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# How pilotage contributes to maritime safety

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## Executive summary

This report was carried out on behalf of the Swedish Maritime Administration to investigate how pilotage contributes to maritime safety and also to some extent, determine whether the current pilotage criterion may be more risk-based. Literature studies, interviews, participant observations, accident statistics and accident reports were used to answer the questions in this report. The main question which this report was based upon was "how does pilotage contribute to maritime safety?". To be able to answer this question, "maritime safety" needed a definition. The theory of Resilience Engineering was applied to maritime safety which has extended the concept further. Then maritime safety could be described in the context of this work as:

> *have and maintain control over a situation, but also to be flexible and adaptive and to adapt the system to a changing world*

Several aspects of how pilots contribute to maritime safety were identified within the literature and empirical studies. For example, the pilots' expertise, experience and local knowledge of the waters and the pilots' ability to make risk assessments based on these as well as local language skills were identified as important contributions to maritime safety. The pilots' advisory role and role as a resource were also identified. If these factors were studied on the basis of Resilience Engineering it gave another dimension to how pilots contribute to maritime safety. Based on this pilots contribute to maritime safety by adapting the current system to new conditions caused by a changing world. Hence, the pilot must be able to be flexible and adaptive to maintain and have control over the system. Pilots should also be seen as an element in the system that affects the overall system performance and therefore the pilot should not be seen as an isolated system but as part of the overall maritime system.

Regarding risk-based criteria for pilotage, the current criteria were considered reasonable during the interviews and there was no apparent need for more risk-based criteria to be identified within this report. Nor was this approved by the Swedish Maritime Safety Inspectorate (now the Swedish Transport Agency). This matter could however be investigated further by someone with nautical skills and experience. A number of risk-based criteria were identified. These consisted of the ship's dimensions, design and maneuverability compared to the fairway and port, ship, and especially the bridge equipment, the cargo the ship is designed to carry, staffing and watch schedule of the vessel, the candidate's competence or qualifications, the candidate's experience in the Swedish coastal waters as skipper and watchkeeping officer and the applicant's ability to communicate in English or Swedish and English. These criteria were similar to the criteria on the Paris MoU black list which includes the states that are considered the worst in terms of deficiencies in safety equipment, deferred maintenance and inadequate training of crew.

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# 1 Introduction

*This chapter begins with a brief background description of the report. Next, aim and objectives and the research question are presented, followed by boundaries, target and finally the outline of this report.*

## 1.1 Background

The importance of pilotage for maritime and environmental safety has been suggested as an area for investigation for a long time. As early as 1979, the Committee for environmental hazards at sea, suggested in the report "Ren tur - program för miljösäkra sjötransporter" SOU 1979:43 that a special assessment should be undertaken to examine the safety-enhancing effect of pilotage (SOU, 2007:106). The need to explore the role of pilotage for maritime and environmental safety was also emphasized in Lotsa Rätt SOU 2007:106.

This report was carried out on behalf of the Swedish Maritime Administration to investigate how pilotage contributes to maritime safety and also to some extent investigate if the current pilotage criteria could be more risk-based.

## 1.2 Purpose and objective

The purpose of this study was to investigate how pilotage contributes to maritime safety and to some extent investigate whether the current pilotage criteria may be more risk-based.

The objective was to study literature, conduct empirical studies in terms of interviews and participant observation, and study accident statistics and accident reports in order to answer the questions in Section 1.3 based on pilotage activities today. The objective was also to reflect different perspectives and aspects, and to investigate several sources, so that the report would cover several dimensions. The final objective was to analyze the results in order to draw conclusions and give suggestions for further work in this field.

## 1.3 Research question

The research question that formed the basis for this report was:

- How does pilotage contribute to maritime safety?

Question that also were examined in the report were:

  - What is maritime safety?
  - What are the safety-enhancing factors of pilotage?
  - Can the pilotage criteria used today be more risk-based?
  - What criteria can pilotage be based on?

The intention was to answer the questions as presented in table 1.1. The summary sections presented in chapters 3-7 discuss how these questions have been addressed.

**Table 1.1 Question to be answered by literature study, interviews, participant observations, maritime accident statistics, maritime accident reports**

| | Literature study | Interview s | Participant observations | Maritime accident statistics | Maritime accident reports |
|---|---|---|---|---|---|
| How does pilotage contribute to maritime safety? | X | X | X | X | X |
| Vhat is maritime safety? | X | X | | | |
| What are the safety-enhancing factors of pilotage? | X | X | X | | X |
| Can the pilotage criteria used today be more risk-based? | X | X | | | |
| What criteria can pilotage be based on? | X | X | | | |

## 1.4 Limitations

This report is about pilotage in the Swedish territorial waters and was limited to studying the pilot's role and nautical work on board the vessel based on the conditions that exists today. The work does not account for the risks that may arise for example when the pilot boards or disembarks from vessels. Accident statistics were studied for the whole of Sweden while interviews, participant observation and accident reports were limited geographically to Malmö and Södertälje. This is motivated further in section 2.3.2. It is outside the scope of this report to estimate the contribution of pilotage to maritime safety in monetary terms and to study the economic impact of introducing more risk-based pilotage criteria.

# 2 Methods

*This chapter describes the scientific methods and techniques used in this study. Some preconditions for this study are first presented. Thereafter follows a description of the literature review, interviews, participant observation, accident statistics and accident reports.*

## 2.1 Preconditions

This study aimed to meet the requirements of science and be factual, objective and balanced. The work also had the aim of answering the questions presented in section 1.3. The scientific methods and techniques used during the work are described in Sections 2.2 - 2.4. Scientific methods describe how a scientific subject is treated while scientific techniques describes how the material has been collected (Ejvegård, 2003).

### 2.1.1 Quantitative and qualitative methods

Both quantitative and qualitative methods were used in this report. Quantitative methods includes numerical measurements or observations that can be expressed as a numerical value, while the qualitative methodologies produce results that are in verbal formulations, written or spoken (Backman, 2008). This study resulted in a qualitative description and analysis that answered the questions in section 1.3.

### 2.1.2 Ethics

Research ethics is all about standards and moral attitudes that researchers should follow. This means for example that the work must be of good quality, follow scientific methods and be morally acceptable (Forskning.se, 2010).
For the empirical studies an ethical approach was applied by informing the respondents of the aims, objectives and methodology of work, guaranteeing anonymity, and offering the opportunity to read and correct the interview. Respondents were also informed about where the final report would be published and were also given the opportunity to choose not to participate.

## 2.2 Literature study

The purpose of this study was to gain a basic understanding of pilotage operations, as well as of safety, maritime safety and accidents. The aim was also to get an idea of what material has been published, which subjects have been treated, and which have not yet been investigated in depth. The literature was used to provide background information and a comprehensive understanding of the field as well as serve as a starting point for answering all questions in section 1.3.

The literature review began with a literature search to obtain a broad scientific basis. Searches were carried out in a number of scientific databases with Google Scholar and ELIN@Lund (Electronic Library Information Navigator), which is a search engine for scientific publications provided by Lund University. Literature searches were also made on government websites and other sites on the Internet as well as in the existing literature on the Swedish Maritime Administration (SMA). The study is divided into areas: piloting and risk-based criteria for pilotage, safety and maritime safety and accidents. These are presented briefly below.

#### 2.2.1 Pilogate and risk-based criterion for pilotage

Literature in the area of pilotage and risk-based criteria for piloting was sought at the Swedish Maritime Administration's library and website and on other relevant authorities and actors' websites. The literature consisted of published research reports, investigations and report and websites involving pilotage.

#### 2.2.2 Safety and maritime safety

Relevant literature on safety and maritime safety was sought in databases as well as in libraries and at the Swedish Maritime Administration. The searches resulted in technical papers, research reports and internal documents. Even rules and regulations were studied to gain an understanding of the current legislation. The information was sought on the respectively relevant agencies websites and among law texts on the Internet.

#### 2.2.3 Accidents

Accident statistics and accident reports were used in the study, so a theoretical background was necessary to get an understanding of the concept of accidents and accident models. Searches were made in both databases in libraries and the literature consisted mainly of published books and research reports.

## 2.3 Interviews

The following text describes the conditions for the interviews, how the respondents were selected and how the interviews were conducted.

#### 2.3.1 Background

Interview is a method to find out the views and opinions of a population (Ejvegård, 2003). The interview method used in this report was a semi-structured qualitative interview method. This method is suitable for the purpose of this study, as the qualitative interview focuses on the respondents' own perceptions and approaches (Bryman, 2006). Semi-structured interviews follow a list, or a so-called interviewguide, which sets out the specific themes that are to be discussed during the interview. The questions in the interview do not have to be asked in the same order as in the interview guide. This interview method is flexible and gives the interviewer much leeway during the interview itself. It was also possible to adjust questions during the interview and ask supplementary questions to follow up the themes and statements from the respondent. It also provided an opportunity to correct misunderstandings. Respondents also had considerable freedom to formulate answers in their own way. These advantages were presented by Bryman (2006). There was no one unqualified who influenced the respondent, which Ejvegård (2003) highlighted. This was further supported by Nilsson, Hederström, and Lützhöft (2006) who pointed out that the strength of prepared questions is that it gives a clear structure and support during the interview and that the material is relatively easy to process.

Interviews were used to answer all questions in section 1.3, and these questions were also used as a basis for the interview questions. Advice presented in Bryman (2006) and Ejvegård (2003) was used when designing the questions and leading or trivial questions were excluded. Prior to the interview methods were studied in Ejvegård (2003) to avoid interview pitfalls.

#### 2.3.2 Selection and implementation

Respondents were selected from a geographical area limited to Malmö and Södertälje. These places were selected because they represent different navigation conditions in Sweden. The fairway in Malmö is relatively uncomplicated and is considered to represent the southern coast of Sweden, although with more traffic. The fairway in Södertälje was chosen because it represents a complex archipelago with more difficult navigation conditions.

To get multiple points of view the respondents consisted of two pilots in Malmö and two pilots in Södertälje, two VTS operators from Sound VTS center in Malmö, a pilot operator in Malmo, and two masters holding a pilot exemption certificate (PEC) in Malmö. The masters holding a PEC for Finnlines passenger vessels which sail between Malmö and Travemünde were selected as representatives of this category. The pilots in Malmö had worked as a pilot for three and a half years and six years respectively, while both pilots in Södertälje had worked as a pilot for 15 years. One master holding a PEC had had the PEC in Malmö for five years, while the others had had a PEC in Malmö for one year and for four years in Stockholm. The two VTS operators and pilot operator had worked on the Sound VTS and the pilot request service since 2006.

The interviews were conducted with one respondent at a time, which is also the most common way to conduct interviews according to Ejvegård (2003). Respondents were asked to answer the questions freely. Notes were taken during the interview since it was considered the best way to document the results. A neutral and objective attitude was pursued during the interviews.

The interviews took place on 24 May 2010 with the two masters holding a PEC in Malmö, on 26 May 2010 with two VTS operators at Sound VTS center in Malmö, on 12 June 2010 with a pilot operator in Malmö, on 14 June 2010 with the two pilots in Malmö and on 17 respectively 18 June 2010 with the two pilots in Södertälje. The interviews resulted in qualitative answers which were compiled and used as the basis for further work.

### 2.4 Participant observations during pilotage

The following section describes the conditions and selection of participant observation as well as how they were conducted. The advantage of participant observation is that it provides the opportunity to get a more in-depth understanding of the various events that occur (Ejvegård, 2003).

#### 2.4.1 Description

Three participant observation were conducted, one in the fairway in Malmö, one through the Sound, from Höganäs to Lomma, and one between Södertälje and Nynäshamn. The purpose was primarily to study pilotage and the interaction between master and pilot. The aim was also to get an idea of how pilotage contributes to maritime safety, and thereby answer the main question, and also to identify the safety-enhancing factors of piloting.

#### 2.4.2 Selection and implementation

Participant observations were carried out in the fairways in Malmö, the Sound and Södertälje. Malmö and Södertälje were selected as described in section 2.3.2. Pilotage through the Sound was chosen as it gave an opportunity to study a pilot on board a vessel which chose to have a pilot even though a passage through the Sound does not require one.

The participant observations took place on 19 February and on 12 June 2010 in Malmö, on 14 June 2010 in the Sound and on 18 June 2010 between Södertälje and Nynäshamn.

## 2.5 Maritime accident statistics

A comprehensive national study of maritime accidents was conducted in order to answer the main question of how pilotage contributes to maritime safety. The statistics are based on the marine accident statistics from the Swedish Transport Agency (SjöOlycksSystem, SOS) from 1985-2009 and were limited to navigation-related accidents in Swedish waters. Navigation-related accidents included the categories grounding, collision with other objects and collision with another vessel. The accidents were studied if they occurred with or without a pilot on board or if the master had a PEC. The accidents where it was unknown whether the pilot was on board or not or whether the master had a PEC or not were excluded.

No distinctions were made regarding length, gross tonnage or type of vessel. Incidents were not studied since there are only a few reported in the SOS.

It should be noted that the database is event-based and that a collision between two vessels could generally be reported twice, (with the exception of collisions involving leisure boats) since two vessels are involved.
To get representative statistics on the number of accidents where a pilot was onboard the accident statistics presented in this report are also event based.

## 2.6 Maritime accident reports

Six maritime accident reports were studied specifically for the fairways in Malmö and Södertälje. These areas were selected as described in section 2.3.2. The accidents that were studied, two in Malmö and four in Södertälje, occurred between 1998-2008. The investigations were conducted by the Swedish Accident Investigation Board (SHK), the Swedish Maritime Administration (now the Transport Agency) and the Swedish Maritime Administration and these are available digitally on each agency's website. The maritime accident reports were studied in order to answer the main question of how pilotage contributes to maritime safety and to identify the safety-enhancing factors that pilotage contributes.

# 3 Literature study

*A summary of the literature study is presented in this chapter. The first section consists of a background description of pilotage. This is followed by sections on safety and accidents in order to both provide a theoretical background in these areas and also to present the relevant literature that can be compared with results from the empirical studies, accident statistics and accident reports. Theory of maritime safety and the links between pilots and marine safety are also presented. Arguments for and against more risk-based pilotage criteria are presented in the section on risk-based criteria.*

## 3.1 Theoretical framework of pilotage

Pilotage is operated by the Swedish Maritime Administration (SMA), which is responsible for providing an efficient and need-based pilotage to enhance maritime and environmental safety and availability of commercial shipping. Pilotage involves "actions for navigation and operations set by a pilot in a fairway which are necessary for safe navigation of the ship[1]" according to the Swedish Transport Agency's (STA) regulations and guidelines TSFS (2009:123) concerning pilotage[2]. Pilotage is regulated in TSFS (2009:123). The following Swedish territorial waters require mandatory pilotage:

- The inner water found off the coasts
- Lake Vänern
- Mälaren
- Södertälje canal
- Canal of Falsterbo
- Canal of Trollhättan including the Göta River
- Ångerman River south of Nyland

The Swedish Maritime Administration also provides pilots outside the inner Swedish waters. Pilotage is included in the traffic department which has divided Sweden into six so-called traffic areas. Pilotage consists of three main functions (Sjöfartsverket, 2009a):

- Ordering pilots including planning and administration of the mission
- Transport of the pilot to and from the mission
- Nautical work of the pilot on board the ship

To be able to perform pilotage outside Swedish waters not subject to pilotage exemption the pilot requires special training to obtain a "Red Card" Certificate (Sjöfartsverket, 2009b).

The Pilot's responsibilities and functions are regulated by Regulation (1982:569) concerning pilotage, etc[3].The pilot is responsible for pilotage while the captain is in charge of the ship and its performance. The pilot may disclaim responsibility for pilotage if the master or other person responsible for the operation of the vessel acts against the

[1] ”åtgärder för navigering och manövrering som en lots anger i lotsled och som krävs för fartygets säkra framförande”

[2] Transportstyrelsens föreskrifter och allmänna råd TSFS (2009:123) om lotsning

[3] Förordning (1982:569) om lotsning m.m

pilot's instructions. The pilot has an advisory role and to define and monitor the activities of navigation and control required for safe navigation. This means for example that the pilot must know the possible disturbances in the area and adjust course and speed of the vessel's maneuverability (van Westrenen, 1999; Statskontoret, 2007). Pilotage should also be conducted with regard to maritime safety and the risk of damage to the environment according to Regulation (1982:569) concerning pilotage, etc.

### 3.1.1 Pilotage criterion and Pilot exemption certificate (PEC)

There has been pilotage since the Vikings and pilotage has been both regulated and voluntary in various periods over the years. The current requirements for pilotage were introduced by the government bill 1980/81:119 on environmentally safe transport and it was introduced on 1 January 1983 (SOU, 2007:106). The purpose of the general pilotage requirements was to prevent many of the accidents that occurred during the time when pilotage was voluntary. The criteria for pilotage today were added at the same time and they were mainly based on the experience of the vessels that previously used to take pilots voluntarily, and also on the dimensions of the vessels that the pilots considered to be reasonable to require pilotage. Hence, the criteria for pilotage are experience based.[4] These criteria have been adjusted during the years, for example when the fairways have been widened. Today, pilotage is regulated in TSFS (2009:123) and pilotage criteria are based in principle on the size of the vessel in relation to the fairway width and depth and the transport of dangerous cargo. However, there have been criticisms against the current regulatory framework that is based only on those criteria and do not weigh in more factors that may affect the safety (SOU, 2007:106).

The master is responsible for engaging a pilot if the vessel is underway and meets the pilotage criteria regulated in TSFS (2009:123). The vessel could be categorized into pilot category 1, 2 or 3, which are described in TSFS (2009:123). There is also a general requirement for pilotage if the vessels' dimensions are equal to or greater than a length of 70 meters long, a width of 14 meters wide and a draught of 4.5 meters. The Transport Agency can also decide that a master is required to engage a pilot if it is deemed necessary for reasons of safety or environmental protection.

Vessels that operate frequently in the fairway can obtain a so called pilot exemption certificate (PEC) for the specific fairway. This is an individual approval to navigate one or more specified ships in specified waters without the requirement to engage a pilot. This is regulated in TSFS (2009:123) and a test for a PEC occurs at the Transport Agency and consists of:

- A safety assessment of the vessel
- A control of the applicant's competence(s)
- A theoretical test and a practical test for the applicant

### 3.1.2 Number of services provided by pilots

The number of services provided by pilots have been relatively constant in recent years, see Figure 3.1. There have been approximately 40 000 services supplied by pilots in total per year in the 2000s, but in 2009 the number of services decreased. The statistics are based on the annual reports for the SMA between 1999-2009. One pilotage service is

[4] Telephone,Carl-Göran Rosén, Swedish Transport Agency, 2010-04-29

considered to be one route segment where the pilot is on board the vessel, for example to or from the port.

The number of services provided by pilots varied geographically and it is mainly related to traffic density, the pilotage criteria in the fairway, the number of passages with PEC, and type of traffic (SOU, 2007:106).

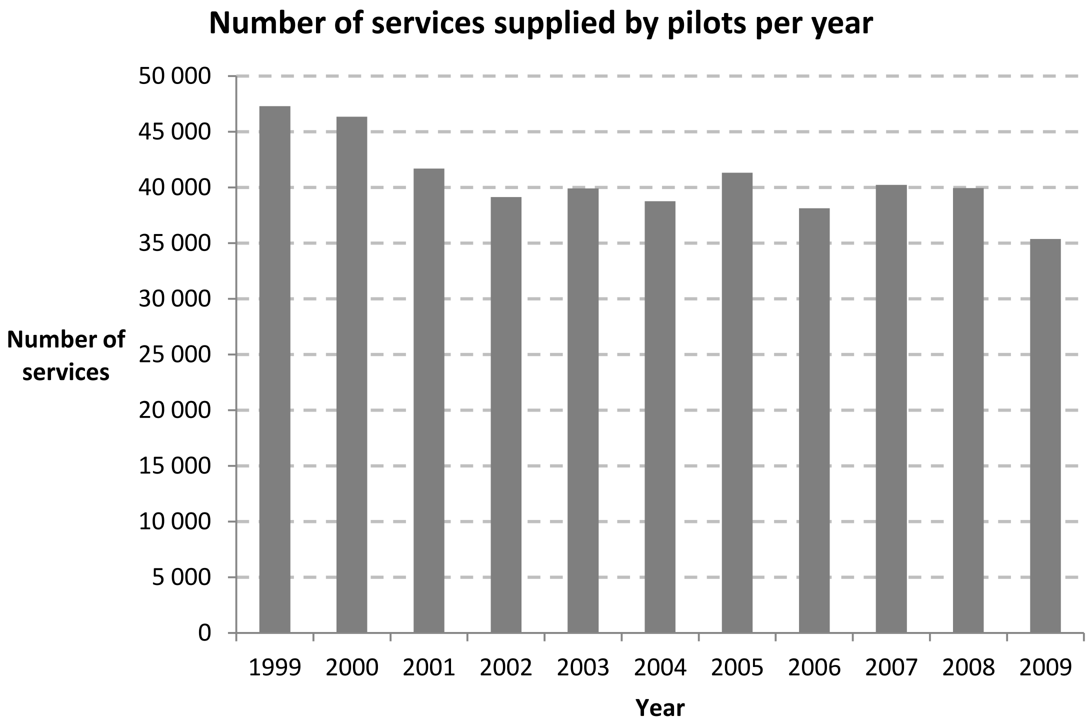


**Figure 3.1 Number of services supplied by pilots per year, based on statistics from SMA between 1999-2009.**

Figure 3.2 shows the number of vessel calls over the same time period as for the number of services supplied in Figure 3.1. One call covers both the arrival and departure of the vessel[5].

[5] Email correspondence with Markus Lundkvist, SMA, 2010-05-03

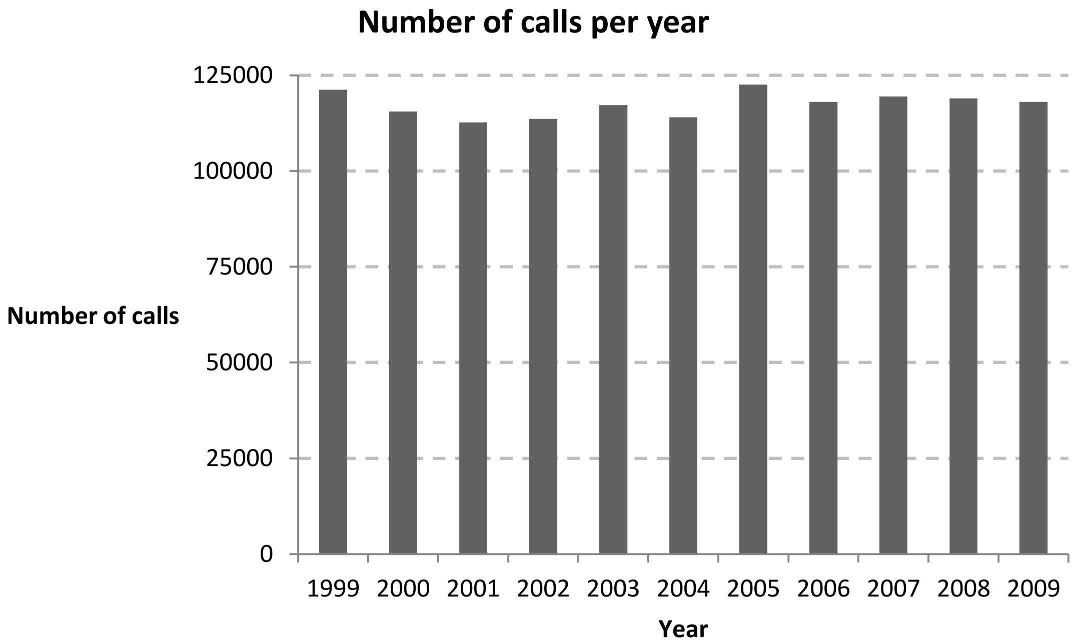


**Figure 2.2 Number of calls per year, based on the annual reports for the SMA between 1999-2009.**

Almost 70 percent of all cargo ships calling at Swedish ports engage pilots, but there is a trend towards fewer port calls requiring pilots and the number of cargo vessels is decreasing due to the increasingly larger ships used (Statskontoret, 2007). The proportion of cargo vessels has decreased in recent years and accounted for 20 percent of calls for the year 2009 while the remaining 80 percent comprised passenger and rail ferries (Sjöfartsverket, 2009b). Ferries usually have PEC (Statskontoret, 2007).

### 3.1.3 Funding for pilotage

The pilotage operation receives no state funds (SOU, 2007:106). Pilotage is financed partly through direct pilotage fees paid by ship piloted and partly by fairway dues paid by all ships carrying goods to and from Sweden (Sjöfartsverket, 2009a). The reason for this is that the pilots must be on standby in case of an accident, since the pilot is always put on board in such a case. A second reason is that a vessel that doesn’t require a pilot may ask for one voluntary. The costs should, as much as possible, be financed by fees (Sjöfartsverket, 2009a). Pilotage fees are related to the size of the vessel and uniform pilot tariffs are applied to make the price independent of demand and costs at each pilot station (Statskontoret, 2007). In 2009, the direct operating costs for pilotage were 470.5 million Swedish kronor. Operating income was 383.5 million Swedish kronor, of which 376.7 million corresponded to the tariffs for piloting (Sjöfartsverket, 2009b).

## 3.2 Safety

Safety can be defined in a number of different ways. Safety can be defined as "the result of actions or characteristics that reduce the likelihood of the occurrence of undesirable events" (NE, 2010) . Safety can also be defined as freedom from unacceptable risk, according to ISO / IEC Guide 51:1999 (ISO/IEC, 1999) . Risk is an uncertain event or set of circumstances that, should it occur, will have an effect on the achievement of objectives (Bartlett, 2004).

Safety is often used as an opposite concept of risk but this description is limited as safety is more than dealing with or avoiding risks and errors. The relationship between safety and risk can be compared with the relationship between wellness and being ill (Reason 1995 quoted by Rochlin (1999)). Reason (1995) argued as well that as wellbeing is more than the absence of being ill, safety is more than the absence of risk. Further arguments were that to define an organization as safe just because it has a low number of accidents or low risk has the same limitations as to define welfare as not being ill. According to Karl Weick, quoted in Hollnagel, Woods and Leveson (2006), safety is dynamic non-events. Thus, safety should be seen as the absence of adverse events or the sum of events that does not occur (Hollnagel, Woods, & Leveson, 2006).

This approach to safety is different from the traditional view of safety and risk management, which Dekker (2006) named the old view. The traditional approach is based on hindsight and reconstruction after the event, stresses human errors and calculates the probability of error. Based on this approach human error causes accidents, and the system is basically safe if it were not for a few unreliable people in the system. The traditional approach is described further in Section 3.5.

On the contrary, the theory resiliency engineering has emerged, as described by Hollnagel, Woods and Leveson (2006). According to this theory safety means adapting the system to a changing world and safety is equivalent to resilience.

Resilience can be described as the ability to prevent incidents or to adapt to changing conditions to maintain control over a system or a particular property. Resilience also means that an organization maintains or quickly recovers to a stable position that allows the system to continue functioning during and following an accident or under the influence of different stressors. Resilience therefore means having and maintaining control over a situation as well being proactive, flexible, adaptive and learnin how different actions affect the situation according to whether they are implemented or not (Hollnagel, Woods, & Leveson, 2006). (Hollnagel, Woods, & Leveson, 2006) and Dekker (2006) referred to this as the new view of safety. This means that safety can't be measured in terms of safety culture, structures, functions, written rules, externally prescribed training, management skills or other empirically observable properties (Rochlin, 1999). Safety is therefore a non-quantifiable term.

## 3.3 Maritime safety

There is no common explicit definition of maritime safety and the International Maritime Organization (IMO) as well as the European Maritime Safety Association (EMSA) has no official definition. Maritime safety is implicitly described in regulatory frameworks and the concept of maritime safety is also described in other literature and on websites of various organizations. Maritime safety is usually described as safety for lives and property at sea and safety of the marine environment from pollution from ships (Urbański, Morgaś, & Kopacz, 2008).

Maritime safety, or safety at sea, can be illustrated as in Figure 3.3. Safety of navigation is a core area of maritime safety and pilotage is included as a system of navigational assistance, which in turn is a sub-area in navigation safety (Kopacz, Morgaś, & Urbańsk, 2001). Safety of navigation means that the "navigation and maneuvering should be done safely and reliably so that groundings and collisions are avoided by a good margin as well as there is an ability to return to the operating speed after an incident" (Sjöfartverket, 2008a). Safety of navigation is regulated in Chapter 2. TSFS 2010:12 and provides, inter alia, that the master shall make an itinerary, the captain has disclosure requirements in case of danger, and that data relating to ship navigation which are important for safe navigation, shall be recorded.

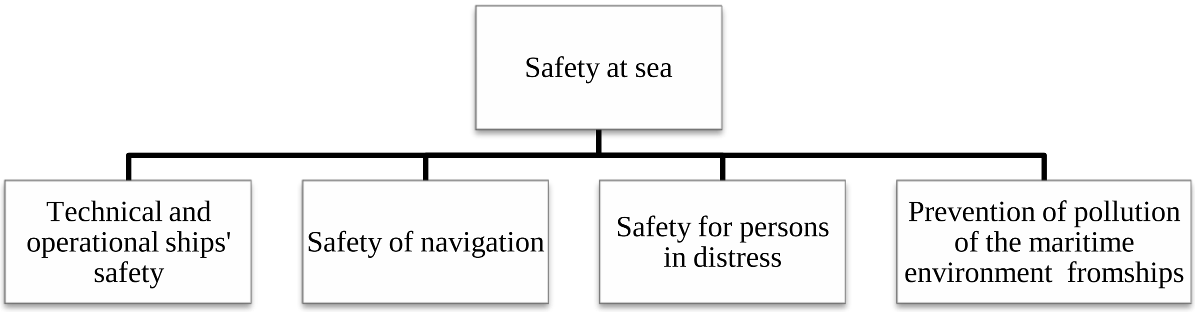


**Figure 3.3 Maritime safety according to (Kopacz, Morgaś, & Urbańsk, 2001).**

It is also possible to extend the concept of maritime safety, or safety at sea, with a systemic approach, where maritime safety consists of four interactive components (Kopacz, Morgaś, & Urbańsk, 2001):

- Legislative institutions and agencies involved in maritime safety. IMO was described as the most important. IMO coordinates the world shipping industry, especially regarding safety issues. Other major organizations are the European Maritime Safety Agency (EMSA), and the Swedish Maritime Administration as well as the Swedish Transport Agency. For a more detailed description of the agencies involved in maritime safety, see for example Praetorius (2009).

- Legal instruments such as international maritime conventions and other legal rules and requirements that specify conditions to ensure safety at sea. The international regulation of shipping is described as the most important factor to ensure a certain level of safety at sea. The International Convention for the Safety of Life at Sea (SOLAS) 1974 is described as one of the most important. For details of other conventions and codes governing safety at sea, refer to Praetorius (2009).

- The operational institutions creating conditions necessary to ensure that maritime safety is achieved.

- The users of the sea who, by obeying all the regulations and requirements, create the conditions to ensure safety at sea.

However, Praetorius (2009) revealed that maritime safety has different meanings depending on the person and situation. Praetorius (2009) pointed out that organizations such as IMO and EMSA have different perceptions and definitions of maritime safety compared to VTS operators. The organizations identified maritime safety as an overarching goal or a generic term for measures such as traffic separation schemes, the design of the fairways and the like, while the VTS operators defined safety as context-dependent and dependent on their own actions.

## 3.4 Pilotage and maritime safety

Pilotage's contribution to maritime safety was described primarily as the pilot's experience and local knowledge of the waters and that the pilot is aware of the specific navigational conditions that the captain of the ship in question can't be expected to be aware of (Grundevik & Wilske, 2007). This, combined with the ability and experience to operate various types of vessels, was described as critical parameters to maintain maritime and environmental safety and accessibility for ships sailing in the inner waters of Sweden (Sjöfartsverket, 2009a). Other qualifications pointed out by van Westrenen (1999) were that the pilots are trained to navigate in narrow fairways in the vicinity of other vessels as well as to operate vessels at very low speed with the help of tugs. The International Maritime Pilots' Association (IMPA) described compulsory pilotage as the most effective and important form of safety of navigation (IMPA, 2010). The European Maritime Pilots' Association (EMPA) described pilotage as a port safety system for the protection of waterways, port facilities and the wider community (EMPA, 2010).

Navigation to the destination safely, without collisions or grounding and without violating maritime regulations was described as the overall objective of the pilots and masters (Nilsson, Hederström, & Lützhöft, 2006). A successful pilotage mission was also described as one where there was no damage to the ship or the environment (Bruno, 2008). The pilot should also avoid dangerous situations and have both long term and short-term planning for the navigation of the ship. The planning should be based on ship motion in relation to its surroundings so that the ship is always well within the safety margin (van Westrenen, 1999; Grundevik & Wilske, 2007). The pilots must therefore know most of the fairway characteristics by heart and be able to plan the voyage based on landmarks (Lützhöft & Nyce, 2006). Apart from the navigational assistance, the pilot also performs other nautical work, such as advising on changes to fairways (Statskontoret, 2007).

The qualifications mentioned above were the most prominent in the literature that was studied. A large number of tasks that a pilot performs during pilotage, and which are important for safety, were also identified. For example, a pilot takes into consideration ship-specific details such as location, course and speed, in relation to environmental factors such as fairway width and depth, currents, wind speed and wind direction, weather and visibility, ice conditions and surrounding traffic (van Westrenen, 1999; Lützhöft & Nyce, 2006). These are not unique to pilotage, as they must be considered at all times. However, pilots work under time constraints. This means that the pilot must detect the slightest change and deviation as these may cause great consequences (Grundevik & Wilske, 2007). According to van Westrenen (1999) pilots base their decisions upon visual references and not so much on the instruments, and the view from the bridge is the best source of information for the pilot.

van Westrenen (1999) pointed out that pilotage is an integrated task that the pilot may perform more easily than the master, and that the captain usually hands over the navigation of the vessel to the pilot. It was also pointed out that the crew has more knowledge about the actual maneuvering capabilities of the ship. The pilot could however determine the ship's status, which according to Bruno (2008) enhances safety directly by adjusting pilotage after the vessel's conditions and indirectly as the pilot can identify and report damages.

Bruno (2008) presented several interesting results and the most prominent was the importance that the pilots place on establishing personal contact with the crew of the ship. To make contact with the crew and to find an appropriate role in the bridge team seemed to be a prerequisite for pilotage to be carried out safely.

Worth noting here is that the length of pilotage varies from one to twelve hours, but can be up to 24 hours[6]. This means that the pilot is on board for a long time and has contact with the crew in the meantime. Hadley (1999) pointed out the importance of the pilot speaking the same language as the port staff, tugboat personnel and VTS operators. Communication and the fact that the pilot speaks the same language can thus be seen as safety-enhancing factors contributed by the pilot.

This indicates that pilots contribute to maritime safety in several ways and van Westrenen (1999) concluded that the pilot is integrated in the control of the vessel and not just an external adviser to the captain. Grundevik and Wilske (2007) pointed out that the pilot also has a facilitating role and can act as a resource on the ship, for example if the ship has insufficient staffing. However, this is not the pilot's actual role, and the crew must comply with applicable staffing and labor laws.

## 3.5 Accidents

An accident is defined as a brief, sudden and unexpected event that results in unintended consequences (Hollnagel, 2004). According to the traditional approach accidents are caused by "the human factor" as people are unreliable, make errors and violate rules; and this causes malfunctions and failures in the system (Hollnagel, 2004). According to this reductionist approach (as opposed to the holistic), components that failed need to be identified, and people are seen as components. Dekker (2006) termed this as the old view of accidents. To find the cause of an accident it is important to identify where people made incorrect assessments and made wrong decisions according to the traditional approach. In order to deal with human error and make the system safe, the human contribution and involvement in the system should be limited by stringent procedures, automation and monitoring so that people can't make the same mistakes again.

[6] Conversation with Anders Alestam, SMA, 2010-08-10

Contrary to this view of "human error" there is an alternative view based in complexity theory. This can be attributed to Perrow (1984) who coined the term "normal accident" and claimed that all accidents are natural rather than unnatural events. From this approach, it is inevitable that accidents occur in tightly coupled complex systems that exist in today's society and accidents are due to complex interactions between components in a system, rather than inadequacies of the individual components. Therefore it is important to focus on the system as a whole and not parts of the system. This theory can be applied to shipping which can be seen as a complex system according to Perrow (1984).

Perrow (1984) also highlighted that small events can reproduce and have a big impact on the system, and more accidents occur nowadays because systems are more complex with more frequent connections and greater variation. In contrast to the traditional view people must be involved at all levels of the system to make a complex system safer (Dekker, 2006). It also means that people are not treated as failing components and accidents should be seen as a symptom of a deeper problem in the system. To be able to understand the failure the system as a whole should be studied and to determine why it was logical to perform an act in the context in which it was performed, instead of dividing the system into parts and trying to identify components that failed (Dekker, 2006). This is based on the following discussion by Hollnagel (2004). People must always meet a number of varying and sometimes conflicting demands in order to perform a task. To handle these complex situations, people must constantly make trade-offs between thoroughness and efficiency and adapt their actions after the situation and to local conditions. People also learn to predict the development of their actions. Accidents happen when the adjustments go wrong, but it is not the act itself or the correction itself that is wrong. Accidents are instead caused by variations in context, rather than because the wrong action was performed. Hence, accidents cannot be explained as caused by defective or abnormal actions. Instead, the accident is seen as caused by ordinary people who perform their ordinary work in what for them seems to be ordinary situations with the usual trade-offs and adaptations of the thoroughness and efficiency (Dekker, 2006). Consequently accidents are caused by the usual measures under usual circumstances, rather than unusual measures under unusual circumstances. Adaption, which is the ability to adapt behavior to changing circumstances, is therefore the reason that actions succeed and fail (Hollnagel, 2004).

### 3.5.1 Accident investigations

Most accident investigations are conducted to describe what happened and the causes of the incident and also to learn from the accident (Myndigheten för samhällsskydd och beredskap [MSB], 2009). Accident investigations should always be based on an accident model and Hollnagel (2004) described the different levels of these, from sequential to epidemiological and to systemic models. The accident is described as a sequence of linear events in the sequential models. This model is based on one cause of the accident, and by identifying and eliminating the cause it is possible to prevent accidents. However, this model is limited and cannot explain accidents in complex systems (Hollnagel, 2004).

The epidemiological model, as Hollnagel (2004) described it, takes the complex systems into account and can be compared to an event tree. An incident can be described as a combination of factors, some latent, that co-exist in time and space. Hence, latent conditions can cause accidents and these are often due to organizational circumstances. According to the epidemiological models, barriers can be used to prevent accidents and these may include the rules and safeguards, which Hollnagel (2004) described. Another difference between this model and the sequential model is the concept of "performance deviations" which is used instead of the concept "human error". Performance deviation can be used for both humans and technology components and is less emotionally charged (Hollnagel, 2004).

In the systemic model, the system as a whole is analyzed and the model takes into consideration that accidents are caused by complex relationships rather than has one cause and thus distinguishes them from the sequential and epidemiological models (Hollnagel, 2004). The accident is seen as a complex and interconnected web of events at different levels in the system in a systemic model. Hollnagel (2004) further highlighted that accidents do not have one single cause but are caused by complex interactions between system components instead of failure of individual components. However, all accident models are more or less an abstraction of reality and an attempt to describe how accidents can occur (MSB, 2009).

#### 3.5.2 Marine shipping accidents

Marine shipping accidents can result in major consequences. An accident involving the release of toxic or hazardous substances and pollutants, which may also have unknown or delayed effects, can have major environmental implications and can affect society in general (Perrow, 1984). Another consequence presented was that both crew and passengers may have to pay directly with their lives in an accident. It was further claimed that consumers indirectly pay the cost of accidents when they have to pay higher prices for goods when there is less availability of a product on the market. Companies may also have to pay the price for an accident since they have to pay for delays and damages and can lose both market share and reputation.

The master of ship is obligated to report marine shipping accidents according to Chapter 6. § 14 in the Maritime Act (1994:1009)[7], which are reported to the Transport Agency and then inserted in the statistic database SOS. The Swedish Maritime Safety Inspectorate (Sjöfartsinspektionen, 2008b) has, based on SOS, compiled accidents between 2003 and 2007 to determine whether the frequency of accidents in any way were related to whether there was a pilot on board or not. However, this internal document cannot be used to prove a definitive view on the pilot's role in safety (Sjöfartsinspektionen, 2008b). This was partly due to the ship's diverse nature, size, staffing on board and because the risk varied between the vessels. Furthermore, the material is brief and has not been studied in detail, which was emphasized. The need for a more detailed study to answer more questions, such as if the presence or absence of the pilot would have had significance for the events or if a pilot could affected the course of events was also highlighted.

However, the Swedish Maritime Safety Inspectorate (Sjöfartsinspektionen, 2008b) concluded that shipping in general is relatively safe and also that pilotage enhances safety and the number of accidents would likely increase without pilotage. It was further asserted that ships with officers holding a PEC was the safest category, probably due to a favorable combination of well-equipped vessels, frequency of service, knowledge of the ship and that masters have skills equivalent to a pilot. It was further stated that many of

[7] 6 kap. 14 § i sjölagen (1994:1009)

the vessels that meet requirements for pilotage represent a higher risk and also that the propensity to take a pilot increases when conditions deteriorate and thus the risk increases, for example in bad weather conditions.

## 3.6 Risk-based criteria for pilotage

Different views on the need for a more flexible regulatory framework and more risk-based criteria for piloting were presented in the literature. The benefit of more risk-based pilotage criteria presented in SOU 2007:106 was that more elements of risk may be subject to pilotage and as a result it would be a more flexible regulatory framework. It also opens up for the possibility to take into account that it can be dangerous for both pilots and boatmen when pilots board and disembark from a vessel. The difficulties of a more flexible framework, such as it must be an objective and predictable regulatory framework was accentuated. This was also the strongest argument used by the Swedish Maritime Safety Inspectorate (now the Transport Agency) against the proposal from SOU 2007:106, in devising a more flexible regulatory framework for mandatory pilotage. The Swedish Maritime Safety Inspectorate (now the Transport Agency) did not support the proposal since it would be unpredictable and lead to continuing problems of interpretation (Sjöfartsinspektionen, 2008a)

Grundevik and Wilske (2007) discussed the advantages and disadvantages of the current pilotage criteria. The advantage of using the ship's main dimensions was that the rules are easy to interpret for the rulemaking agencies, ships and shipping companies. However, the main dimensions do not always represent the ship's ability to be handled in the fairway or in the harbor. Grundevik and Wilske (2007) also suggested using some type of channel standard, for example, "Approach Channels - A guide for design." This is a model for the channel design developed by PIANC (Permanent International Association of Navigation Congress). This calculation takes into account several factors such as fairway, wind, current, maneuverability of the ship, how it is sailed, and is used for calculating the required width of the fairway and the size of the control positions. Grundevik and Wilske (2007) suggested that the method could be used backwards to calculate the maximum size of ships. Then simulation studies could be conducted to evaluate the ship with respect to operating performance and to identify operational limits with respect to wind, currents and light and visibility conditions. Furthermore, it was suggested that the nautical expertise, such as pilots, would be involved in the assessment process. These criteria could possibly be used to obtain a more flexible regulatory framework, but as Grundevik and Wilske (2007) pointed out, the channel norm does not take into account the manning of the ship or the skills of the crew. The development and presence of vessel navigation and control systems were suggested as potential parameters for more flexible and risk-based criteria in SOU 2007:106. Vessels from flag states listed at The Paris Memorandum of Understanding on Port State Control, also known as the Paris MOU[8] , black list, with a gross tonnage of 300 or more were proposed to have compulsive mandatory pilotage requirement under all circumstanses (Sjöfartsinspektionen, 2008a; Sjöfartsverket, 2008b). The Paris MoU black list includes the states that are considered the worst in terms of deficiencies in safety equipment, deferred maintenance and inadequate training of crew. The list is

[8] Paris MoU region includes the European coastal states and the coastal states in the North Atlantic from North America to Europe (Paris MoU, 2010)

updated every year when the Paris MoU makes a gradation of all flag states in the world on the basis of the implemented port state control (SOU, 2007:106). The Swedish Maritime Safety Inspectorate (Sjöfartsinspektionen, 2008a) pointed out that the safety gained from this action should not be exaggerated, but that such a rule would be a manifestation of a fundamental position that the quality of the world merchant fleet will be increased.

## 3.7 Summary of this chapter and comments

The purpose of this literature study was to answer all questions in sections 1.3 and below is a brief description of where and how each question was answered. The issues "how pilotage contribute to maritime safety" and "the safety-enhancing factors of pilotage" were presented in section 3.4. Experience and local knowledge were identified as key parameters. Section 3.2 introduced the concepts of safety and section 3.3 addressed maritime safety and the question "what maritime safety means." It turned out that there is no single explicit definition of maritime safety, but the concept was described in the literature and includes the safety of navigation as an important factor. The view of safety from the resilience engineering-perspective was also highlighted and safety was described as the ability to adapt the system to a changing world. Accidents were described as normal occurrences caused by normal measures under ordinary circumstances.

Perrow (1984) pointed out that shipping is a complex system, but an example is presented below to clarify this. It is impossible to completely describe a complex system because it is changing constantly and hence, there is always a new system to describe. Instead of identifying all future changes in the system, the focus is on adapting the system to the changes. It is however possible to describe a complicated system, hence there is a difference between complex and complicated systems. A ship, for example, can be seen as a complicated system because it can be described. The actual running of a ship is complex since it is not possible to describe the system completely as it changes all the time. There are a number of factors affecting the situation which are not possible to anticipate fully, but the ship still has to adapt, for example wind, weather, changes in traffic or altered economic situation. These are possible to predict to some extent, but because they are constantly changing, it is impossible to describe the system completely.

Pilotage is part of the complex maritime safety system, as identified in the literature. Since shipping is to be regarded as a complex system the systemic accident model is theoretically most suitable for analyzing maritime accidents. The reason for this is because the systemic models consider accidents caused by complex interactions between system components, rather than inadequacies of the individual components. This is based on the accident theory presented in Section 3.5. Another important finding was that safety is more than the absence of accidents. This means that it is misleading to only study the frequency of accidents as a measure of safety because safety can also be demonstrated in terms of the events that do not occur. This section served as the basis for describing "maritime safety" and thus answer the main question "how pilotage contributes to maritime safety".

Advantages and disadvantages regarding risk-based pilotage criteria were presented in section 3.6, which can provide a basis for answering the questions "if the current pilotage criteria can be more risk-based" and "what criteria pilotage can be based on". Possible criteria were presented, but these must be objective and predictable.

# 4 Results from interviews

*Nine interviews were conducted and the results from these are presented in this chapter. Five key areas were identified during the interviews and these were maritime safety, the importance of pilotage for maritime safety, maritime accidents, the importance of technology for the maritime safety and pilotage criteria. All respondents, regardless of profession, had similar responses to the interview questions and for that reason all responses were compiled togethert. Specific responses from the various professional categories are highlighted in particular below.*

## 4.1 Maritime safety

A summary of respondents' perceptions regarding maritime safety resulted in the following description:

> *Maritime safety is getting the ship from point A to point B in the most well-thought out and safe manner as possible without harming the ship, crew, passengers, cargo and the environment, and that risks are minimized and that there are margins.*

Maritime safety was also equated with "good seamanship", which in turn is based on good judgement according to the respondents. A number of factors were identified as important for safety and these are presented briefly below.

### 4.1.1 Standards and regulations

All respondents stressed the importance of having common standards and well-designed rules for shipping and that everyone complies with these. It was further stated that the standards and rules must include limits on what is considered safe. Wind and current restrictions from SMA were pointed out as examples. It was further stated that there are rules for staffing and rest and these should be followed as it is for example important that the crew is rested.

### 4.1.2 The vessel and its safety equipment including backup systems

The ship and its equipment such as safety equipment and physical structure were considered important for safety. The importance of safety equipment such as lifesaving equipment was mentioned as well. It was further claimed that there must be backup systems to equipment and redundancy in the system.

### 4.1.3 Language

All respondents agreed that the language was important for safety. The benefit of all people speaking the same language was that everybody can understand each other and it is also possible for other ships to understand conversations that take place on an open channel. However, as the respondents pointed out, the quality of the English language varied between ships and this was seen as a danger.

### 4.1.4 Cooperation and communication

Cooperation and communication between pilots, VTS operators, pilot operators, as well as ship and shipping company or ship and authority were considered to have a significant impact on safety. Furthermore, the importance of keeping track of other traffic in the surrounding area and to cooperate and be considerate at sea was mentioned.

Examples of cooperation that emerged during the interviews were the pilots' working with pilot operators who coordinate and send out pilots. They also cooperated with VTS operators, who in turn collaborated with other vessels in the fairway. VTS operators felt it had a double impact on safety that they monitor the vessels. The VTS operators can call upon a ship on its way out of the fairway or warn if the ship is heading for a place where it is at risk for grounding. The VTS-operator also felt that if the master of the ship knows that they are monitored they thereby improve their performance. However, VTS operators, as well as the pilot, only have an advisory role.

#### 4.1.5 Crew training and skills

A well-educated and trained crew with skills was considered important for safety as well as the crew was practiced in various operations, such as putting out fires, saving lives and sealing leaks. "Safety considerations" of staff were also mentioned as an important factor for maritime safety, but that concept was not developed further.

#### 4.1.6 Reporting accidents and incidents

The importance of reporting incidents, accidents and breakdowns, as well as the crew learning from them was also stressed. SOS as well as companies and pilots' internal reporting system were given as examples. This accumulated experience was considered important by pilots and commanders holding a PEC.

#### 4.1.7 Ambient factors

Ambient factors, such as SMA making the right Aids to Navigation and that the seacharts are correct were considered important for safety.

#### 4.1.8 Stress and time pressure

Stress and time pressure were mentioned as two factors that may affect safety adversely. Masters holding a PEC pointed out that their time schedules are reasonable but highlighted that many vessels have tight time schedules which could affect maritime safety.

## 4.2 The importance of pilotage for maritime safety

All respondents agreed that the main contribution of pilotage was maritime safety and the pilots claimed that some ships would not not make it to port without a pilot. All respondents also emphasized that there will always exist risks and the pilot's primary role is to reduce the risks to ships in narrow fairways and ports. The pilots asserted that pilotage is not a full solution in itself but that the goal of pilots is to enhance safety. The factors identified as pilotage’s contribution to maritime safety are presented below followed by the factors considered important to carry out safe pilotage.

#### 4.2.1 Expertise, local knowledge, experience, and risk assessments

All respondents agreed that pilots contribute to maritime safety since they are experts in the field, and have local knowledge and experience. The pilots themselves claimed that they have the ability to make risk assessments based on their local knowledge and experience. They also highlighted that they are doing risk assessments constantly in order to avoid adverse events and that they, by being aware that a situation is risky, can lower the risk. A pilot pointed out weather and visibility as two critical parameters which, if they deteriorate, mean higher risk.

The importance of having margins was also highlighted. Local knowledge and experience helps the pilot to determine the margins since they know which parameters affect the margins such as dangerous areas, currents and what resources are available in case of an emergency. This combined with the pilots' knowledge of various vessels and equipment meant that the pilots, according to themselves, are better equipped than a master, who does not know the waters, to correct a situation that is growing critical.

#### 4.2.2 Language skills, advice and relieving recourse

The factors identified as significant for marine safety in section 4.1 were also identified during the interviews, such as how pilots contribute with local language skills. Pilots also serve as advisors and the pilots highlighted that they, in addition to navigation-related advice, can give advice on whether, for example, a ship should have tug. A pilot stated that in this way, it is possible to 'buy safety' and thereby reduce the risks. The pilot also serves as a relieving resource and one pilot stated that when pilots are on board, the crew can rest or perform other tasks. The pilot may also act as a relieving resource if staffing or rest time rules are not followed. However, this is not the pilot's role, but the pilot's role is advisory as pointed out by respondents.

#### 4.2.3 Safe pilotage

To ensure safe pilotage, both pilots and masters need to be very well prepared. This was considered very important and mutual information and communication were identified as two key parameters to obtain safe pilotage. Thus, the master and pilot must agree on which way to go and the pilot must inform the master if there are special conditions to take into account. The master has the same information obligation as the pilot regarding, for example, information about the ship and if there are any anomalies or special circumstances to consider. Before commencing pilotage service, the pilots said they wanted to have relevant and updated meteorological information such as weather, wind, water and current as well as information on the quay and if tugs will be used. Ship-specific information as well as how they use hand control were also relevant information for the pilots. The pilots also described how they can get an indication about the vessel, its equipment and personnel when they come on board.

Pilots pointed out the importance of having a mental picture of the pilotage plan and that they also must be able to compensate for deviations from the plan as well as having alternative plans. However there is sometimes the need for improvisations. The pilots emphasized that it is the big vessels that have pilotage and that pilots needs to make quick and correct decisions. Therefore the pilots must be tolerant to stress and be able to focus on the task. This ability to recognize and interpret situations could be related to the pilots' experience and local knowledge. One pilot also informed that it always is the one who perceives the greatest risk who has the last word, for example, if the master perceives a situation as more risky than the pilot does, the pilotage will be terminated, and vice versa.

One pilot informed that it takes three control means to carry out pilotage and these were visual observations, compass and watch, and radar. All three should be functioning, but if one fails, for example, the visual if there is fog, it is possible to carry out pilotage using the other two means. If two fail, it is impossible to carry out pilotage, the pilot stated.

During the interviews, the question also arose about whether there are situations where pilotage is not needed even if the ship fulfilled the criteria for pilotage. The only situation identified by the respondents was when the master has good knowledge of both the vessel and the fairway. That may be a small vessel that frequently operaties in the fairway but the master has not applied for a PEC or a vessel where the master is about to get a PEC.

## 4.3 The importance of technology for maritime safety

The development of technology was regarded as important for maritime safety by the respondents. Technology contributed valuable information and the AIS, which makes it possible to get information about other vessels in the vicinity, was given as an example of technology that has improved maritime safety. The masters holding a PEC gave the example of how the AIS facilitated calling up other ships, partly because the information about the ship is displayed and also because surrounding vessels can hear the call, which made it more likely that the ship being called answers. ECDIS was also mentioned as an additional tool that enhances safety, but stressed it was just a tool and not a system that could replace one of the other pilot control systems which were needed for safe pilotage. The pilots also pointed out that ECDIS is based on historical data. The technology was perceived as more important in bad weather by the pilots.

Masters holding a PEC stated that it is possible to get a large amount of information at any time with today's technology and that there may be too much information. The importance of the human having control and making decisions was highlighted, and technology should not take over too much. This led to the question of whether technology could replace the pilot on board.

The majority of respondents were convinced that the pilots were needed on board the vessel and did not believe that technology could replace the pilot on board. One reason was that the pilot should have a "feeling for the ship" and a pilot gave an example of how a pilot on board can identify and correct interference which has direct relevance to navigation. Technologies on the other hand need time before responding to the disturbance, as stated by the respondents. Their arguments were that if a pilot is not onboard the vessel, the technology must first identify the disruption and then respond to the officer that something is wrong so that a measure can be taken. Again, one pilot underlined the importance of using the three control systems for pilotage, see section 4.2.3, and pointed out that the visual means disappear if the pilot is not onboard. Another argument was that technology today is not sufficiently developed, which causes lags in the system, which means it takes longer to detect anomalies compared to if a pilot is on board and can detect these discrepancies. Further arguments were that the technology cannot "think by itself" and cannot correct all errors that can occur.

Other arguments stated by the respondents were that it would be impossible not to have a pilot on board since the vessel is not alone and it is impossible to monitor all vessels in the fairway. Today there are sailing boats, fishing boats and other vessels without AIS in the same fairway as the ship that has pilotage. If it was possible to control the entire fairway and when the technology is better developed there might some situations when technology could replace the pilots on board, for example in the Sound, a pilot thought. However, it would be impossible for the ship to use a tug boat without a pilot onboard since the tug crews require an experienced pilot on board the vessel to communicate with.

Another argument was that pilotage is about trust, and it was pointed out that it could be harder to gain trust if the pilot is not on board. Misunderstandings due to language difficulties was another argument and the pilots argued that many masters have poor English skills, but if pilots are onboard they can observe if the master has interpreted a message correctly or not.

## 4.4 Criteria for pilotage

The present criteria for pilotage were considered reasonable by the respondents who also pointed out that the criteria have been tested for a long time. The pilots accentuated that large vessels means a higher risk which also was pointed out as an underlying reason for having a pilot on large vessels or vessels carrying dangerous cargo. The pilots also stated that their primary task is to increase safety and minimize risks.

The respondents did not approve more risk-based pilotage criteria since the criteria must follow a simple yardstick and be easy to handle. It was further stated that it is possible to apply for a PEC and this seemed to imply sufficient flexibility for the respondents who did not consider that the criteria needed to be changed. However, several factors for more risk-based criteria such as type of ship, ship's age, status and equipment, and training and knowledge of the crew were suggested by the respondents. They were however critical and pointed out that it could be difficult to use these types of criteria in reality. Nevertheless other criteria were suggested. One criterion suggested was language skills, including adequate pronunciation and vocabulary. One pilot highlighted that masters that don’t understand English or cannot make themselves understood can jeopardize safety. Inadequate equipment on vessels, even though the ship is not obliged to have a pilot, could be another criterion. Poor management or inadequate procedures were also suggested, and temporary pilotage was suggested for these until the situation gets under control again.

The masters holding a PEC compared the pilotage criteria in Sweden with the criteria in Travemünde in Germany. There are restrictions on the pilot exemption for reduced visibility and strong winds in Travemünde which meant that the commander holding a PEC must have a pilot onboard on those occasions. This form of weather and wind-related restrictions are not used in Sweden, neither for masters holding a PEC nor for other types of vessels not fulfilling the criteria for pilotage. However, it is the responsibility of the master of a ship to have a pilot when necessary. This was rather unusual, according to the pilots, because pilots costs money. Nevertheless some types of vessels take pilots if there are external demands from shipping companies or oil companies even though the vessel doesn’t fulfill the pilotage criteria. This is the case particularly for tankers, vessels carrying cars or other high value cargo. The pilots gave an example of the Sound where larger vessels tend to take a pilot even though the Sound is an international waterway and hence no mandatory pilotage is applied. Both pilots and VTS operators suggested that vessels exceeding a certain size should have a pilot onboard through the Sound. Restrictive draught was another suggestion for pilotage through the sound.

## 4.5 Summary of this chapter and comments

The interviews were used to answer all questions in Section 1.3. Section 4.1 identified a number of factors which together accounted for or were important to maritime safety.

These can be used to answer the question "what is maritime safety" and the factors identified were:

- Standards and regulations
- The vessel and its safety equipment including backup system
- Language
- Cooperation and communication
- Crew training and skills
- Reported accidents and incidents
- Ambient factor
- Stress and time pressure

Section 4.2 was intended to answer the main question "how pilotage contributes to maritime safety" and to identify "the safety-enhancing factors of pilotage." In particular, the pilots pointed out:

- Expertise
- Local knowledge
- Experience
- Ability to make risk assessments
- Local language skills
- Advisory role
- Function as relieving resource

These factors were identified as the pilots' contribution to maritime safety and hence reduction of risk. Exchange of information and communication were identified as necessary to ensure safe pilotage. The respondent interview results were that pilotage is very important for safety, and that pilots are needed on board the ships. The only situation that was identified, when the pilot did not contribute so much to maritime safety, was when the master has good knowledge of both the vessel and the fairway. This strengthens further the statement above.

The importance of technology was presented in section 4.3 and can serve as a basis to answer the question "what is maritime safety". The results indicate that technology has great significance and has increased maritime safety. The AIS was given as an example of important technology but the importance of allowing people to retain control over the situation was highlighted. All respondents agreed that a pilot must be on board and that technology today cannot replace the role of the pilot on board.

Section 4.4 highlighted the respondents' opinions about whether the "pilotage criteria can be more risk-based" and if so, "what criteria can pilotage be based on". The criteria used today were considered reasonable and useable and there was no apparent need for more risk-based criteria. One aspect was that the criteria must follow a simple yardstick and be easy to handle. Nevertheless, several criteria were suggested such as:

- Type of ship
- Vessel age
- Ship status
- Ship Equipment

Some examples were given such as:

- Education, knowledge and language skills of the crew
- Defective equipment of vessels that does not fulfill the criteria for pilotage today
- Vessels with poor management or procedures
- Larger vessels through the Sound

# 5 Results of participant observations during pilotage

*This chapter presents the observed differences and similarities between the participant observations in Malmö, Södertälje and the Sound.*

## 5.1 Differences and similarities at the participant observations

The navigational conditions in Södertälje differed compared to Malmö and the Sound since pilotage took place in the archipelago. This meant that the vessel passed through narrow passages and the pilot pointed out that these were much harder to navigate in the dark and under poor weather conditions. The pilot also noted that long turns must be planned well in advance. The traffic situation was also different since there was considerably more traffic in Malmö and the Sound compared to Södertälje.

This meant that the pilot had to put more focus on the surrounding traffic and more communication with other vessels was required in Malmö and the Sound. Pilotage also varied in time where pilotage to or from Malmö Port was the shortest at about one hour, while piloting through the Sound and Södertälje took longer. This meant that pilots had to be alert for a longer time in the longer pilotage services. Another difference was that most of the vessels had pilots onboard in Södertälje and only a few of the masters had a PEC. A larger proportion of the vessels sail without a pilot or with a master holding a PEC in Malmö. Numerous vessels pass through the Sound without a pilot since it is international waters. The pilot in Södertälje pointed out that there usually is a pilot in an oncoming vessel and this was considered an advantage since the pilot knows that they speak the same language. The pilot exemplified this by explaining that it is not possible to meet anywhere in the fairway and that it is sometimes impossible to pass each other according to the regulations[9] and then it will be easier to agree upon where and how to meet when everyone speaks the same language. Corresponding narrow venues were not identified in Malmö or the Sound.

There were a number of common denominators for all participant observations. Advisory role, exchange of information and communication were identified as three key parameters to obtain safe pilotage, thus contributing to maritime safety. The pilot and master discussed the route as well as specific details for the vessel, first when the pilot got on board but even during the voyage. How information is communicated with the master was also important. One pilot described pilotage as ”this is a lot of psychology". The pilots give navigational advice during the voyage, but it is the master who is ultimately responsible for the ship and the master must feel safe and understand what is happening during pilotage. In some of the participant examples the pilot was maneuvering while an officer or the captain was maneuvering on other ships. According to the pilots, this variation depended on the captain's wishes, and the pilots also highlighted that it is the captain who has most knowledge about the ship.

Communication with the surrounding vessels as well as with VTS operators was also important. This is however not specific to pilotage, since it has to be done even when a pilot is not onboard. Communication with the tugs was thought a specific task for the pilot because all vessels using tugs must have a pilot on board. The pilots explained that the operators of the tug want someone they know and trust on the bridge.

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[9] Regulations for avoiding collisions at sea

The physical presence of the pilot seemed to be important to some masters who seemed to be calm and feel secure when having a pilot on board. Some captains seemed to have less need for the pilot's physical presence. The pilot could also give advice that could support the captain in discussions with the shipping company. One pilot gave an example of how they could support a master. A master could have economic restrictions from his shipping company and if the captain for example wants two tugs, it can be difficult to justify this economically for this shipping company. However, if a pilot claims that the master needs two tugs this can support the master's decision to the company. The physical presence of the pilot could also be seen as a relieving resource when the pilot was maneuvering during the voyage and the crew was performing other tasks.

## 5.2 Summary of this chapter and comments

Research questions "how pilotage contributes to maritime safety" and "the security-enhancing factors of pilotage" got an extra dimension by doing these participant observations. Despite differences in navigational status, the length of pilotage and traffic situation numerous common factors were identified such as the pilot's advisory role, communication and exchange of information. The pilot's physical presence seemed to be of different significance to the masters and sometimes the pilot also had a facilitating role. These qualitative results proved to have similarities with the results of the interviews.

These results are based on the participant observations which all were carried out in the daytime and in relatively good weather conditions, as pointed out by the pilots. The surrounding environment was fully visible and it was easy to board and disembark from vessels. Nevertheless, the factors identified as important for pilotage are presumed to be valid even under more difficult conditions. More factors may have been identified during worse weather conditions.

# 6 Results from statistics for maritime accidents

*This section presents the results from studies of accident statistics in SOS. Presented first are the number of navigation-related accidents with and without a pilot on board, and accidents where the master had a PEC, as well as the type of vessels involved in accidents and the severity. Navigation-related accidents with pilots on board are specifically presented.*

## 6.1 Number of navigations-related accidents

The number of navigation-related accidents in Swedish waters are presented in Figure 6.1. The curves should not be compared with each other since Figure 6.1 should only be used to show trends of accidents in each category.

The majority of accidents have occurred without a pilot onboard. The accidents without a pilot on board have varied over the past 25 years but have showed a downward trend after 1985, when the statistics began to be documented in the SOS. In the late 1990s the number of accidents increased again, to be followed by a downward trend again.

The number of accidents with pilots varied similar to the number of accidents without a pilot onboard over the years, but still the number of accidents with pilots on board has been relatively constant over the past 25 years. Like the accident without a pilot, the number of accidents with pilots on board increased in the late 90s. Subsequently, the accidents decreased slightly, with only a few acccidents in certain years. Although the number of pilotage services has decreased as well over the last ten years, see figure 3.1 in section 3.1.2.

The number of accidents where the master had a PEC showed a relatively stable trend. There have been fewer accidents in this category compared to accidents with and without a pilot on board, but in recent years the number of accidents has increased marginally.

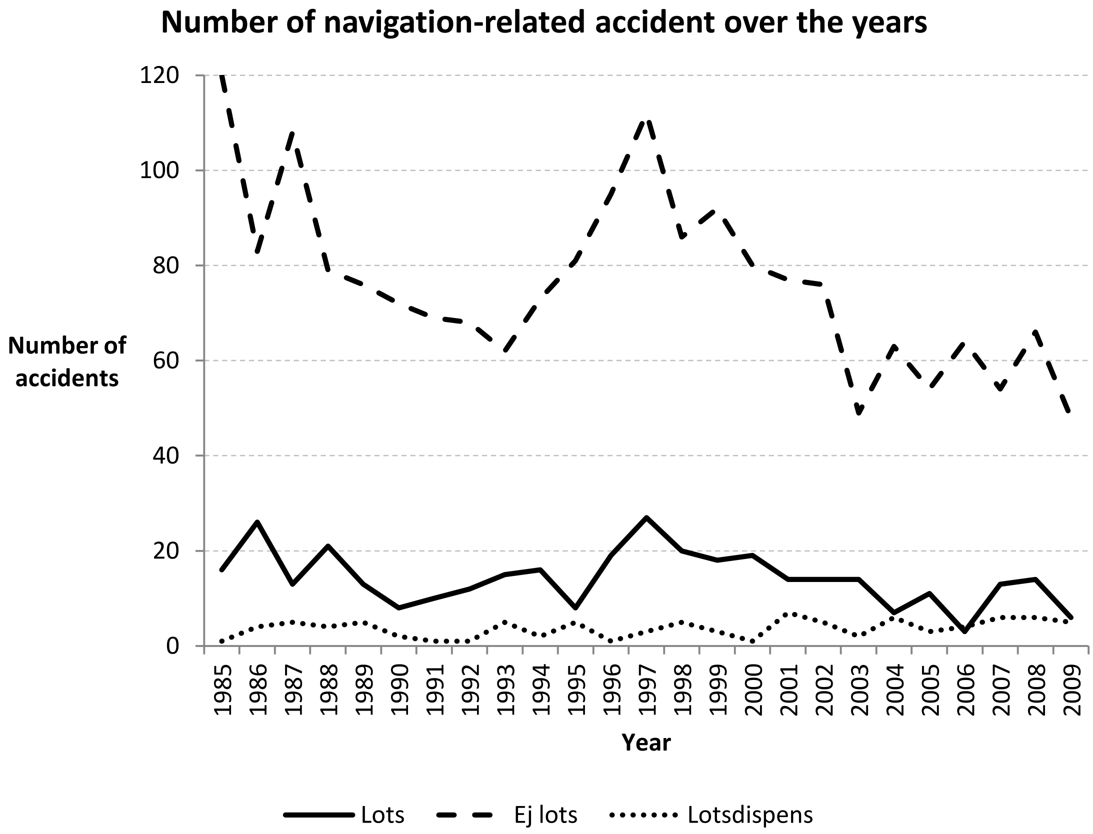


**Figure 6.1 Number of navigation-related accidents with ("lots") and without ("ej lots") pilot onboard as well as accident where the master had a PEC ("lotsdispens"), between 1985-2009, based on SOS.**

## 6.2 Navigations-related accidents with pilots onboard

A total of 2356 navigation-related accidents occurred during the studied period. 582 of these were collisions between vessels. Collisions should generally be reported twice which is why the number theoretically should be halved. However, leisure boats are not required to report and therefore it is not possible to directly halve the number. Pilots have been on board for 54 collisions between ships over the years, but in recent years pilots have not been involved in this type of accident. Grounding accidents and collisions with other objects were the most common accident types when a pilot was onboard, see Figure 6.2.

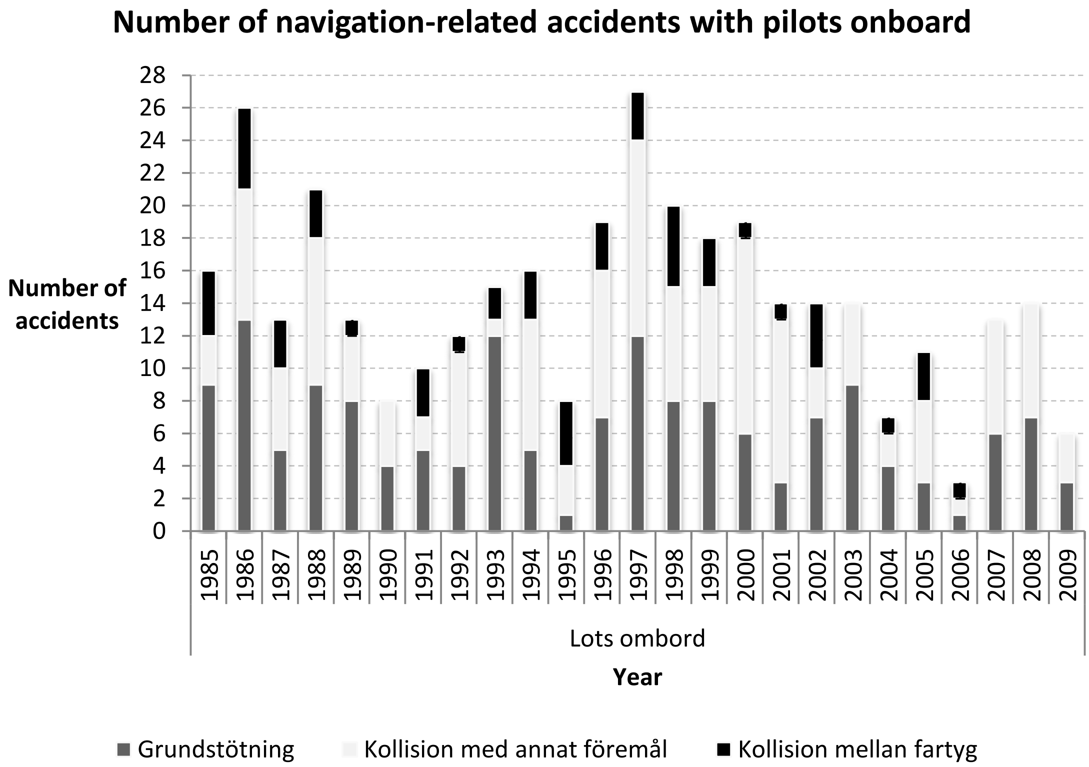


**Figure 6.2 Navigations-related accidents with pilots onboard, divided in the three categories grounding (grundstötning), collision with other objects (collision med annat föremål) and collision between vessels (collision mellan fartyg), between 1985-2009, based on SOS.**

A comparison between the number of pilot services in Sweden and the number of navigation-related accidents with pilots on board showed that between one to four navigation-related accidents occurred per 10 000 pilot services, see Table 6.1.

**Table 6.1 Number of navigation-related accidents with pilots onboard**

| Year | Number of pilot services in Sweden | Number of navigation-related accidents with pilots onboard | Navigation-related accidents with pilots onboard presented in percent |
|---|---|---|---|
| 2009 | 35 364 | 6 | 0,017 |
| 2008 | 39 926 | 14 | 0,035 |
| 2007 | 40 217 | 13 | 0,032 |
| 2006 | 38 133 | 3 | 0,008 |
| 2005 | 41 316 | 11 | 0,03 |

| Year | Number of pilot services in Sweden | Number of navigation-related accidents with pilots onboard | Navigation-related accidents with pilots onboard presented in percent |
|---|---|---|---|
| 2004 | 38 756 | 7 | 0,02 |
| 2003 | 39 914 | 14 | 0,035 |
| 2002 | 39 126 | 14 | 0,036 |
| 2001 | 41 694 | 14 | 0,034 |
| 2000 | 46 336 | 19 | 0,041 |
| 1999 | 47 288 | 18 | 0,038 |

## 6.3 Type of vessel

The types of vessels that have been involved in the navigation-related accidents are presented in Figure 6.3, divided into the categories pilot on board, not on board and the master had a PEC. The number of accidents should not be compared between the different categories as the figure shows trends of accidents in each category.

The most common vessel types for pilots involved in accidents were vessels carrying dry cargo and tanker vessels. Some accidents with these types of vessels involved a master holding a PEC, but the majority of accidents involving these vessels occurred without a pilot on board. The master of passenger ships that frequently call at a port usually has a PEC, which may explain why pilots only have been on board in a few accidents with this type of vessel  over the past 25 years. Pilots are not normally on board fishing vessels which explains why pilots not have been on board during these accidents. It is difficult to comment on the category other vessels, but pilots have only been on board during a few accidents involving these types of vessels.

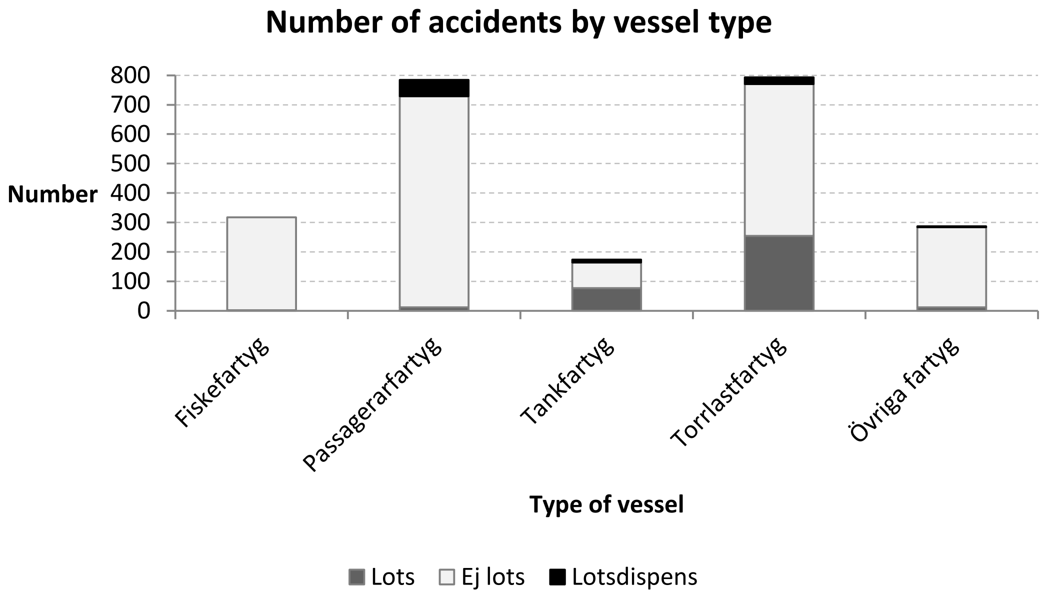


**Figure 6.3 Navigation-related accidents presented as type of vessel for the categories with (lots) and without (ej lots) pilot on board and whether the master had a PEC, between 1985-2009, based on SOS.**

## 6.4 Severity

The most common type of all navigation-related accidents was the category "less serious accident", see Table 6.2. Pilots were predominantly involved in less serious accidents and only a few serious accidents. However, the difference between the categories was not stated.

**Table 6.2 Navigation-related accidents divided in the categories pilot on board or not and master holding a PEC, based on SOS, between 1985-2009**

| | Pilot | No pilot onboard | Master holding a PEC | Total |
|---|---|---|---|---|
| **Grounding** | **159** | **1 184** | **46** | **1 389** |
| Severe accident | 4 | 31 | 4 | 39 |
| Shipwreck (disable vessel) | | 18 | | 18 |
| Less serious accident | 155 | 1135 | 42 | 1332 |
| **Collision with other object** | **144** | **220** | **26** | **390** |
| Severe accident | 3 | 8 | 1 | 12 |
| Shipwreck (disable vessel) | | 1 | | 1 |
| Less serious accident | 141 | 211 | 25 | 377 |
| **Collision with other vessel** | **54** | **491** | **20** | **565** |
| Severe accident | 4 | 30 | 1 | 35 |

| | | | | |
|---|---|---|---|---|
| Shipwreck (disable vessel) | | 8 | | 8 |
| Less serious accident | 50 | 453 | 19 | 522 |
| **Total** | **357** | **1 895** | **92** | **2 344** |

## 6.5 Navigation-related accidents in Malmö and Södertälje

Navigation-related accidents were studied specifically for Malmö and Södertälje over the period 1985-2009, based on SOS. The number of accidents is presented in Table 6.3 for the categories with and without a pilot on board and the master holding a PEC for each area.

**Table 6.3 Number of navigation related accidents in Malmö and Södertälje in the period 1985-2009, based on SOS**

| | Pilot | No pilot onboard | Master holding a PEC | Total |
|---|---|---|---|---|
| Malmö | 6 | 16 | 5 | 28[10] |
| Södertälje | 16 | 12 | 3 | 31 |

For Malmö the number of accidents with a pilot on board and a master holding a PEC were similar, but there have been more accidents when there was no pilot onboard. In Södertälje, on the contrary, there have been more accidents with a pilot on board than without, and only a few accidents have occurred when the master holds a PEC. However, this does not show the whole picture, and in order to compare the number of accidents in these areas it requires information of the number of services supplied, the number of calls without a pilot on board and the number of vessels which have been operated by a master holding a PEC in each area for each year.

## 6.6 Summary of this chapter and conclusion

Accident statistics were studied to answer the main question "how does pilotage contribute to maritime safety". The statistics stretch back to 1985, but because the mandatory pilotage criteria that are used today were introduced in 1983 the statistics are considered to represent the development of what has happened since the pilotage criteria were introduced. The statistics illustrate that the number of navigation-related accidents in general have decreased since 1985, although the number of accidents declined only to peak again in the late 90s and then decline again. It is a legitimate question to ask what the increase was due to and partly why the number of accidents decreased again. The first decrease may be a result of the introduction of the pilotage criteria on 1 January 1983, but there are also a number of other factors that may have influenced the decline such as the development of new technologies and how the traffic intensity varied. This is analyzed further in Section 8.2.

[10] Including one when it was unknown if there was a pilot on board or not or if the master had a PEC or not

Based on the statistics, between one and four accidents happens per 10 000 pilotage services supplied. Pilots were usually involved in less serious accidents, typically groundings or collisions with another object. It was also rare that a pilot was onboard for collisions between vessels. The types of vessels that were involved when a pilot was onboard were mainly dry cargo and tanker vessels.

It is somewhat misleading to compare number of collisions with other vessels with collision with other objects and groundings, since collisions should be reported twice. The number of collisions should therefore theoretically be divided by half to get the right number of accidents, and attempts were made to halve the number of collisions. However, it was impossible to get the accurate number of accidents as it can for example be a collision of vessels in which a pilot is on board at one vessel, but not on the other one. Then it was impossible to determine which group should be excluded and for that reason, the statistics are presented in the form of events.
This had no major impact on the analysis since it was rather unusual that a pilot was on board for collisions between vessels.

The statistic database SOS that was used is detailed and provides a structured overview of marine shipping accidents, but a comparison with theory in Chapter 3 showed that safety is much more than just the absence of accidents. Therefore statistics alone cannot be used to answer the question "how does pilotage contribute to maritime safety". However, the statistics showed that the number of accidents has decreased after the criteria for mandatory pilotage were introduced. One explanation can possibly be that pilotage increased safety. However this conclusion is only a hypothesis and cannot be concluded from the statistics. The more detailed analysis from Södertälje even shows the opposite, but due to limited knowledge of complementing data no comparative conclusions are drawn between the statistical accident results using a pilot, no pilot onboard and a master holding a PEC. There may also be other possible explanations to the trend of decreased number of accidents, as for example better tools on the bridge (electronic charts, AIS, etc.), marking of fairways, traffic separation schemes as well as stricter policies regarding alcohol on board.

# 7 Results of analysis of maritime accident reports

*This chapter presents the six maritime accident reports that were studied, along with an analysis of two of these with respect to whether a pilot could have affected or averted the accident.*

## 7.1 Compilation of maritime accident reports

A number of accidents occur each year but only a limited number are investigated further. Six maritime accident reports were studied for accidents in the waters at Malmö and Södertälje between 1998-2008. These were:

- Report RS 2009:04, Lister Country, Södertälje Canal, 29 October 2008 (SHK, 2009)
- Cargo Ship WING - Sjans Sodertalje, 23 July 2008 (Sjöfartsinspektionen, 2008c)
- Report RS 2008:01 M / T Brovar Breeze, Södertälje, 14 February 2007 (SHK, 2008)
- Cargo Ship OOSTERBRUG PJCQ Malmö September 16, 2003 (Sjöfartsinspektionen, 2003)
- Cargo Ship ODIN - V2AF6 - Södertälje December 8, 1998 (Sjöfartsverket, 1998)
- MV Hyphestos, Malmö harbor on 16 March 1998 (SHK, 1999)

The full reports are available on the websites of the Board of Accident Investigation (SHK) and the Swedish Transport Agency.

Pilots were on board for four of the six studied accidents. The vessels Vinga and Oosterbrug did not fulfill the criteria for mandatory pilotage and did not have a pilot on board when the accidents occurred. For the other four accidents when a pilot was onboard, the comments on the pilot’s role on board were compiled. All reports which were studied, except one, resulted in recommendations. These recommendations were not personal but often related to organizational factors. Some of these referred to the pilot's role, for example the accident with the Listerland which resulted in the recommendation to review the training plan for pilots when manoeurving in fog. The SHK performed a barrier assessment for the Brovig Breeze accident in order to evaluate if these barriers would have been able to stop the accident provided that the barriers had been introduced earlier and used. Pilot procedures were identified as one possible, but weak barrier, in this accident report. The pilots’ role was for example described by Sjöfartsverket (1998) in the accident report for Odin. "The pilot started, for no apparent reason, making the turn at light Rökogrundet about two cable lengths ahead of schedule. ... It is likely that the error of the turn would have been detected in time if the lighthouse had been functioning, and thus could have been observed visually, showing most of its characteristics. The pilot had probably been able to discover how light from the lighthouse wandered from port to starboard side." The recommendations in the accident report were regarding the lighthouse's character and the commitment and involvement of the vessels duty officer. There was no recommendation regarding Hyphestos, but it was stated in the report that: "the pilot has said he believes that the entire maneuver was performed according to the program but that he must have misjudged the distance to the quay".

A former investigator from the Swedish Transport Agency has at the request of the Maritime Administration under the project EffcienSea made assessments regarding whether the pilot on board should have been able to influence events and averted the sequence of events in the circumstances for a number of accidents. These estimates are based on previous investigations at the Transport Agency. Assessments have been made for Vinga and Odin. The assessment for Vinga, where there was no pilot onboard, was that a pilot would have turned at the right place and that a pilot probably would have averted the accident under the circumstances. The assessment for Odin was that the pilot, who was on board, made a miscalculation and that pilots should not have averted the accident under the circumstances.

## 7.2 Summary of this chapter and comments

These reports were studied to investigate "how pilotage contributes to maritime safety" and "the safety-enhancing factors of pilotage". The pilots' role on board and whether they affect or prevent the events has not been investigated further in the accident reports, except for the accident with Brovig Breeze where SHK conducted a barrier analysis. Accident reports are thus considered too blunt an instrument to answer the questions above.

The assessments conducted by a former investigator at the Swedish Transport Agency gives better conditions to answer the questions. This is because the investigator had nautical knowledge and insight into the accidents and thereby was in a position to assess whether a pilot would have been able to influence or prevent the accident. For one of the accidents it was determined that a pilot could have affected the outcome of an accident. However, the vessel did not fulfill the criteria for mandatory pilotage. The assessment of the other accident concluded that the pilot could not have affected the outcome of the accident. These two assessments are not considered as enough material to obtain evidence that could be used to answer the questions.

# 8 Analysis

*The results are analyzed in this chapter in order to answer the questions that form the basis of this report. Maritime safety is analyzed first. This is followed by an analysis of how pilotage contributes to maritime safety based on the description of maritime safety. The importance of technology for maritime safety is analyzed in the next section, followed by an analysis of the criteria for mandatory pilotage that are used today and whether they can become more risk-based, and if so what criteria can they then be based on.*

## 8.1 What is maritime safety?

There was no official definition of maritime safety identified in the literature study, but implicit definitions were found in other literature covering maritime safety. It was a surprise that there was no official definition of maritime safety, and this complicated the task of analyzing how pilotage contributes to maritime safety since there was nothing to measure it against. The literature study as well as the interviews and participant observation served as a base to investigate the meaning of maritime safety and the results gave an indication of what was considered important for maritime safety.

The concept maritime safety seemed to be self-evident to all respondents who had similar responses in the interviews, and comparable factors were recorded at the participant observations. These factors all showed great similarities with the factors that were identified in the literature. For example, the vessel and its safety equipment as well as standards and regulations were identified as important for maritime safety, both in the literature and by the respondents. However, some literature was based on interviews and cannot complement the empirical studies. More factors were identified from the interviews compared to the literature, such as the importance of language and the importance of reporting accidents and incidents. This shows that it is important to use multiple sources and different approaches to analyze maritime safety. Even qualitative characteristics were mentioned during the interviews, such as maritime safety being equated with "good seamanship". The concept of good seamanship is defined in ”internationella sjövägsreglerna i Sjöfartverkets sjötrafikföreskrifter” (Sjöfartsverket, 2004).

Based on the interviews, the qualitative characteristics are just as important for marine safety as safety of navigation, which also was highlighted as an important part of maritime safety. The description of maritime safety given by the respondents resembled the description of the safety of navigation presented in the literature. This indicates that safety of navigation is an area of maritime safety where the respondents felt they have the main influence. Other areas of maritime safety were identified in the literature such as safety for persons in distress, prevention of pollution of the maritime environment from ships as well as technical and operational ships' safety. This bears a strong resemblance with the respondents' description of maritime safety provided in section 4.1.

> *Maritime safety is getting the ship from point A to point B in the most well-though out and safe manner as possible without harming the ship, crew, passengers, cargo and the environment, and that risks are minimized and that there are margins.*

Although the respondents reported similar responses, Praetorius (2009) stated that maritime safety has different meanings for different people and in different contexts.

Praetorius (2009) concluded that there is a need to build common values, norms and identities around the concept of maritime safety in order to increase the overall safety in the marine field. This indicates that even if the perceptions are equal in some occupations it may differ between other professions. As an example, all respondents, pilots, master holding a PEC, the VTS operators and pilot operator, reported similar responses, but Praetorius (2009) claimed that the perception differed between the VTS operators and organizations such as IMO and EMSA. Therefore, Praetorius' (2009) conclusion is reasonable and worth striving for in the maritime organization.

However, this gives no description of what maritime safety is and the qualitative results that have emerged are not sufficient to constitute a definition of maritime safety based on Praetorius' (2009) conclusions. Nor is description of maritime safety as safety of navigation, persons in distress, prevention of pollution of the maritime environment from ships as well as technical and operational ships' safety considered enough to build the common values suggested by Praetorius (2009). As a suggestion the concept of safety, according to the theory resiliency engineering, could serve a starting point to describe maritime safety. Then maritime safety can be described as:

> *have and maintain control over a situation, but also to be flexible and adaptive and to adapt the system to a changing world*

This description can be applied to all actors in the maritime safety system, from the sailors to the legislative institutions and agencies, which all can contribute to maritime safety based on their role and focus. How pilotage contributes to maritime safety is analyzed in section 8.2.

Adaption, which is the ability to adapt behavior to changing circumstances, is a key word in the description and could therefore be a key word for maritime safety as well. According to Rochlin (1999), it is impossible to measure safety, hence it is not possible to measure maritime safety. On this basis the importance of pilotage for maritime safety has been analyzed.

## 8.2 How pilotage contributes to maritime safety

The contribution of pilotage to maritime safety and the safety-enhancing factors of pilotage are analyzed from several aspects below.

### 8.2.1 Pilotage and accidents

Pilotage was considered a safety-enhancing measure for the shipping industry. According to the Swedish Maritime Safety Inspectorage (Sjöfartsinspektionen, 2008b) there would have been more maritime accidents if the vessels that fulfill the criteria for mandatory pilotage today would not have had a pilot. This was also suggested during the interviews. Although the accident statistics do not fully capture the complexity of accidents, the statistics presented how the number of accidents have decreased since the mandatory pilotage criteria were introduced. This was also the objective for introducing the mandatory pilotage for those who fulfill the criteria. The number of accidents decreased for the first ten years, especially for vessels without a pilot on board. The question is whether this was due to the pilotage criteria which resulted in many more vessels were sailed with a pilot onboard and therefore there were fewer vessels without a pilot onboard. However, the number of accidents increased again in the late 1990s to about the same level as in 1985, and then decreased again. Another explanation could be that there has been a reduced number of calls and fewer vessels require pilotage and the number of cargo vessels has decreased due to the use of increasingly larger vessels according to Statskontoret (2007). Improved technology may be another reason for the decline, or it could be a combination of fewer calls and improved technology. The respondents gave the AIS as an example of technology that has improved maritime safety. Another explanation could be that the reporting method, or the propensity to report accidents, has changed over this time period, leading to the variation in number of accidents. It is only possible to speculate on the reasons and it is difficult to make causal relationships in complex systems. Furthermore, most accidents were classified as less serious, and only a few were serious accidents. Since accidents are relatively rare events, the statistics are a blunt tool.

Another interesting aspect is liability for accidents. According to Perrow (1984), the master has control over his vessel but when two vessels are heading towards each other, they can be seen as a tightly coupled system where neither of the captains are in charge of the system, although there are regulations to follow[11]. Based on the statistics it was unusual for a pilot to be on board when a collision occurred between vessels. The question is whether the pilots take more control over the situation compared to the masters. In such cases this may be another contribution to maritime safety.

Nevertheless, the statistics gave no clear indication that pilotage has reduced the number of accidents and thus made the shipping industry more safe*.* To draw conclusions from the accident numbers it requires more information like the number of calls with and without a pilot and much more. This information was not available. However, safety is more than just the absence of accidents, according to Reason (1995) (quoted in Rochlin (1999)) and therefore it is not as simple as stating that shipping has become safer just because the accidents have been reduced. That's because safety can also be manifested in the form of so-called non-events and can then be seen as the sum of events that did not happen. This means that there are several other aspects of how piloting can contribute to maritime safety.

### 8.2.2 Pilotage and adaption

A number of factors that can be seen as the contribution of pilotage to maritime safety were identified in the literature study and the empirical studies. If these factors are studied from a resilience engineering perspective, then the question how pilotage contributes to maritime safety gets an extra dimension.

Pilotage is part of the maritime safety system based on the literature study. Hence, the pilot should not be seen as an isolated system but as an artifact of the overall maritime safety system. This systematic approach is important in the analysis of how pilotage contributes to maritime safety, since the performance of the overall system is the result of interactions between all artifacts in the system according to Hollnagel (2004). Consequently, the pilot should be seen as an artifact of the system that affects the

[11] regulations for avoiding collisions at sea

performance of the overall system and since shipping is a complex and dynamic system it requires constant adaptation.

Expertise, experience and local knowledge of the waters and the pilots' ability to make risk assessments were identified as important contributions of pilotage to maritime safety, both in the literature and from the empirical studies. The former investigators at the Transport Agency stated that a pilot probably would have averted the accident with Vinga by turning in the right place. This can be interpreted as much confidence is put in the characteristics of the pilot mentioned above. It also means that pilots have good conditions to adapt their actions according to the situation, which is consistent with adaptation theory. This flexibility and capability to adapt is, based on resilience engineering, the key to meeting varying and sometimes conflicting requirements, in order to maintain control of a complex situation.

Another factor that was identified both in the literature and from the empirical studies was that pilots usually have to perform their work under time constraints and often have to make quick decisions. Again, this can be linked to the pilots' ability to adapt. Since the pilot has the experience and local knowledge it will be difficult for a commander who does not know the waters to compensate for this information asymmetry that arises. This means that pilots could have an advantage compared to the master when they make quick decisions. It also means that pilots can have advantages when it comes to performing a task that is outside the normal duties and can probably identify hazardous situations earlier than a master who does not have local knowledge of the waters. One pilot stated that they can feel the slightest disturbance of the vessel, which a master can also identify. However, this could, in combination with the pilot being familiar with the navigation-related conditions and having knowledge about dangers in the area, mean that the pilot more easily can compensate for the disturbances and avoid other dangers in the area and steer the ship to a safe area. Experience and local knowledge means that pilots have a lot of "tacit knowledge", as described by Argyris and Schön (1996). Since this might be difficult to explain in words, it could also be difficult to consider, but it should be seen as a contribution to maritime safety.

Since pilots are experts on the local conditions and have often experienced similar situations in the area, they could also make decisions on a different mental level compared to the master who is unfamiliar with the area. The characteristic of naturalistic decision making is that the decisions are made by experts and that the decisions are based on the recognition of a situation, made under great uncertainty and under time pressure and that the stakes are high (Lipshitz, Klein, Orasanu, & Salas, 2001). This is consistent with the type of system that the pilot is working in, which supports the theories of naturalistic decision making. This can also be seen as part of the pilots' ability to adapt. Thus, the pilot can be an additional source of knowledge to the master if he or she has no experience of the waters.

Expertise, experience and local knowledge of the waters, the pilots' ability to make risk assessments and naturalistic decision making are factors that can be difficult to define and take into account, but these are the basis for the pilot's ability to adapt and can consequently be seen as the contribution of pilotage to maritime safety.

The advisory role and language skills were easier to identify. With these qualifications the pilot can adapt the system, in this case the vessel, which in turn is part of the overall maritime system, to a changed world. This shows great similarity with the description of maritime safety under section 8.1. The pilot can also have a role as a relieving resource on the vessel, as identified both in the literature and the empirical studies. Even if relief is not the primary role, this effect should not be underestimated. Instead it should also be included in the valuation of the contribution of pilotage to maritime safety.

#### 8.2.3 External effects

Pilotage can have a double-sided effect, as the pilot increases safety on board the vessel which they are on, as well as for the other vessels in the fairway; compared to if the pilot not had been on board any of the vessels. This seemed to be the general opinion among the respondents who claimed that the vessels that must have a pilot according to the criteria also represent a higher risk and thus it was more likely that these would be involved in accidents.

Hence, pilotage contributes to safety for both the vessel being piloted and also for other vessels in the fairway. Pilotage may therefore contribute to external effects. This theory was supported by the Statskontoret (2007), in which it was stated that a pilot on board increases the benefit to society as it enhances safety and minimizes the risk of accidents and damage to nature and the environment.

#### 8.2.4 Why would a pilot not be wanted?

Since the general opinion was that the pilots contribute to maritime safety, a legitimate question was why the ship owners and masters do not want to take a pilot. The main reason identified was financial reasons as the ship owners wanted to minimize their costs and pilotage charge is an expense (Hadley, 1999). The economic aspects of the individual ship should theoretically not be the determining factor for whether the manager chooses to take a pilot or not. Instead, the impact of a decision should be studied for shipping as a system and it should be considered the decisive parameter. Even though it is desirable, the question is whether this is realistic or not. Another reason, according to Hadley (1999), was that the captain considered it possible to navigate without a pilot. However, it is the captain's responsibility to engage a pilot if needed with regard to maritime safety or the marine environment under TSFS (2009:123).

#### 8.2.5 Outline

The factors analyzed above indicate that the pilots contribute to maritime safety with much more than just advice. This is also indicated in the definition of pilotage in TSFS (2009:123) as "measures ... necessary for safe navigation". In conclusion, the pilot is well placed to contribute to maritime safety based on the theory resilience engineering since the pilot can adapt the system to new conditions and the pilot must be flexible and adaptive to be able to have and maintain control over the system. The pilot should also be regarded as an artifact of the system that affects the performance of the overall marine system. This system includes several components, including technology, and while it is in the periphery of this report, it is nevertheless an aspect that is relevant to pilotage and maritime safety.

## 8.3 The importance of technology for maritime safety

The importance of technology for maritime safety as well as whether pilotage is necessary today given all the technology that is constantly evolving, were two questions that emerged during the interviews. These are interesting questions because the technology has evolved and improved over the years while piloting has a long tradition. The opinion among the respondents was that that technology that is used today not could replace a pilot on board the vessel. This claim may be partly supported by the allegation that the pilots’ adaptation capability, which in turn is based on the pilots' expertise, local knowledge and experience, is important for safety. Hollnagel (2004) pointed out that people have the ability to identify discrepancies and adjust their actions to the situation. Machines, on the other hand, can only detect the discrepancies that they are programmed to detect and cannot respond to other errors that humans can detect. Furthermore, the operators do not get the same experience with performing duties if they monitor the system instead of managing it. Another aspect was that there are delays in the technology today and the pilots said that they can detect and correct interference directly if they are on the ship while it takes longer if they are not on board.

The technology has great significance for safety based on the literature as well as the interviews where the respondents highlighted that the safety has improved since the AIS was introduced. At the same time, the respondents warned against relying too much on the technology, and the pilots pointed out that the technology should be seen as a tool, but that technology cannot take over the pilot's task. Technology seemed to be appreciated as long as it could be used as a tool, since it seemed like the respondents wanted to be in charge of the situation and not let technology take over too much. This implies that people want to have and retain control over a situation and this is consistent with the view of maritime safety.

Both pilots and technology should therefore be included as artifacts in the maritime safety system, and these are in turn integrated. The significance of this is that if the system is to be changed in any way, for example if technology would replace the pilot's role on board, this creates a new cognitive system with new relationships between the various artifacts, and this must be analyzed from a systemic perspective. The new technology also represents a new approach and thus a new system with new risks and these must also be analyzed from a systemic perspective. Consequently, it has to be constantly analyzed how different changes affect the overall system and this is important to bear in mind when discussing for example the future of pilotage. This is also relevant when discussing more risk-based pilotage criteria since these criteria also are part of maritime safety system.

## 8.4 Risk-based criteria for pilotage

The current mandatory pilotage criteria were considered reasonable by the interview respondents and there was no apparent need for more risk based criteria to be identified. The Swedish Maritime Safety Inspectorate (now the Swedish Transport Agency), which was the authority that was asked to design a more flexible regulatory framework for pilotage under SOU 2007:106, did not support this proposal (Sjöfartsinspektionen, 2008a). Some respondents pointed out the need for even tougher mandatory pilotage criteria and suggested that certain types of vessels with inadequate equipment and large vessels that pass through the Sound, should be subject to pilotage. The other criteria that were suggested by the respondents were similar to the ones identified in the literature, for example to take account of ship-specific factors such as age, equipment and status as well as training and knowledge among the crew. These proposals were very similar to the proposal that vessels over 300 gross tons listed on the Paris Mous black list could be subject to pilotage. This can be seen as a risk-based criterion since the list includes deficiencies in safety equipment, deferred maintenance and inadequate training of crew. A comparison with the regulations of PEC (fairway specific or generic) showed further similarities. Although the general PEC is considered obsolete (SOU, 2007:106; Sjöfartsinspektionen, 2008a; Sjöfartsverket, 2008b) the criteria can be regarded as a form of risk-based criteria, which allow for individual assessment. Some of the criteria for PEC under TSFS (2009:123) have similarities with the proposals that emerged during the interviews, for instance that pilotage comprise certain vessels even if they don't fulfill the criteria being used today. The criteria that are similar are as follows:

- Vessel dimensions, design and maneuverability compared to the fairway and port
- Ship equipment (especially the bridge)
- The cargo that the vessel is designed to carry
- Staffing and watch schedule on the vessel
- The candidate's competence/s
- The applicant's experience in the Swedish coastal waters as master and watchkeeping officer
- The candidate's ability to communicate in English or Swedish and English

Language skills were also highlighted during the interviews and the pilots stated that a master that cannot communicate with other vessels poses a great danger. Nevertheless, the question is how these types of criteria should be measured and who should set the criteria. However, the criteria identified above are measurable provided that there are set criterion to measure against, but it also means that there will be many more criteria to consider compared to the criteria today. This is not going to be a set of rules to follow as requested by the Swedish Maritime Safety Inspectorate (now the Transport Agency) and by the respondents. At the same time it gives the opportunity for individual assessments of the vessels. This also means that vessels which have inadequate equipment, staffing or language skills could be subject to pilotage, as recommended by some respondents. Other criteria that emerged from the literature studies were poor visibility, inclement weather and icy conditions. These factors can also be used as risk-based criteria, but it may be difficult to set boundaries for them. The criteria are however measurable, which otherwise was an argument against the introduction of more risk-based criteria. It seems to be possible to have these types of criteria and an example of this was that there are visibility and wind restrictions for PEC in Germany.

Similar factors were identified in the literature and at the interviews which indicates that there are similar aspects of what might be considered as more risk-based pilotage criteria. No proposals concerning the design of the fairway were suggested. This is another factor which could be considered as a possible criterion. All respondents were opposed to more risk-based criteria, and both the respondents and SOU 2007:106 stressed that the current criteria are risk-based in the sense that they are developed in terms of length, width and depth in relation to the fairway and with regard to dangerous cargo. The criteria have further been adapted over the years, and respondents also pointed out that it is possible to have PEC which means that there is some flexibility in current regulations.

The question is whether there is a need for more risk-based criteria for pilotage and what consequences it would have for the shipping industry with more risk-based criteria. Based on the results, the introduction of more risk-based criteria would probably meet resistance and not even the Swedish Maritime Safety Inspectorate (now the Transport Agency) supported a more risk-based criteria for mandatory pilotage. If the opinion would change and hence, more risk-based criteria are a possible alternative, it is important to analyze how changes in pilotage criteria would affect the entire shipping system, see Section 8.3. One example is how the cost of pilotage would be affected by more risk-based criteria, as the cost of a pilot was one of the arguments for not taking a pilot. If the number of users of the pilot would decrease it could result in more expensive pilotage for those who still have to have one (Hadley, 1999).

# 9 Discussion

*This chapter contains a discussion of whether the questions in this report have been answered and the problems that arose. This is followed by a discussion of the methods that were used and the sources are critically reviewed. Reliability and validity are also discussed.*

## 9.1 Have the questions been answered?

In order to answer the main question "how does pilotage contribute to maritime safety" a definition of maritime safety was required. It therefore became a sub-question and it proved difficult to find an official definition of maritime safety. A starting point was to use relevant literature to find a definition since there was no explicit official definition. A scientific description of safety was used as a starting point, and the description of the safety based on resilience engineering was applied to maritime safety. This study of safety proved to be valuable on several levels and it developed the author's understanding of safety. It also gave another dimension to the concept of maritime safety, as this description differed from the descriptions in the literature studied and the results of empirical studies. The traditional view of safety and accidents seem to be prevailing among the respondents and in the literature, and this has a major impact on the perception of safety, accident statistics and accident reports.

The view of accidents in both statistics and accident reports showed strong similarities to what Hollangel (2004) described as the traditional view. From this approach, accidents are caused by human errors, malfunctions and failures in the system. To find the cause, it is necessary to identify where people made incorrect assessments and took wrong decisions and accidents can be prevented by barriers. This approach seems to be the prevailing one. Hence, accidents were seen as something that can be planned out and barriers can be placed in order to prevent accidents and ensure that people cannot make the mistakes again. However, perfection, no errors, error-free performance and infallible people are unreasonable expectations  (Weick & Sutcliffe, 2001). The author agrees with Dekker (2006) who argued that to understand a failure it is necessary to study the whole system and it is logical to perform an act in the context that it was performed, instead of dividing the system into parts and trying to identify components that failed. As a result, maritime safety could, like safety, be described according to the theory resilience engineering as:

> *have and maintain control over a situation, but also to be flexible and adaptive and to adapt the system to a changing world*

Although this description may be perceived as vague, it gives a relevant and comprehensive description of safety that could be used to describe maritime safety. This description gives another view of maritime safety, which in turn can affect the accident statistics and accident reports because the system as a whole is studied, including why human behavior was logical in the context it was performed. This is based on Hollnagel (2004) who argued that humans constantly have to make adjustments that are logical in the context in which they are performed, but when combined unexpected interactions may occur. All the components may work individually, but it is the unexpected combinations of adjustments that cause accidents. This means that accidents are caused by complex combinations of system variations rather than by the failure of individual components. This is also the core of the systemic models and the benefit is that the system as a whole is analyzed.

Thus, the question "what is maritime safety" has been answered, partly by description from the interviews and the literature and partly from a scientific perspective. It has also provided a deeper understanding of safety and accidents, and resulted in suggestions for changes in the maritime industry.

Much time was spent on answering the main question for this report, namely "how does pilotage contribute to maritime safety". The factors identified in the literature and from the empirical studies were conclusive and therefore assumed to be reliable. However, pilotage has a long tradition and hence there might be a general opinion that pilotage contributes to improving safety, and this may affect the results to some degree. However, the factors that emerged in the empirical studies as well as from literature studies were analyzed from the resilience engineering perspective, which gave another dimension to the contribution of pilotage to maritime safety. The main question "how does pilotage contribute to maritime safety" is therefore answered from a complexity perspective. The question "what are the safety-enhancing factors of pilotage" is similar to the main question and has therefore been answered in a similar manner as the main question has been answered.
Although the importance of technology for maritime safety was not a question, it was inevitable that this issue was raised. However, this matter was not investigated further since it was outside the scope of the report.

The questions of whether "the pilotage criteria used today can be more risk-based" and "what criteria can pilotage exemption be based on" were more difficult to study compared to the other issues. It was also difficult to comment on these issues due to the main investigator's lack of nautical skills / experience and that is the reason that the respondents' answers were compared with the literature. Hence, the questions are answered in these contexts, but if this report would be done again this issue should be subject to its own investigation. The results can still be used by staff, for example by the Transport Agency or the Maritime Administration who are better placed to comment on such matters. However, the Transport Board, then Sjöfartsverket, has already commented on this matter and did not support the proposal for a more flexible framework for pilotage. They have at the same time suggested that vessels with a gross tonnage of over 300 listed on the Paris MOU black list could be subject to mandatory pilotage, which could be seen as a form of risk-based pilotage criterion. If the opinions about this matter change in the future, it is possible that the results from this study will also be changed as it partly is based on interviews. This is a limitation of this study.

This limitation is valid for all the results in this report since the conclusions are based on pilotage activities today. So changes in the future may result in different conclusions. There are also a number of inquiries about the future of pilotage that the reader should be aware of. Two examples relating to maritime safety that may change the conditions are navigational assistance from shore, and if pilotage should be run by the authority or by private companies. Such changes should be analyzed from a systemic perspective to investigate how different changes affect the overall system. The importance of this was analyzed in Chapter 8.3 and the same applies in case of change of pilotage criteria.

## 9.2 Criticism of sources and methodological reflection

Several methods and techniques were used to analyze the complex systems, in which pilotage is performed, from multiple perspectives. Thus, the objective of the study, under section 1.2, is satisfied. The aim was to have a transparent process to provide an opportunity for readers to discuss the results based on methodology and choice of techniques. The methods and techniques that have been used are discussed below and examined critically.

### 9.2.1 Literature study

The literature studies were considered to be a good method of obtaining a scientific report with a width beyond the empirical studies, accident statistics and accident reports. The literature was collected and chosen systematically and the literature that was used was considered relevant in this context. The scientific literature gathered from scientific databases was considered to fulfill the requirements of objectivity and impartiality. The books, reports and studies that were considered to meet the requirements of science, were scientific papers or technical reports. Although these are secondary sources they were considered reliable since the authors of such papers and reports are assumed to have been careful to examine, verify and compare all data.

Primary sources consisted partly of laws and regulations and partly of the statistical database SOS. These were judged to be reliable, but even if accident reporting is regulated there might be underestimates of the accident database. Literature from the authorities, such as the Maritime Administration, the Transport Agency and the Swedish Civil Contingencies Agency (Myndigheten för samhällsskydd och beredskap, MSB) was also assessed as reliable.

### 9.2.2 Interviews

Interviews were considered to be a good way to reflect reality and hence broaden the work. The interviewed group consisted of four pilots, two VTS operators, a pilot operator and two masters holding a PEC. This is considered as a group that has a basic positive attitude towards pilotage. During the interviews it was noted that all respondents had similar responses. Although the respondents are working in different fields they have the same basic training, which may have affected their responses and this might be a reason that the responses are similar for the different occupational categories. Furthermore, particularly the pilots have an interest in the issue, but since their answers were similar to other respondents it is assumed that their responses may still be relevant. However, pilotage has a long tradition and it may be difficult to question the significance of something that has always existed and this may also have influenced the responses. Since the results are based on interviews of nine persons, which is a relatively small group, their representativeness can be questioned. Nevertheless all respondents gave similar answers, regardless of profession, which strengthens the theory that this sample represents the general views in these professions. More factors would probably have emerged if more interviews were to be conducted, especially if a broader representation from the masters in the merchant fleet had been interviewed. However, the results were used to get an indication and they were compared with the other results of this study to investigate their relevance. However, parts of the literature are based on interviews which have the same limitations as the interview results and they can therefore not complement each other fully.

### 9.2.3 Participant observations during pilotage

Participant observations were undertaken in order to study a small part of a major course of events and these observations were assumed to represent the rest of Sweden. This was considered a good method to study pilotage activities in reality since it gave the opportunity to interpret various events. However, only one or a few observations cannot represent a complex and changing reality and a potential source of error is that the studied events do not represent all possible situations, which means that some factors have been omitted. These participant observations have provided a subjective basis, which may be another possible source of error. The primary investigator's personal experience and what they have read about pilotage before participating in pilotage may have affected attempts to be objective. It means that the investigator may have been influenced by the general view that seems to prevail in the maritime industry, namely that pilotage contributes to maritime safety. The results from the participant observations were supplemented by other sources and compared with the results from the literature study and the interviews. The results from the participant observation have the same level of reliability and relevance of the interviews.

### 9.2.4 Accident statistics

There are a number of weaknesses with the study of statistics in the SOS as emphasized by the Swedish Maritime Safety Inspectorate (Sjöfartsinspektionen, 2008b) which also pointed out that it was not possible to continue the assessment without more knowledge of traffic and therefore it was impossible to draw any conclusions from the statistics. Although the study of statistics was more comprehensive, there are still shortcomings. The statistics are based on SOS, but since the pilots and many shipping companies have their own internal reporting system, it means that accidents have to be reported in two systems. This may affect the number of accidents that are reported to the SOS. Another problem is that reality is complex and cannot fully be represented in the SOS. This means that there are weaknesses in the description of the causes of the accident and text describing if the pilot was on board or not, or if the master had a PEC. At the same time there are numerous issues in the SOS to be answered, suggesting that SOS tries to capture the complexity. Furthermore, it is a simplification just to compare the number of accidents with and without a pilot and the accident where the master had a PEC, because pilots and PEC are only involved with a relatively small percentage of the total number of vessels. Thus there are a large number of occasions when pilots are not on board when accidents can happen. To make a fair comparison, details are needed for the number of pilotage services, the number of calls without a pilot, and the number of passages with vessels where the master had a PEC for various defined areas and for each year. It also requires data on the number of vessels that only pass the area since they may also be involved in accidents in the area. This information can be compared with the number of accidents in each category and then it is possible to make comparisons between different areas of the country and from year to year.

There are a number of possible sources of error in the statistics, but at the same time the statistics gave an actual number which makes it easier to make comparisons between years and see trends. Underestimates of accidents and incidents is another potential source of error in the statistics, which means that statistics are not completely accurate. This means that it is even more difficult to draw conclusions from statistics and hence the results from the statistics were seen as indications.

### 9.2.5 Accident reports

The accident reports are seen as secondary sources and the results presented in these are based on the investigators' choice of accident model and the perception of the accident as well as the information that the investigator has received from those involved. To investigate how pilotage contributes to maritime safety by studying these reports would mean that it will be an assessment of an assessment. However, this was not the main reason that conclusions were not drawn from the study of the accident reports, as this limitation applies to all types of investigations. One reason was that accident reports did not expressly make any assessment of the pilot's role on board, which could have been used to investigate the piloting contribution to maritime safety. Another reason was that the principal report author considers that they do not possess the nautical skills required to make such an assessment. The pilot's role was only evaluated for two of the studied accidents by a former investigator at Transport Agency at the time of this report. To get an indication of how pilotage contributes to maritime safety more assessments are needed. There are more evaluations available for other accidents, but they have not been studied further since it is outside the scope of this study. However, these assessments do not include evaluations of the factors that pilotage can contribute with. The assessments could be extended by describing how a pilot could influence or prevent the course of events.

To investigate if the accident reports were a reliable and valid tool to answer the questions, a comparison were made with the accident theory in section 3.5.This comparison indicates that the accident reports that were studied are based on, what Hollnagel (2004) called, epidemiological models.

A combination of several factors were often mentioned as the cause if the accident in the accident reports that were studied and the recommendations in these reports normally involved organizational factors. The recommendations for RS 2009:04 Listerland and cargo vessel Vinga - Sjan were for example to develop standards for conditions of restricted visibility in Södertälje Canal and revise training plans for pilots on sailing in fog and that the VTS should review their procedures to obtain necessary information for unexpected maneuvers of vessels in the VTS area.

According to the epidemiological models, accidents can be stopped or prevented by barriers. The Swedish Accident Investigation Board (SHK) have adopted a barrier analysis in the accident report RS 2008:01 for M/T Brovig Breeze, in which the VTS and the pilot's role as barriers were analyzed. Barrier analyses are present in other accident reports as well, for example, Report RS 2008:02 by SHK, but these have not been used since they are outside the scope of this report. There are no barrier analyses in the other reports that were studied but there have been recommendations that are comparable to barriers such as rules and routines. Since the SHK has introduced a barrier analysis they propose that epidemiological models should be used. This led to the question: are epidemiological models are best suited for analyzing maritime accidents?

The maritime industry was described as a complex system in section 3.5 and systemic models are theoretically better suited for accident investigations in these types of cases since they analyze the system as a whole and take into account that accidents are caused by complex relationships rather than have one cause. A combination of several factors was often given as the cause of the accidents in the accident reports that were studied. The report about Brovig Breeze contained a description about the events based on the master, the pilot, VTS operator, the agent and the company. This suggests that the accident reports, particularly the one for Brovig Breeze, have tried to take the complexity into account.

From a strictly scientific perspective, it is easy to state that accident investigations always should be made with the best theoretical model. The accident reports should theoretically be based on an accident model that is appropriate for the investigation. This means that if a complex system is to be analyzed, a systemic model should be used, or alternatively an epidemiological or a sequential model can be the most suitable one.

In reality, there are limitations in terms of time and resources. There may also be difficulties in collecting the underlying data. Shipping is an international business which means that an unfortunate vessel may be registered in one flag state, have crew from another flag state and the shipping company could be in a third flag state. This complicates the investigations further. These limitations have to be taken into account, but it could also be relevant to do some sort of cost-benefit assessment to compare the costs and benefits of using an epidemiological model compared to a systemic model or a combination thereof.

If systemic models would be used for accident reports, it would probably require further and hence longer investigations, for example, to depict a variety of perspectives. More comprehensive reports also require more time and resources devoted to this. Further the reports will always be based on the investigators' assessments, and there will always be a limited basis from which to draw conclusions. Another important aspect to consider is that the accident reports are primarily written for the maritime industry. However, a systemic accident model does not require a more "scientific report " in the sense that they would be scientifically designed, or for that matter, more difficult to read. It is important that such investigations are easy to read, like now, and that they are adapted to the target group involved, in this case the maritime industry.

Finally, this discussion above about the systemic models assumes that safety and accidents are based on a resilience engineering perspective. This means that the system as a whole is studied including why it was logical to perform an act in the context it was performed. The book *A Field Guide to Understanding Human Error* by Dekker (2006) provides concrete suggestions on how a business can change and adapt its approach and this book can tentatively be used as an inspiration.

## 9.3 Reliability and validity

Both reliability and validity must be considered in scientific studies. Reliability means the reliability and usefulness of a measuring instrument and of the unit of measurement (Ejvegård, 2003). This means that a study should give the same results when it is implemented again. If a study is influenced by chance it is not reliable (Bryman, 2006). Validity means measuring that which is supposed to be measured (Ejvegård, 2003). Hence, it means to make an assessment of whether the conclusions in an investigation are related to the observations and the theory (Bryman, 2006).

However, the requirements of reliability and validity are primarily focused on quantitative research and therefore, these are not entirely relevant in evaluating qualitative research. This thesis is primarily qualitative and hence, the requirement of reliability and validity are not appropriate. However, the requirements for reliability and validity are met to some extent.

Data from the literature study, accident reports and accident database are considered to be reliable as they are based on facts that should produce similar results if the investigations were to be repeated.

Most of the literature was scientific, but some of the reports were based on interviews and personal opinions, which means that their reliability is questionable. This gives at the same time a breadth to the results when compared to interview results and this allows for more opinions to be taken into account. The results from the semi-structured interviews do not have high reliability in the traditional sense as it is individually what respondents think about the various issues and the respondents also have an interest in the matter. In addition, the way questions and follow-up questions were asked may also have affected the responses.

The results of participant observation are not considered reliable as these depend on several factors such as the pilot who carried out the pilotage, the type of vessels using pilot service, the crew, weather and wind conditions as well as several other factors.

Therefore, it is unlikely that these studies would give exactly the same results if they were to be repeated. However, the respondents reported similar responses which indicate that there still exists a certain degree of reliability in this particular study. Accident statistics and accident reports may give the same results if they were to be studied again and are therefore considered reliable. The conclusions may be interpreted differently if more facts were accessible. Also, persons with more nautical skills may be able to identify more contributions from the pilot in the accident investigations.

Validity refers to whether the methods used are measuring that which is supposed to be measured. Neither accident statistics nor accident reports fully satisfy the requirement of validity because it was difficult to use these to evaluate how pilotage contributes to maritime safety. It was also difficult to determine whether interviews and participant observations measure what was intended, but the validity pursued in the formulation of interview questions. Moreover, the semi-structured interview that was conducted is an established interview form.

# 10 Conclusion

*This chapter contains the conclusions of this report. The intention was to answer the questions in section 1.3. However, this is a limited study and the results should be used with caution until more extensive studies are completed.*

## 10.1 What is maritime safety?

This study showed that maritime safety should be equal to safety based on the theory resilience engineering. Maritime safety can then be described as to have and maintain control over a situation, but also to be flexible and adaptive and to adapt the system to a changing world. To understand accidents it is important to understand the human behavior in the context it was performed.

## 10.2 What are the safety-enhancing factors of pilotage?

A number of factors were identified. These were:

- Expertise
- Local Knowledge
- Experiences
- Ability to make risk assessments
- Local language skills
- Advisory role
- Function as relieving resource

## 10.3 Can the pilotage criteria used today be more risk-based?

Based on the interview results and the literature study, the current criteria for mandatory pilotage are reasonable and there was no apparent need for more risk-based pilotage criteria identified among the respondents. However, this issue should not be considered complete and could be investigated further by people with nautical skills and experience.

## 10.4 What criteria can pilotage be based on?

The criteria presented can be used as a basis for further discussion of risk-based pilotage criteria.

- Vessel dimensions, design and maneuverability in relation to the fairway and port
- Ship and especially the bridge equipment
- Ship design in agreement with cargo load
- Crew and watch schedule on the ship
- The bridge team competence/s
- The bridge team experience in the Swedish coastal waters as master and watchkeeping officer
- The bridge team ability to communicate in English or Swedish and English

## 10.5 How does pilotage contribute to maritime safety?

According to this limited study the conclusion is that based on the theory of resilience engineering, the pilot is well placed to contribute to maritime safety as the pilot can adapt the system to new conditions. The pilot must therefore be flexible and adaptive to be able to have and maintain control over the system. The pilot should also be seen as an artifact of the overall maritime safety system and thus the pilot affects the performance of the overall system.

# 11 Suggestions for future research

*This chapter presents suggestions for further research.*

Further research about the perception of maritime safety in the whole maritime industry is required to be able to draw more reliable conclusions. As a suggestion, this matter could be investigated further by studying other areas in the maritime industry, from sailors to the legislative institutions and agencies involved in maritime safety. The theory of resilience engineering may serve as a starting point. One proposal is to examine whether and how this would affect the accident investigation process. Another important area to investigate is the practical difficulties it can pose to implement this interpretation of maritime safety. An additional suggestion for further research is to explore cultural differences between the flag states and whether and how it affects safety.

The issue with risk-based pilotage criteria should be investigated further by people with nautical skills. One suggestion of is to determine the impact that such criteria may have on the entire maritime system, such as number of accidents, how the criteria affects PEC and economic consequences.

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