Report on the investigation of

injury to a passenger on board a

Delta 8.5m RIB

River Thames, London

6 May 2010

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United Kingdom
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Report No 1/2011
January 2011

Extract from

The United Kingdom Merchant Shipping

(Accident Reporting and Investigation)

Regulations 2005 – Regulation 5:

"The sole objective of the investigation of an accident under the Merchant Shipping (Accident Reporting and Investigation) Regulations 2005 shall be the prevention of future accidents through the ascertainment of its causes and circumstances. It shall not be the purpose of an investigation to determine liability nor, except so far as is necessary to achieve its objective, to apportion blame."

NOTE

This report is not written with litigation in mind and, pursuant to Regulation 13(9) of the Merchant Shipping (Accident Reporting and Investigation) Regulations 2005, shall be inadmissible in any judicial proceedings whose purpose, or one of whose purposes is to attribute or apportion liability or blame.

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GLOSSARY OF ABBREVIATIONS AND ACRONYMS

ALARP	-	As low as is reasonably practicable
BML	-	Boat Master's Licence
CPBS	-	Capital Pleasure Boat Services
EAV	-	Exposure Action Value
ELV	-	Exposure Limit Value
ERRV	-	Emergency Response and Rescue Vessel
EU	-	European Union
g	-	Acceleration due to gravity
GRP	-	Glass Reinforced Plastic
Knots	-	Nautical miles per hour
MCA	-	Maritime and Coastguard Agency
MGN	-	Marine Guidance Note
m/s^2	-	metre per second squared
MSN	-	Merchant Shipping Notice
PLA	-	Port of London Authority
RIB	-	Rigid Inflatable Boat
RNLI	-	Royal National Lifeboat Institution
RYA	-	Royal Yachting Association
SI	-	Statutory Instrument
UKHMA	-	United Kingdom Harbour Masters' Association
WBV	-	Whole Body Vibration

Times: All times in this report are local (UTC + 1) unless otherwise stated

SYNOPSIS

At approximately 0708 on 6 May 2010 a male passenger on a Delta 8.5m rigid inflatable boat (RIB) suffered lower back compression fractures while the boat was transporting him, with fellow workers, to a jack-up rig on the River Thames. The injury occurred as the passenger landed heavily on a locker lid, where he had been sitting, after he had been momentarily lifted off the lid due to the motion of the craft.

After the accident, the passenger was landed ashore and taken to hospital, where he received prompt attention for his injuries. He was subsequently fitted with an external body support brace and was unable to return to full-time employment until 6 months after the accident. He was still receiving physiotherapy treatment at the time this report was published, some 8 months after the accident.

Passengers in small high-speed craft are subject to potentially high shock and vibration impacts, and the MAIB is aware of 12 other accidents that have occurred in the 2 years following the similar *Celtic Pioneer* accident in August 2008, which also resulted in lower back compression fractures.

The risk of this type of injury can be reduced by ensuring that:

- occupants are seated in appropriate seating
- the boat's helmsman has received suitable training
- the boat is appropriately designed and outfitted
- procedures are in place to exclude passengers who may be particularly at risk, based on medical grounds.

A recommendation has been made to the Maritime and Coastguard Agency (MCA) to prioritise and resource the revision of MGN 280 to ensure the updated code of practice for small commercial vessels is published as early as possible.

A recommendation has also been made to the Royal Yachting Association (RYA) and the MCA to jointly issue a safety alert to promulgate the lessons learnt from this accident.

SECTION 1 - FACTUAL INFORMATION

1.1 PARTICULARS OF DELTA 8.5m RIB (Figure 1) AND ACCIDENT

Figure 1

The Delta 8.5m RIB on its launching trailer

Vessel details

Owner	:	Fugro Seacore
Type	:	Delta 8.5 X-Range fitted with 4 single Jockey Pod seats with back rests
Built	:	1998
Certifying Authority	:	Port of London Authority
Construction	:	GRP hull with rubber inflatable tubing
Length overall	:	8.5m
Engine power and type	:	1 x 300hp Yanmar 6LY-STZE stern drive
Service speed	:	30 knots

Accident details

Time and date	:	0708 on 6 May 2010
Location of incident	:	Wapping Reach, River Thames
Persons on board	:	9 (helmsman + 8 passengers)
Injuries/fatalities	:	One male passenger suffered anterior wedge fractures of the L1 and L3 vertebrae

1.2 BACKGROUND

In July 2009, jack-up rigs began drilling boreholes at various locations along the River Thames to obtain soil samples beneath the river bed. The samples were required to confirm ground conditions to aid in the design and possible construction of a major utilities tunnel. The jack-up rigs **(Figure 2)** were owned and operated by Fugro Seacore Ltd and each had a drilling team of three men, plus an engineer provided by the project contractor. The men, who worked 12-hour shifts, were initially transported to the rigs on a daily basis in boats owned and operated by Capital Pleasure Boat Services Ltd (CPBS).

Image courtesy of Thames Water

Figure 2

Fugro Seacore jack-up rig operating on River Thames

In October 2009, the drilling locations of the jack-up rigs moved away from the CPBS operating base at Temple, central London. Fugro Seacore then decided to utilise its 8.5m Delta RIB, which had been released from another job, to transport the personnel to and from the jack-up rigs. This was to reduce the transit times to the rigs because the boat had a significantly higher service speed than the craft owned and operated by CPBS.

On 15 October 2009, Fugro Seacore contracted CPBS to provide a helmsman to *'pilot and maintain'* the 8.5m Delta RIB. On 21 October the Port of London Authority (PLA) undertook a "*Fitness for Purpose Inspection*" of the boat to assess its suitability to operate commercially on the River Thames. Following the inspection, the PLA advised CPBS that a number of items needed to be

addressed before a licence could be issued. The PLA granted CPBS a 4-week period during which the boat could continue to operate while the remedial works were undertaken.

Borehole drilling work was suspended between January and March 2010, during which time the boat underwent repairs that included the fitting of new heavy duty inflatable buoyancy tubes with reinforced patches on the upper parts of the tube. Drilling operations resumed in April, when Fugro Seacore repeated Health and Safety briefings for all the personnel involved in the operation. The 8.5m Delta RIB was again utilised to transport the workforce to and from the jack-up rigs. In May the rigs were operating in the Battersea area of the river and the crews were accommodated in the Greenwich area, some 6 miles from the rigs by river.

1.3 NARRATIVE

At 0700 on 6 May 2010, the 8.5m Delta RIB arrived at Greenwich pier to embark eight workers for transfer to the rigs. At 0701 the last of the men arrived and boarded the boat **(Figure 3)**. He donned a lifejacket and sat on the locker forward of the helmsman's console, as there was no other area of the boat available to him **(Figure 4)**.

Image courtesy of London River Services Ltd (CCTV)

Figure 3

Personnel embarking at Greenwich Pier - Image from CCTV

The boat then departed from the pier and proceeded at a speed of approximately 30 knots, towards central London. The man sitting on the forward locker had a rucksack with him, which he had placed on the deck in front of him. As the boat's motion increased the rucksack began to move around, so he picked it up and placed its carrying loops around his arms so that the bag was on his chest **(Figure 4)**.

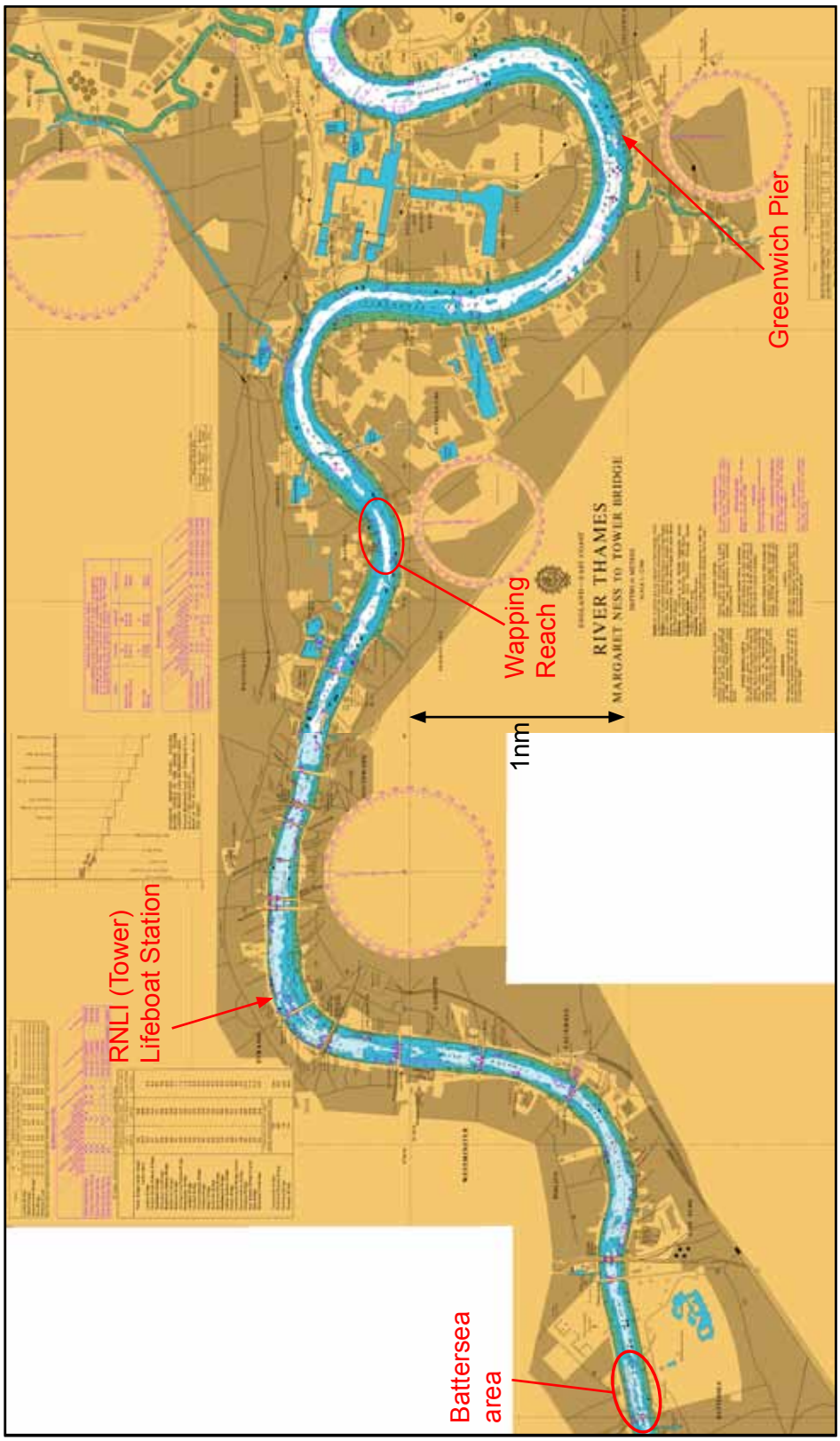
Figure 4

Reconstruction showing location of injured person and other passengers at the time of accident

There were no hand-holds or foot straps in this location so he alternated his grip between a vertical stanchion on the helmsman's console and the lip of the locker on which he was seated. During the passage, the man was frequently lifted bodily from the locker and, due to the motion of the boat was unable to alert the helmsman to his discomfort.

At 0708 the boat was in Wapping Reach **(Figure 5)** when the man felt an intense pain in his lower back. He cried out and immediately placed himself in a prone position on the forward deck of the boat. The helmsman stopped the boat and a co-worker assisted the injured man, who was in considerable distress and unable to move without intense pain in his back.

Figure 5



Chartlet of River Thames from Waterloo Bridge to Greenwich showing location of accident - Wapping Reach

The helmsman decided that the man required immediate medical attention and resumed the boat's passage, at slow speed, towards the Royal National Lifeboat Institution's (RNLI) Tower lifeboat station. The boat arrived at the RNLI station, on Victoria Embankment, at 0725.

The lifeboat men on duty responded promptly to the situation, although they had received no advance notice that an injured person was arriving. The London ambulance service was summoned and the lifeboat men administered first-aid until the ambulance arrived. A specialist stretcher was then used to remove the injured man from the boat, from where he was taken to the nearby St Thomas' hospital for treatment.

1.4 ENVIRONMENTAL CONDITIONS

At the time of the accident the wind was easterly Force 2. The accident occurred 1 hour before high water and the river state was generally slight with occasional waves of approximately 0.5m in height. The tidal stream was flooding at a rate of approximately 1 knot.

1.5 THE INJURY

As a result of the accident the injured person suffered anterior wedge fractures of the first and third lumbar vertebrae (L1 and L3) **(Figure 6)**. While in hospital he was also given a neurological assessment, which proved to be normal. He was mobilised and discharged the day after the accident, and a few days later was fitted with an external body brace. He remained off work for more than 4 months while he recovered from the injury. He commenced a graduated return to work a few months later and resumed full-time employment 6 months after the accident, although he was still receiving physiotherapy treatment at the time this report was published, some 8 months after the accident.

At the time of the accident, the casualty was 34 years old and was in good health with no previous history of back injuries.

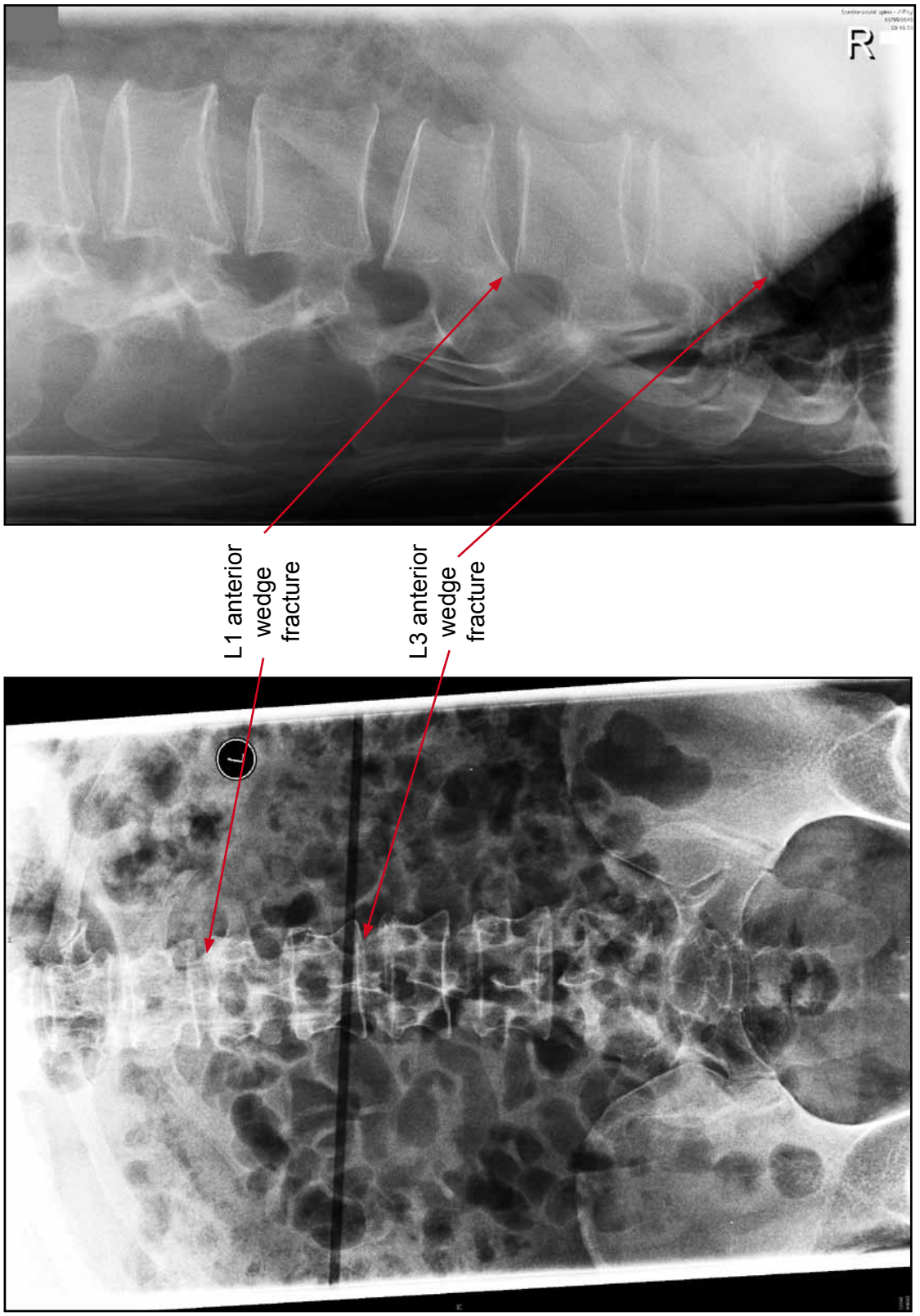
1.6 THE MECHANISM OF INJURY

A spinal wedge compression fracture typically occurs in the lumbar spine as a result of an axial load[1] being applied with a degree of forward flexion. It is commonly referred to as a *'wedge'* compression fracture **(Annex A)**. The injury often results from accidents such as: a fall from height; a head-on car crash; ejection from a military aeroplane; or from being incorrectly seated in RIBs and other, relatively small, fast craft.

The motion of a small boat proceeding at speed is such that the shocks and vibrations, resulting from the impacts between a boat's hull and the surface of the water, are transmitted through the deck and seats to the boat's occupants. The magnitude of the shocks experienced by the occupants is significantly magnified when their bottoms are lifted off their seats and then land again as the boat rises up to meet them **(Annex B)**.

[1] Axial load – a load applied compressively through the longitudinal axis of the spine.

Figure 6

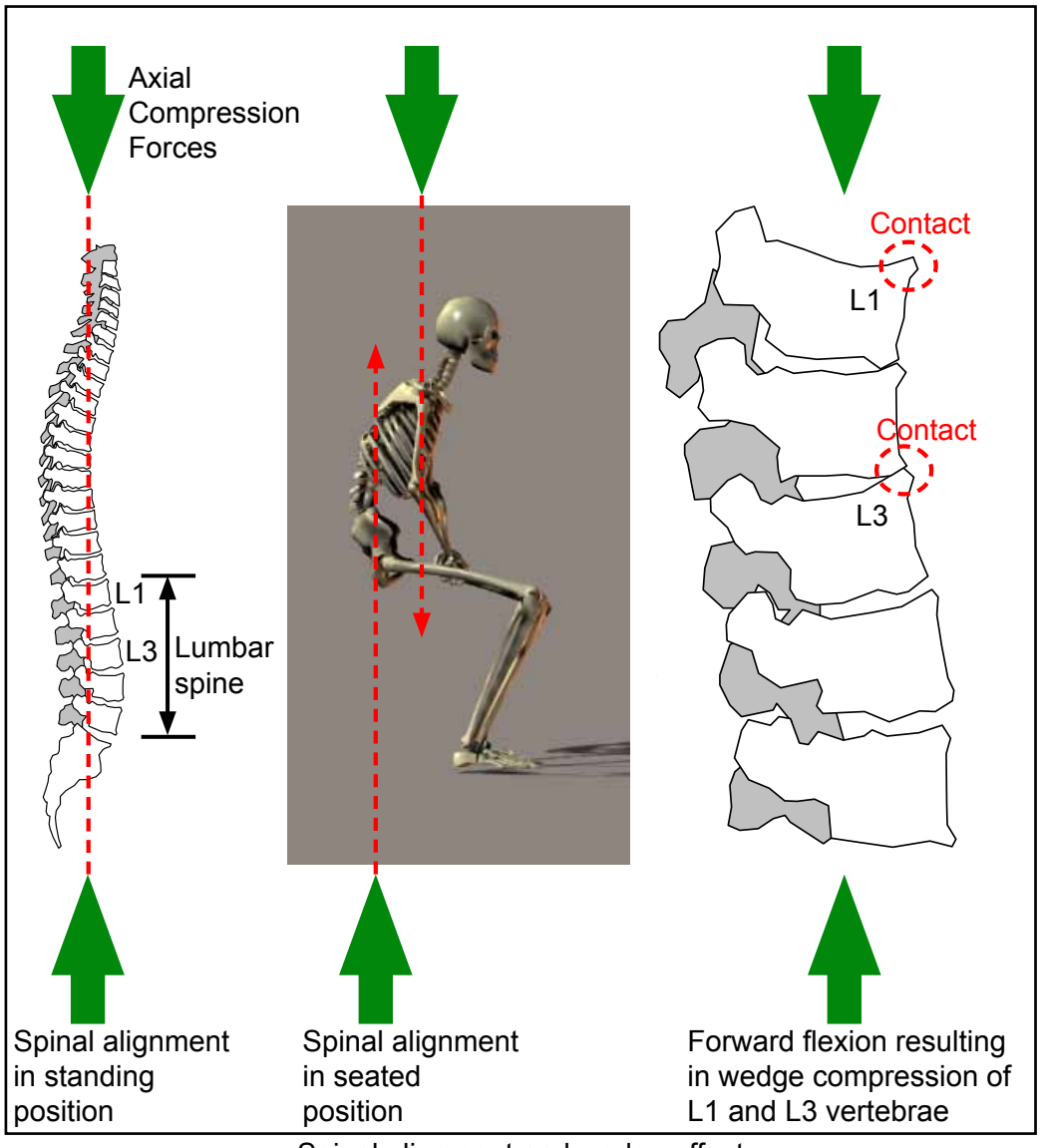


X-ray images of injury

The human spine is at its strongest when in the standing posture on a stable surface, when it assumes a natural "*S*" shape and can readily support the weight of the trunk and head. In this posture an evenly distributed gap is maintained between the vertebrae by the discs, and maximum support is offered by the trunk and abdominal muscles. The spine is weaker in the seated position, when it assumes a slumped posture and many of the muscles supporting the spine cannot function effectively. The body's centre of gravity moves forward, increasing the risk of the spine bending forward (forward flexion) during axial loading. It is the combination of the flexion of the spine and the axial forces applied that causes contact between the vertebrae and results in fractures due to the wedging effect **(Figure 7)**.

In this accident the injured person's spine was subjected to the additional loading of his rucksack.

Figure 7



Spinal alignment and wedge effect

1.7 DELTA RIB

1.7.1 Operator

At the time of the accident, the boat was operated by CPBS, which also owns and operates Class V passenger vessels. It also operates smaller passenger vessels and workboats on the River Thames, licensed by the PLA. The company's marine operations are managed by a person with 23 years' experience of working and operating vessels on the river. He held a Boat Master's Licence (BML) for the river, he had worked for the PLA for 11 years, and was an examiner of "*Local Knowledge"* for the BML (Thames waterman) examination.

1.7.2 Crew

The helmsman of the boat at the time of the accident had been employed by CPBS for 7 years. He was 22 years old and held a Tier 1 Level 2 UK BML for the River Thames. In 2009 he obtained specialist endorsements for passenger operations and for towing/pushing. He also held an RYA Powerboat Level 2 Certificate.

1.7.3 Maintenance

As part of the investigation the boat was inspected by MAIB inspectors on the day of the accident. It was observed that several of the remedial items identified by the PLA at the *"Fitness for Purpose Inspection"* in October 2009 had not been addressed. It was also noted that the emergency shut down cord (kill cord) for the engine was broken and inoperable. The rail around the console, in front of the helmsman's position, was observed to be broken, with an unprotected jagged edge. The seat coverings were worn and some of the foot straps were broken or missing.

1.8 PLA BOAT LICENCE

1.8.1 Fitness for Purpose Inspection, 21 October 2009

Following the "*Fitness for Purpose Inspection"* on 21 October 2009 the PLA provided CPBS with a report **(Annex C)** which stated that: the 'Capital RIB' (a name given to the boat by CPBS for licensing purposes) "*is not to be worked, navigated let for hire or used for the purpose for which it is licensed other than in accordance with the restriction(s) set out below until the following remedial works have been carried out to my reasonable satisfaction"* [sic]. The report gave CPBS a 4-week period of grace in which it could "*continue to operate the vessel while the required remedial works were addressed*".

In the report, the PLA listed 18 items which needed to be addressed following the inspection, one of which indicated that *"During the inspection the available seating for passengers and crew was observed as six; operations should be limited to two crew and four passengers until such time that additional seating is provided up to a maximum total of eight"*.

The report also advised that: *"there was heavy wear on both Port and Starboard sides. Periodic inspection should be undertaken. Any defects identified should be suitably repaired when necessary"*.

1.8.2 Boat licence, 6 May 2010

On 6 May, after the accident, CPBS contacted the PLA to request a copy of the boat's licence. The PLA advised CPBS that no licence had been issued as it had not been advised that the 18 remedial items, identified at the "*Fitness for Purpose Inspection"* on 21 October 2009, had been addressed.

CPBS then advised PLA, by return email, that the items had been addressed, and the PLA immediately issued the boat's licence.

The following day, the PLA carried out an inspection of the RIB, and on 20 May the PLA revised the boat's licence to restrict the number of persons to be carried to a maximum of four, consistent with the number of seats fitted on the RIB.

1.8.3 PLA licensing regime

The Port of London Act 1968, section 124 and the PLA Craft and Boat Registration and Regulations 2000 require all vessels operating commercially on the River Thames to be licensed by the PLA. Certain vessels are exempted from this requirement, eg vessels coded by the MCA or vessels licensed by other specified authorities.

The PLA inspects and licenses small passenger vessels (carrying 12 or fewer passengers) operating in its waters, none of which extend to sea, in accordance with the requirements of the Inland Waters Small Passenger Boat Code. This code provides standards for vessel construction, equipment, stability, operational manning levels and maintenance requirements and is similar, in many respects, to the Harmonised Small Commercial Vessel Code, published by the MCA as an annex to MGN 280 (M).

Other, non-passenger vessels are inspected in accordance with the MCA's Fitness for Purpose standard for Inland Waterway vessels. This scheme has been developed by the MCA for application to United Kingdom existing inland waterways vessels, which are not passenger ships or pleasure vessels, but which operate commercially on categorised waters but not to sea (MSN 1776 refers).

The PLA licenses over 500 craft and employs qualified marine surveyors to inspect and license these craft.

1.9 SPEED LIMITS, RIVER THAMES

An 8 knot speed limit applies in certain parts of the River Thames, specifically, *"upstream of Wandsworth Bridge and in adjoining creeks and areas around Canvey Island"*. However, there was no speed limit in force for the area of the river in which the accident occurred.

1.10 FUGRO SEACORE'S HEALTH AND SAFETY REGIME

1.10.1 Risk Assessments and Method Statements

Prior to the borehole drilling operations commencing on the River Thames, Fugro Seacore completed risk assessments and produced method statements for the various tasks associated with the planned works. On 16 January 2009 the risk assessment for *Boat Transport and Access to the Platform* was undertaken and an associated method statement was produced **(Annexes D and E)**. These documents were reviewed and reissued on 21 April 2010.

The risk assessment identified the hazards of: poor weather conditions, collision, mechanical failure and having loose articles in the boat during transportation. The associated method statement **(Annex E)** identified that the helmsman of the transfer vessel was responsible for the safety of the crew and the passengers. The method statement also required all the occupants to be wearing *"a properly fitted and fastened lifejacket (to BSEN ISO 12402-3) prior to boarding"*.

The main focus of the risk assessment and the method statement was the physical transfer of personnel on and off the jack-up rigs, using either a personal transfer basket, the stairway or via the rig's own RIB.

1.10.2 Induction Training

In May 2009 the personnel involved with the project received safety induction training. The injured person, who had not previously worked on Fugro Seacore rigs, attended a 1-day course entitled *Personal Survival Techniques,* at Warsash Maritime Academy, on 14 May 2009. This course met Fugro Seacore's minimum requirements for personnel working on their jack-up rigs.

1.11 SIMILAR ACCIDENTS

In August 2008, a passenger on board the RIB *Celtic Pioneer* suffered a similar back injury when the boat was engaged in a thrill ride trip. The MAIB carried out a Full Investigation into the accident and published a report[2] which found that 28 similar accidents resulting in lower back compression injuries had occurred between 2001 and 2008.

The MAIB is aware of a further 12 accidents which occurred during the 2 years since the *Celtic Pioneer* accident, which have resulted in lower back compression injuries on board RIBs operating in UK waters.

2 *Celtic Pioneer* MAIB Report No 11/2009
http://www.maib.gov.uk/publications/investigation_reports/2009/celtic_pioneer.cfm

1.12 THE VIBRATION REGULATIONS

The Merchant Shipping and Fishing Vessels (Control of Vibration at Work) Regulations 2007 (SI 2007/3077), commonly referred to as "*The Vibration Regulations"*, implement the EU Physical Agents Directive[3] and came into force in February 2008. MGN 353 (M+F)[4] summarises the provisions of the Vibration Regulations and provides guidance to employers on their application. In section 3.3 it states that *"Whole-body vibration may be most apparent in smaller, fast craft such as fast rescue boats, RIBs or work boats, particularly when operating in choppy conditions".* Whole-body vibration (WBV) is defined as the mechanical vibration that, when transmitted to the whole body, entails risks to the health and safety of workers, in particular, lower back morbidity and trauma of the spine.

The regulations require employers to assess the level of mechanical vibration to which workers are exposed and sets daily exposure limit values (ELV). The regulations are explicit in their requirements with regards to risk assessment in that they shall:

- include "*the level, type and duration of exposure, including any exposure to intermittent vibration or repeated shocks*" and
- be based on observation of working practices, information provided by the manufacturer and, if necessary, "*measurement of level of mechanical vibration to which workers are likely to be exposed"*.

The regulations also require employers to ensure that the risks identified in the risk assessment are either eliminated at source or reduced to a level which is as low as is reasonably practicable (ALARP). In any event the ELV is not to be exceeded unless a specific exemption by the Secretary of State has been granted. No such exemption had been requested for the 8.5m Delta RIB operated by CPBS.

The exposure limits for WBV are:

- the ELV, standardised to an 8-hour reference period, is 1.15 m/s^2; and
- the daily exposure action value (EAV)[5], standardised to an 8-hour reference period, is 0.5 m/s^2.

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3 EU2002/44/EC Directive of the European Parliament and of the Council on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibration) (sixteenth individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC).

4 MGN 353 (M+F) – The Merchant Shipping and Fishing Vessels (Control of Vibration at Work) Regulations 2007

5 EAV – means the level of daily exposure for any worker which, if exceeded, requires specified action to be taken to reduce the risk

1.13 MAGNITUDE AND FREQUENCY OF SHOCK AND VIBRATION

The High Speed Craft Human Factors Engineering Design Guide[6], sponsored by the UK Ministry of Defence with the support of the ABCD Working Group on Human Performance at Sea[7], was issued on 31 January 2008 to provide a resource for those involved in the design, study, purchase, legislation and operation of high-speed craft. A summary report for the MAIB is included at Annex B.

The guide explains, inter alia, the type, magnitude and frequency of shocks and vibrations generated during high-speed craft transits at sea and the effects of repeated shock and WBV on crew and passengers.

Research, referenced in the guide, provides a graphical example of the magnitude and frequency of repeated shocks measured during trials on the deck of an 8.5m RIB travelling at 40 knots between a sea state 1 and sea state 2 **(Figure 8)**. The trials found that the occupants were exposed to constant shocks in the region of 2*g*, regular shocks in the region of 6*g* and occasional shocks of up to 20*g*. These figures equate to the WBV EAV being exceeded within 15 minutes and the ELV within approximately 30 minutes **(Figure 9)**. The guide also states that "*the risks of acute and chronic injury are manifested in an increase in spinal, knee, arm, or neck injury. This can be from a single high energy event (e.g. a single 20g impact) or as a result of a long term exposure to a large quantity of smaller energy events (e.g. multiple 2g impacts)".* The research also found that the magnitude of shocks transmitted through the deck of a high-speed craft is greater towards the bow.

1.14 RYA powerboat qualifications

The RYA, as part of its National Powerboat Scheme, has developed a series of training courses for the helmsmen of sports boats, RIBs, dories and launches. The courses are provided within the UK via a network of RYA approved training centres and schools, and the qualifications are recognised internationally. They range from the Powerboat Level 1 certificate for beginners to advanced levels for instructors.

The Powerboat Level 2 Certificate, which was held by the helmsman of the Delta RIB in addition to his BML, is the recognised minimum standard for commercial powerboat helmsmen. The training course for this certificate takes 2 days and includes both practical and theoretical elements. The course is assessed, but there is no formal examination. The syllabus includes practical high-speed manoeuvring, and requires the candidate to have a theoretical knowledge of the advantages and disadvantages of different hull forms with respect to their sea keeping ability. However, when this course was taken by the helmsman, it did not cover the risks associated with vibration and shock, the Vibration Regulations or MGN 353 (M+F).

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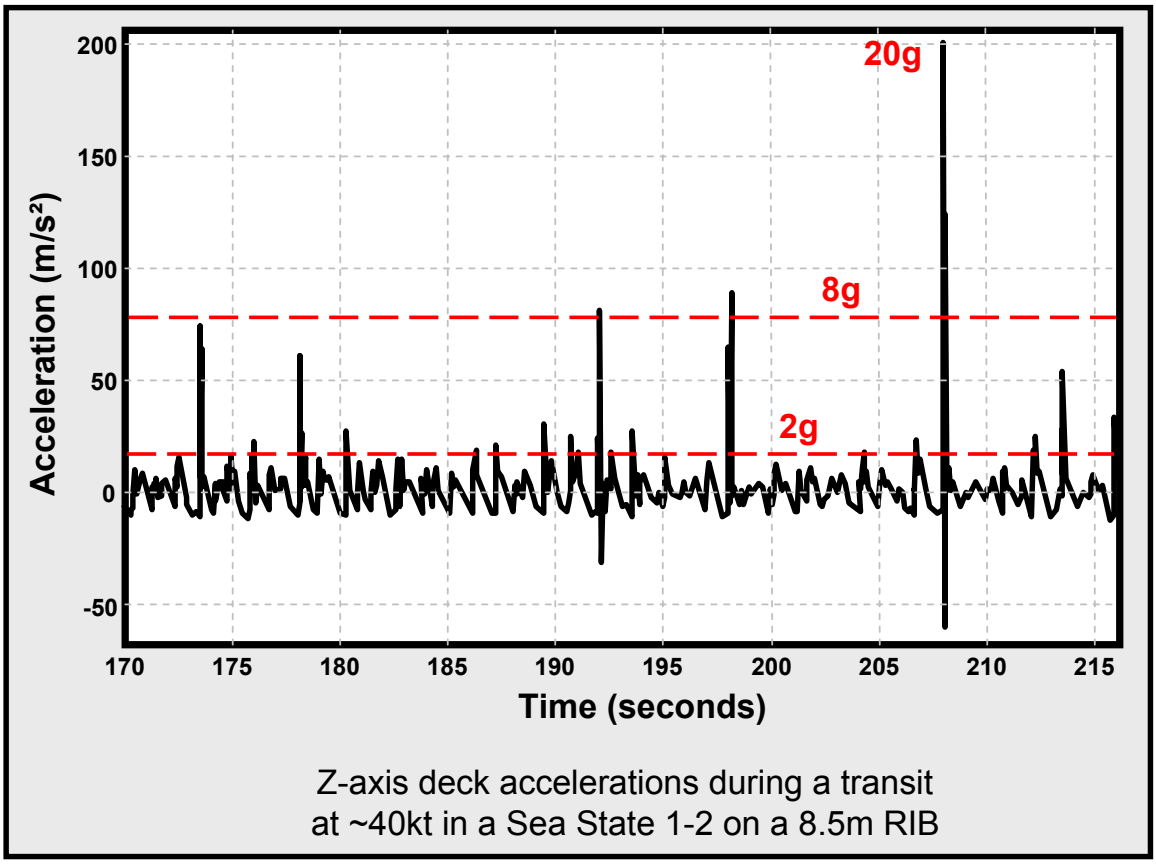
[6] http://www.highspeedcraft.org/HSC_HFE_Design_Guide_v1.0.pdf

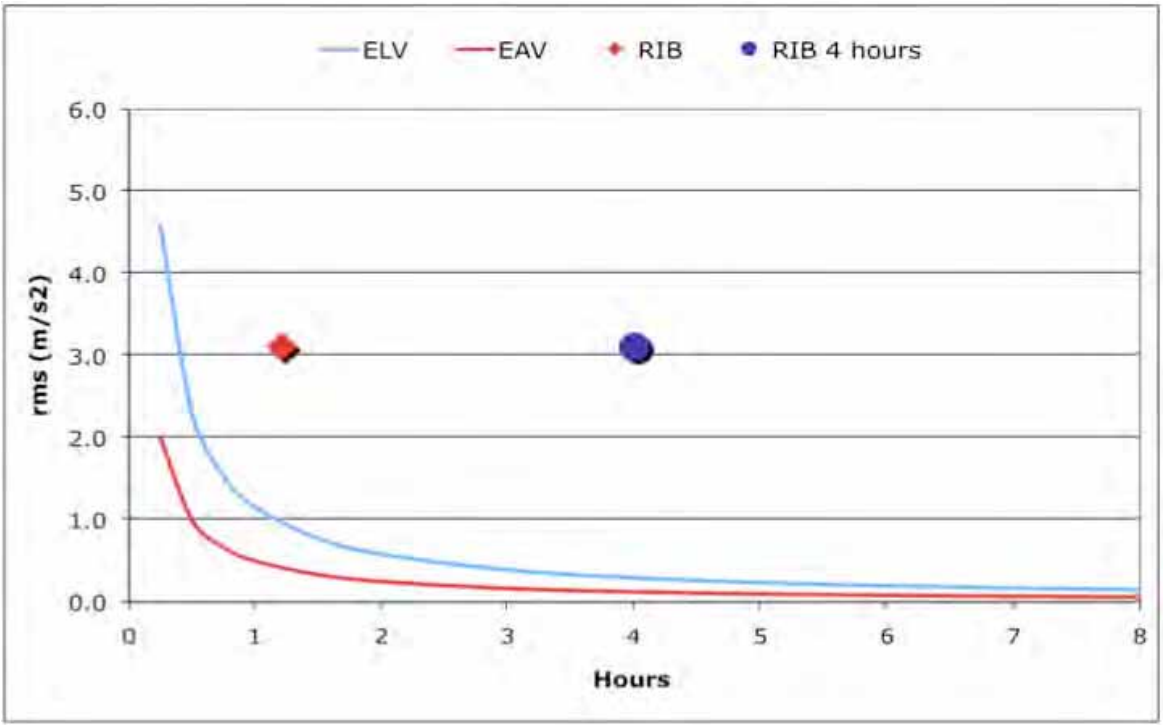
[7] ABCD Working Group on Human Performance at Sea is an ad-hoc international group consisting of hydrodynamics and human factors researchers from the US, Australia, UK, Canada and the Netherlands.

Figure 8



Magnitude and frequency measurements for repeated shocks recorded on an 8.5m RIB

Figure 9



An example of how a 28' RIB travelling at ~40kts in a sea state 2 will exceed the EU WBV Exposure Action and Limit Values.

SECTION 2 - ANALYSIS

2.1 AIM

The purpose of the analysis is to determine the contributory causes and circumstances of the accident as a basis for making recommendations to prevent similar accidents occurring in the future.

2.2 CAUSE OF THE INJURY

The injury to the passenger occurred when he was subjected to a series of relatively low energy shocks, possibly with occasional high energy shocks, with resultant force acting along the axis of his spine of sufficient magnitude to fracture the L1 and L3 vertebrae.

The motion of the boat, while proceeding at about 30 knots in relatively calm and sheltered waters, was sufficient to cause the man to be successively bounced on and off the surface on which he was seated. The surface was the lid of a storage locker which, although regularly used as a seat, had no effective back rest or padding and was not fitted with the hand-holds or foot straps necessary for safe seating.

The injured person had his rucksack across his chest at the time of the accident, as it had not been secured for the passage. This additional weight would have acted as a further load on his spine, exacerbating the poor posture he had to adopt by twisting to hold onto a stanchion behind his shoulder.

If a twist or bend is introduced to the lower back region the risk of this type of injury is further increased by a factor of about one third **(Annex B)**. It is for this reason that prominent medical opinion **(Annex A)** also states that it is important that passengers on RIBs are not seated on the sponson (buoyancy tubes) as this invariably results in loss of spinal alignment.

2.3 RISK OF INJURY

2.3.1 Trend from previous accidents

This accident occurred on a routine passage in sheltered waters. However, the statistics from similar accidents (paragraph 1.11) show an increasing trend over the last 2 years. This trend is of concern and should be noted by all high-speed craft operators to assist in preventing a recurrence of this type of injury.

2.3.2 Exposure to shock and vibration

The research conducted by the ABCD working group and incorporated into the High Speed Craft Human Factors Engineering Design Guide attempts to quantify the levels of shock and vibration transmitted through the hull of high-speed craft when underway. Although the findings presented in the guide are based on trials undertaken on military craft, they can be applied equally to similar, commercially operated, high-speed craft such as the one involved in this accident.

The trials demonstrated that the repeated shocks experienced during a high speed passage can be of sufficient magnitude to cause impact injuries. They also concluded that a person exposed to the shock and vibration levels shown in **Figure 8** dramatically exceeds the exposure limits set by the Vibration Regulations.

The trial data was obtained during a high speed, 40 knots, passage in calm conditions, similar to the conditions on the day of the accident. However, it should be noted that evidence from other accidents indicates that similar impact injuries can also occur at lower speeds when large waves or wakes are encountered.

Operators must ensure that the vibrations and shocks that passengers and crew are exposed to are reduced to as low as is reasonably practicable (ALARP) and kept below the exposure limits set by the Vibration Regulations.

2.4 RISK MITIGATION

The Vibration Regulations and MGN 353 (M+F) both list measures which can be used to bring exposure to vibration to ALARP levels. The appropriate measures in this case can be grouped into the following three areas:

- Human factors engineering and design
- Boat-handling training
- Operating procedures

2.4.1 Human factors engineering and design

In this accident the injured person was seated on a forward locker. This was not intended for use as a seat, it had no padding and no available hand-holds or foot straps **(Figure 4)**. His situation was exacerbated by the location of the locker in the forward part of the RIB, where the motion is most violent **(Annex B)**.

The lack of restraints forced him to hold on to the stanchion located behind his shoulder. His posture was further worsened by the need to wear his rucksack on his chest due to the lack of available safe stowage **(Figure 10)**. It is notable that the casualty in the *Celtic Pioneer* investigation (Report No 11/2009)[2] was also seated in the forward part of the RIB and the report cites this and the casualty's posture as contributory factors to the injury.

Figure 10

Illustration of the possible spinal alignment of the casualty
at the time of the accident

"Seating in high speed craft needs to be such that the individual is coupled to the seat as effectively as possible and that any comfort layer helps to attenuate rather than reinforce the impact" **(Annex A)**. Even in benign conditions, at moderate speeds the locker lid would have made a poor seat and, as the accident shows, at high speeds the risk of injury from such ad hoc seating arrangements is significant. There are an increasing number of manufacturers producing dynamic seats designed to mitigate the effects of WBV and shock impacts, thus enabling the requirements of the Vibration Regulations to be met **(Figure 11)**.

Ideally, dynamic seats would be provided for all occupants. However, this is not always appropriate. Manufacturers need to give clear guidance on the level of protection from vibration and shock afforded by the seating provided, taking into account the intended use and the requirements of the Vibration Regulations. They should also ensure that the hull shape is suitable for the craft's intended use and area of operation and that there is sufficient provision to stow baggage and equipment. Similarly, owners need to take account of the limitations imposed by the seating arrangements, available stowage and hull shape when determining the operating procedures and limitations.

Figure 11

Examples of high-speed craft seats, which are designed to reduce the effects of vibration and shock impacts

2.4.2 Boat-handling training

While it is important, at the design and construction stages, to produce a boat which is as safe as is reasonably practicable for its occupants, the skill, training and experience of the helmsman remains a major factor in safeguarding those on board.

The ability to judge and anticipate the effects of the prevailing sea conditions, combined with the knowledge of where and how the occupants should be located in a high-speed craft can be gained through training and experience. This was highlighted both in the *Celtic Pioneer*[2] report and in the summary report at **Annex B** which states under the heading of Shock Mitigation "*The principal mechanism influencing craft performance and therefore shock exposure is throttle response i.e. reducing power before reaching the top of a wave"*.

Had the helmsman appreciated the dangers associated with vibration and shock resulting from high speed, he would have been able to mitigate the risks associated with the poor seating arrangements to some degree. However, none of his training had brought these risks to his attention.

The Vibration Regulations require operators to provide any employees at risk of exposure to vibration, with suitable information, instruction and training. This must be sufficient to enable them to understand the requirements of the Vibration Regulations including the ability to identify risks and recognise how they might best be minimised.

As a result of recommendations made in the *Celtic Pioneer* report[2] the RYA is currently revising the syllabus of the Powerboat Level 2 training course. A reference to *"the importance of boat control in waves and adequate seating to minimise the possibility of back injury"* will be incorporated into the syllabus.

The RYA is also currently developing Guidance on Passenger Safety for Small Commercial High Speed Craft. Similar guidelines are also being developed jointly by the Passenger Boat Association/MCA/RYA, specifically targeted at the High Speed Experience ("Thrill Rides") sector.

However, it is the employer's responsibility to ensure that their employees are suitably trained. This has been recognised in other sectors of the industry including the Oil and Gas industries' Emergency Response and Rescue Vessel (ERRV) sector. Here, the hazards associated with WBV have been recognised, as has the helmsman's role in helping to minimise the risk of injury. Specific training and guidance is included as an element in the training module for the Oil and Gas Academy's Approved Standard for training boatmen on high-speed rescue craft and helmsmen of daughter craft operating from rescue vessels.

2.4.3 Operating procedures

In addition to providing a safe craft and ensuring they employ suitably trained and experienced individuals, operators of high-speed small craft are required by the Vibration Regulations to ensure that they have clear procedures in place, to safeguard the occupants of the craft from exposure to vibration.

The risk assessment and associated method statement produced by Fugro Seacore **(Annex D and E)** to cover the transfer of crew from shore to jack-up rigs make no reference to the risks associated with WBV or shock. It would appear that in October 2009, when Fugro Seacore started using the faster boat for crew transfers, the vibration risks associated with this change were not considered. Therefore no procedures to mitigate exposure to vibration or shock were developed.

The required procedures are intended to provide the helmsman with clear guidelines on the measures to be taken to ensure the safety of the occupants and of the boat itself. They should include reference to passenger safety, passage planning, speed control, area of operation, weather limitations, and guidance on the pre-departure passenger briefing. This latter point is particularly significant in that the helmsman must be aware of his duty, as the operator's representative, to exclude any passengers who, on the basis of their vulnerabilities or the lack of safe seating, may be exposed to an unacceptably high risk of injury during the passage.

It is of note that the existing procedures did require all items for transportation to the rig to be securely strapped in the boat. On the day of the accident this was not extended to the casualty's rucksack.

2.5 MAINTENANCE

The routine maintenance of the RIB once Fugro Seacore had contracted CPBS to "*pilot and maintain"* the craft appears to have been below the high standards CPBS set on the craft it owned and operated. This may be because no clear agreement was reached between the two companies as to the level of maintenance expected within the contract.

Notwithstanding this, the fact that the engine kill cord was broken and ineffective, removed an essential safety mechanism; the boat should not have been used in this condition. Owners and operators have a duty to ensure that all safety equipment provided on their craft remains in a good and serviceable condition at all times.

When a contract such as this is agreed, the responsibility for maintaining the boat and its gear to a safe and serviceable standard should be clearly stated as a condition of the agreement.

2.6 PLA LICENCE

The PLA licensing regime for passenger vessels is linked closely to the port's Safety Management System which, as well as ensuring that passenger carrying craft are safe to operate in their waters, provides the PLA with the opportunity to establish and maintain a working relationship with its stakeholders.

When the boat was first inspected by the PLA on 21 October 2009, a number of deficiencies were identified. The operators were given a 4-week period in which to continue to *"work or navigate"* the boat while the remedial works were addressed. Generally, the PLA will not allow any vessel to continue to operate if the remedial items are identified as being safety critical. In this case, the remedial items included repairs required to defective seating, the carriage of sufficient approved 150 Newton lifejackets, and other items which could have been classed as safety critical.

However, the results of the inspection on 21 October were communicated to CPBS by a facsimile on 23 October 2009, the opening paragraph of which stated that *"the… RIB is not to be worked, navigated let for hire or used for the purpose for which it is licensed other than in accordance with the restrictions set out below*" (**Annex C**). With this wording, even though the operator held other licences and was familiar with the PLA's licensing regime, it was possible to assume that the boat was, in fact, licensed from 21 October 2009.

The inspection also identified that the RIB had available seating for passengers and crew to a maximum of six persons "*until such time that additional seating is provided up to a maximum total of eight*".

Also, although a 4-week period was granted for the remedial works to be completed, no system was in place to ensure that the works had been undertaken before the licence was issued.

The wording of the information provided to the prospective licensee by the PLA was potentially ambiguous as it implied that a licence had been issued. It is essential that all such correspondence from the PLA is clear and not open to misinterpretation. However, despite the ambiguity, it should have been clear that the licence had not been issued and, in any event, the very clear limitations placed on the number of persons to be carried at the "*Fitness for Purpose"* inspection should not have been exceeded.

2.7 SPEED LIMIT RIVER THAMES

The fact that the RIB was able to proceed at high speed without restriction in port limits is relatively unusual in UK ports. In general, UK statutory harbour authorities regulate the speed of vessels navigating within their areas of jurisdiction in order to safeguard all the users of their ports.

If there had been a speed limit in place the vessel would not have been operating at such high speed, without additional safeguards being in place. The likelihood of the injury occurring would then have been significantly reduced.

The requirement to regulate the speed of craft in the area of the accident had been previously indentified by the PLA, and in 2009 the legal process was commenced to introduce a Byelaw for this purpose.

SECTION 3 - CONCLUSIONS

3.1 SAFETY ISSUES DIRECTLY CONTRIBUTING TO THE ACCIDENT WHICH HAVE RESULTED IN RECOMMENDATIONS

1. The injured person was permitted to sit in a location in which, with the boat proceeding at high speed, he was unable to maintain the posture necessary to prevent injury. [2.2]

2. The trend of occurrence of this type of accident is increasing. Operators of high-speed craft should take note of the potential for passengers being injured due to vibration and shock impacts. [2.3.1] [2.3.2]

3. Manufacturers and owners need to take account of the best practices for vessel and seat design to reduce vibration and shock impacts to those on board. [2.4.1]

4. The training of high-speed craft helmsmen should include awareness of the dangers to passengers associated with vibration and shock in this type of craft. [2.4.2]

3.2 OTHER SAFETY ISSUES IDENTIFIED DURING THE INVESTIGATION ALSO LEADING TO RECOMMENDATIONS

1. It would be beneficial to owners and operators of small high-speed commercial craft if they were provided with guidance on seating which is likely to meet the requirements of the Vibration Regulations. [2.4.1]

3.3 SAFETY ISSUES IDENTIFIED DURING THE INVESTIGATION WHICH HAVE NOT RESULTED IN RECOMMENDATIONS BUT HAVE BEEN ADDRESSED

1. The syllabus for the RYA Powerboat Level 2 training course did not include reference to the hazards of shock and vibration impacts which passengers may be exposed to on small high-speed craft. [2.4.2]

2. The risk assessment for the transfer of workers to the jack-up rigs by high-speed craft must include consideration of the hazards associated with vibration and shock impacts. [2.4.3]

3. The maintenance contract for the RIB must ensure that safety equipment remains fully serviceable at all times. [2.5]

4. The number of persons licensed to be carried on the RIB may not exceed the number of suitable seats fitted. [2.6]

5. There was no speed limit on the River Thames in the area in which the accident occurred. [2.7]

SECTION 4 – ACTIONS TAKEN

4.1 MAIB

The MAIB has issued a Safety Flyer **(Annex F)** highlighting that, on small high-speed craft, passengers should be in appropriate seating. It further states that helmsmen should have received adequate training and be sufficiently experienced to minimise the likelihood of vibration and shock related injuries.

4.2 FUGRO SEACORE

Fugro Seacore has:

- Conducted an internal investigation into the accident and has reviewed the risk assessments associated with the boat transfer operation.
- Conducted safety briefings to all personnel engaged on the project to ensure the lessons learned from the accident are widely disseminated.
- Promulgated the circumstances of the accident and the lessons learned within the company to avoid recurrence.
- Promulgated, through industrial groups such as the UK Renewables Safety Committee, the lessons learned from this accident.

4.3 CAPITAL PLEASURE BOAT SERVICES

CPBS has:

- Issued a revised memo to its staff advising that the maximum number of persons to be carried in this boat must not exceed four.
- Fitted a new kill cord (on the day of the accident) and introduced a daily checklist to ensure the RIB, and its equipment, is maintained in a fully serviceable and safe condition at all times.

4.4 PORT OF LONDON AUTHORITY

The PLA has:

- Undertaken an internal investigation of this accident.
- Commenced a review of its licensing regime for passenger vessels with particular emphasis on the advice given to operators regarding remedial actions required.
- Ensured that the number of persons carried on small high-speed craft operating commercially in its area of jurisdiction does not exceed the number of appropriate seats fitted to the craft.

At the time of the accident, the PLA had already commenced the legal process to introduce a speed limit for the River Thames in the area in which the accident occurred.

4.5 ROYAL YACHTING ASSOCIATION

The RYA, following the *Celtic Pioneer* Report (No 11/2009) has:

- Revised the syllabi for powerboat training courses to raise awareness of the importance of boat control and adequate seating to minimise the possibility of back injury.

4.6 THE MARITIME AND COASTGUARD AGENCY

- The MCA has drafted a Marine Guidance Note which will provide guidance on the design of seating and best practice in vessel design and operation to reduce shock impacts.
- The MCA is reviewing MGN 280 with a view to publishing a revised code of practice for small commercial vessels in late 2011. The revised code will include reference to the Control of Vibration Regulations and also provide guidance on passenger safety.

4.7 THE UK HARBOUR MASTERS' ASSOCIATION

The UKHMA has agreed to bring the findings of this report to the attention of its members.

SECTION 5 - RECOMMENDATIONS

The **Maritime and Coastguard Agency** is recommended to:

2011/101 Prioritise and resource the revision of MGN 280 to ensure the updated code of practice for small commercial vessels is published as early as is possible.

The **Maritime and Coastguard Agency** and **Royal Yachting Association** are recommended to:

2011/102 Jointly produce a Safety Alert in relation to this accident, issuing guidance on the safe operation of RIBs and other small commercially operated vessels when conducting high speed passages.

The alert should highlight:

- The risk of injury to the passengers and crew of such craft if they are not properly seated.
- The requirement to comply with the MS Control of Vibration Regulations 2007 during all modes of operation.
- The range of dedicated seating available which is designed to mitigate the effects of shock and Whole Body Vibration impacts.

Marine Accident Investigation Branch
January 2011