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REPORT ON MARINE ACCIDENT POLARIS I, IMO NO 4500163, PERSONAL INJURY, YMERBUKTEN BAY IN THE ISFJORD ON SVALBARD, 21 AUGUST 2012

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This report has been translated into English and published by the Accident Investigation Board Norway (AIBN) to facilitate access by international readers. As accurate as the translation might be, the original Norwegian text takes precedence as the report of reference.

Photo of ferry on the Norwegian west coast: Bente Amandussen

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NOTIFICATION OF THE ACCIDENT

The AIBN did not become aware of this marine accident until summer 2013, one year after the accident took place. The shipping company had not reported the accident to the Norwegian Maritime Authority in accordance with the Regulations of 27 June 2008 No 744 on the obligation to notify and report marine accidents and other incidents at sea (Regulations on the obligation to notify and report marine accidents). The captain of the vessel had reported the accident to the French consulate in Oslo, but the French maritime authorities were not informed of the accident. The AIBN did not receive notification of the accident from other national authorities.

According to Directive 2009/18/EC of the European Parliament and of the Council of 23 April 2009 establishing the fundamental principles governing the investigation of accidents in the maritime transport sector and amending Council Directive 1999/35/EC and Directive 2002/59/EC of the European Parliament and of the Council, no investigation duty applies to very serious marine accidents involving '*pleasure yachts and pleasure craft not engaged in trade, unless they are or will be crewed and carrying more than 12 passengers for commercial purposes*' (Article 2.2.b).

On 11 September 2013, the AIBN and the French Marine Accident Investigation Office (BEAmer) decided to initiate a safety investigation into this very serious marine accident.[1] The AIBN has coordinated this work.

Figure 1: The accident occurred in Ymerbukten bay in the Isfjord on Svalbard. The accident site is marked on the map by a red x. Source: AIBN

[1] The definition of 'very serious marine accident' is set out in Section 472a of the Norwegian Maritime Code. See also Directive 2009/18/EC Article 3.2.

SUMMARY

The accident took place on 21 August 2012 at approximately 1006, in connection with the vessel *Polaris I* sailing a 12-day cruise around Svalbard. The passengers and guides were on a daytrip in rubber dinghies in Ymerbukten bay in the Isfjord on Svalbard. While the dinghies were near the Esmarkbreen glacier, a large piece of the glacier front calved off and hit dry land (shallow water), which caused lumps of ice to fly across the water with tremendous force. A passenger on board one of the dinghies was hit by lumps of ice on the back of her neck and head. She died almost instantly as a result of her injuries.

Because it took a long time before the AIBN and the French Marine Accident Investigation Office BEAmer became aware of the accident, the safety investigation is limited in scope.

Before the accident, both the guides and the passengers had been made aware that the glacier front might calve and that the ice could land on dry land, but they did probably not anticipate such violent calving.

There is a high degree of uncertainty regarding how far the dinghies were from the glacier front when it calved. The AIBN estimates the distance to the glacier front at the time of the accident to have been between 100 and 130 metres. It cannot be ruled out that the distance was greater than this, however. Regardless of the actual distance, the dinghies were so close to the glacier front that a person was killed by a lump of ice that was sent flying when the glacier calved.

The tour operator's instructions for the guides stated that the dinghies were to stay at least 200 metres from the glacier front. If the dinghies were actually closer to the glacier front than the tour operator's instructions recommended, the safety investigation points to two factors:

- Through the advertising brochure and the safety instructions, the tour operator may have put the guides in a position where they had to deal with conflicting expectations. It was left to the guides to consider the passengers' expectations of getting close to the glacier front in relation to the instructions on minimum safety distance, based on their own experience and understanding of the situation. If the guides intentionally chose to move closer to the glacier front than 200 metres, the considerations described above could have influenced their decision.

- The guides judged the distance to the glacier front by eye only, which proves to be difficult. The tour operator had not made sufficient arrangements for the guides to use adequate methods to determine the actual distance to the glacier front. There is a need for guidelines on practical methods by which guides and ships' crews can obtain information about the actual distance to a glacier front. This need is assumed to apply to several tour operators, and the AIBN submits a safety recommendation in this connection.

The tour operator's instructions to keep a minimum distance of 200 metres to the glacier front corresponded with the Governor of Svalbard's recommendations. The consequences of subaerial calving hitting dry land are not included in the Governor's assessment of the minimum safety distance to the glacier front. The Governor of Svalbard has initiated measures to describe this phenomenon and to consider whether the previous minimum safety distance recommendation should be changed.

1. FACTUAL INFORMATION

Figure 2: Photo of the vessel Polaris I. Photo: Polaris Expedition Sarl.

1.1 Details of the vessel and the accident

Details of the vessel

Owner of the vessel:	Polaris Expedition Sarl, France (IMO no 5631397)
Shipping company and operator:	Polaris Expedition Sarl, France
Tour operator:	Grands Espaces Sàrl, Switzerland
Home port:	Marseille
Flag state:	France (Registre International Français, RIF)
IMO no:	4500163
Type:	Pleasure craft, commercial yacht, max. 12 passengers
Shipyard:	Charles D. Holmes & Co, Beverly
Build year / build no:	1973/1023
Construction material:	Steel
Length overall:	32.22 metres
Gross tonnage:	345
Engine power:	492 kW
Other relevant information:	The dinghies were inflatable rubber boats of the Waterworld brand

Details of the accident

Date and time:	21 August 2012, just before 1006 (local time)
Site of accident:	At the edge of the Esmarkbreen glacier in Ymerbukten bay in the Isfjord on Svalbard. The accident occurred near the position 78°17.5'N 013°55.0'E.
Persons on board	There were six passengers and one guide in each dinghy.
Injured persons/fatalities:	1 passenger died
Injuries:	1 passenger suffered injuries, but was not seriously physically injured

1.2 The sequence of events

1.2.1 Chain of events

In the summer season of 2012, the commercial yacht *Polaris I* sailed 12-day trips around Svalbard. The vessel was registered in France. It was 32.22 metres long and could accommodate up to 12 passengers. The tour operator Grands Espaces Sàrl had chartered the vessel for the whole summer season. The ship had a crew of five plus two guides. One of the guides had also been assigned the role of expedition leader on behalf of the tour operator.

The accident took place on the vessel's second last Svalbard cruise of the season. The vessel left Longyearbyen on 10 August, heading north-west along the island of Spitsbergen. It continued north to the Liefdefjord/Woodfjord before turning back. The vessel was scheduled to return to Longyearbyen on 22 August.

The night before the accident, on 20 August, the vessel anchored on the west side of Ymerbukten bay. The bay is on the north side of the Isfjord, north-west of Longyearbyen.

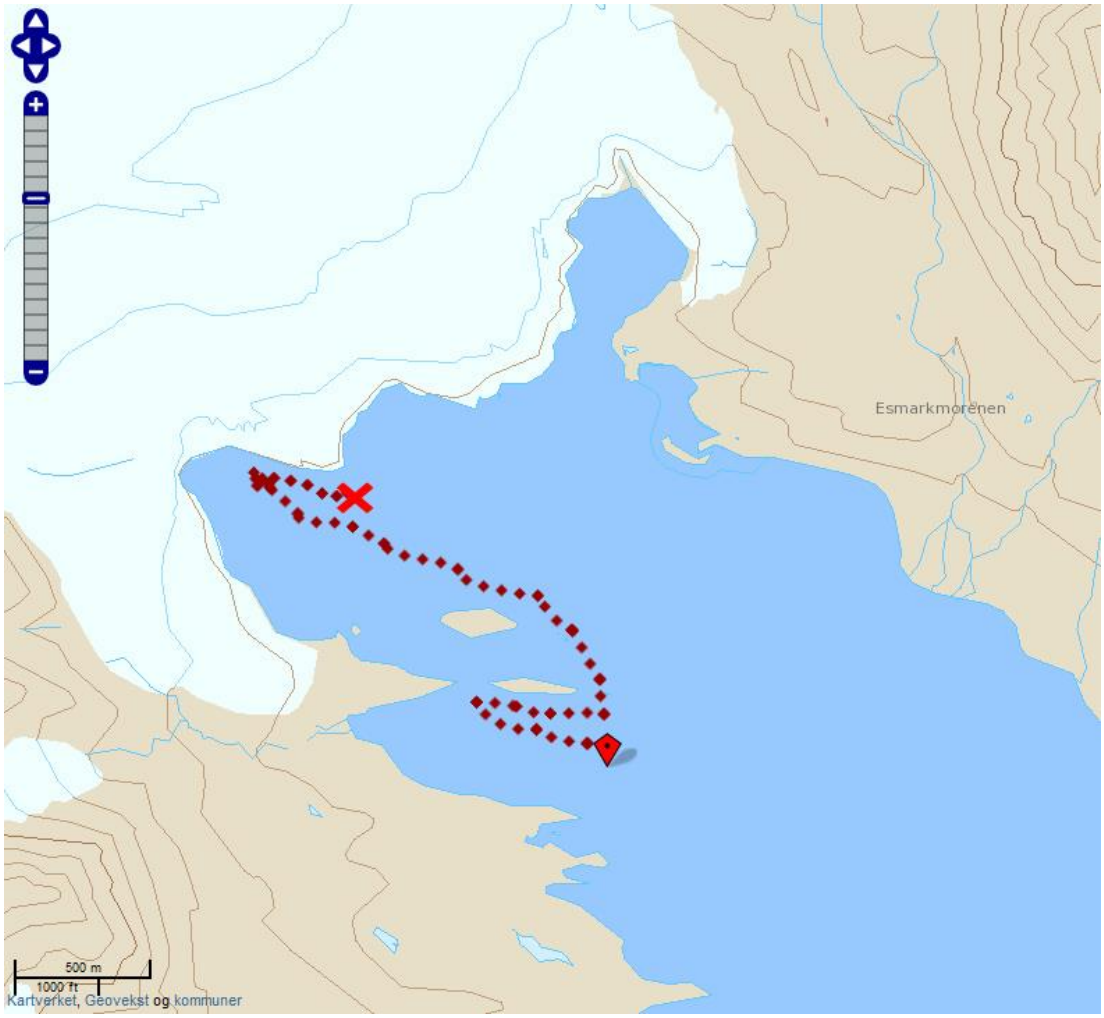

Figure 3: Map of Ymerbukten bay and the Esmarkbreen glacier. As the glacier is constantly changing, the map does not given an accurate description of the glacier front. Polaris I was anchored further out in Ymerbukten bay, indicated by a diamond-shaped tag. The red line indicates where the dinghies went before the accident, but this is not stated in more detail in relation to the position and distance to the glacier front. The accident took place in the area around the red X. Source: the Norwegian Mapping Authority

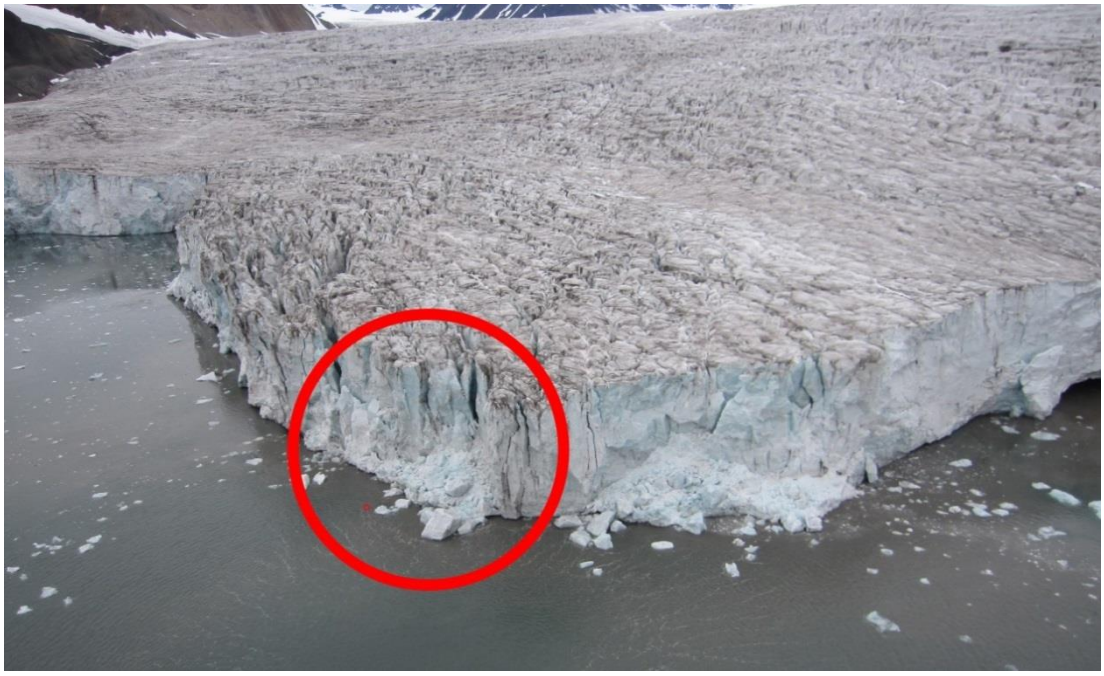

Figure 4: Aerial photo of the front of the Esmarkbreen glacier. The photo was taken the day after the accident. At the bottom of the photo, two areas where large sections of the front have recently calved off from the glacier can be seen. These areas can be recognised by the ice in the water and by the colour of the ice being lighter (bluish green) than the rest of the glacier front. Of the two areas, the one on the left is where the calving took place when the accident occurred. To the left of this area, there are larger blocks leaning out over the fjord. The dinghies went along this part of the glacier front before the accident. Photo: The Governor of Svalbard.

The next morning, the guides considered that the conditions were suitable for a daytrip. The crew had not observed any significant calving during the night. The sea in front of the glacier only contained scattered brash ice, which the guides saw as a sign of low calving activity.

Two dinghies were lowered into the water at about 0915. The guides and passengers then boarded the dinghies. Each of the rubber dinghies carried six passengers and a guide. They will hereinafter be referred to as Dinghy 1 and Dinghy 2, respectively. The guides steered the boats. It was one of the passengers on board Dinghy 1 who later died.

At approximately 0930, the dinghies left the vessel. They went towards the western side of the Esmarkbreen glacier.

At approximately 0938, i.e. 28 minutes before the accident, the passengers and the guide on board Dinghy 2 saw that the glacier front calved. The ice hit dry land and lumps of ice were thrown horizontally from the shore; see Figure 5. This instance of calving was considerably smaller than what occurred at the time of the accident.

Just in front of the western side of the glacier front, they discovered a seal. The dinghies lay still near the seal for about 15 minutes to allow the passengers to observe and take photos of it. While they were laying still, they could hear the glacier calving.

Figure 5: Calving from the front of the Esmarkbreen glacier. The blocks of ice landed on dry land and lumps of ice came flying across the water. The photo was taken by a passenger approximately 28 minutes before the accident. Photo: Private.

Figure 6: The photo shows Dinghy 1 on the west side of the bay. The photo was taken from Dinghy 2 before the accident. Photo: Private.

The dinghies then turned and proceeded eastward. This was probably just after 0952. The guides steered the dinghies towards the eastern side of the Esmarkbreen glacier. The plan was to go to a small, ice-free lagoon on the east side of the glacier, and then to go ashore to show the passengers what a glacier looked like from land.

The dinghies proceeded at low speed towards the middle of the glacier front. Dinghy 1 was in front of Dinghy 2. From the point where they saw the seal, the dinghies probably went diagonally away from the glacier and then continued along a course parallel with the glacier front.

Figure 7: The photo shows Dinghy 2 close to the glacier front. The dark area by the glacier front is dry land. The photo was taken from Dinghy 1 before the accident. Source: Private.

The front of the Esmarkbreen glacier terminates in Ymerbukten bay. The main section continues into the sea. Where the accident took place, however, the glacier front is on dry land. This was visible from the water. Other areas had visible signs of calving (blue ice), but the glacier front was white and covered in snow in the area where the accident occurred. The guide interpreted this as a sign that there had been little calving activity in the area recently. The glacier front was approximately 33 metres high.[2]

While the dinghies continued eastward, the passengers observed several smaller instances of calving.

At approximately 1000, the passengers on board Dinghy 2 heard noises from the glacier and saw part of the glacier front fall into the sea. No large waves occurred after the block of ice had hit the water. The guide on board Dinghy 2 stopped the boat and encouraged

[2] The stated height is based on surveys carried out by the Governor of Svalbard the day after the accident.

the passengers to observe the glacier. He expected more calving. The guide was prepared to leave if necessary.

This was probably the same calving observed by the passengers on board Dinghy 1.

After the guide on board Dinghy 1 had observed a tall ice tower / ice pillar calving, he steered the dinghy further away from the glacier. Dinghy 1's bow was then facing the glacier front. The passengers and the guide's attention was directed towards it.

Some of the passengers have estimated the distance between the glacier front and the dinghies at the time to have been between 100 and 400 metres, while others have been unable to estimate a figure. The guides and some of the passengers believed that they kept an adequate distance to the glacier front. The guides have later explained that they kept at a distance of 200 metres.

The Governor of Svalbard's office is of the opinion that the actual distance between the dinghies and the glacier front is unclear. Its assessment was that Dinghy 1 could have been less than 200 metres from the glacier front, but that there were no indications that Dinghy 1 was closer to the glacier front than 60–80 metres. The Governor's office cannot rule out that the dinghy was more than 200 metres away from the glacier front, however.

1.2.2 Description of the accident

At approximately 1005, a massive calving event started. First some ice fell and a loud bang was heard, then a large section of the glacier front came loose and fell forward. The ice blocks were approximately 33 metres high, and they came down on dry land (shallow water). Because of the weight of and tension in the glacier ice, the blocks that hit dry land caused lumps of ice to fly across the fjord with tremendous force.

The passengers and guides on board both dinghies observed the massive calving event. Photos and video recordings were taken of the calving; see Figure 8, Figure 9 and Figure 10. Small and big lumps of ice came flying towards Dinghy 1 in the form of a white cloud mixed with hard ice. Most of it hit the water in front of Dinghy 1.

But some of the lumps of ice hit Dinghy 1. One of the passengers was struck by lumps of ice on the back of her neck and the left side of the back of her head. She suffered severe head injuries and died almost instantly. The deceased was 47 years old.

One of the other passengers was also hit by lumps of ice, but did not suffer serious injuries. The accident occurred at approximately 1006. It took less than a minute from the glacier started calving until the passengers in Dinghy 1 were hit.

The guide on board Dinghy 1 saw that the passenger fell forward in the boat, and it was clear that she was seriously injured. The injured woman's husband understood that there was something seriously wrong with her. A lump of ice the size of a fist was later observed in Dinghy 1.

Lumps of ice also landed in the water near Dinghy 2, but no one was hit. The wave caused by the calving was small, but noticeable on board Dinghy 2.

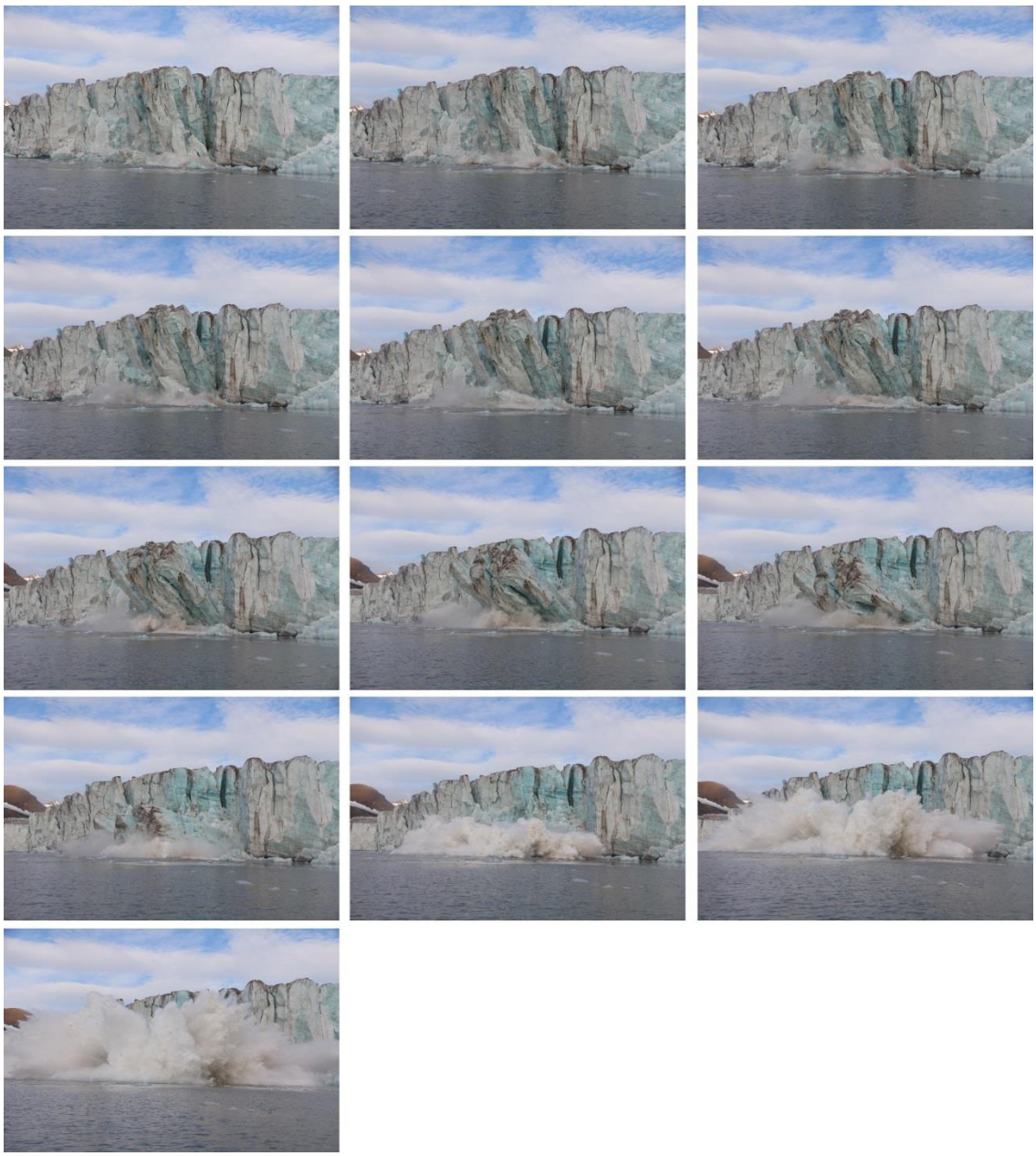

Figure 8: Photos taken from the dinghy where one of the passengers died. The photos show that a large section of the glacier front calved off. The blocks of ice are about the same height as the glacier front, i.e. approximately 33 metres. The ice blocks fell down and hit dry land (shallow water). Lumps of ice were then sent flying across the fjord with tremendous force. Some of the lumps struck one of the passengers on board the dinghy, killing her almost instantly. The 13 photos were taken within the space of a minute. Photo: Private

Figure 9: The photos show the same calving event as Figure 8. They are taken from a video filmed on board the dinghy in which the passenger died. Photo: Private

Figure 10: The photo shows the same calving event as Figure 8 and Figure 9. The photo was taken from the other dinghy. The photos show that a large section of the glacier front calved off and hit dry land (shallow water). Lumps of ice came flying across the fjord with tremendous force. The dinghy in which the accident took place can be seen on the right-hand side of the photo. Photo: Private.

1.2.3 The rescue operation

The guide on board Dinghy 1 immediately alerted the other guide via VHF radio. The injured woman was found to be unconscious, and, after a short while, she did not have a pulse and was not breathing. The other dinghy arrived on the scene, and cardiopulmonary resuscitation (CPR) was immediately initiated. At the same time, the head of the expedition called the captain via VHF radio and notified him that emergency assistance was needed. This was at approximately 1015. The CPR continued until the dinghy arrived

at the vessel at 1020. The crew and passengers continued to do CPR, the injured woman was attached to a defibrillator, but it showed no signs of a heart rhythm.

The captain of the vessel contacted the Governor of Svalbard at 1020 and requested immediate assistance. The Governor alerted the hospital and the company that operates the rescue helicopter in Longyearbyen, Airlift. A rescue helicopter from Longyearbyen arrived at the vessel at 1100. The crew took over the first aid. The injured person was pronounced dead 15 minutes after the doctor arrived the vessel.

1.3 The voyage and the tour operator

1.3.1 Description of the voyage

In the summer season of 2012, the commercial yacht *Polaris I* sailed round trips in the Svalbard area on behalf of the tour operator Grands Espaces Sàrl. The round trips lasted for 12 days, with departure and arrival in Longyearbyen. The voyage went along the north-west side of the island of Spitsbergen, returning via the Woodfjord. The tour operator offered passengers an opportunity to observe colonies of walrus, seals, birds, whales and polar bears, to look at mountain formations and glaciers, and to see cultural history sites used for whaling and other forms of hunting.

As part of the marketing campaign for this trip, the tour operator prepared an advertising brochure. The following photos are taken from this brochure:

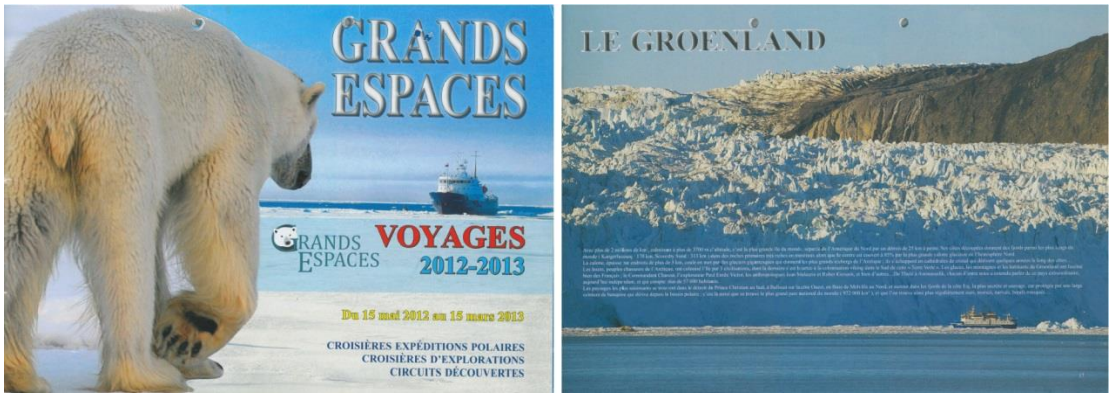

Figure 11: The photo on the left is the cover photo of the tour operator's advertising brochure. The photo on the right shows the vessel in front of a glacier front. Photo: Grands Espaces Sàrl

Figure 12: The photo shows two dinghies in front of a glacier. From page 7 of the tour operator's advertising brochure. Photo: Grands Espaces Sàrl

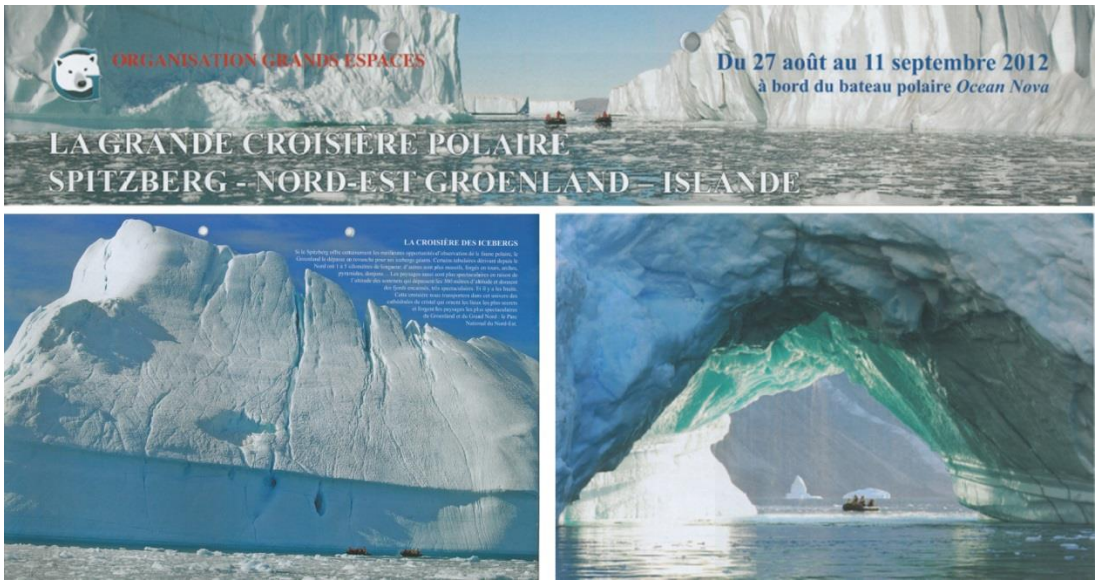

Figure 13: The photo shows a dinghy close to an iceberg. From pages 18, 19 and 21 of the tour operator's advertising brochure. Photo: Grands Espaces Sàrl

Figure 14: The photo on the left shows a dinghy with passengers close to a herd of walrus. The photo on the right shows a walrus next to a dinghy with passengers. From pages 8 and 34 of the tour operator's advertising brochure. Photo: Grands Espaces Sàrl

1.3.2 The tour operator

The tour operator Grands Espaces Sàrl chartered *Polaris 1* for the whole summer. Grands Espaces is a Swiss tour operator founded in 1998 registered in Sion (Valais) in Switzerland.

The tour operator presents itself as a specialist on cruises in the Arctic. Its market is mainly French-speaking individuals living in Switzerland, France and Belgium.

Grands Espaces had four employees and hired approximately 20 freelance guides and several vessels for the cruises every year. Its main destinations were Svalbard and Northeast Greenland. The company organises around 15 cruises per year, mainly to the Arctic, but also to the Antarctic and other nature-based destinations.

The CEO of the company owned 99 % of the shares and had extensive experience of polar expeditions and guiding. He was aware of the danger of ice splinters flying from collapsing ice towers and had observed this himself several times.

The company has stated that, except for medical evacuation due to minor injuries or illness, this was its first accident in the Arctic since the company was founded.

Grands Espaces is a member of 'Fonds Suisse de Garantie de Voyage' and of the Arctic Expedition Cruise Organisation (AECO).

1.3.3 The tour operator's instructions for the guides

The tour operator established written instructions for its guides in 2005. The tour operator had stipulated that the journeys were to be carried out in accordance with 'AECO's guidelines for expedition cruise operations in the Arctic'. See section 1.8 for a description of the guidelines.

The tour operator's instructions for the guides stated the following, among other things, about the use of rubber dinghies:

> *Examples of dangerous situations:*
> *- Glacier fronts: Keep a distance of 200 metres. There is a permanent risk of accidents, primarily near glacier fronts and icebergs, where you must be aware of the possibility of calving both below and above the water surface. A study conducted by the Norwegian Polar Institute indicates that the safety distance from glacier fronts should be 200 metres.*
> *- When approaching an iceberg, identify an escape route in case the iceberg tips over.*
> *…*
> *Safety and passengers:*
> *- The drivers have GPS at their disposal (they should be able to give their position and, if relevant, find a new position in order to go to a meeting point).*
> *…*
> *- Inform the passengers of potential dangers, and go through the procedures. …*

The instructions concerning walrus in the sea include the following information:

> *1. Dangerous animals*
> *All, especially females with calves. The animal must be considered dangerous when it is closer than 10–15 metres*
> *2. Behaviour in areas where there are walrus*
> *Avoid them by proceeding to open water, or by going ashore. …. In case of immediate danger, tell passengers to get on their knees instead of sitting on the edge [of the rubber dinghy].*
> *3. In case of confrontation*
> *We must act with the greatest caution, as walruses are calm, but dangerous animals.*
> *…*
> *5. Behaviour*
> *Clear and swift, firm, loud engine noise. Stopping to take photos is prohibited. (A walrus can surprise you from behind, and the animals can get used to small (fragile!) boats.)*
> *Explain the danger to the passengers, and convince them that the photos will be better from ashore.*
>
> *…*
> *Information to passengers is provided in the document 'Danger – polar animals' and during the briefings.*

The tour operator and the guides were familiar with the report published by the Norwegian Polar Institute in 2009; see section 1.7.

1.3.4 Information about the tour operator's guides

There were two guides on board during this voyage. There had previously sometimes been three guides on similar voyages. One of them functioned as the expedition leader.

The expedition leader was responsible for all activities taking place outside the ship. This included day trips such as the one on the day of the accident. The guides used to take turns being expedition leader, depending on who knew the voyage and area in question best.

Both guides had undergone training before each summer season. The training was organised by the tour operator and involved firearms training (due to the risk of encountering polar bears) and first aid training. In addition, the tour operator organised an annual meeting for the guides, at which, among other things, the guidelines for the guides were reviewed.

The guide on board the boat where the accident took place was 53 years old and had worked as a guide on Svalbard, Greenland and in the Antarctic for about 11–12 years. He has a master's degree in geology and ecology. About 30 years ago, he completed a dinghy course in France. During a voyage earlier in the season, the guide had asked the captain to use the radar to measure how far 200 metres was from another glacier front. The guide was in the dinghy and was told by the captain when he was at the right distance. The guide did this to ensure that he was able to measure the right distance to the glacier front by eye.

The guide on board the other dinghy was 51 years old and was expedition leader for this voyage. He visited Svalbard for the first time in 1981 and has since worked as a guide or captain on several sailing boats and expeditions. Since 2004, he has worked as a guide for tour operators on board ships and had participated on 6–8 trips to the Arctic and the Antarctic every season. Some of this work was as a guide for the tour operator Grands Espaces Sàrl.

1.4 Research on people's ability to judge distances

Research on people's ability to judge distances shows that many factors influence the judgements, and that people are likely to make inaccurate judgements.

Examples of factors that can lead to an inaccurate judgement of distance is the position of the eyes and depth vision at different distances, where the perceived distance exceeds the actual distance to objects at a short distance, while the perceived distance is less than the actual distance to objects far away (Foley, J.M. 1980).

Another study (Konkle, T. & Oliva, A. 2011) indicates that people's knowledge of the physical size of an object automatically affects how much of the field of vision we prefer to see the object in. People seem to prefer that large objects take up a larger part of the field of vision than small objects. That directly influences how close we prefer to be to an object when we are look at it.

The number of physical reference points around the object, light conditions and how much training a person has had in judging distances can also influence the assessment of distances.

In general, people's judgement of distances is not a static, objective and reliable registration, but rather a dynamic, complex and subject process. This is why answers will vary greatly if you ask people to judge the distance to an object.

1.5 The shipping company and the vessel

The vessel was originally built for the British Royal Navy in 1973 and was called Cockchafer-01. It was built at Charles D. Holmes & Co in Berely. Since 2000, the vessel has been sold and has changed flag states several times.

On 23 June 2011, the vessel changed flag states from the UK to France.

It was registered in France as a pleasure craft, in the subcategory 'commercial yacht'.[3] By this is meant that the purpose of the pleasure craft was commercial assignments. The vessel could carry a maximum of 12 passengers and a crew of 9.

The company that owned the vessel, Polaris Expedition Sarl, was registered in France and owned by three people. The company was formed in 2011.

The captain on board when the accident happened was one of the owners and the manager of the company. He was responsible for all activities on board *Polaris I*, including the crew and guides. The expedition leader was responsible for all the

[3] This is a subcategory defined by the French Flag Register (Registre International Francais, RIF).

excursions from the vessel. The remaining crew consisted of two able seamen, an engineer and a cook.

The dinghies that were used at the time of the accident were inflatable rubber dinghies made by a French manufacturer under the product name Waterworld. They were 4.70 metres long and 2.00 metres wide. According to the shipping company, each dinghy could carry a maximum of eight passengers.

1.6 Previous accident in Svalbard – the Hornsund accident, 2007

On 8 August 2007, the vessel *Aleksey Maryshev* sailed off the Storbreen glacier at the head of the Hornsundet sound in Svalbard. The glacier front was 32–36 metres high. There were 55 passengers from the UK on board the vessel, plus one expedition leader and two guides from Oceanwide Expeditions B.V. The ship's crew of 19 were from Russia.

The vessel was less than 36 metres from the glacier front when a block of ice calved off. The calving event caused a big wave, and passengers on board were injured as a result.

Figure 15: The photos were taken by one of the passengers on board Aleksey Maryshev as a large block of ice calved off the glacier front. The vessel was less than 36 metres from the glacier front at the time. The calving event caused a big wave, and many of the passengers on board were injured as a result. Photo: Private

1.7 Recommendations from the Norwegian Polar Institute

After the Hornsund accident in 2007, the Governor of Svalbard tasked the Norwegian Polar Institute with issuing a recommendation for a minimum safety distance from calving glacier fronts. The assignment also included assessing whether it was possible to predict when a glacier front would calve.

The conclusions of the assignment were published in the report 'How close should boats come to the fronts of Svalbard's calving glaciers?'.[4] The report had two main conclusions, which follow below:

> *At the level of individual events, calving is a random process. It is impossible to predict precisely when calving may occur, how large a block will be created, or how it will enter the water.*

[4] Jack Kohler, Norwegian Polar Institute, 2009. The report was downloaded from www.npolar.no on 9 Sept. 2013. The report is available at http://brage.bibsys.no/npolar/handle/URN:NBN:no-bibsys_brage_8591

200 m is a safe minimum distance, with a good margin for safety, for avoiding both direct hits and the largest waves.

The recommended minimum safety distance was based, among other things, on an assessment of subaerial calving in the sea[5] and the waves it would cause. The recommendation was not based on an assessment of the consequences should subaerial calving hit dry land.

The basis for the main conclusion regarding the minimum safety distance from a glacier front was as follows:

- If the glacier front is 20–50 metres high, there will be a risk of direct hits from the calving if the distance to the glacier front is 60–80 metres or less.
- The waves from the calving will be so big that the vessel will be in danger if the distance to the glacier front is 120–160 metres or less.
- Due to other conditions, such as the local topography, a greater safety distance will be required. The study therefore concludes that the minimum safety distance to a glacier's front should be 200 metres.

1.8 Guidelines prepared by the tour organiser AECO

AECO is an organisation for tour operators that operate passenger vessels in Arctic waters. The guidelines prepared by AECO[6] of March 2011 state the following about calving glacier fronts:

Glaciers fronts may calve, causing flood waves. Keep your distance! Never approach closer than 200 meters from the glacier front. At some glacier fronts even this may be too close, especially in narrow fjords, shallow fjords and fjords with high cliffs – use good judgment.

- *All glaciers may calve, even if the probability of a glacier calving may differ. E.g. the probability of the Bråsvell glacier calving is much smaller than the Monaco glacier, but still the Bråsvell glacier may calve.*
- *All zodiacs must keep an appropriate distance (including a buffer zone) away in order to handle a possible calving.*
- *Avoid being trapped by islands close to the glacier front if a calving should occur.*
- *Factors that might affect the probability of a calving:*
  - *Glacier front height.*
  - *Gradient of the glacier.*
  - *The speed of the glacier front.*
  - *Degree of fracturing in the glacier front.*

[5] By subaerial is meant calving of the glacier front above the water surface.
[6] AECO's guidelines for expedition cruise operations in the Arctic – March 2011. Downloaded on 9 September 2013 from www.aeco.no.

- *Sea and current dynamics under the glacier front.*
- *Fjord width, sea depth and topography as high cliffs.*

Regarding qualification for the use of rubber dinghies, the guidelines state the following:

Driver qualities

- *Experience and training: All drivers should have gone through satisfactory driving practice before operating any vehicles.*
- *Technical skills: All guides should be acquainted with basic technical skills concerning zodiacs. This is due to the necessity of handling unforeseen situations.*

The guidelines also set out requirements for the operator, crew and ship's crew concerning planning, preparations and the implementation of the guidelines in advance of the voyages.

With reference to section 2.3, the guidelines describe icebergs and walruses as follows:

Icebergs

- *Potentially unstable: All icebergs can suddenly flip over, causing flood waves. Keep your distance! Icebergs are continuously under the influence of waves, tides, currents and temperature, and therefore potentially unstable. Remember that 90% of the iceberg is under water.*
- *Sudden flipping might cause huge waves, or parts of the iceberg might come to the surface at unexpected places.*
- *Never approach an iceberg too closely.*
- *Details: See glacier fronts.*

Swimming walrus

- *Do not go close to swimming walrus. Walruses are very powerful swimmers, and might attack the zodiac using their tusks, if they feel threatened.*
- *Draw back if walrus approach.*
- *Never swim, kayak or dive in walrus waters – it is very dangerous!*
- *Actively prevent being surrounded by walrus in the water. Make sure you are always in the periphery of the group of walrus in the water.*
- *Greenland: Keep a minimum distance of 75 meters from swimming walruses.*

1.9 Applicable laws and regulations

1.9.1 French legislation

Since July 2008, France has had regulations dedicated to recreational vessels, including commercial yachts.[7]

When an accident involving a French-registered vessel occurs in another country's port, the captain's report must be submitted to the French consulate.[8]

1.9.2 Norwegian legislation

The Norwegian legislation in force at the time of the accident includes Regulations No 671 of 18 October 1991 relating to tourism and other travel in Svalbard.

The regulations set requirements stating that tour operators and tourist carriers are responsible for the safety and behaviour of participants (Section 5).[9] The regulations also require travel operators to give notice of their tour plans to the Governor of Svalbard or a person authorised by the Governor (Section 7). The Governor may require changes to be made to tour plans or prohibit tours.

Act No 9 of 16 February 2007 relating to ship safety (the Norwegian Ship Safety and Security Act) applies to Norwegian and foreign ships in Norwegian territorial waters, including Svalbard and Jan Mayen.

The pertaining regulations to the Ship Safety and Security Act include Regulations No 1400 of 24 November 2009 relating to the operation of vessels carrying 12 or fewer passengers etc. These regulations concern the operation of small passenger vessels and apply to shipping companies that operate vessels carrying 12 or fewer passengers in Norwegian territorial waters, including Svalbard. Among other things, the regulations set out requirements for the shipping company to establish a safety management system (Section 4).[10] Following the accident, amendments have been made to the regulations, including the requirement for operational limitations in Svalbard.

Other pertaining regulations include Regulations no 744 of 27 June 2008 on the obligation to notify and report marine accidents and other incidents at sea. The regulations also apply to foreign ships involved in marine accidents in Norwegian territorial waters. Among other things, the regulations require the ship's master or the shipping company to report marine accidents to the Norwegian Maritime Directorate using the prescribed form within 72 hours of the incident (Section 6).[11]

[7] The regulations are derived from the regulations of 23 May 2008 amending the regulations of 23 November 1987 and its appendix entitled Division 242. See also Inter-ministerial Circular no 423 of 9 July 2008. The regulations are inspired by the British Large Yacht Code.
[8] Cf. Article 13 in Décret du 19 juin 1969 relatif à l'armement et aux ventes maritimes.
[9] See http://lovdata.no/forskrift/1991-10-18-671/§5 (read on 6 February 2014)
[10] See http://lovdata.no/forskrift/2009-11-24-1400/§4 (read on 6 February 2014)
[11] See http://lovdata.no/forskrift/2008-06-27-744/§6 (read on 6 February 2014)

1.10 Measures implemented after the marine accident

Following the marine accident involving *Polaris I*, the Governor of Svalbard contacted the Norwegian Polar Institute in July 2013. The Polar Institute was asked to describe the phenomenon of subaerial calving that hits solid ground and to consider whether the previous recommendation on minimum safety distance to glacier fronts should be upheld.

After the accident, both the tour operator and AECO have provided information about the dangers associated with a glacier front calving on solid ground. The information has been provided in the form of information letters and presentations given at meetings organised by AECO, and the owner of the tour operator company has described the danger in a book that he published in May 2014.

After the accident has one of the guides acquired a laser for measuring distances up to 1000 metres. His experience is that this equipment gives accurate precision when measuring distance to a glacier front. The guide recommends keeping a minimum safe distance of 300 metres from a glacier front.

2. ANALYSIS

2.1 Failure to report the marine accident

The captain on board reported the accident to the Governor of Svalbard. By mistake, neither the Joint Rescue Coordination Centre Northern Norway (JRCC-N) nor the Governor of Svalbard informed the AIBN or the Norwegian Maritime Authority of the accident. The Governor has since changed the procedures, and the AIBN now receives notice of marine accidents from the Governor of Svalbard via JRCC-N as a matter of standard procedure.

The shipping company did not report the accident to the Norwegian Maritime Directorate as required by the Regulations on the obligation to notify and report marine accidents; see 1.9.2. The shipping company reported the accident to the French consulate in Oslo, but the French maritime authorities were not informed. Therefore, neither of the respective countries' accident investigation organisations were informed about the accident.

The AIBN did not become aware of this accident until a long time after it happened, and it was considered that it would be difficult to obtain reliable first-hand information about the accident. The information collected about this accident has therefore been limited in scope. In this investigation, the AIBN has obtained most of its information from the tour operator, the Governor of Svalbard, the French authorities, the Norwegian Polar Institute and the Association of Arctic Expedition Cruise Operators (AECO). The information included photos and video recordings taken by the passengers before and during the accident.

2.2 Assessment of the chain of events

The guides had several years' experience from Arctic areas. They were familiar with the dangers of calving glacier fronts and knew that it was impossible to predict when calving might take place. They had previously experienced that ice that calved off could be thrown with great force if it hit dry land. This was also observed by the passengers and guides on the same morning the accident occurred.

The guide steering Dinghy 2 interpreted the events immediately before the accident as a sign that a large section of the glacier front could soon calve. The guide on board Dinghy 1 may have interpreted the situation in the same way, because the dinghy had been turned towards the glacier front. Several of the passengers took photos and filmed the calving event that caused the accident. This can be understood to mean that the passengers were prepared for a calving event, but not necessarily that it would be such a violent one.

When the accident happened, Dinghy 1 was just off the site of the calving. Dinghy 2 was further east, i.e. at a greater distance from where the calving occurred. Lumps of ice came down near both dinghies.

The greatest uncertainty factor relating to the chain of events is the distance between the dinghies and the glacier front at the time of the accident. The witness statements give different accounts of this. Based on information from witnesses, the Governor of Svalbard's assessments and available photos from the site of the accident, the AIBN has estimated a distance between the glacier front and Dinghy 1. The estimate suggests that Dinghy 1 may have been between 100 and 130 metres from the glacier front, but this is

an uncertain estimate. No corresponding estimate has been made for Dinghy 2, but the distance was probably about the same as for Dinghy 1. The estimate is uncertain. The distance may also have been greater than 200 metres.

Regardless of the actual distance, the dinghies were so close to the glacier front that a person was killed by the ice that came flying when the glacier calved.

The AIBN would like to comment on the fact that the dinghies were probably even closer to the glacier front in the period before the accident. The chain of events shows that the dinghies first moved diagonally away from the west side of the glacier front, before continuing in parallel with it. The aerial photo taken the next day shows that part of the glacier front was in much the same condition as on the site of the accident. Just before the accident, Dinghy 1 had moved further away from the glacier front.

Both guides considered the distance to the glacier front to be safe and were aware of the instructions that required a safety distance of at least 200 metres.

The uncertainty about whether the guides actually complied with the tour operator's instructions on minimum safety distance steers the analysis towards three questions:

- If the guides intentionally chose to move closer to the glacier front than the minimum safety distance, what could have influenced their decision? This is discussed in section 2.3.

- If the guides intended to comply with the instructions on minimum safety distance, why may they have been closer to the glacier front than 200 metres? This is discussed in section 2.4.

- If the dinghies actually complied with the instructions on minimum safety distance, the basis for these instructions is discussed in section 2.5.

2.3 Conflict between nature experience and safety

The discussion in this chapter is based on the assumption that the guides were aware that they were closer to the glacier front than dictated by the instructions. The question is what may have influenced them to behave in this manner.

As described in the previous chapter, the guides' experience indicated that they kept a safe distance to the glacier front on the day of the accident. They had many years' experience as guides in Arctic areas. The tour operator had not experienced accidents like this before, which is often used as an argument that previous operations were safe. However, the AIBN would like to point out that the fact that no accidents have occurred does not necessary mean that the practice has been safe.

The AIBN does not know to what extent it has been the guides' practice to maintain a safe distance from the glacier fronts. Nor has the AIBN considered whether any special conditions applied to this trip. However, as stated below, the AIBN believes that the passengers' expectations of the excursions must be seen in relation to the tour operator's instructions for its guides.

Presumably, passengers who travel to polar areas have expectations of seeing spectacular scenery and getting close to exotic animals such as polar bears, walrus, seals and birds.

The passengers do not necessary have previous experience of such areas, and it is probably precisely this element of the unknown that is perceived as exotic and exciting to take part in. The passengers also expect the vessel they travel on to be well suited for transporting passengers in polar areas and to be taken good care of by the crew and guides.

The AIBN understands that the guides have stated that they did not perceive any verbal statements from passengers about sailing closer to the glacier front. Thus, the guides felt that they had not been pressured into something they considered to be unsafe.

However, by comparing the tour operator's advertising brochure for the cruise and the tour operator's own instructions for the guides, the following contradictions are observed:

- The advertising brochure shows photos of rubber dinghies that appear to be very close to a glacier front. There is a great deal of ice in the water, which could prevent a swift retreat away from the glacier front; see Figure 12. The instructions for the guides state that the minimum safety distance is 200 metres. The instructions also state that there is always a danger associated with calving from glacier fronts. This is also emphasised in AECO's guidelines.

- The advertising brochure shows photos of rubber dinghies that appear to sail very close to icebergs. In one of the photos, there is a great deal of ice in the sea just outside where the dinghy is. The photo gives the impression that the ice prevents a swift retreat away from the iceberg; see Figure 13. The instructions for the guides state that, when approaching an iceberg, you should identify a possible escape route in case the iceberg tips. AECO's guidelines are more detailed in this regard. Here, it says that icebergs are potentially unstable, that they can quickly tip and it is therefore necessary to keep distance. It also makes reference to a description of calving glacier fronts.

- The advertising brochure shows photos of a rubber dinghy in the water right next to a herd of walrus, only a few metres away. One of the photos shows a walrus in the sea that appears to be only centimetres away from the rubber dinghy. Some of the passengers are sitting on the edge of the boat, while others are standing up taking photos; see Figure 14. In the instructions for the guides, the walrus is described as a dangerous animal. It must be considered dangerous when it is closer than 10–15 metres from the dinghy. In such case, passengers shall be instructed to get down on their knees. The dinghy shall not remain stationary and wait for the passengers to take photos, but move quickly away from the walrus. AECO's guidelines contain similar instructions.

- The advertising brochure shows photos of the vessel that give the impression that it is right next to a glacier front; see Figure 11. In another accident on Svalbard in 2007, several passengers suffered injuries because the vessel was too close to the glacier front when it calved. It is assumed that this accident may have been known to the tour operators on Svalbard.

In summary, the tour operator's brochure advertised the possibility for passengers to be able to get up close to both glaciers and wildlife. To the passengers, the photos in the advertising brochure gave the impression that this was justifiable from a safety

perspective. The passengers' expectations of getting close to glacier fronts, icebergs and walrus did not have to be expressed verbally to the guides, as the tour operator had already created such expectations through the advertising brochure. Compared with the instructions that the tour operator has requested its guides to follow, however, the photos give the impression of showing several breaches of the instructions.

In addition, a sensory-psychological phenomenon may have contributed to the wish of getting close to the glacier front. The fact that people seem to prefer large objects to take up a greater proportion of their field of vision than small objects may have influenced the guides' assessment of how close to the glacier front it was desirable to go in order to give the passengers a satisfying visual experience of this extremely large object.[12]

Through the advertising brochure and the instructions, the tour operator may have put the guides in a position where they had to deal with conflicting expectations. On the one hand, the passengers expected to get close to glaciers and wildlife – in line with the advertising brochure. On the other hand, the guides were expected to act in a safe and responsible manner – in line with the instructions. The guides probably found themselves in a situation where they had to weigh these conflicting expectations against each other, based on their own experience and assessment of the situation. If the dinghies went closer to the glacier front than 200 metres, and the guides consciously made the decision to do so, the considerations described above could have influenced their decision.

2.4 Difficult to judge the actual distance to the glacier front

The discussion in this chapter is based on the assumption that the guides all along intended to comply with the instructions on minimum safety distance to the glacier front, but that they may have been closer than 200 metres.

The description in section 2.2 shows that there is a possibility that the dinghy was closer to the glacier front than 200 metres. It is also possible that the distance was even shorter before the accident happened.

The guides judged the distance to the glacier front by eyesight only. The guides' experience indicated that they keep a safe distance from the glacier front. They had many years' experience of guiding in Arctic areas.

However, it is well documented that people's judgement of distances – especially long distances like in this case – is generally inaccurate, with great individual differences. The witnesses' differing assessments in this case are testament to that.

Incorrect judgement of distance on the part of the guides may have been one of the factors that contributed to the dinghies perhaps being closer to the glacier front than 200 metres.

At the start of the season, one of the guides had used the ship's radar to measure the 200-metre distance to a glacier front. He had then taken the dinghy along the glacier front and been told by the captain where the limit actually was. This way, the guide meant that he would be able to measure the correct distance by eye. If the intention was to observe the

[12] It is not reasonable to expect that the people involved in this accident were aware of this phenomenon.

200-metre limit on the day of the accident, it means that the exercise early in the season was not sufficient to be able to judge distances by eye.

The tour operator has described that the guides received training every year and participate in annual seminars, but there is no information about whether these or other instructions dealt with practical methods for determining safe distance to a glacier front.

Several practical methods can be used to determine the correct distance to a glacier front. One may be the one that the guides themselves described, namely to use the vessel's radar and ensure follow-up by the ship's crew while the guides are in the dinghies. This can possibly be combined with identifying onshore reference points or entering positions in a GPS unit. We have also seen the use of distance meters has been proposed. What the suggestions have in common is that they require planning of the choice of method, the choice of equipment, assigning tasks and equipment, and that the guides (and, if relevant, the crew of the ship) have experience of using the chosen method.

The tour operator had instructed the guides to observe the 200-metre limit, but left it up to the guides to find practical ways of ensuring that the limit was complied with. In other words, the tour operator had not made sufficient arrangements to allow for the guides to use expedient methods to objectively determine the actual distance to a glacier front. Nor do the AECO guidelines address how this can be done in practice.

As the AIBN assumes that this issue concerns several tour operators, we submit a safety recommendation that guidelines should be prepared on practical methods whereby guides and ships' crew can obtain information about the actual distance to a glacier front.

2.5 The basis for safe distance to a glacier front

The discussion in this chapter is based on the assumption that the dinghies actually complied with the tour operator's instructions on minimum safety distance.

The guidelines prepared by AECO form the basis for the tour operator's instructions about keeping a distance of at least 200 metres to glacier fronts.

Those guidelines are in turn based on a study conducted by the Norwegian Polar Institute in 2009 on assignment for the Governor of Svalbard. However, this study did not include the phenomenon where subaerial calving hits dry land so those blocks of ice are sent flying across the fjord. In July 2013 the Governor of Svalbard asked the Norwegian Polar Institute to describe this phenomenon and to consider whether the previous recommendation for minimum safety distance should be changed.

3. CONCLUSION

3.1 The dinghies were too close to the glacier front

The accident took place on 21 August 2012 at approximately 1006. The passengers and guides were on a daytrip in the dinghies. While they were close to the Esmarkbreen glacier, a large piece of the glacier front calved off and hit dry land (shallow water), which caused lumps of ice to fly across the water with tremendous force. One of the passengers was struck on the back of her neck and head by lumps of ice. She died almost instantly as a result of her injuries.

Before the accident, both the guides and the passengers had been made aware that the glacier front might calve and that the ice could land on dry land, but they did probably not anticipate such violent calving.

There is a high degree of uncertainty regarding how far the dinghies were from the glacier front when it calved. The AIBN estimates that the distance to the glacier front may have been between 100 and 130 metres at the time of the accident. It cannot be ruled out that the distance was greater, however. Regardless of the actual distance, the dinghies were so close to the glacier front that a person was killed by the ice that came flying when the glacier calved.

3.2 Conflict between closeness to the glacier front and minimum safety distance

Through the advertising brochure and the instructions, the tour operator may have put the guides in a position where they had to deal with conflicting expectations. On the one hand, the passengers expected to get close to glaciers and wildlife – in line with the advertising brochure. On the other hand, the guides were expected to act in a safe and responsible manner – in line with the instructions. The guides probably found themselves in a situation where they had to weigh these conflicting expectations against each other, based on their own experience and assessment of the situation. If the dinghies went closer to the glacier front than 200 metres, and the guides consciously made the decision to do so, the considerations described above could have influenced their decision.

3.3 Lack of methods for and training in judging the distance to a glacier front

If the guides intended to observe the instructions on minimum safety distance, but nonetheless were closer to the glacier front than 200 metres, one of the reasons may have been that it is difficult to judge distances by eyesight. The tour operator had not made sufficient arrangements for the guides to use adequate methods to determine the actual distance to the glacier front. Nor did the guidelines issued by the tour operator organisation AECO address how distance measuring could be done in practice.

There may be several ways of ensuring that a distance is observed, but they all require planning of the choice of method, the choice of equipment, assigning tasks and equipment, and that the guides (and, if relevant, the crew) have experience of using the chosen method. There is a need for guidelines that describe practical methods whereby guides and ships' crews can obtain information about the actual distance to a glacier front. This need is assumed to apply to several tour operators, and a safety recommendation is submitted in this connection.

3.4 Safe distance to subaerial calving over dry land

The tour operator's instructions on the minimum safety distance to glacier fronts were based on guidelines issued by the tour operator organisation AECO, which in turn were based on a study conducted by the Norwegian Polar Institute on assignment for the Governor of Svalbard.

However, this study did not include the phenomenon where subaerial calving hits dry land so that blocks of ice are sent flying across the fjord. The Governor of Svalbard has initiated measures to describe this phenomenon and to consider whether the previous recommendation for minimum safety distance should be changed.

4. SAFETY RECOMMENDATIONS

The investigation of this marine accident has identified areas in which the AIBN deems it necessary to propose safety recommendations for the purpose of improving safety at sea.[13]

Safety Recommendation MARINE No 2013/13T

The tour operator had instructed the guides to observe the minimum safety distance of 200 metres, but had left it up to the guides to find practical ways of ensuring that the limit was complied with. The guides judged the distance to the glacier front by measure by eye, which proved to be difficult. The tour operator had not made sufficient arrangements for the guides to use adequate methods to determine the actual distance to the glacier front. Nor did the guidelines issued by the tour operator organisation AECO address how the distance to a glacier front could be determined in practice. There is a need for guidelines that describe practical methods whereby guides and ships' crews can obtain information about the actual distance to a glacier front. This need is assumed to apply to several tour operators.

The Accident Investigation Board Norway recommends that the Governor of Svalbard coordinate the work on preparing guidelines that set out practical methods whereby guides and ships' crews can obtain information about the actual distance to a glacier front.

Accident Investigation Board Norway

Lillestrøm, 2 July 2014

[13] The investigation report is submitted to the Ministry of Trade, Industry and Fisheries, which will take necessary action to ensure that due consideration is given to the safety recommendations.