand by. Cap Ferrat Signal Station advised that a Tug was on the way ETA 2100Hrs.

1.3.15 **1307Hrs**

1.3.15.1 The Master returned to the starboard flybridge and observed flotsam, presumed from the starboard rudder.

1.3.15.2 The Mate came alongside in the tender and the Bosun and Deckhands passed a stern line to him. The Mate used the tender to pull the stern of the yacht to windward, keeping it into the weather. With the wind and sea no longer on the beam their effect was reduced and the situation was stabilised slightly. However after a short while the tender lost power, because of a line stuck in its jet drive. The yacht returned to being 'beam on' to the wind and sea.

1.3.15.3 The Chief Engineer went to the wheel house to try to lift the keel using the computerised control system. However, the lifting mechanism for the keel was showing many alarms. The Chief Engineer tried to override the alarms manually but was unable to do so. By this time the keel had dropped down onto the seabed and the yacht was heeled over by the waves/wind. The Chief Engineer looked forward out of the wheelhouse and observed the keel load bearing cassette lifting. This unit joins the top of the keel lifting ram to the keel box. It had been sheared off, and was lifting as the seabed took the weight of the keel.

1.3.15.4 During the first hour on the rocks the Chief and Second Engineer checked the bilges several times. Hydraulic oil was found in the crew mess bilge. It was noted that a hydraulic pipe for one of the keel release rams had burst. They found no water ingress.

1.3.16 **1350Hrs**
Yachts 'Big Roi' & 'Ecstasea' arrived in the bay. These yachts are large motor yachts who had heard the situation develop over the VHF radio and voluntarily came to assist. 'Big Roi' deployed her tender and rigged a dynema line (see Annex V, photo 6), with difficulty, between 'Big Roi' and the stern of 'Mirabella V'. 'Big Roi' attempted to pull 'Mirabella V' off the rocks twice but was unsuccessful.

1.3.17 **1615Hrs**
The company Designated Person Ashore boarded with difficulty and began to assist the Master co-ordinating with the rescue services.

1.3.18 **1700Hrs**
A line was attached from 'Ecstasea' to the stern of 'Mirabella V'. This line broke and another line, all dynema, was rigged. 'Ecstasea' managed to pull the stern of 'Mirabella V' away from the rocks. This improved the situation reducing the list to zero and making the leeward starboard side of the yacht accessible.

1.3.19 **1705Hrs**
With the situation stabilised and the leeward side of the yacht available to position a tender alongside, all non-essential personnel, including the 4 stewardesses and 2nd Chef were evacuated to the fuel dock in Saint Jean.

1.3.20 **1745Hrs**
The line between 'Ecstasea' and 'Mirabella V' broke and the stern of 'Mirabella V' swung back towards the rocks.

1.3.21 **1800-1930Hrs**
'Ecstasea' was anchored, using both anchors, to windward and dynema lines were passed between the two yachts. The tension was taken up on a large winch at the stern of 'Mirabella V' and this was effective in keeping her stern towards the wind and seas.

1.3.22 **1930Hrs**
The weather had subsided and this was considered a stabilised condition, pending arrival of the tug.

2 COMMENTS AND ANALYSIS

The purpose of a casualty investigation is to determine the reasons why the incident occurred and then to use this information to help to prevent recurrence and to improve the safety of life at sea and pollution prevention.

Sources of evidence were interviews with the crew and an inspection of the vessel after the incident.

For this casualty a number of questions need to be asked:-

- Was enough anchor chain paid out?
- What effect did the large swing of the yacht around the anchorhave?
- Why did the anchor drag?
- Was the anchoring equipment fitted to the yacht in accordance with the Classification Requirements?
- How do the requirements from different Class Societies compare?
- Do the Classification Society Rules for anchoring equipment adequately cope with this type of vessel?
- What effect did the novel design of the lifting keel have?
- Was the selection of this anchoring position safe?
- Were the anchoring procedures followed correct?
- Was the yacht in a suitable state of readiness at anchor?

The yacht operates under an ISM system which provides some limited guidance on anchoring.

Draft copies of this report were circulated to all interested parties. Where they have made comments of value, these have been incorporated.

2.1 Was enough anchor chain paid out?

2.1.1 The crew had paid out approximately 65m of chain in the water depth of 17-18m. The 600kg anchor was used, which is fitted with 169m 24mm diameter U2(a) stud link chain cable in total.

2.1.2 Yachtsmen traditionally pay out chain on a 3:1 scope rule (i.e. pay out three times as much chain as water depth) as a minimum. Normally the scope would be increased to 4:1 for longer stays and 5:1 for greater confidence in medium/heavy weather. In this instance, the crew paid out chain with a scope of 3.7:1. There was negligible tidal current and a light breeze.

2.1.3 It is concluded that the crew paid out a reasonable amount of chain for a standard yacht in the weather conditions at the time of anchoring. This was in accordance with their training (RYA Yachtmaster Ocean/MCA Master Yachts (over 500GT)).

2.1.4 On a merchant (cargo ship) the crews traditionally pay out chain on a $27\sqrt{D}$:1 scope rule (D being water depth). Therefore, a merchant ship would have paid out about 114m (6:1 Scope) in this water depth.

2.1.5 Anchors deployed on merchant vessels primarily provide a securing point for the end of the cable. The cable sits on the seabed and provides a large proportion of the holding force for the vessel. This is why so much chain is deployed.

2.1.6 The type of HHP (high holding power) anchors fitted to 'Mirabella V' originate from the offshore industry, where they are often deployed in multi-anchor systems for oil rigs. In this scenario, they provide a high proportion of the holding force themselves without the large amounts of chain cable sitting on the seabed. They do not work by virtue of their weight alone. Their complex shapes work to dig them deep into the seabed under load. Hence their 'high holding power' is mainly attributable to their design.

2.1.7 By providing high holding power through their design rather than weight these HHP anchors are attractive to the yachting industry, where weight saving and small size are important.

2.1.8 A yacht, or a ship, will both yaw and swing (through 360^{o}) at anchor, with changing tides and winds. It is important that there is sufficient chain cable on the seabed to provide a reasonably constant direction of pull on the anchor. The pull should also be parallel to the seabed, as far as possible.

2.1.9 In good holding ground (mud/sand) these HHP anchors have the ability to veer with a slowly changing direction of pull, and can actually work themselves deeper and deeper into the seabed. Sometimes it is hard to retrieve the anchor after a long time in position, because it has worked itself in so far. However, a sudden lateral 'jerk' can break one of these anchors out from its holding position. Therefore again, it is essential that sufficient chain is paid out so that any lateral forces are dampened out by the chain dragging across the seabed and not transmitted directly on to the anchor shank.

2.1.10 It is concluded that although the type of anchor fitted to the 'Mirabella V' is different to that fitted on most merchant vessels, the size and purpose of the chain is very similar. The merchant philosophy, with regard to a greater amount of chain to be paid out (scope), may have been more appropriate, especially when the weather deteriorated.

2.2 What effect did the large swing of the yacht around the anchor have?

2.2.1 Although all yachts (especially ones with single mast rigs) sail at anchor, some are more extreme than others. ‘Mirabella V’ is an extreme case because the owner’s design goal was to be able to anchor in shallow water and this required a fully lifting keel. When ‘Mirabella V’s’ keel is raised (less than 4.0m draught) her lateral resistance (area of boat under the water) is well aft, primarily due to the effect of her rudders and skegs area. This fact, related to her single mast and three headsail rig (windage well forward of underwater area centre), causes her to bear away at anchor and start sailing.

2.2.2 During the preceding few days to the incident, the wind was light. The period of the swing was very long and the crew were unconcerned. Log book entries reflect this; ‘ECDIS showing our usual semi-circle’ entry was made 2100Hrs 15th September 2004 when the wind was SE 5 Knots.

2.2.3 It is possible that as the wind increased, the period of the swing decreased. It is possible that at the extremity of a quicker swing the cable can become taut quickly causing it to snatch/jerk.

2.2.4 The crew had encountered this scenario before when anchored in strong winds (around 30 Knots). The jerking/snatching of the chain made loud clanking noises as the chain rattled around in the cassette (hawse pipe). These noises reverberated throughout the yacht and were clearly audible in the Bridge. At the time of the incident no such noises were heard.

2.2.5 A tendency to swing heavily at anchor will inevitably place both a cyclical load on the whole anchor system and a sideways load on the anchor itself, at the extremities of the swing, unless there is enough length of chain cable paid out. With a scope of 3.7:1 it is considered highly likely that, when the wind increased, at the extremities of each swing there was a direct pull on the anchor shank itself from a sideways direction. The observed bend in the anchor shank post incident clearly supports this.

2.2.6 It is concluded that the tendency of this yacht to swing at anchor, coupled with a short scope of cable deployed, in all probability caused a lateral load on the anchor shank.

2.3 Why did the anchor drag?

2.3.1 The type of seabed the anchor is embedded into is of paramount importance.

‘G*ood holding ground’* for the type of anchor fitted is mud. In mud the anchor should sink into the mud completely (about 1m below the seabed). As the yacht above slowly rotates, in the tide or varying wind above, the anchor should veer, to keep in line with the direction of pull, whilst remaining firmly embedded. Sand has similar but not quite so good holding capability.

On a rocky bottom the holding capacity of the anchor depends on a fluke becoming snagged on a rocky outcrop. When the yacht above rotates and the anchor veers it may well drag until it gets snagged again.

’Poor holding ground’ for this anchor is shingle, where the larger particle size allows the anchor to move through the substrate like a plough, loosing much of its high holding capacity. In this ground the anchor will slowly drag its position.

2.3.2 The reputable pilot book and the Admiralty navigation charts on board the yacht, for Saint Jean, give no indication of the seabed properties in this anchorage.

2.3.3 The pilot book makes reference to yachts anchoring off the breakwater of the marina and to the North of the entrance during summer. This is where the ‘Mirabella V’ was anchored.

2.3.4 After the incident the anchor shank was found bent.

Figure No. 4
Anchor shank deflection against a straight edge

Figure No. 5
Deflection at end of anchor shank against a straight edge

2.3.5 The damage to the anchor suggests that it was in sufficiently good holding ground and firmly secured in the seabed. The holding capacity of the anchor was clearly used to its full extent, taking the equipment to its failure limit.

2.3.6 The nature of the damage indicates a very high transverse pull bending the shank.

2.3.7 It is possible that this high transverse pull would have been cyclical, induced by the yacht swinging around the anchor. This would have the tendency to work the anchor from side to side, breaking it out from its holding position.

2.3.8 It is concluded that the anchor was pulled out from its holding position by a large transverse pull on the anchor shank as the yacht swung about her anchor.

2.4 Was the anchoring equipment fitted to the yacht in accordance with the Classification Requirements?

2.4.1 The vessel was built in accordance with Det Norske Veritas (DNV) 'Rules for High Speed, Light Craft and Naval Surface Craft'. The rules for the anchoring equipment are contained within Chapter 5, Section 3.

2.4.2 To calculate the required size of anchors and chain, first the Equipment Number for the yacht is calculated, which is then cross referenced against a table, to read off the required weight of anchor and length & size of chain.

Equipment Number (EN) = $(\Delta)^{2/3} + 2BH + 0.1A$

$(\Delta)^{2/3}$ is a function of displacement which takes account of the tidal drag on the wetted surface below waterline

BH is a component for frontal area which takes account of the windage, presuming that the yacht will roughly point into the wind. It is given double loading

A is a component for side profile area windage. It is given 10% loading

2.4.3 The equipment number was calculated as follows:-

$(\Delta)^{2/3} = 85.17$ $\Delta = 786$(full load displacement)

B = 14.82 (beam)

$H = a + \sum(h_i \sin\theta)$ a = 3.5m (freeboard to main deck amidships)
h_i = height of the superstructure tiers
θ = angle of inclination aft of each front bulkhead
. *Main deck house:-*
$h_i\sin\theta = 2.1\sin(21) = 0.75.$
Flybridge:-
$h_i\sin\theta = 1.3\sin(27) = 0.59$
$H = 3.5 + \sum(0.75+0.59)$
$H = 4.84$

A = Area of side profile of Hull + Superstructures + Arch + Mast + Boom + Sails (stowed/furled)
A = 529 + Sails
A = 529 + 21.25(Main) + 26.25(Working Jib) + 34.0(Main Jib) + 14.1 (staysail)
A = 625

Therefore:-
EN = 85.17 + (2 x (14.82x4.84)) + 0.1x625
EN = 291

2.4.4 For DNV Rules this Equipment Number correlates to a requirement for 1 anchor 370kg & 1 x anchor 246kg, each fitted with 175m of 24mm diameter K2 chain.

2.4.5 The anchors provided to the yacht (600kg & 400kg) were in well in excess of the of the DNV minimum rule requirements.

2.4.6 The anchor chain fitted to the yacht was in accordance with DNV minimum rule requirements for diameter and grade (24mm K2) but slightly shorter than required (175m required 169m provided). This slightly shorter chain had no impact on the incident (only 65m was paid out and there was plenty spare).

2.5 How do the requirements from different Class Societies compare?

2.5.1 Lloyd’s Register (LR) Rules are calculated in much the same way. However they would require 2 anchors of 585kg and 410kg with 165m of 24mm diameter U2(a) stud link anchor chain cable. The equipment actually fitted is much more in line with the Lloyd’s Register Rules requirements, which are more onerous than the DNV Rules.

2.5.2 RINA Yacht Rules do not cover such a high Equipment Number. If their Merchant Rules are used they would require 2 x 600kg anchors fitted with 178.6m of 26mm K2 Chain, which is a similar requirement to LR.

2.5.3 The chart below plots what would be required by various Class Societies Rules for anchor weight. It is based on a yacht being fitted with 2 HHP Anchors and the plot is for the biggest anchor fitted.

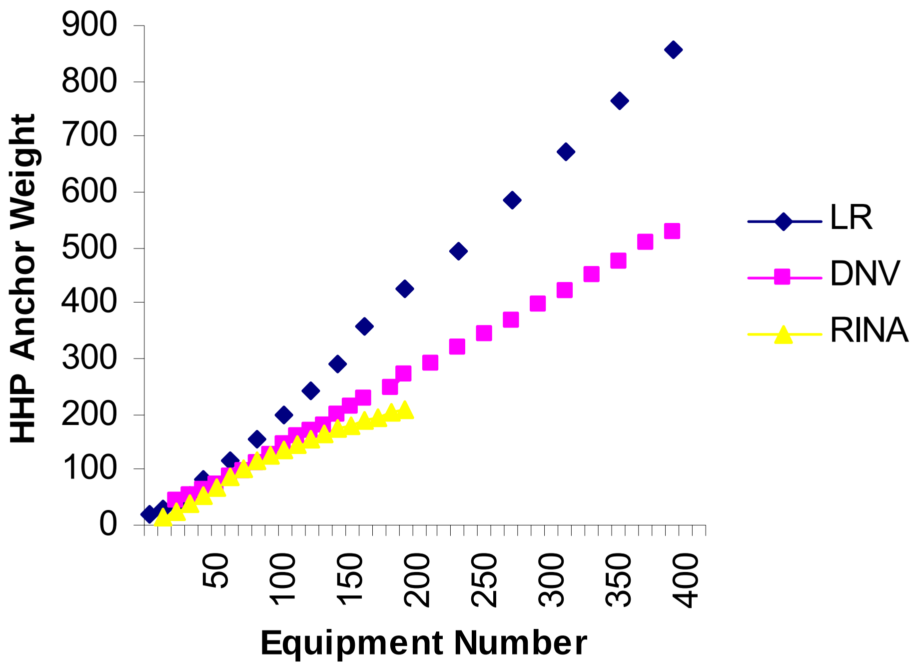


Figure No. 6
Comparison of Classification Society Requirements

2.5.4 It is concluded that there are large differences between the requirements of the various Classification Societies. This is in contradiction to the assumption by the industry and the Large Yacht Code that ‘Class’ represents a common standard.

2.6 Do the Classification Society Rules for anchoring equipment adequately cope with this type of vessel?

2.6.1 The ‘Mirabella V’ is unique in that she is the yacht with by far the tallest mast in the world. It is 88.5m long with a conventional shape in section. It is constructed of carbon fibre.

2.6.2 In the calculation for Equipment Number, the function for windage is calculated in two parts, considering the windage from the front and from the side.

2.6.3 Windage is assumed to be directly proportional to the surface area in the direction being considered. Surfaces which are not perpendicular to the wind are reduced by the Sine of their angle of attack.

2.6.4 The function for windage weights the area from the front by 200% and the area from the side by 10%. This assumes that the vessel will sit more or less head to wind when at anchor, the side windage function takes account of the vessel taking a slight yaw. Therefore it is the frontal area which is the all important feature.

2.6.5 The frontal area function (based on breadth x freeboard (amidships) + superstructures) of the hull & superstructure was calculated as $71.7m^2$.

2.6.6 The DNV Rules do not require the area of the rig to be considered. In the calculation used at construction, the area of the rig was included for side windage but not for frontal windage.

2.6.7 The frontal area of the mast is approximately $40m^2$. The area of the furled main jib, working jib & staysail is approximately 74 m^2. Therefore a very approximate frontal area for the rig is $114m^2$(compared to 71.7 m^2 for the hull) This does not include the standing rigging, spreaders, radars etc.

2.6.8 LR Rules do require 25% bigger anchors to be fitted to 3 or more masted square rigged sailing vessels (considered to have high rig windage). This in turn would require heavier anchor chain to be fitted. This factor was not applied to ‘Mirabella V’ because she only has a single mast. However it is agued that such a factor should be applied to yachts such as the ‘Mirabella V’ as the hull/rig windage ratio would be similar. Without this 25% factor, the same equipment would be required with or without the rig, which is wrong.

2.6.9 It is concluded that because the frontal area of the rig is more than the frontal area of the hull, it should have been factored into the calculations for the size of the anchoring equipment fitted.

2.6.10 If the rig had been included in the frontal area, the Equipment Number would have been 529 (as opposed to 291).

2.6.11 LR Rules would require 1 x 1080kg anchor with 220m of 34mm diameter chain & 1 x 756kg anchor with 192m of 28mm diameter chain. These anchors would have been 80% bigger than fitted. The chain would have been slightly heavier.

2.6.12 DNV Rules do not go this high but would require, at least 2 anchors of 628 & 418kg, each with 197m of 32mm diameter K2 chain. These anchors are similar to the ones fitted. The chain would have been significantly heavier, which is what is required to enable shorter scopes to be used, when anchoring in confined anchorages.

2.6.13 It is concluded that the Classification Society Rules, relating to the anchoring equipment, which are based on empirical formulas derived from standard motor vessel designs, do not adequately cope with the design of this yacht with comparatively high rig windage in relation to hull windage.

2.6.14 It is concluded that the designers used the most onerous Classification Rules available to them (LR), which required much larger equipment than the DNV Rules, in accordance with which the yacht was being built. However it is argued that because of the 'Mirabella V' novel design, additional safety factors for rig windage should have been applied or the equipment should have been assessed by direct calculation, perhaps supplemented by wind tunnel model testing.

2.7 What effect did the novel design of the lifting keel have?

2.7.1 'Mirabella V' has a novel design of keel. The keel is constructed of an aerofoil beam with a heavy bulb on the bottom. The keel weighs about 150Tonnes. The keel can be lifted up and down, to suit the draught restrictions or stability requirements, using a hydraulic ram. The aerofoil section slides through a watertight slot (keel box) which extends from the opening in the bottom to an opening in the coach roof. It can be left in a choice of four positions, at each of which it is secured in place by a system of hydraulic locking pins. The four positions are known as 'down', 'mid', 'up' and 'up up'. At the time of the incident the keel was in the 'up' position (with the top of the aerofoil section of the keel level with the coach house roof). This gives the yacht a draught of 4.0m.

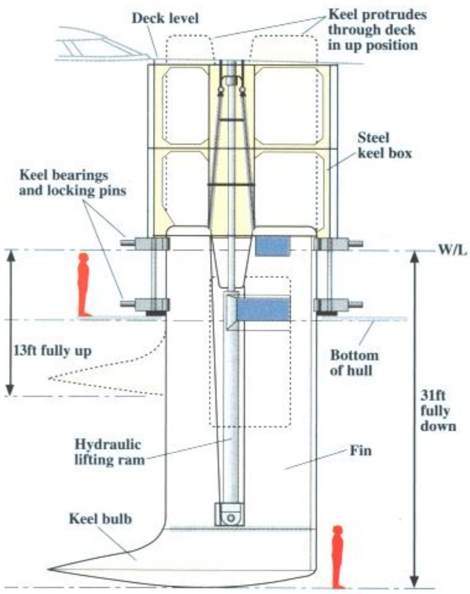


Figure No. 7
Diagram of lifting keel arrangements

2.7.2 The bulb of the keel, extending well below the bottom of the hull was the first part of the yacht to ground. The first couple of bumps sheared the bolts connecting the load bearing cassette around the top of the hydraulic lifting ram. The keel bulb then sat on the bottom with the yacht sliding up and down on the aerofoil section of the keel, with the motion of the waves. The benefit of this was that it kept the main hull of the yacht floating above the rocks, relatively undamaged and prevented the yacht from being driven further ashore. If this foil keel had been of the solid type, the weight of the yacht bouncing up and down on it would have pushed it through the bottom of the hull, causing one or two compartments to become flooded.

2.7.3 The detriment of this design was that it made it impossible to pull 'Mirabella V' off the rocks. The weight of the keel had to be borne by the yacht before she could be re-floated. It was fortunate that the weather soon abated to allow this to be successfully conducted.

2.7.4 It is concluded that the yacht did not ground because of a failure in the hydraulic lifting system for the keel.

2.8 Was the selection of this anchoring position safe?

2.8.1 When 'Mirabella V' was anchored Monday 13th September 2004 just off the port of Saint Jean, Cap Ferrat in position 43° 41.8'N 007°20.4'E the sea was calm with wind SE 4-6 Knots. There were other yachts anchored nearby in the bay.

2.8.2 Until the morning of Thursday 16th September 2004 the sea remained calm and the wind 4-8 Knots from various directions, i.e. 'light and variable'. It was not until 0800Hrs Thursday 16th September 2004 that the wind is recorded as SE 15 Knots and the sea state Beaufort 2 (small wavelets, crests do not break). Not until this stage could the yacht be considered anchored on a lee shore.

2.8.3 For this SE wind there is a good protected anchorage, on the opposite (western) side of the Cap Ferrat peninsula at Villefranche.

2.8.4 Both of these anchorages had been used by 'Mirabella V' during the season. Initially the Saint Jean side of the peninsula was selected because there was so little wind and it was a very convenient position for making trips into Saint Jean with the tender, for errands and picking up the guests. Villefranche anchorage is a 'Regulated Area' where all vessels over 50m length must engage a Pilot to enter. The use of anchors is not permitted and yachts are required to tie up to mooring buoys. These regulations were perceived as an inconvenience by the crew.

2.8.5 It is concluded that the selection of the anchoring position was not unsafe in the light and variable wind conditions prevailing when the yacht anchored. This anchorage would be the preferred anchorage over Villefranche, had the wind turned to the South West. Sailing directions for Saint Jean refer to yachts being anchored off the breakwater of the marina and to the North of the entrance during the summer.

2.8.6 The recent safety audit by the Company DPA highlighted that the NAVTEX was turned off, out of paper and there was no evidence of the last voyages' weather forecasts on board. Despite this being highlighted by the Company DPA just the day before the incident, no alternative provisions for obtaining weather forecasts were made. This could have been done temporarily via the radio or the internet connections on board. This is not in accordance with good seamanship. The wind did rise quickly on Thursday morning, 16th September 2004, but the crew should have been aware that this was going to happen, via a weather forecast.

2.8.7 At 0800Hrs Thursday 16th September 2004 the crew decided not to move to Villefranche, believing that the prevailing conditions were well within the capability of the anchoring system. Arrangements had been made to pick the guests up from Saint Jean in a few hours and they would be going soon anyway. They did not want the inconvenience of engaging a Pilot at Villefranche for such a short stay in port.

2.8.8 At 1115Hrs 16th September 2004 the guests contacted the yacht to advise that they were delayed, The wind had picked up very slightly to SE 17-18 Knots. The crew were confident these conditions were still well within the capability of the anchoring system. The crew had anchored in higher winds before without any problems. The Chief Engineer and the Mate went ashore. No weather forecast was obtained. No decision to move to Villefranche was made. The anchoring arrangements were not altered and the Engine Room was not put in an increased state of readiness.

2.8.9 At 1255Hrs, just before the anchor dragged, the wind reached SE 20-22 Knots, the sea state had deteriorated slightly. The crew decided that it would be prudent to move to Villefranche. Before they could start engines and weigh anchor, it dragged and the incident took place.

2.8.10 It is clear that this anchorage was safe when the vessel arrived and at some point became unsafe. The precise point when it became unsafe is not readily determined and clearly lies with the discretion and judgement of the Master. It is invariably a personal and subjective decision. In making his decision, on when to move the Master can however be guided by a number of objective factors including:

- his experience of the yacht under similar conditions
- his knowledge of the capabilities of the anchoring system
- the current weather forecast
- the geography of the anchorage
- availability of engines
- the degree of risk attached to various foreseeable events, including a dragging anchor, etc

2.8.11 The level of risk can be reduced by improving the arrangements on board. However, in this case with the yacht anchored close to a lee shore, with a small scope of chain cable deployed, with little opportunity to pay out more chain cable and with the engines and steering not instantly available, no appropriate arrangements were made.

2.8.12 The decision making process led to a decision to move that coincided with the point when the anchor system failed. This was too late.

2.8.13 It is concluded that the Master did not take into account all the information available to him, preceding the incident. The decision to leave was taken too late.

2.9 Were the anchoring procedures followed correct?

2.9.1 The anchor held firm from arrival and through the steady wind increase on the morning of Thursday 16th September 2004. There is therefore no evidence to suggest that it was not laid effectively. Later as the wind rose even higher it would have been normal practice to pay out more chain cable to increase the holding capacity of the whole system. This was not done. This would however have taken the yacht closer inshore and more cable would increase the time required to weigh anchor.

2.9.2 There are several ways that the large swing around the anchor could have been corrected. For instance, the laying of the second anchor at the extremity of the swing and then dropping back so the yacht lies on both anchors laid out in a 'V', or streaming a stern anchor, or dropping the second anchor directly under the bow to act a damper. With the initial light and variable wind direction these would have lead to problems with the chains getting tangled or the stern anchor having to be reset. However, once the wind rose to a steady SE15 Knots these could have been prudent moves.

2.9.3 It is concluded that once the decision to remain anchored off a lee shore had been made, prudent measures could have been taken to improve the anchoring arrangements in the increased weather conditions.

2.9.4 There was no formal anchor watch maintained. During the day, in the calm weather preceding the incident, the position of the yacht was checked using the GPS trace on the ECDIS display, morning, evening and before bed. No anchor watch through the night was maintained.

2.9.5 Anchor watches would normally be maintained on merchant cargo vessels for compliance with the Collision Regs Rule 5, although SCTW 95 Section A-VIII/2 part 3-1 Reg 51 states that only 'If the Master considers it necessary, a continuous watch shall be maintained at anchor'.

2.9.6 Keeping track of the vessel's anchor position is traditionally done using methods such as using Variable Range Measure fixes or Electronic Bearing Lines to known points on the radar or triangulating bearings to fixed points. Monitoring the yacht's position by using the GPS trace on the ECDIS display is also a reasonable method. GPS fixes are now reliable and of similar or better accuracy to the more traditional methods.

2.9.7 At the time of the incident, the Master was in the bridge and fully aware of the conditions. He immediately realised when the anchor began to drag by observing a sudden shift in position and heading, out of the bridge windows.

2.9.8 Of concern in this case is that the wind filled in over night 15th/16th September 2004. At this time all the crew were asleep and nobody knew. The anchor could have dragged undetected. The ECDIS system is fitted with the capability for setting depth alarms but this capability was not used. This could have been disastrous, especially if 12 inexperienced guests had been aboard. This has been quickly addressed through the vessels Safety Management System and a system of anchor watches has now been introduced.

2.10 **Was the yacht in a suitable state of readiness at anchor?**

2.10.1 Engines on any vessel can be left in various states of readiness, ranging from propulsion plant out of action (engine dismantled undergoing maintenance), through various levels of standby (some engines need preheating etc), to "ready for immediate start" from the Bridge. The required level of readiness is determined by the management team of the vessel, based on the vessel's position, perceived risk and the prevailing conditions.

2.10.2 Ideally the main propulsion systems should be kept ready for immediate starting whilst at anchor close to a lee shore. Control for this operation should be left with the Officer keeping anchor watch, as long as it is safe to do so. Should there then be any problem with the anchor dragging then the main propulsion system can be immediately started and the vessel re-positioned.

2.10.3 At the time of the incident, there was an Engineer in the Engine Room and it took him about 90-120 seconds to start the engines and hand control over to the Master at the Bridge Wing (S). Although this seems reasonable, it proved too long for the yachts position and the prevailing conditions.

2.10.4 Whilst at anchor the Engine Room is left periodically un-manned. The Engineers could be engaged anywhere on the yacht conducting their duties. It would have taken longer to bring the propulsion plant on line, had the Engineer not been in the Engine Room.

2.10.5 It took firstly a short time to contact the Engineer to start the engines and then again a while to get the power to the propellers. The Master did not use the Bridge/Engine Control Room fixed telephone to raise the Engineer (this would have sounded a siren and activated a flashing light in the Engine Room). The Master contacted the Engineer on his portable UHF radio. He used this method of communication out of habit and because he was not sure where the Engineers were.

2.10.6 The Engineer could not hear his portable UHF radio properly, therefore proceeded to the quieter Engine Control Room to work out what all the raised voices over the radio were about. This caused a slight delay in getting the engines started.

2.10.7 This highlights the difference this size of yacht makes with reference to communication. The Yacht is so big that the crew do not necessarily know where each other are, as would be the case on a smaller sailing yacht.

2.10.8 The Main Engines were not in a state ready for immediate starting from the bridge. This was because:-

a) The Engineers prefer to start the engines locally. When the engines start they prefer to be 'hands on' to make sure that there is nothing untoward (leaks, vibration etc).

b) It is desirable not to leave the pumps for the steering gear and Kamewa CPP controls running constantly. This would unnecessarily build up running hours, wear on the equipment and waste power.

c) Control of the machinery via the Praxis platform management system can be assigned to any one of the consoles in the ECR, Bridge, Bridge Wing (P), Bridge Wing (S) at a time. The Engineers felt it unsafe to assign any control to a console they were not at because unqualified personnel/guests could inadvertently remotely activate pumps and winches. For example, a guest could inadvertently tension the hydraulic backstay by sitting on a button and bring down the rig.

2.10.9 The system is not configured with any emergency start sequence. If all the equipment was in 'auto' it would still require an Engineer to click on the right icons on the computer screen, in the correct sequence, to activate the plant. At the time of the incident only the Chief and Second Engineer had the 'know how' and trainingto run this procedure.

2.10.10 Although the engines were swiftly started by the Engineers, the time lag proved too long. The vessel was not in a suitable state of readiness, given the high level of risk created by the yacht's position and the prevailing weather conditions.

3 CONCLUSIONS

3.1 The crew paid out a reasonable amount of chain, for a standard yacht, in the weather conditions at the time of anchoring. This was in accordance with their training.

3.2 Although the type of anchor fitted to the ‘Mirabella V’ is different to that fitted on most merchant vessels, the size and purpose of the chain is very similar. The merchant philosophy, with regard to a greater amount of chain to be paid out (scope), may have been more appropriate, especially when the weather deteriorated.

3.3 The tendency of ‘Mirabella V’ to swing at anchor, coupled with a short scope of cable deployed, caused a lateral load on the anchor shank.

3.4 The anchor was pulled out from its holding position by a large transverse pull on the anchor shank, possibly cyclical as the yacht swung about her anchor.

3.5 The anchoring equipment provided to ‘Mirabella V’ is well in excess of the of the DNV minimum rule requirements.

3.6 There are large differences between the requirements of the various Classification Societies. This is in contradiction to the assumption by the industry and the Large Yacht Code that ‘Class’ represents a common standard.

3.7 The frontal area of the rig is more than the frontal area of the hull and therefore should have been factored into the calculations for the size of the anchoring equipment fitted. The Classification Society Rules, relating to the anchoring equipment, which are based on empirical formulas derived from standard motor vessel designs, do not adequately cope with the design of this yacht.

3.8 The designers used the most onerous Classification Rules available to them (LR), which required much larger equipment than the DNV Rules, in accordance with which the yacht was being built. However it is argued that because of the ‘Mirabella V’ novel design, additional safety factors for rig windage should have been applied or the equipment should have been assessed by direct calculation, perhaps supplemented by wind tunnel model testing.

3.9 The yacht did not ground because of a failure in the hydraulic lifting system for the keel.

3.10 The selection of the anchoring position was not unsafe in the light and variable wind conditions prevailing when the yacht anchored. This anchorage would be the preferred anchorage over Villefranche, had the wind turned to the South West.

3.11 The Master did not take into account all the information available to him preceding the incident, including weather forecasts, so that the decision to weigh anchor and move to Villefranche was taken too late.

3.12 Once the decision to remain anchored off a lee shore had been made, prudent measures should have been taken to improve the anchoring arrangements in the increased weather conditions.

3.12.1 At the time of the incident, the Master was in the bridge and fully aware of the conditions. The Master became immediately aware when the anchor began to drag by looking out the bridge windows and observing a sudden change in heading (the bow falling away to starboard).

3.13 Although the engines were swiftly started by the Engineers, the time lag proved too long. The vessel was not in a suitable state of readiness, given the high level of risk created by the yacht's position and the prevailing weather conditions.

4 RECOMMENDATIONS

4.1 The MCA and other Administrations issuing qualifications for yacht masters on large yachts should reassess their requirements for training in anchoring techniques to reflect the existence of very large yachts.

4.2 The crew of this yacht should develop techniques for reducing the amount of swing at anchor. The owners should provide the necessary technical back up and equipment to enable them to do so.

4.3 The owners should work together with DNV to reassess the capabilities of the anchoring equipment fitted to this yacht.

4.4 All Classification Societies, involved in classing large yachts, should re-evaluate their Rules pertaining to yacht anchoring equipment and work together through IACS to develop a common standard, relevant to these types of vessel.

4.5 Owners should provide more guidance within their ISM system for the allowable parameters for anchoring and remaining at anchor, on a lee shore.

4.6 Owners should reconfigure the engine platform management system to provide a safe option for leaving the propulsion system in an immediate state of readiness at anchor. In an emergency, the propulsion system starting sequence should be easy to initiate, by the Anchor Watch Keeper, from his watch keeping position, without the assistance of an Engineer. The vessel’s procedures should specify the various states of engine readiness options available and the characteristics of each.

Annex I

Weather conditions as observed at the by Semaphore Station on Cap Ferrat

Wednesday 15th September 2004

1500Hrs	Wind 06 knots	180°	Sea Calm
1800Hrs	Wind 10 knots	70°	Sea Slight
2000Hrs	Wind 10 knots	80°	Sea Slight
2400Hrs	Wind 0 4 knots	60°	Sea Calm

Thursday 16th September 2004

0400Hrs	Wind 08 knots	90°	Sea Calm
0800Hrs	Wind 10 knots	90°	Sea Slight
1200Hrs	Wind 14 knots	130°	Sea Rough
1300Hrs	Wind 23 knots	100°	Sea Rough
1500Hrs	Wind 21 knots	110°	Sea Rough
1800Hrs	Wind 17 knots	80°	Sea Rough
2000Hrs	Wind 12 knots	90°	Sea Rough
2400Hrs	Wind 04 knots	320°	Sea Calm

The weather conditions used in the Narrative of Events are as stated by the crew on board the yacht.

Annex II

Anchors fitted to the Mirabella V

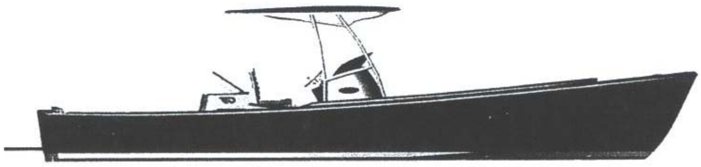
Annex III

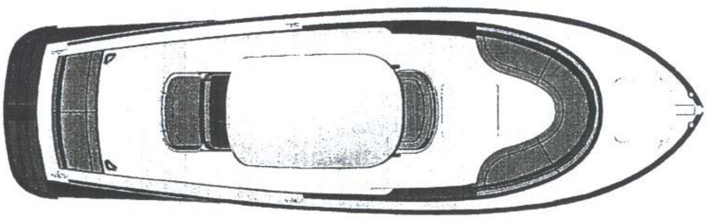
Specification for the Hinckley Tender

5

T-29 C Principal Dimensions

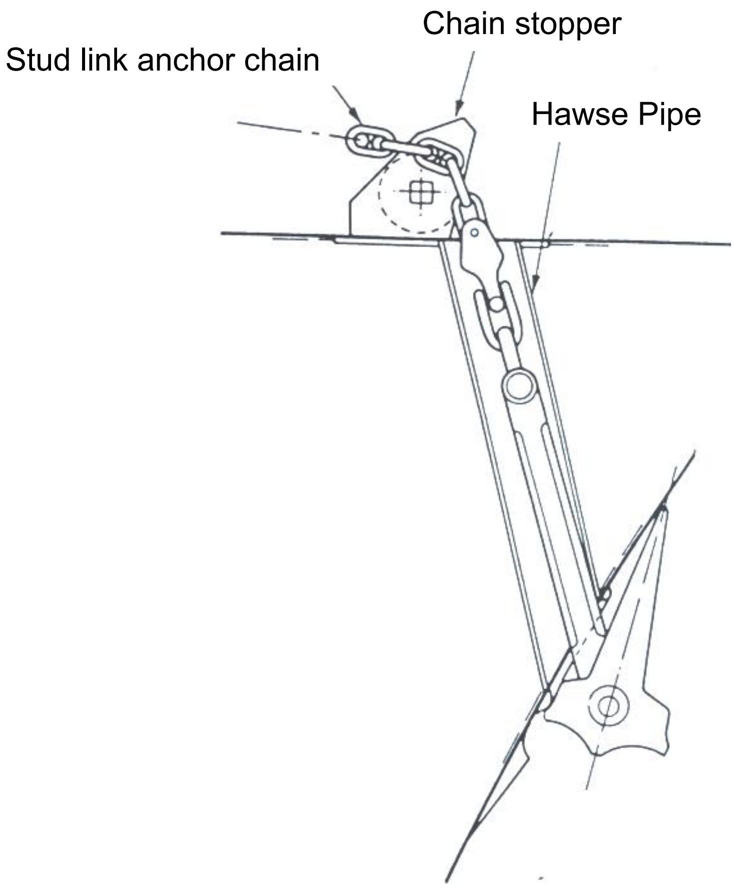
LENGTH OVERALL	29'-2"	8.89 m
LENGTH AT THE WATERLINE	26'–8"	8.13 m
BEAM	9'–1/2"	2.75 m
DRAFT	18"	0.46 m
DISPLACEMENT	7,500 lbs	3,402 kg
HEIGHT OF T-TOP ABOVE WATERLINE	7'–8"	2.34 m





Annex IV

Anchoring Equipment Nomenclature



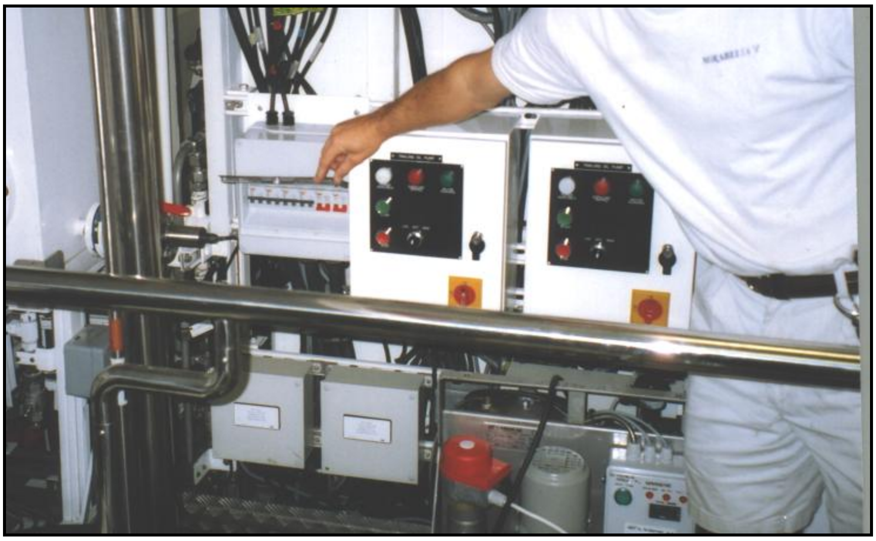
Annex V

Photographs

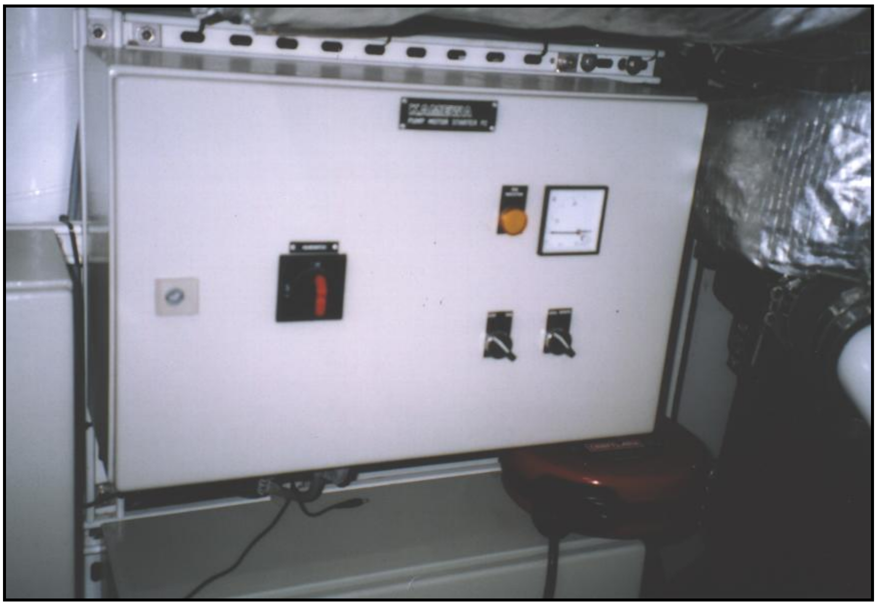
1. Hinkley tender

2. Anchors in stowed position

3. Engine Platform Management System on Main Engine Start Page



4. Main engine start electrical breakers



5. Kamewa CPP hydraulic pump starter panel

6. Dynema rope

7. Temporary repairs made to keel lifting mechanism