Stability of beam trawlers

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Ministerie van Infrastructuur en Waterstaat

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Note of the authors

Groningen, November 24th, 2022

This report is dedicated to the crews of the beam trawlers involved in the accidents we investigated and those of them, who did not return. With this report, we want to contribute to the safety of their colleagues. Below you will find pictures of the beam trawlers that capsized and sunk.

















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Abstract

Since the start of beam trawling and growth of beam trawling in the 1960's, every now and then capsizing accidents with fishing vessels happen. Especially accidents with beam trawlers (in Dutch: "boomkorkotters") have happened with alarming frequency.

After the two most recent capsizing incidents, with UK-165 'Lummetje' and UK-171 'Spes Salutis', the "Onderzoeksraad voor Veiligheid" (OVV - Dutch Safety Board) concluded that more extensive research needed to be done on the stability, stability rules and stability failures of beam trawlers.

Because of our expertise in the field of ship stability, the Ministry of Infrastructure (Ministerie van Infrastructuur en Waterstaat) has assigned Conoship International to perform the research on the stability of beam trawlers. The following research goal was defined:

Establish the risks of capsizing and sinking induced by asymmetrical loads, for fishing vessels within the Dutch beam trawler fleet.

For this investigation 19 accident reports of capsized beam trawlers were analyzed. (chapters 2 and 3). Also an inventory was made of the applicable regulations (chapter 4), the beam trawler fleet of the EU and the UK. (chapter 5) and safety systems (chapter 6).

Soon after the start of the investigation it became clear that the stability information required by the authorities only consists of loading conditions during sailing from port to the fishing grounds and back. None of the fishing conditions are mentioned in the stability booklets, so an approved stability booklet gives no information at all on the stability of the vessel during fishing operations. Although this fact has been mentioned in several investigations over the past 50 years, no specific additional requirements have been added to the regulations, depriving the fishermen of literally vital information!

In order to qualify the stability risks during the fishing operations a qualitative assessment was made of the effect of various factors on the stability during fishing operations. This assessment was based on the Failure Mode Effect Analysis (FMEA) method.

The factors affecting the stability were divided in 'hard factors', that could be incorporated in the stability calculations and 'soft factors'. Hard factors are for example the position of the derricks, symmetrical and asymmetrical loads, wind and waves. Soft factors are for example training of the crew, available stability information and law enforcement by the authorities. The used method results in risk ratings for each factor. Combining these risk ratings give the risk rating for operational situations. Chapter 7 describes the FMEA-based analysis of the stability.

The results of the FMEA-based analysis were used to identify the fishing conditions for which the stability needed to be calculated. For each conditions the heeling moments caused by fishing activities and external factors (waves, wind etc.) were calculated. This was subtracted from the righting moment in the basic loading condition *Departure from fishing grounds, 100% Catch, 50% Consumables derricks in store position,* resulting in a remaining righting moment. This was the quantitative analysis (Chapter 8).

In chapter 9 the results of chapters 7 and 8 were analyzed. This resulted in risk ratings for various fishing operational conditions, the remaining righting moments for these conditions and the relation between these remaining heeling moments and the heeling moments required by the criteria of the regulations. All three items were shown in so called 'score cards': Appendix XVI: 'Combined risk ratings score card', Appendix XXII: 'Score card of remaining righting moments' and Appendix XXIII: 'Score card for remaining righting moments compared to the regulations'

The following conclusion are written in chapter 10:

- In the basic condition (Departure from fishing grounds, 100% Catch, 50% Consumables, derricks in stored position) without wind and waves, the vessels < 24 meter have approximately 10% of the remaining righting moments of the larger vessels. The beam trawlers < 24 m do not only have considerably less remaining righting moment in the basic condition, they are also significantly more vulnerable to weather and fishing conditions;
- In the situation with empty nets and no wind or waves, just moving one derrick from 80 to 45 degrees causes an asymmetrical load on the vessels, resulting in 25 – 67% reduction of the remaining heeling moments. The effect of other asymmetrical conditions is far greater.
- The loss of one fishing gear reduces the remaining righting moments of the vessels by 20 – 30% in the operational condition without wind and waves. The remaining righting moments in this situation, compared to the righting moments required by the regulations, range from 90% for the larger beam trawler, to 40% of the required righting moment for the 20 m beam trawler with heavy gear (Sole-gear).
- In 25% of the examined operational conditions the vessels have **no remaining righting moment**. Examples of these conditions are:
  - Most operational conditions in wind force 6 Bft. with a longitudinal wave, for all beam trawlers except for the 43 m trawler with light gear;
  - All situations where a one fishing gear skips over to the other side, for all vessels;
  - For most vessels < 24 m: wind force 10, with wind gust and water on deck in most operational conditions
- In 11% of the examined operational conditions the vessels have a remaining righting moment of less than 20% of the required value. The vessels > 24 m have considerably less situations where this happens. Would the extra 20% stability for beam trawlers not be required, this 11% of the examined situations would have no remaining righting moment anymore. The origin of the 20% extra stability requirement could not be traced.
- On the other hand: Not complying with the criteria of the regulations does not automatically mean that the vessel has no remaining righting moment left.
- The stability in longitudinal waves with a wavelength equal to the length of the vessel decreases rapidly. Especially for smaller vessels (<24 meters) the most unfavorable wave heights occur at relatively smooth seas at wind force 3-6 Beaufort, making these smaller vessels particularly susceptible for this phenomenon.
- The conditions during fishing are not included in the stability information made available to the crew. Stability booklets only contain information on four loading conditions during sailing. Although it is requested to include any other, regularly happening condition, that is unfavorable than these conditions, no fishing conditions (lifting of the nets, moving derricks etc.) are included.
- The effect of enlarging derricks by 1 meter reduces the remaining righting moment with up to 7 %.
- For the beam trawlers < 24 m the effect of the storage of the stern trawl gear on the net drums is significant: it reduces the remaining righting moment 3 – 5 % . The effect on the larger vessels is far less: < 1 %.
- None of the wind contours included in stability booklets examined during this investigation were accurate: Regularly derricks, standing rigging and radar masts were missing. Correcting this resulted in an average increase of the wind heeling lever of 15%;
- Mitigation of the risk can partly be done, mainly by training of students and crew and also by law enforcement and review of stability information.
- **For all aspects considered during this investigation, beam trawlers < 24 m prove to be far more vulnerable than the vessels > 24 m.**

These recommendations were given in chapter 11:

- Since the remaining righting moments are quickly decreasing above wind force 6 Bft. for the vessels examined, it is recommended to determine the limit of the wind force for the fishing operations for each vessel;
- In order to provide the fishermen with adequate information, developing guidelines for stability criteria during fishing operations is recommended, taking into account the fishing conditions in a way comparable to guidelines for other vessel types, such as the lifting code. This is best done together with other national authorities of the EU and UK.
- Since training of students and crew is of the utmost importance, special bridge simulators for beam trawlers must be used for training. They are being developed, amongst others by MARIN.
- An active safety system like the Marelec system significantly enhances the safety of the beam trawlers and also supplies data to the fishermen, enabling them to make the fishing more efficient. Since this is an expensive system, support from the authorities can help.
- The gap between the way the stability information is presented and the need of the crew is to be closed, stability information and training must be more accessible;
- Inspections on alterations of the vessels that influence the stability, such as added masts, lengthened derricks or stern trawl gear remaining on board during beam trawling have to be intensified;
- During document review more attention has to be given to the items included in the wind contour.
- Based on the new insight of the risks during operational conditions, risk-based designing will help to make beam trawlers safer;
- The dynamic effects of waves must be further investigated to assess the resulting stability risks.

Glossary

Definitions	
Cod-end	End of the net containing the catch. In Dutch this is called the 'kuil'

Abbreviations	
BadZ	Bekendmaking aan de Zeevisvaart (Announcement to the Sea fishing sector)
FMEA	Failure Mode Effect Analysis
IL&T	Inspectie Leefomgeving & Transport
IMO	International Maritime Organization
LCG	Longitudinal Centre of Gravity
LOA	Length over All
LSW	Light Ship Weight
MCA	Maritime and Coastguard Agency
PIAS	Program for the Integral Approach of Ship Design (stability software that is used)
PS	Portside
SB	Starboard
TCG	Transverse Centre of Gravity
VCG	Vertical Centre of Gravity
Vvb	Vissersvaartuigenbesluit

Contents

1 Introduction

Since the start of beam trawling and growth of beam trawling in the 1960's, every now and then accidents with capsizing fishing vessels happen. Especially accidents with beam trawlers (in Dutch: "boomkorkotters") have happened frequently in Dutch waters. Fishing with a beam trawl (bottom trawling with booms over the sides) is very common for the Dutch fishing fleet.

After two recent capsizing incidents, with UK 165 Lummetje and UK 171 Spes Salutis, the "Onderzoeksraad voor Veiligheid" (OVV - Dutch Safety Board) concluded that more extensive research needs to be done to the stability, stability rules and stability failures of specifically beam trawlers. The report of the OVV had a major impact on the Dutch fishing sector, supporting the need for and importance of further research.

To further emphasize the importance of further research and measures, the following fact is interesting: The average fatality rate in the fishing industry in the UK[1] in the 1998-2000 was almost 2 per 1000 fishermen/year (MAIB, 2002, p. 33). The traffic fatality rates in the UK and Netherlands are very similar and in 2000 were 0.1 per 1000 road users (CBS and UK government) (which dropped to about 0.05 per 1000 road users in the year 2021 due to concrete safety improving measures). So, the fatality rate among fisher men is roughly 20-50 times higher compared to road users.

Because of our expertise in the field of ship stability, the Ministry of Infrastructure (Ministerie van Infrastructuur en Waterstaat) has assigned Conoship to perform the research on the stability of beam trawlers. The following research goal has been defined:

Establish the risks of capsizing and sinking induced by asymmetrical loads, for fishing vessels within the Dutch beam trawler fleet

The research has been subdivided into the following phases:

1. Inventarisation phase: reported in chapters 2 – 6;
2. Calculation phase: reported in chapters 7 and 8;
3. Analysis phase: reported in chapter 9;
4. Conclusions and recommendations: reported in chapters 10 and 11.

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[1] The fatality rate among fishermen in the Netherlands could not be found. It is assumed to be similar to the UK.

2 References

In order to be able to assess the stability risks during fishing, a reference study was carried out. This chapter provides an overview of the references that have been used. The documents have been categorized into the following categories:

Category	Number of reference documents
Accident report	15
Stability	10
Resistance & propulsion	6
Fishing gear	16
Economics & efficiency	3
Design	2
Regulations & definitions	20
Education	8
Safety	1
Not categorized	5
Total	86

Table 1: Overview of reference documents collected for this study.

A complete and detailed list of references is found in Appendix I. The most relevant categories, considered being the accident reports and regulations, are treated in the paragraphs below.

2.1 Accident reports

A total of 19 accident reports of specifically floodings and capsizing accidents have been analysed. A summarized overview indicating flag and main dimensions, is shown below. Multiple Western European countries are featured. However, it is important to realize that this is only a small fraction of the total amount of accidents occurred in these countries over the past decades. It only consists of flooding and capsizing accidents, which is a category among others such as machinery failure or fire.

Ship's name	Flag	Loa	B	Year of construction	Date accident
UK-165 Lummetje	Dutch	19.75	5.30	1986	28-11-2019
UK-171 Spes Salutis	Dutch	23.46	5.80	1963	9-12-2020
Z-19 Sonja	Belgium	30.70	7.27	1974	25-8-2018
O-13 Morgenster	Belgium	23.94	6.00	1989	7-11-2018
fv Flamingo	Belgium	23.82		1988	7-7-2002
N-28 Mooie Meid	Belgium	19.60	5.60	1989	2-3-2011
Z-122 Noordster	Belgium	23.78	6.08	1985	13-12-2005
Z-85 Morgenster	Belgium	23.82	6.00	1996	28-1-2015
Z-700 Rapke	Belgium	16.80	5.06	1996	20-4-2011
Z-582 Assanat	Belgium	21.00	5.43	1961	27-12-2016
NN194 Catrina	UK	13.92	4.84	1991	13-10-1998

SM74 Sally Jane	UK	13.60	4.86	1990	17-9-2013
PH409 Pescado	UK	22.00	5.83	1956	25-2-1991
BM148 Margaretha Maria	UK	22.80	5.82	1958	11-11-1997
WR15 Pieter Cornelis	Dutch	21.42		1960	16-8-1995
OD52 Jet	Dutch	16.18	4.02	1962	6-11-1997
WR22 Barend Jan	Dutch	22.27		1956	3-6-1998
PH199 Solstice	UK	9.90		2000	26-9-2017
SB14 CONDOR	Germany	16.10	5.1	1943	6-2-2016

Table 2: Overview of analyzed accident reports.

Chapter 3 describes in detail the main causes of capsizing and flooding, the key elements and failure modes and accident statistics.

2.2 Regulations

Summarized, the list of references about regulations consist, among others, of the following:

- IMO stability criteria: IS 2008 code, etc.
- Several Marine Guidance Notes (MGN) documents issued by the MCA;
- Dutch regulations; Vissersvaartuigenbesluiten, Bekendmakingen aan de Zeevisvaart (BadZ)

The inventarisation and more detailed overview of the relevant regulations is found in chapter 4.1.

2.3 How fishing works

To get a better understanding of how fishing with beam trawlers works, the lecture *Vissen met korren* was consulted on the website Vistikhetmaar.nl. and internet research was done. After that, the everyday practice of fishing was discussed during several meetings with fishermen.

The following is observed and can be concluded about the operation and operational conditions of the vessel:

- When hoisting the nets, the derricks are raised to 30 – 45 degrees by default; lifting only the weight of the fishing gear or also the weight of the catch. The vessel with raised derricks is therefore considered to be a very common operational condition;
- When a fishing net is hauled in, the cod-end[2] it is pulled in on the line called lazy-deckie, attached at center line at the top of the mast;

In *The Stability of Beam Trawlers* (Wolfson, Unit, 2001), the following fishing gear handling procedures are identified. For each procedure, they describe the working and the risks involved.

1. Shooting the gear
2. Trawling
3. Raising the gear
4. Boarding the Cod-end
5. Retrieving heavy gear
6. Freeing fastened gear
7. Boarding the gear

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[2] Cod-end is the last part of the net containing the catch. In Dutch called the ‘kuil’.

3 Accident reports

This chapter focuses on the accident reports. First, a number of accident statistics are shown. Then, the main causes that could be extracted from the accident reports are mentioned and then the key elements and failure modes that were extracted from these causes are described.

In chapter 2.1, a summarized overview is found of the accident vessels that have been considered and analysed. A complete overview of analysed accident reports is found in Appendix II.

As the focus of this investigation is on beam trawlers, most analysed accidents feature a beam trawler. However, also two non-beam trawler vessels have been considered: Trailer Suction Hopper Dredger (TSHD) Spauwer (flooded in 1995) and Stern Trawler PH199 Solstice (flooded in 2017), as those reports contain several interesting elements. Those are described in more detail in chapter 3.4.

3.1 Accident statistics

Below, statistics from analysed accident reports are presented, providing a better understanding and context of the analysed accidents.

3.1.1 Number of fatal casualties

First, the severity of the accidents is shown by the number of fatal casualties. This once more clearly emphasizes the need for measures. What do we find acceptable?

Number of fatal casualties: from the number of 19 investigated accident reports, covering a period of 1991 – 2020, the total number of fatal casualties is 34. Resulting in an average of 1.8 fatal casualties per accident. The diagram below shows that more than 50% of the accidents feature one or more fatal casualties.

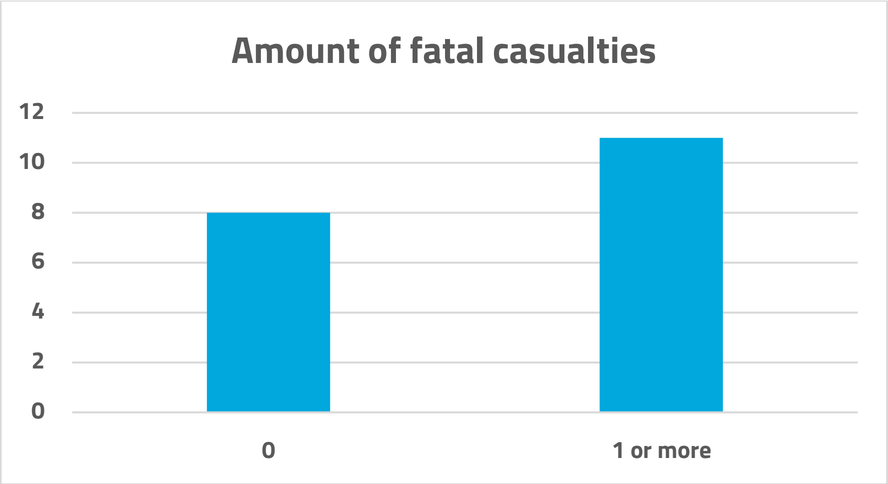

Figure 1: Amount of fatal casualties involved in the analyzed accidents.

3.1.2 Countries involved

Several countries appear in the accident reports, of which: The Netherlands, UK, Belgium, Germany. See Figure 2.

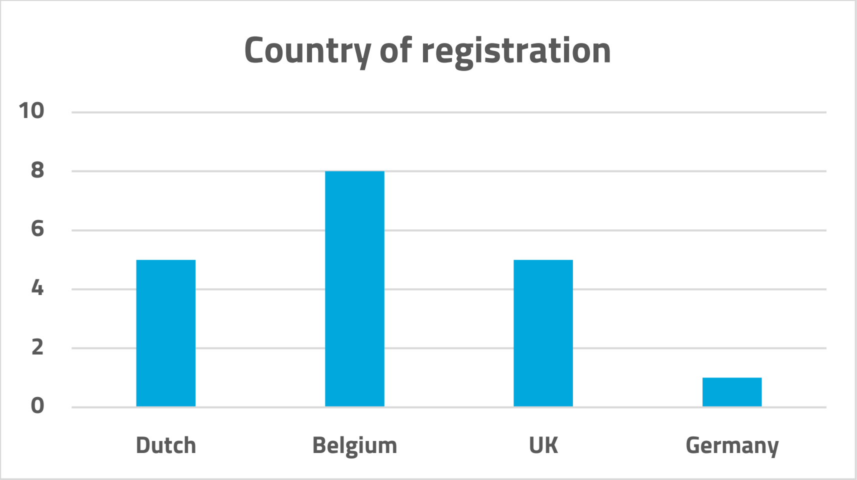

Figure 2: Countries that appeared in the analysed accidents.

3.1.3 Dimensions of the vessels

Except for one, all vessels involved in these accidents have a length of less than 24m. This is presented in Figure 3, indicating the length/breadth ratio of the vessels.

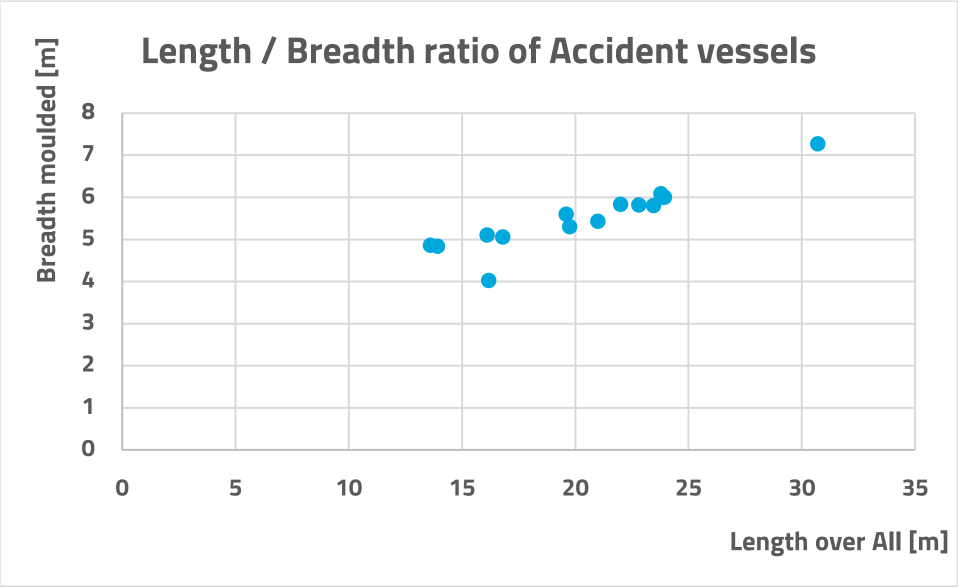

Figure 3: Length/Breadth ratio of accident vessels.

To provide more context this data is plotted in a graph resembling the EU + UK beam trawler fleet. See chapter 5, in Figure 8. This indicates how the wrecked vessels compare to the entire EU + UK fleet.

3.1.4 Involvement of asymmetrical loading

From the accident reports, it has been extracted if the capsize was caused by asymmetrical loading; either if one of the nets got stuck, a difference in cargo weight in one net compared to the other, or asymmetrical loading on deck. It can be concluded that in 47% of the cases, asymmetrical loading definitely played a key role. And in at least 74% of the cases asymmetrical loading definitely or possibly played a key role. This is illustrated in Figure 4.

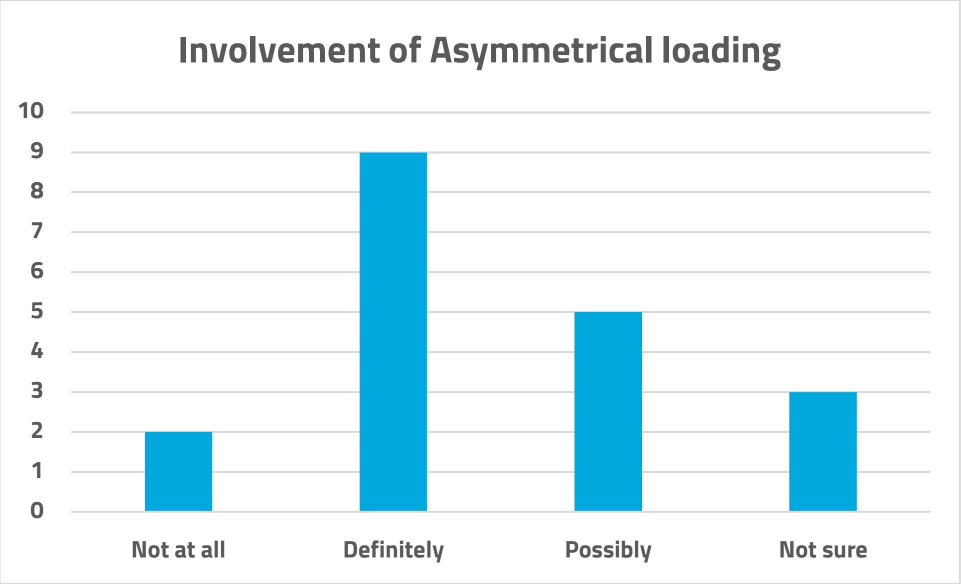

Figure 4: Involvement of asymmetrical loading in the analyzed accidents.

3.2 Causes of capsizing and flooding

Mainly, the following direct causes of capsizing were identified:

- Crew hoists the nets above the water and both nets contain a large, or even excessive, weight, resulting in a dramatic loss of stability or even a negative initial stability. Then only a small disturbance is enough to make the vessel capsize.
  - Important element here is that the crew often continues hoisting, even if it is clear that the weight is excessive, because the catch is too valuable to let go. There are even examples that one winch broke due to excessive load, and they continued hoisting on the other winch.
- Crew hoists the nets to above the water and one of the nets contains far more weight than the other one, or there is a sudden loss of fishing gear and/or cargo on one side, resulting in heavy listing of the vessel to one side. Due to the load of the fishing gear and cargo, the amount of remaining stability already is lowered. The remaining stability in heeled condition is much less than in upright condition, so not much of a disturbance is needed to make the vessel capsize. This is illustrated in Figure 5.
- Snagged fishing gear on one side of the vessel; the vessel then can act like a pendulum and swing around the snagged gear and capsizes due to the heeling moment caused by the centrifugal force. When turning to the side of the snagged gear, it is even possible that the line of the other gear gets underneath the vessel and pulls the vessel in the same direction as the snagged gear. The vessel is then pulled over to the other side, increasing the angle of heel already started by the centrifugal force.
- The portside derrick was in horizontal position and the starboard derrick topped (or mirrored), causing a direct asymmetrical loading situation and heeling angle to one side, making the vessel susceptible to capsize.
- Vessel makes a turn and capsizes. Vessel speed and centrifugal force causes a heeling moment and heeling angle, contributing to the capsize. In some of these cases, heavy or excessive weight was on deck or lifted.

- Quick release is used to release excessive weight on one side[3] leading to the vessel swinging over to the other side in some cases causing direct capsize, in other cases excessive heel to the other side and resulting in very little remaining stability.

Causes that contributed to the capsize and/or speed of flooding:

- Flooding of downflooding points like ventilation and deairation openings, hatches and or doors not being closed etc.
- Freeing ports being blocked;
- Quick release gear that does not work;
- Auto-pilot. In one case the auto-pilot was turned on without any crew being in the wheelhouse. The vessel broached on following waves and helm response of auto-pilot was insufficient to correct the course of the vessel.

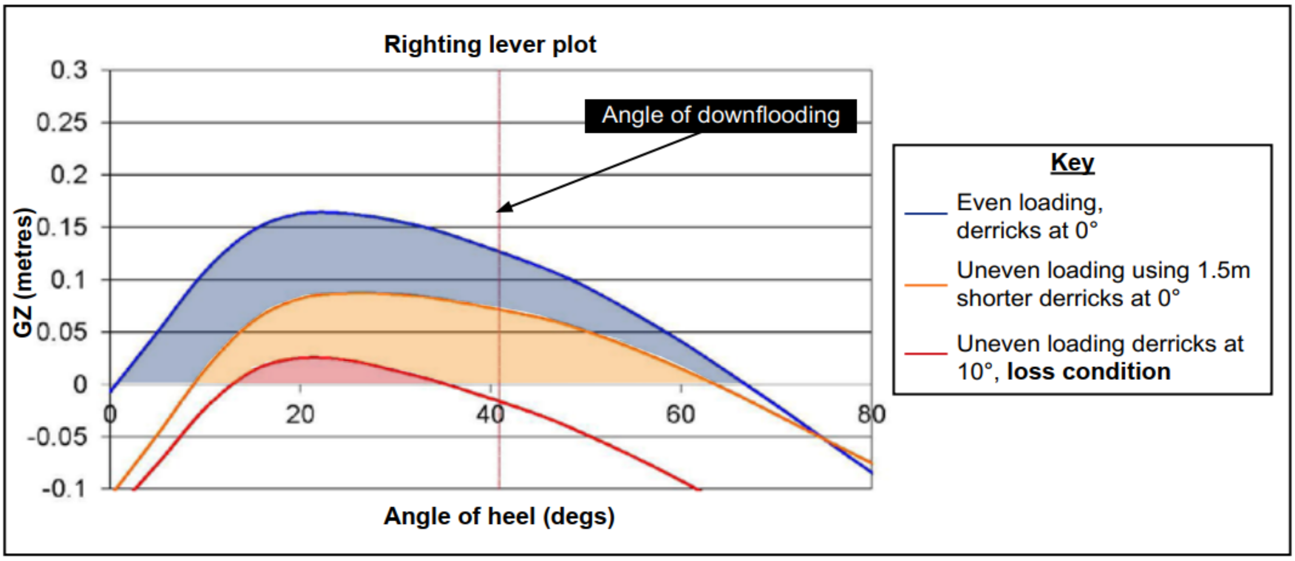

Figure 5 Righting lever plot showing the effect of several uneven loading conditions [(MAIB, Capsize and foundering of beam trawler Sally Jane, 2014)]

3.3 Identified key factors and failure modes

Key elements extracted from the analysed accident reports are, in the order of relevance mentioned:

- Loss of stability: due to lifting of the fishing gear and/or excessive weight;
- Asymmetrical loading: due to lifting of different weights PS and SB, different positions of the derricks or weights on deck. Results in less or insufficient remaining stability;
- Freeing ports (water on deck); due to freeing ports being blocked or the area is insufficient, water on deck is trapped resulting in free surface moments and thus heeling moments and loss of stability;
- Downflooding points. When hatches, doors and ventilation openings are not secured when at sea they can be flooded when excessive heel angles occur or when the vessel is capsizing; either leading to capsize or accelerating the capsize;
- Quick release gear. Some types of quick releases can only be used on one side at a time. Either it happens that the quick release does not work when needed, or using the quick release causes the vessel to heel over to the other side, which in some cases can cause capsize or

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[3] In most cases, the quick release can only be used on one side at a time, leading to dangerous asymmetrical loading situations and leading to a false sense of safety (MAIB, 1999)

large heeling angles to that side, depending on the weight distribution and remaining stability of the vessel.

- Certification of vessel and crew (education). It happens that the approved stability information on board has not been updated for modifications to the vessel, imposing the risk that the vessel has less stability than the documents show. Also, the crew knowledge of stability characteristics and risks of their vessels is in general insufficient;
- Broaching. There beam trawlers of 24 m and less are vulnerable for broaching.

3.4 Other findings

A number of other findings from the accident reports are mentioned here. The following quotes provide insight in the daily operational practice.

The original Dutch quote from the report of WR-22 Barend Jan:

“Ik heb in mijn loopbaan vele malen vastgezeten met de tuigen. Soms gebeurde dit één maal per twee weken, soms wel drie keer per week” [Skipper of WR-22 Barend Jan]

-English translation-

“In my career, we have faced snagged nets many times. Sometimes once per two weeks, sometimes three times a week”

The original Dutch quote from the report of OD-52 Jet:

"Ik ben op voorgaande reizen wel vaker scheef gegaan; soms zover dat het water aan dek kwam. Dit gebeurde als wij met de netten vastliepen of doordat de kuilen te zwaar waren geworden" [Skipper of OD-52 Jet]

-English translation-

“The vessel inclined regularly on previous trips, sometimes almost that far that the deck edge became submerged. This happened when the nets got snagged or if the cod-ends became to heavily loaded.”

Furthermore, the under-reporting of accidents is mentioned in (MAIB, 2002). It mentions that probably many more accidents and near-misses occur than is available from literature.

4 Regulations

This chapter provides an overview of the different regulations applicable to fishing vessels, focusing mainly on stability. The first part describes the relevant stability criteria, international as well as national regulations and additions. Then the loading conditions which are to be analyzed are described. Also regulations on determination of Lightship Weight and center of gravity are covered.

Furthermore, an overview of guidance notes and safety flyers to the fishing sector is given, providing more insight into the history of this subject.

Finally, a number of approved stability booklets of existing vessels are analyzed and an overview is given of other regulations that might be useful in the rest of the research.

4.1 Stability criteria

4.1.1 International criteria

The following sets of international stability criteria for fishing vessels have been identified: These criteria generally apply for vessels of over 24m in length

- IMO Resolution A.168 (ES.IV) Recommendation on Intact Stability of Fishing Vessels (obsolete);
- IMO Code on Intact Stability, 2008 (2008 IS Code) – Part B, Ch.2.1 Fishing Vessels.

International stability criteria for fishing vessels (IMO, 2022):

	Criterium	**Value**	**Unit**
1	Minimum metacentric height (GM’)	>= 0.35	m
2	Righting arm at 30º angle of heel	>= 0.20	m
3	Area under righting lever curve up to 30º angle of heel	>= 0.055	mrad
4	Area under righting lever curve up to 40º angle of heel	>= 0.090	mrad
5	Area under righting lever curve between 30º and 40º angle of heel	>= 0.030	mrad
6	Maximum righting arm should occur at an angle of heel preferably exceeding 30º but not less than 25º		

Table 3: Intact stability criteria for fishing vessels.

The above criteria are already present in the first IMO resolution: A.168, and are still the same in the 2008 IS Code.

In addition to the above mentioned criteria, Fishing Vessels also have to comply with the IMO Weather Criterion (*2008 IS Code, part A, Chapter 2.2.3*), in which the influence of wind and waves is taken into account. Please note that the Weather criterion has been amended several times, meaning that in details the calculation is different depending on the referred resolution. Especially, for fishing vessels the assumed wind velocity profile was changed in the last Weather criterion amendment.

4.1.2 Dutch criteria

The Netherlands legislation is issued by the Ministerie of Infrastructuur en Waterstaat, based on the international legislation and, when deemed necessary, with additional national rules. The following regulations on stability criteria of specifically Dutch flag have been identified:

- Vissersvaartuigenbesluit 1989; applicable to fishing vessels <24m in length
- Vissersvaartuigenbesluit 2002: applicable to fishing vessels >24m - 75m in length

The department Inspectie Leefomgeving en Transport (IL&T), previous name Scheepvaartinspectie (SI), enforces these rules and legislation. In addition, this department issues additional rules, interpretations and clarifications in the form of Bekendmakingen aan de Zeevisvaart. On stability, the Bekendmaking aan de Zeevisvaart 12/1989 – Stabiliteit was issued.

Regarding Vissersvaartuigenbesluit 2002: the basic stability criteria from BadZ 12/1989, as also mentioned in Table 3, have been adopted. But the specific criteria and allowances for beam trawlers, as mentioned in paragraph 4.1.2.1, have been left out and are not referenced to. Thus, at this moment, beam trawlers of >24m in length do not have to comply with the more stringent criteria that were once issued for beam trawlers.

Both issues show that there are defects in the Dutch regulations for fishing vessels, that are over 20 years old and, for unknown reasons, have not been dealt with.

4.1.2.1 Specific criteria for beam trawlers

In (NSI, 1989) the following specific criteria for beam trawlers are stated:

1. The criteria values mentioned in Table 3 under point 2-5, are to be increased by 20%.
2. Minimum GM’: >= 0.50 m

Furthermore, it is required to increase the stability criteria values by the ratio of installed power to the ‘standard power’. This ratio is called the *Stability factor* in this study. This ‘standard power’ is calculated according to the following formulas:

- 0.6 Ls^2 for vessels with a length equal to or smaller than 35 m;
- 0.7 Ls^2 for vessels with a length equal to or greater than 37 m;
- For intermediate lengths interpolation between 0.6 and 0.7 applies.

In case the installed engine power exceeds the value of this ‘standard power’, the criteria values mentioned under Table 3, point 2-5 shall be increased by the proportion of increased engine power (*Stability factor*).

Interesting to mention is that in (Beer, 1972), a ‘standard power’ of 0.8 Ls^2 is mentioned and that in stability booklets of Conoship designed trawlers in the 1980’s and beginning of the 1990’s a value of 0.9 Ls^2 is used. Thus, it seems that this value has changed throughout the years. Unfortunately, sources explaining these changes could not be found.

4.1.3 Foreign criteria

Besides the Dutch specific criteria, also the country specific regulations of several other Western European countries have been inventoried. Mainly the countries of which also accident reports were analysed: Belgium, UK, Germany. In Appendix III an overview is given of all the stability criteria applicable in each country. The standard IMO criteria are also added to be able to compare the national criteria with the international criteria.

The following is noted:

- Dutch and Belgium regulations are very similar. And the only ones that feature the stability factor based on installed engine power.
- Dutch, Belgium, UK and Spain regulations feature the 20% allowance for beam trawlers on criterium 2-5.
- The Belgium allowance based on engine power is less strict than the Dutch one. However, the Dutch wind criterium is less strict than the Belgium one.
- Only German criteria do not feature any allowance for beam trawlers, not even the 20% allowance.
- UK and German criteria do not feature any criteria for wind and waves (weather criterion).
- Only UK and Spain regulations mention lifting operations specifically and draw criteria. So, these are the only countries pointing to actual fishing conditions, instead of only sailing conditions.
- Only Dutch and Belgium regulations feature criteria on determining the vertical centre of gravity of the lightship weight. The Dutch regulations are less strict and resulting in a lower VCG. Other foreign regulations do not mention this. The question is then: is the standard procedure to determine VCG with topped derricks? That would be the worst-case scenario. This could, however, not be found.

4.2 Loading conditions

In the international regulations (IMO resolution A-168) as well as the Dutch regulations, the following set of loading conditions is to be taken into consideration and checked against the above mentioned stability criteria.

No.	Condition	Specific regulation
1	Departure condition for the fishing grounds with full fuel, stores, ice, fishing gear, etc.	IMO, Vissersvaartuigenbesluit 2002, BadZ 12/1989 Stabiliteit.
2	Departure from the fishing grounds with full catch	IMO, Vissersvaartuigenbesluit 2002
2	Departure from the fishing grounds with an amount of fuel and freshwater corresponding to 50 percent of the available content of the tanks, fish hold completely filled with a homogeneous load with a stowage weight of 0.55 t/m3, as well as a deck load with a mass of 4 percent of the displacement, which belongs to the loading condition referred to under 1.	BadZ 12/1989 Stabiliteit.
3	Arrival at home port with 10 per cent stores, fuel, etc., remaining and full catch.	IMO, Vissersvaartuigenbesluit 2002, BadZ 12/1989 Stabiliteit.
4	Arrival in home port with 10 per cent stores, fuel, etc. remaining and with 20 per cent of full catch	IMO, Vissersvaartuigenbesluit 2002, BadZ 12/1989 Stabiliteit.
5	Any other loading condition, which occurs regularly and which is more severe than the conditions mentioned under 1 to 4.	IMO, Vissersvaartuigenbesluit 2002, BadZ 12/1989 Stabiliteit. However the wording differs between these regulations.

Table 4: Standard loading conditions covered by the regulations.

In addition, allowances like ice accretion, weight of wet fishing nets and deck load must be taken into account.

Foreign regulations feature similar loading conditions. What is considered important to mention is that all regulations only feature loading conditions considering free sailing conditions. None feature any specific loading conditions considering actual fishing conditions. However, loading condition number 5 states that any other loading conditions which is more severe than the other conditions is to be considered. It is argued that several specific fishing conditions could fall into this category. Furthermore, UK and Spanish regulations mention that lifting conditions and operations are to be taken into consideration.

In none of the analysed stability booklets (paragraph 4.6) extra (fishing) loading conditions have been found.

4.3 Determination of Lightship Weight

As already mentioned in paragraph 4.1.3 and shown in Table 4, the rules for the determination of the vertical centre of gravity of the Lightship Weight differs among the different countries. Only Dutch and Belgian regulations mentions this specifically:

In the Dutch additional regulations (NSI, 1989), for beam trawlers the following is stated (original Dutch text):

“Voor vaartuigen die zijn ingericht voor de boomkorvisserij, mag de ligging van het zwaartepunt in hoogte worden berekend met de gieken in horizontale stand.”

So, the vertical center of gravity of the Lightship Weight may be determined with the derricks in horizontal position.

Belgium regulations state the following (Federale Overheidsdienst Mobiliteit en Vervoer, 2015):

“Voor vissersvaartuigen welke zijn ingericht voor de boomkorvisserij, mag de ligging van het gewichtszwaartepunt in hoogte worden berekend met de gieken onder een hoek van tenminste 45 ° met het horizontale vlak.”

So, the vertical center of gravity of the Lightship Weight may be determined with the derricks in a position of 45 degrees from the horizontal plane.

It is not clear what the standard procedure for the calculation of VCG is, but it is plausible that this should be done for the situation in which the derricks are in vertical position (topped) because this is the worst-case situation. It looks like both Dutch and Belgium regulations on this are relaxations, of which the Dutch variant is the more relaxing. In this case the height of VCG can be significantly underestimated. To put this into perspective: the proportion of the weight of the derricks compared to the lightship weight can be up to 5% and the difference in VCG of the LSW can be up to 15cm on a VCG of about 2.50m at vessels of the Eurocutter size (up to 24m in length).

4.4 Guidance notes

Throughout the years, based on accident reports, several guidance notes have been issued, mainly by the MCA. These guidance notes contain lessons learned, points of attention, recommendations, tips etc. about how to operate fishing vessels, the do's and don'ts considering vessel's stability etc.

- MGN 415(F) FISHING VESSELS: The Hazards Associated with Trawling, including Beam Trawling and Scallop Dredging
- MGN 427(F) Stability Guidance for Fishing Vessels of under 15m Overall Length
- MGN 503(F) Procedure for Carrying out a Roll or Heel Test to Assess Stability for Fishing Vessel Owners and Skippers
- MGN 526(F) Stability Guidance for Fishing Vessels - Using the Wolfson Method

As an example, MGN 526(F) explains the Wolfson stability guidance method. This method mainly provides guidance for vessels without stability booklets; mainly for vessels <15m. Although, from a fishermen's perspective it still seems to be difficult matter. However, it does provide the possibility to calculate and position a freeboard mark indicating a green, orange and red zone. Besides lifting criteria and actual operating conditions are mentioned.

4.5 Safety flyers to the fishing sector

Over the years, several safety flyers have been issued, addressing a number of issues that recurred in accident reports and investigations. The following documents have been found and analysed:

- Ongevallen in de visserij – Vistikhetmaar.nl
- Safety Flyer to the Fishing Industry – Fishing vessel Solstice, capsize and sinking resulting in the loss of one life - MAIB[4]
- Safety Flyer to the Fishing Industry – Capsize and sinking of the scallop dredger Joanna C (BM265), with the loss of two lives – MAIB
- FISHING VESSEL STABILITY GUIDANCE (MCA, UK)
  - https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/690564/10743-MCGA-Fishing_Vessel_Stability_Guidance-WEB.pdf
- A guide to fishing vessel stability (Australian Government)
  - https://www.amsa.gov.au/sites/default/files/amsa507.pdf
- Safety practices related to small fishing vessel stability (United Nations)
  - https://setsail.com/FAO%20Small%20Vsl%20Stability.pdf
- Stabilitetsguide for mindre fartoy (Norwegian government)
  - https://www.yrkesfisker.no/globalassets/publikasjoner/92275-stabilitetsguide.pdf
- STABILITY GUIDE FOR SMALLER VESSELS (Danish government)
  - https://f-a.dk/wp-content/uploads/2015/02/StabilityGuide_FA_UK.pdf
- A Best practices Guide to Vessel Stability – Guiding Fisherman into the future (US Coast guard)
  - https://www.dco.uscg.mil/Portals/9/DCO%20Documents/5p/CG-5PC/CG-CVC/CVC3/references/Stability_Reference_Guide.pdf
- OMI - IMO761E - FAO/ILO/IMO Voluntary Guidelines for the Design, Construction and Equipment of Small Fishing Vessels 2005

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[4] MAIB = Marine Accident Investigation Branch; the UK version of the Dutch OVV.

    - Not publicly available

In these safety flyers and articles, the following common issues, relevant for this study, are addressed:

- Very clearly stating that raising the derricks can lead to loss of stability and increasing the risk of capsizing;
- General warning that high lifting points (occurring in both beam trawlers and stern trawlers), especially in combination with excessive weights, results in a high risk of capsizing;
- Risks involved with the modification of fishing vessels and changing of fishing methods. For every modification, advice shall be gathered from a naval architect and the MCA or other relevant institutes;
- Risks involved with snagging of fishing gear, especially in combination with insufficient reserve stability caused by for example modifications to the vessel and high lifting points;
- Warning for risks involved with lifting excessive weights. Recommendation to stop hauling and let the catch go;
- These safety flyers have typically been developed following recommendations of accident investigations to increase awareness of stability failures in smaller vessels.
- Many countries feature a *stability* safety leaflet issued by the government. For some countries it is even mandatory to have the leaflet on board. The Netherlands do not feature such a *stability* safety leaflet .

4.6 Stability booklets

The regulations generally state the following about the information that needs to be available to the master:

"Suitable stability information shall be supplied to enable the skipper to assess ***with ease*** *and certainty the stability of the vessel* ***under various operating conditions****.* ***Such information shall include specific instructions to the skipper*** ***warning him of those operating conditions which could adversely affect either the stability*** *or the trim of the vessel."*

Stability booklets of several beam trawlers from archives have been analyzed. It has been checked which loading conditions are included in the booklets and to which extent the above stated rule is met. The investigated booklets were mainly of beam trawlers of around 40m LOA.

The following stood out:

- The high *stability factor* [5] of these vessels of 1.15 – 1.70 caused by the high installed power (between 2000 and 3000 hp). This trend is also confirmed in Figure 10, in which the stability factor of the EU fleet is calculated and plotted;
- No *notes to the master* are included at all, referring to stability risks etc.
- No additional loading conditions, including for example fishing operation conditions, falling under category 5 in Table 4, are included.

It can be concluded that the above-mentioned rule is not met to a large extent. The booklets do not contain specific instructions to the master warning him for dangerous operating conditions; also example conditions like in which the derricks are raised to a certain level with the weight of fishing gear and catch acting upon them, are missing. It must also be concluded that the regulations do not provide

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[5] The extra stability required based on engine power, see paragraph 5.5

specific criteria for these cases. However, that nothing is mentioned about risky operating conditions at all can be considered as a serious defect.

Another finding from the accident reports is that in most cases the stability booklets are not very well understood by the crew and not used at all (MAIB, 2014). This is an issue that is generally understood by regulatory authorities.

4.7 Other regulations

Other regulations that are (currently) not applicable to fishing vessels, which were found useful are:

- MSC.415(97) Amendments to Part B of the International Code On Intact Stability, 2008 (2008 IS Code) → Ships engaged in lifting operations
    - For ships which have lifting appliances which give a larger heeling moment than a certain factor compared to the ships beam, displacement, freeboard and GM, this regulation applies.
    - For lifting operations, under certain limits of operational conditions, requirements are imposed on stability values and the ability to withstand 'sudden loss of hook load'
    - As beam trawlers are also performing lifting operations, and could also face 'sudden loss of load', these regulations could be useful.

5 Beam Trawler fleet

This chapter provides an overview and inventarisation of the Dutch beam trawler fleet and it is shown how the Dutch fleet compares to the EU and UK fleet. Also, the analyzed accident vessels (chapter 3) are compared to the EU and UK fleet.

5.1 Dutch fleet compared to EU and UK fleet.

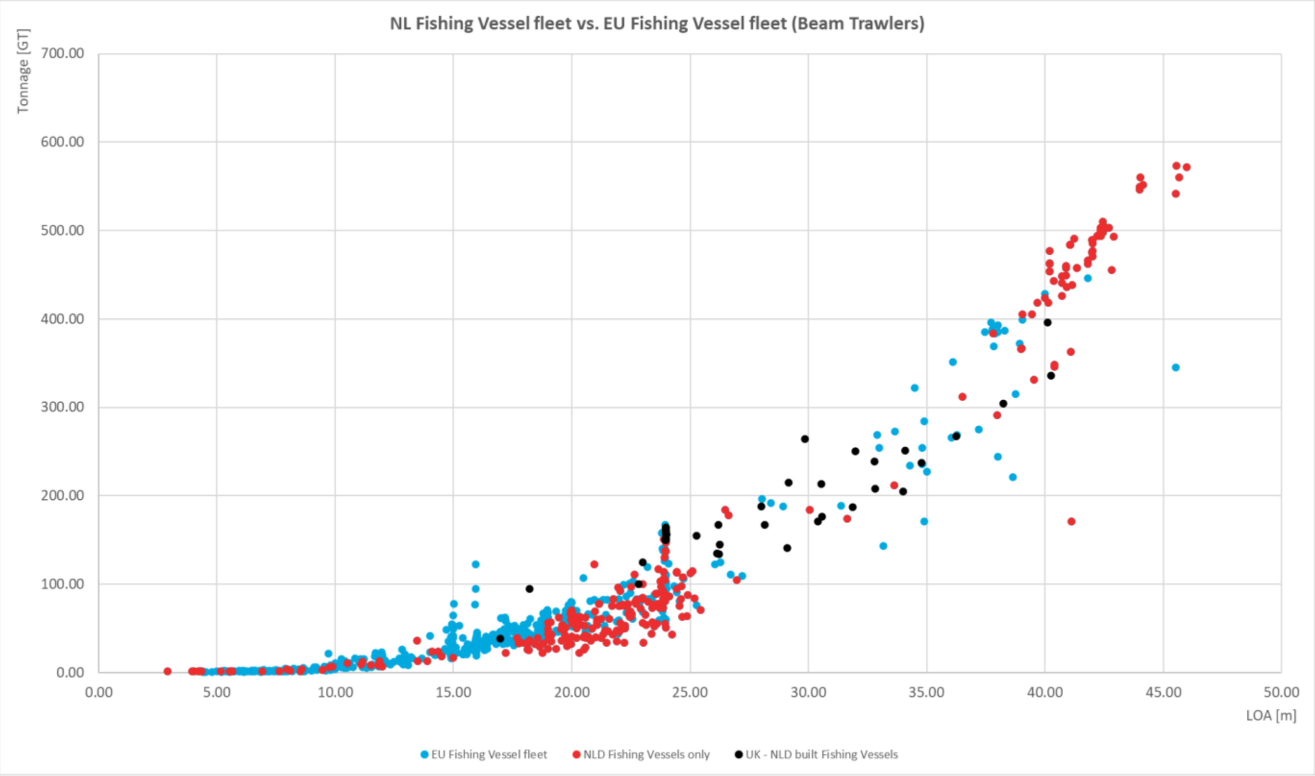

Figure 6: Dutch beam trawlers plotted in the total EU beam trawler fleet

As can be seen in Figure 6, the Dutch beam trawler fleet is concentrated in the length “categories” of 18 – 24 meters LOA and >40 meters LOA. Furthermore, Dutch built vessels that are registered in the UK are also plotted in this graph and it is noticed/stands out that the “gap” in the Dutch registered fleet between 24 and 40 meters LOA is partly filled by these UK registered Dutch built vessels.

The reason that only the Dutch built UK vessels have been taken into account is twofold. 1) to show which vessels moved from NLD to the UK. And 2) because in the UK database, no specific categorization of fishing vessel type is present and beam trawlers could not be filtered. It was investigated that the Dutch built vessels are all beam trawlers, so these are added to the overview. But from samples of the rest of the database it is concluded that the rest of the database largely consists of other vessel types such as stern trawlers, flyshooters etc. It was not possible to filter the beam trawlers, thus the rest of the database was not used.

Figure 7 shows the Year of construction of the fleet presented above. Most of the beam trawler fleet is built between 1970 and 2000, with a peak in the 1980’s. This means that the fleet is about 40 years old on average. Also, almost no new beam trawlers are being built in recent years, not one of them under Dutch flag. Furthermore, it stands out that there are only 11 registered Dutch vessels built in the 1970’s, compared to 81 in the rest of the EU. Probably, a large number of Dutch vessels from the

1970’s are sold and/or moved to other countries or scrapped and replaced by larger vessels in the 1980’s.

Conoship has a rich history of fishing vessels and beam trawlers designed and built, mainly from the late 1980’s and early 1990’s. It shows that in this period, only large beam trawlers were designed within the 2000 hp (1470 kW) limit.

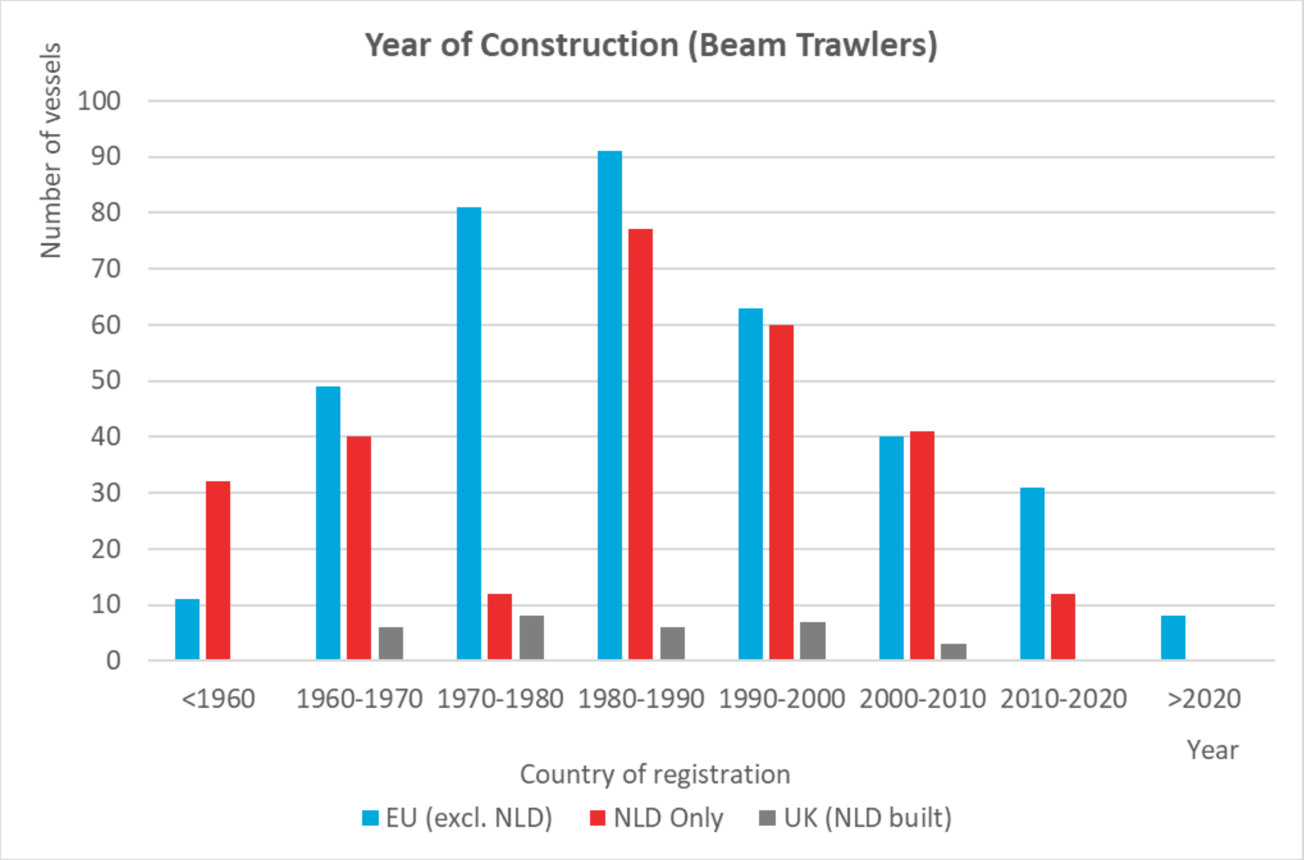

Figure 7: Year of construction of Beam trawlers registered in the EU, NLD and UK

5.2 Accident vessels compared to EU + UK fleet

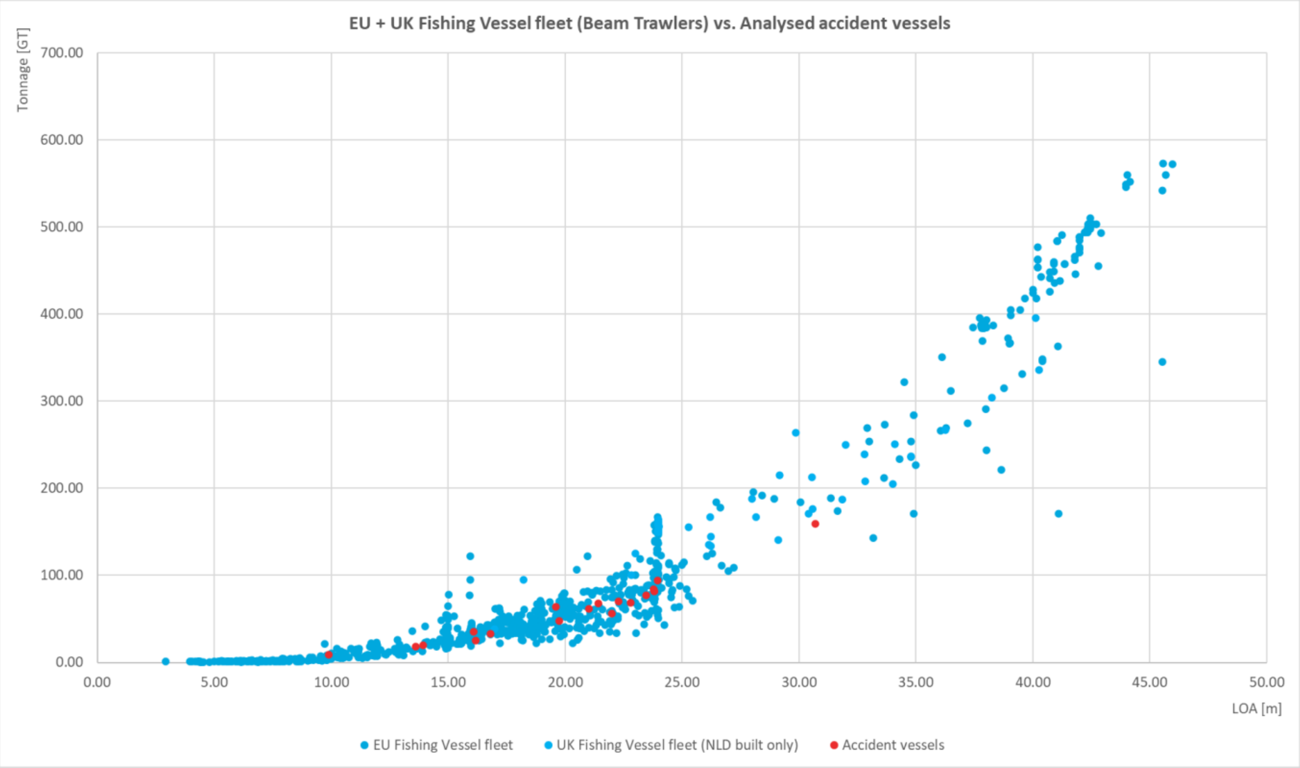

Figure 8: EU + UK Beam trawler fleet with the analyzed accident vessels plotted.

Figure 8 shows how the analysed accidents from chapter 3, compare to the EU and UK beam trawler fleet. It shows that all of the accident vessels are average vessels and that none are found at the limits. From this, no causes and key elements for capsizing regarding dimensions of the vessel can be extracted.

5.3 Difference in vessel dimensions

What is also remarkable, is the large spread in GT value between 20m and 24m length. The variation in length is small, but the lowest GT in this 34, and the highest GT value is 160. The vessel with 34 GT is the OD-2 Neeltje (1917) and the vessel with 160 GT is the HD-3 Nieuwe Diep (2002). Both are shown below. This indicates the very large variation in main dimensions and age of the (Dutch) beam trawler fleet. Everything in between these two extremes occurs and actually operates in Dutch and foreign waters.

Table 5: Main particulars of OD-2 Neeltje and HD-3 Nieuwe Diep indicating the large variation in beam trawler dimensions

and Figure 9 show the main particulars of these vessels and an overview respectively.

Parameter	OD-2 Neeltje	HD-3 Nieuwe Diep
Year of construction	1917	2002
Length over All	22.21 m	23.99 m
Breadth moulded	4.00 m	7.00 m
Draught	1.60 m	3.80 m
Gross Tonnage	34 GT	160 GT

Table 5: Main particulars of OD-2 Neeltje and HD-3 Nieuwe Diep indicating the large variation in beam trawler dimensions

Figure 9: Picture of OD-2 Neeltje and HD-3 Nieuwe Diep (MarineTraffic.com)

5.4 International fleet

As is already showed in the previous paragraph, a look has been taken across the borders and also foreign, mainly Western Europe, beam trawler fleets have been investigated. This to draw a comparison with the Dutch beam trawler fleet and to get insight in elements like: are there significant differences in dimensions compared to Dutch beam trawlers? Are there other important differences that increase the safety of those vessels? Or is the situation just as bad or even worse compared to the Dutch fleet.

These foreign fleets were not investigated in detail, because the investigation focusses on the Dutch fleet, but from the investigated vessels and foreign accidents (see chapter 3), it can be concluded that the stability issues are not limited to the Dutch fleet, but are Europe-wide.

Western-European countries with beam trawlers:

- Belgium
- France
- England/UK
- Ireland
- Denmark
- Germany

To pick one example: Ireland only has a very small beam trawler fleet. However, the first Irish vessel that was considered in the EU fleet list, was the WD-30 Mary Kate. An article mentioning this vessel was found (Buitendijk, 2021) referring to the report of the Dutch Safety Board about the capsized vessels UK-165 and UK-171. In this article it is mentioned that WD-30 Mary Kate was part of a series of 9 identical vessels built in the Netherlands. All of these vessels were found to have serious stability issues when the stability was re-examined for the Irish fishing vessel fleet around 2009. Mary Kate's stability was deprecated so much that it was considered to be totally unseaworthy. This strengthens the conclusion that the stability issues are not bounded to The Netherlands.

5.5 Stability factor

To identify the *stability factor* (introduced in chapter 4.1.2.1), and thereby the possible influence on the minimum applicable stability criteria, the stability factor is calculated for every vessel, and is plotted against LOA. See Figure 10.

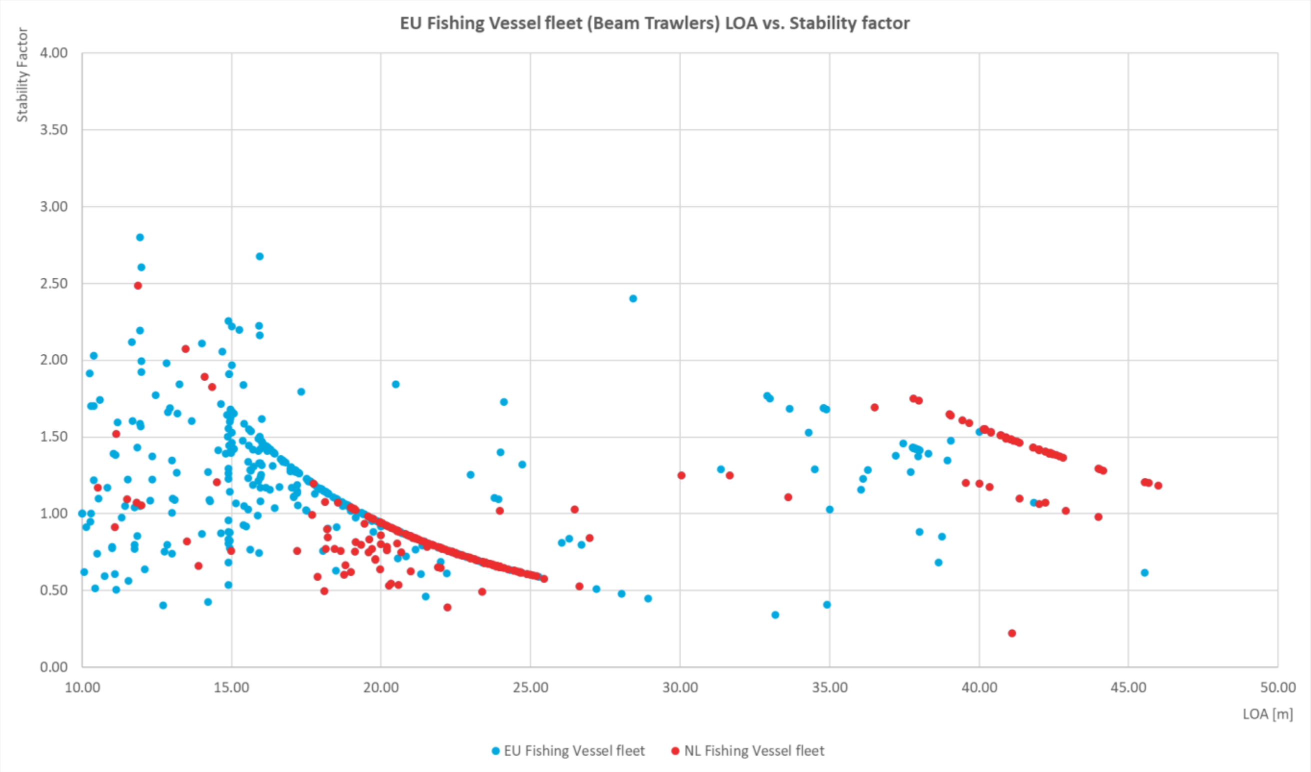

Figure 10: Length over All plotted against stability factor for EU Beam Trawlers

The following boundaries can clearly be distinguished:

- Between 15m and 25m LOA, clearly the Euro Cutter boundary can be distinguished, with a maximum installed power of 300 hp (221 kW);
- Between 37m and 47m LOA, the 2000 hp (1470 kW) limit;
- Between 28m and 45m LOA, the 1500 hp (1100 kW) limit, although less clearly.

At smaller lengths, namely below 15m LOA, the spread in stability factor is much larger due to the larger variation in installed power.

Interesting to notice is the following:

- Between 20m and 24m in length, the stability factor is less than 1. This means that no allowance to the minimum stability criteria is applicable for these vessels;
- The majority of these vessels are Dutch registered vessels;
- Above 24m in length the majority of the vessels features a stability factor of greater than 1. In some cases this value is as big as 1.70, which means that the minimum stability criteria are to be increased by 70%. This means that the areas below the GZ-curve need to be 70% larger areas;
- The majority of these vessels, especially the 2000 hp vessels, are Dutch registered vessels, to which this allowance actually applies.

The following is to be noted: as this *stability factor* is only applicable to Dutch and Belgium vessels, it would be of interest to check if the non-Dutch and non-Belgian vessels having a *stability factor* >1 according to the Dutch and Belgian *stability factor*-regulation, actually feature less stability, and are thus more vulnerable to capsizing and to what extent.

6 Safety systems

Beam trawlers are equipped with safety systems, that decrease the load on the top of the derrick when the tension of the fishing line is too high. This prevents too high asymmetrical loads and thus dangerous heeling moments. There are several types of systems, both hand operated and automatic.

Table 6 provides an overview of the safety systems available and applied for (beam) trawler vessels that reduce risks involving loss of stability / improving stability in certain parts of the fishing operations.

System	Working	Vessels fitted	Purpose
Marelec D-Protec[6]	Wire load monitoring and constant tension measuring system. When tension builds up alarms are raised. Automatic safety measurement can be implemented: - Intelligent control of winch brakes in case of overload - Propeller pitch control.	Larger vessels >24m Except for Belgium vessels; the government has supported the installation on all smaller vessels as well.	Main purpose: Lowering of the force on the rigging and the end of the derrick. Result: Prevent or lowering of asymmetrical load, and thus heeling moment, due to nets get stuck or overload.
Slipping wire system (Slipdraad-installatie)	Works by means of activating the dedicated "slipping wire installation". The dedicated slipping wire winch drum is hauled in and the "visblok" is pulled towards the bulwark. Once it has positioned next to the bulwark, the forces will no longer act at the top of the derrick, but at the bulwark, much closer to the centreline and much lower, resulting in considerably less heeling moment.	Larger vessels (separate "slipping wire drum" on the winch needed)	Main purpose: Reduce the lever of the acting force of the rigging to the centerline. Result: Prevent or lowering of heeling moment due to asymmetrical load, caused by snagged nets, etc.
Slip hook system (Sliphaaksysteem)[7]	By releasing the slip hook (manual action), the "visblok" is released from the top of the derrick, and by the tension on the "vislijn", the "visblok" is pulled towards the bulwark. Once positioned next to the bulwark, the forces will no longer act at the top of the derrick, but at the bulwark.	Probably mostly applied on smaller vessels	Main purpose: Reduce the lever of the acting force of the rigging to the centerline. Result: Prevent or lowering of heeling moment due to asymmetrical load, caused by snagged nets, etc.

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[6] https://www.marelec.com/industries/marine/trawl-control/d-protec/

[7] (Bremer, 1975)

Van Damme patent[8]	The system is activated when the derrick hoisting wire the "giekdraad/hangerdraad" is tensioned by excessive force on the fishing line. The system is then automatically activated and the "visblok" is released and moves towards the bulwark. Once positioned next to the bulwark, the forces on the fishing line will no longer act at the top of the derrick, but at the bulwark.	Smaller vessels / Euro Cutters (with no space for larger winches and additional drums)	Main purpose: Reduce the lever of the acting force of the rigging to the centerline. Result: Prevent or lowering of heeling moment due to asymmetrical load, caused by snagged nets, etc.
Winch operated aft and front derrick line (lierbediende voortui/achtertui)	With this system, the derricks can be pulled alongside the side of the vessel completely. Once the derricks are positioned alongside the hull, the forces on the fishing gear will act much closer to the centerline.	Larger vessels >24m	Main purpose: Reduce the lever of the acting force of the rigging to the centerline. Result: Prevent or lowering of heeling moment due to asymmetrical load, caused by snagged nets, etc.
Luyt patent	Unknown: no information found		
Goeree patent	Unknown: no information found		

Table 6: Overview of safety systems

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[8] (Bremer, 1975) & https://vistikhetmaar.nl/onderwijs/lesmodules/vissen-met-korren-2/

7 FMEA-based analysis of stability

7.1 Introduction

For this investigation the analysis method was based on the Failure Mode Effect Analysis (FMEA) principle. In the FMEA failure modes of a system are defined and a risk rating is given for each failure mode, based on severity of the failure mode, the occurrence and the detection / mitigation possibilities. In chapter 7.2 criteria for the ranking of the severity, the occurrence and the detection / mitigation are given.

The ranking of the severity, the occurrence and the detection/mitigation makes it possible to give a risk rating for each failure mode. Based on the risk ratings, a priority for each failure mode can be established. For this investigation the FMEA-method was used to quantify risks of working situations of the beam trawlers.

In the FMEA-method systems are analysed. Based on this the 'stability of beam trawlers' was considered to be a system and as such analysed by the Conoship researchers in consultation with fishermen. Failure modes were related to the stability of the vessel, from (a)symmetrical loads on derricks to transverse waves and crew related failure modes like training. For each failure mode the risk rating was determined, and these risk ratings were used for the analysis of combinations of failure modes. This analysis is discussed in chapter 9.

7.2 Categories of failure modes

A diagram was made showing the relations between failure modes for each category. The following categories of failure modes were assessed:

- External factors: Wind, waves, water on deck etc.;
- Internal factors: Position of the derricks, stern trawl gear on net drums or not, enlarged derricks;
- Loads on derricks, both symmetrical and asymmetrical: fishing gear empty, with catch, with debris, stuck to the ground, with functioning or not functioning safety system;
- Symmetrical loads on derricks: fishing gear in both derricks, empty, with catch, with debris, stuck to the ground, with functioning or not functioning safety system;
- Hauling catch: symmetrical or asymmetrical hauling of the cod-end of the net to deck for emptying;
- Fishing net to side of the vessel, of which an example is shown in Figure 11;

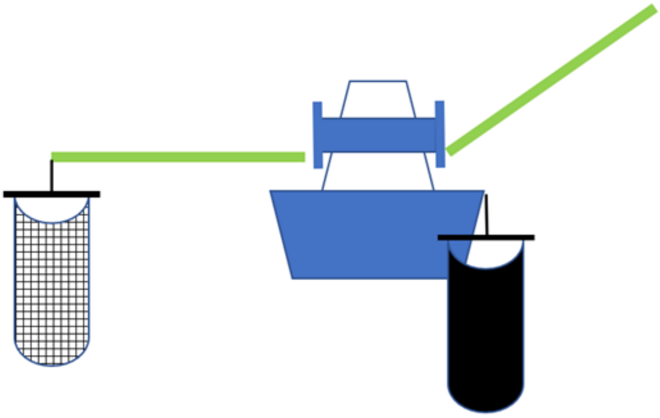
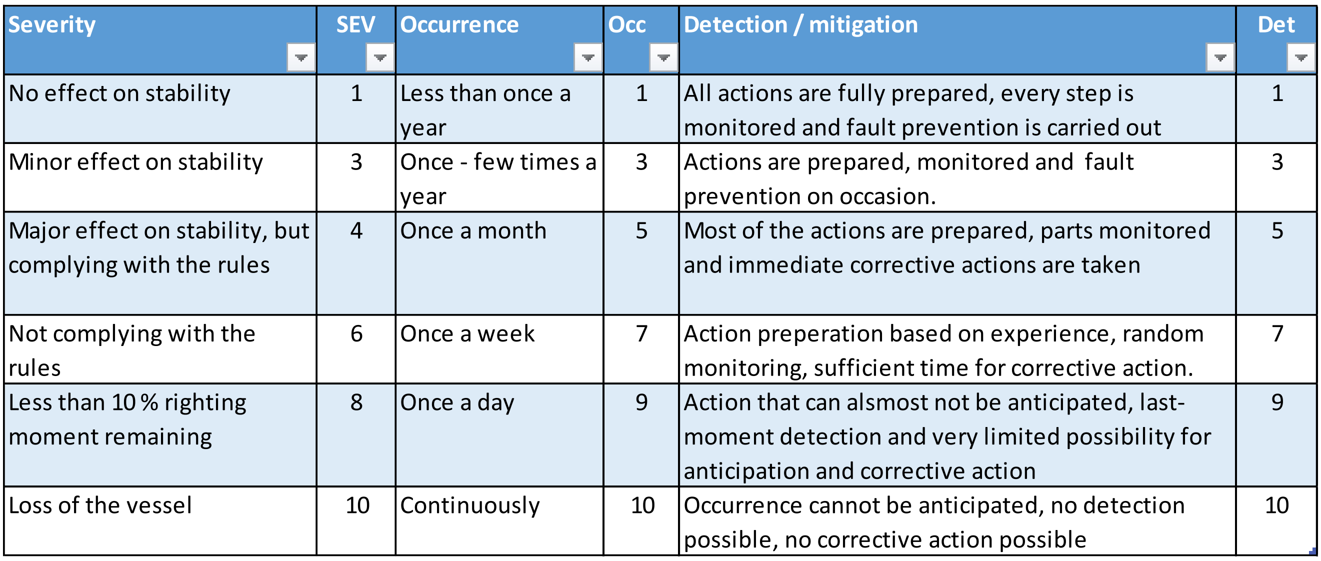


Figure 11: Fishing net to side of the vessel

- Maneuverability: the effects of loss of propulsion or steering gear failure;
- Crew: knowledge and training, fatigue and economic considerations;
- Authorities: rules and regulations and the effects of inspections and law enforcement;
- Stability information: the effects of the accuracy of stability information and the effect of lacking guidelines for fishing conditions.

7.3 FMEA risk rating matrix

For each failure mode the risk rating was determined based on the severity of the effect on the stability of the failure mode, the occurrence, and the possibility to detect and mitigate the failure mode, each on a 1 – 10 scale. Table 7 shows the risk rating matrix.



Severity	SEV	Occurrence	Occ	Detection / mitigation	Det
No effect on stability	1	Less than once a year	1	All actions are fully prepared, every step is monitored and fault prevention is carried out	1
Minor effect on stability	3	Once - few times a year	3	Actions are prepared, monitored and fault prevention on occasion.	3
Major effect on stability, but complying with the rules	4	Once a month	5	Most of the actions are prepared, parts monitored and immediate corrective actions are taken	5
Not complying with the rules	6	Once a week	7	Action preperation based on experience, random monitoring, sufficient time for corrective action.	7
Less than 10 % righting moment remaining	8	Once a day	9	Action that can alsmost not be anticipated, last-moment detection and very limited possibility for anticipation and corrective action	9
Loss of the vessel	10	Continuously	10	Occurrence cannot be anticipated, no detection possible, no corrective action possible	10

Table 7: Risk rating matrix

For example: The risk rating for wind force 6 Bft.:

- Severity: Minor effect on stability, so ranking is 3;
- Occurrence: Once a week, so ranking is 7;
- Detection / mitigation: Once the vessel is at sea, there are limited possible actions for mitigation, such as adjusting course within the limits of the fishing operations, so ranking is 9.

7.4 FMEA results

For each failure mode the risk rating was determined as described above. The outcoming results have been marked with colours. If a failure mode has a severity of 6 (not complying with the rules), happens once a week (rating 7) and is part of routine operations (rating 7), the risk rating is 6*7*7 = 294 it is considered to be significant and marked orange. Risk ratings of more than 8*9*9 = 648 is marked red, because they correspond with effects that decrease the remaining righting moment to 10%. In this case, a heeling moment comparable to wind force 6 with gusts, or caused by water on deck (see chapter 8.5) can reduce the remaining heeling moment to a dangerous level.

In the chapters 7.4.1 – 7.4.9 the risk ratings for individual factors will be explained. The combined risk ratings for operational conditions during fishing are given in chapter 9.1.

7.4.1 External factors

External factors that were considered are:

- The direction of the waves related to the vessel;
- The wind force, without and with gusts;
- A longitudinal wave with a wave length equal to the vessel's length;
- Water on deck;
- Switch of fishing gear to the other side, as shown in Figure 12;

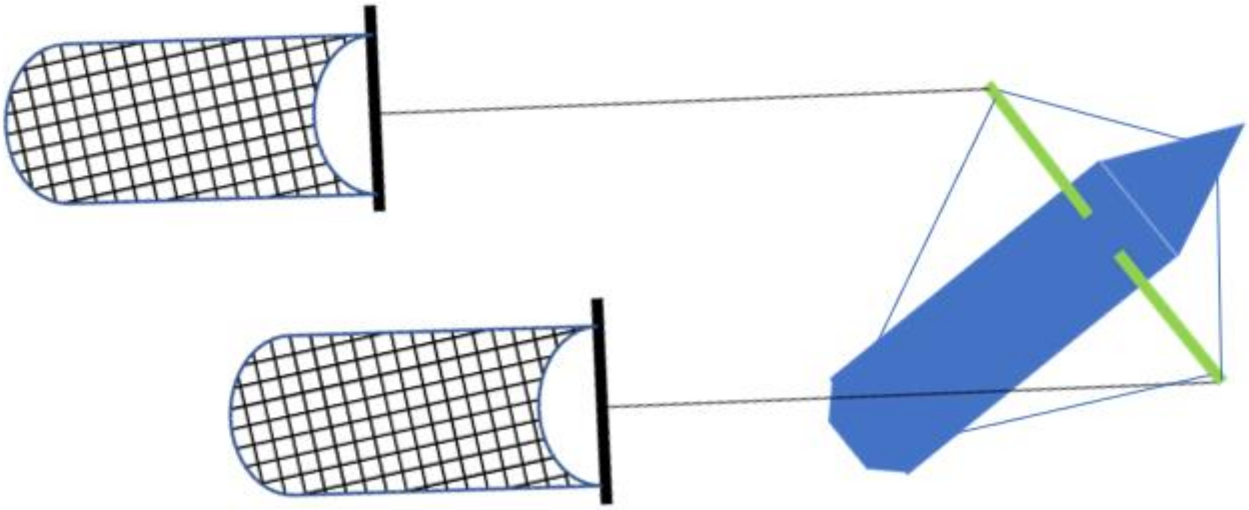


Figure 12: Fishing gear switching to the other side of the vessel

The effect of the course related to the wind direction is occurring on a daily basis. Therefore, the occurrence is 9. The severity is depending on the wind force and ranges from 3 to 7. The mitigation factor is high, because once at sea there is little mitigation possible for the weather conditions.

Water on deck in rough seas occurs regularly and can hardly be anticipated.

The situation were the vessel turns and the fishing line flips over or under the aftship to the other side occurs not very often, but, as several fishermen said: "It has happened to all of us." The effect on the stability is immense, because it often leads to one derrick slamming to upright position by the fishing line and both nets are hanging at one side of the vessel. It was considered to be the cause of the capsizing and sinking of UK-171 'Spes Salutis'. (Dutch Safety Board, 2021)

The resulting risk ratings for the external factors are shown in Appendix VI.

7.4.2 Internal factors

The internal factors that were considered are:

- Combinations of the positions both derricks: 80 and 45 degrees as well as horizontal;
- The effect of the stern trawl gear being stored on the net drums during beam trawling;
- The effect of enlarged derricks.

The resulting risk ratings for the internal factors are shown in Appendix VII.

For the positions of the derricks the severity of asymmetric positions is higher than symmetrical positions and the occurrence is high, because the positions happen constantly, except for the 80/00 position. The mitigation factor is 7 because the positions of the derricks can be adjusted, within limits.

The net drums at the aft ship, meant for the stern trawling gear, can have a significant impact on the stability and once the ship has sailed there is nothing that can be done to alter the situation. Illustrative for the severity of the impact on stability is that, according to the approved stability booklet of UK-171 ‘Spes Salutis’, during beam trawling these drums must be empty and gear left ashore. For UK-165 ‘Lummetje’ not only the gear, but also the net drums have to be left ashore when beam trawling. This remark in the stability booklet is made on a regular basis, especially for the beam trawlers up to 24 m Lpp. (Dutch Safety Board, 2021).

Once derricks have been enlarged, there is also no possibility to change the situation and the impact on the stability is large. As can be seen from the results, the lengthening of the derricks (failure mode ‘1.2.3 Derricks enlarged’) has a very high risk rating.

During interviews with inspectors of ILT and designers it became clear that derricks are regularly lengthened without updating the stability booklet. An example was found on the internet, showing a beam trawler with a clearly recently lengthened derrick.

7.4.3 Loads on derricks

During the investigation the effect of fishing gear was being empty, filled with catch and filled with catch and debris like sand or rocks was assessed for both symmetrical and asymmetrical situations.

The situation where the net is hoisted and is filled with a combination of catch and debris, like sand or rocks, can hardly be detected, unless a Marelec system is installed, which most smaller beam trawlers do not have. The impact on the stability is great and it happens regularly, depending on the fishing ground. This results in a high risk rating matrix.

The effect of one or both fishing nets getting caught at the ground was also assessed, in two variations: One where the safety system (e.g. Van Damme patent) is functioning and one where the system does not work. Especially the Van Damme patent tends to get stuck and needs regular maintenance and testing. A Marelec system is more expensive, but also more reliable. Given the significant difference in risk rating it is worth considering.

The Belgium Authorities has issued the Marelec system for all beam trawlers, without costs. This makes the vessels a lot more safe. This system has another advantage: Because it measures the tension in the fishing line and its data can be used in an onboard monitoring system, which helps the crew to operate more efficient. The Belgium beam trawler fleet has already achieved a substantial gain in efficiency, thus reducing the fuel costs per kilogram fish.

The resulting risk ratings of the loads on derricks are shown in Appendix VIII.

7.4.4 Hauling catch

Once the nets are hoisted to blocks, the cod-end is attached to the jumper line and hoisted above the deck for emptying. In the investigation this is called ‘hauling catch’. Figure 13 shows the hoisting the cod-end of a shrimp beam trawl net. The net can contain caught fish, but also sand or rocks, depending on the fishing ground and the type of net used. Often the catch is hauled in symmetrically, but also asymmetrically, depending on the situation.

The results of the risk ratings for hauling catch are shown in Appendix IX.

Figure 13: Hauling the cod-end of a net (picture source 'Globalseafood.org)

7.4.5 Fishing net to the side of the vessel

When a heavy load is detected in one or both nets, the safety system can be activated. This system lowers the fishing block from the top of the derrick to the side of the vessel, thus drastically reducing the heeling moment acting on the vessel.

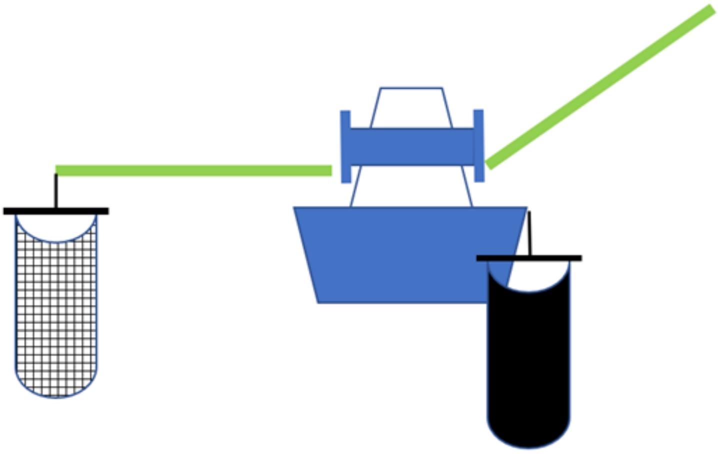


Figure 14: Fishing net lowered to the side of the vessel

However, when activating the safety system on one side, this can lead to a sudden movement of the vessel to the other side, where the load is still acting at the end of the derrick. A similar situation caused the capsizing of WR-15 ‘Pieter Cornelis’ (Raad voor de Scheepvaart, 1996).

A symmetrically activated safety system is to be preferred, because that does not cause asymmetrical loads on the vessel.

Appendix X shows the risk ratings of the fishing net to side of the vessel.

7.4.6 Maneuverability

During fishing, especially when on current during heavy winds and waves, the maneuverability of the beam trawler is of vital importance. The vessel is to be maneuvered in between the fishing lines. Lack of propulsion or rudder pressure can cause the vessel to drift over the fishing line, or the fishing line can skip over the aftship to the other side of the vessel, as shown in Figure 15. This can result in dangerous asymmetric loads on the vessel.

The impact on stability is high, although the occurrence is low. Mitigation is possible by regular maintenance of the engine and rudder systems. This results in relatively low risk ratings, as can be seen in Appendix XI.

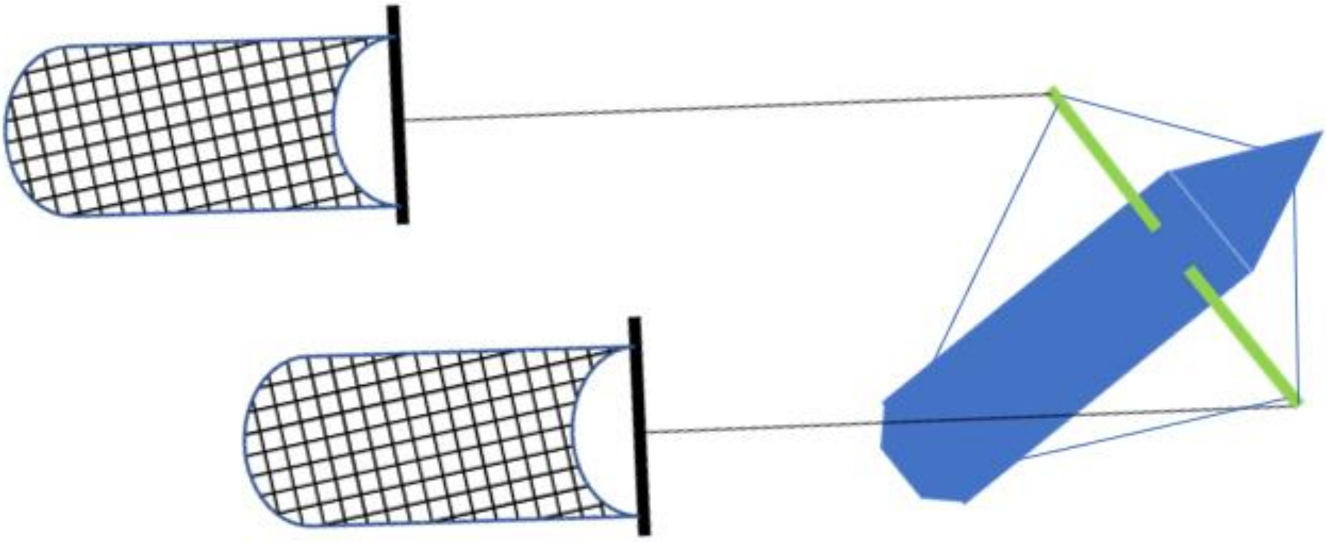


Figure 15: Fishing vessel turning over the fishing line

7.4.7 Crew

‘The vessel is as safe as its crew’ is a true saying. The effects of crew training, risk assessment and physical condition are shown in Appendix XII.

Appropriate training on stability is crucial, but at this moment all too often the crew is not able to interpret the stability information available on board. This observation was made not only by international researchers, who carried out the investigations on the accidents with beam trawlers, but also by teachers at the schools. This also makes it hard for the crew to do a balanced risk assessment during sailing and fishing.

Stability training that is better suited for the crew of beam trawlers will surely reduce this risk rating.

The effects of insurance of the fishing gear are also evaluated. Since the fishing gear represents a big investment, insuring the (salvage of) the fishing gear will influence the decision on whether or not extra risks will be taken during attempts to retrieve a fishing net that got stuck. This will lead to a reduction of the risk rating compared to the situation where the fishing gear is not insured.

7.4.8 Authorities

The role of the Authorities, both ILT and the Ministry of Infrastructure and Water Management, but also the IMO is important for the risk rating for several reasons.

The first is that at this moment there are no rules or guidelines on the stability of beam trawlers while fishing, which is a logic part of their task.

Setting up guidelines, as recommended by the Dutch Safety Board in the report on the capsizing and sinking of fishing vessels (Dutch Safety Board, 2021), will help to give more insight in the stability during these conditions, for both designers and fishermen.

The other reason is that the Authorities carry out inspections and document approval. Due to lack of capacity, inspections of beam trawlers by ILT are reduced to the bare minimum. Because of the lack of enforcement of the rules, beam trawlers often sail while the stern trawl gear is still fitted, although the stability booklet instructs the removal of the nets of even nets and drums. During the accidents of both UK-165 ‘Lummetje’ and the UK-171 ‘Spes Salutis’ the stern trawl gear was present.

More inspections on this topic will help to reduce risk rating and enhance the safety of beam trawlers. Appendix XIII shows the risk ratings of the Authorities.

7.4.9 Stability information

During the investigation it was found that the wind contour included in the stability booklets generally lacks the derricks and their wires and it is not corrected for items that are later added, such as VSAT-masts or deck gear. Especially for the smaller vessels this can make a significant difference, as can be seen in chapter 8.4.1. Therefore, also for this subject is assessed and risk ratings were determined.

According to article 1 of the Bekendmaking aan de Zeevisvaart 12/1989 (NSI, 1989) the VCG of the derricks in horizontal position can be used for the stability calculations. However, during normal fishing operations the VCG changes considerably when derricks are moved while the fishing gear is in the derricks.

Alterations of the vessel, e.g. the lengthening of the derricks or change of fishing gear also lead to difference in VCG and the stability information must be corrected accordingly. Example is the story of fishing vessel Mary Kate, where there was a huge difference between the Light Ship Weight and its centre of gravity and the actual measured centre of gravity. This resulted in a dangerous situation. (Buitendijk, 2021)

The fact that the fishing conditions are not included in the stability information available to the crew is a serious defect with high severity.

None of the factors of stability information can be mitigated by the crew during sailing.

Appendix XIV shows the risk rating of the stability information.

7.4.10 Conclusion

The FMEA-based method qualifies the contribution of the various factors to the risks for the stability of beam trawlers during fishing operations. The risk factors of wind are relatively low at wind force 6 and increase with the wind force. The effect of longitudinal waves with a wavelength similar to the vessel’s length however, is already substantial at winds of 4 – 5 Bft. (Appendix XVIII)

The risk ratings for asymmetrical positions of the derricks are moderate, but the risk ratings of asymmetrical loads on the derricks are high, depending on the contents of the net. The effect of failure of a safety system in case of a net getting stuck, is also rated with a high risk factor.

The mitigating effect of a functioning safety system is significant: When the fishing block of a heavy of stuck net is lowered from the top of the derrick to the side of the vessel, the risk rating drops with it form high to low.

The risk ratings for the education and training of the crew are high, because additional training focused on the stability risks will help them to make more risk-based decisions. Also, the effect insurance of the (salvage) of the fishing gear on the risk of stability is rated.

Setting up dedicated guidelines for the stability during fishing and inspections focused on topics such as lengthened derricks or the storage of stern trawl gear during beam trawling will reduce the safety ratings of the factor authorities considerably.

Accurate stability information with a correct wind contour and VCG and fishing conditions added, will have a huge effect on the risk ratings of stability information. Now they are the highest risk ratings.

8 Setup of the calculation-based analysis of stability

The FMEA-based analysis of stability as described in the previous chapter is considered as qualitative analysis, giving information on the risk ratings of fishing conditions. Based on these risk ratings, conditions were selected that needed analyzing with stability calculations.

To assess the stability risks of the various fishing conditions, the heeling moment induced by each factor (mentioned in chapter 7.4) was added to the basic loading condition of the vessel. For the purpose of the calculation this basic loading condition is one selected condition[9] out of the stability booklet, complemented with derricks in the upright (store) position. The result of this calculation is the remaining righting moment, which is used to quantify the stability risk of the vessel.

It would have taken too much time to calculate every possible condition, for each beam trawler included in the investigation, in the stability calculation program PIAS. Furthermore, PIAS-models of existing vessels of the fleet are not always available. Therefore, for each condition the remaining righting moment was calculated in Excel, based on data from the stability booklet, the General Arrangement plan and information on the fishing gear. Random checks with PIAS were done to verify the outcomes.

By doing so, the remaining righting moments can easily be calculated for other beam trawlers, based on the data from the stability booklet and information on the derricks and the fishing gear. This makes it possible to extend the calculation to the whole fleet of beam trawlers and thus assess the risks for the stability for each vessel.

The following paragraphs describe the calculation method, the input of the calculations, the options available, and assumptions that were used.

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[9] Departure from fishing grounds, 100% Catch, 50% Consumables (chapter 8.2)

8.1 The basis of the calculation method

The basis and working of the calculation method is presented in the flowchart below (Figure 16). An explanation of the steps are given below:

1. Determine GZ-curve and righting moment of *basic loading condition*;
2. Calculate the change in stability of the vessel due to the *operational condition* considered; position of the derricks, the lifting of fishing gear, weight of catch and debris, etc.(paragraphs 7.4.2 – 0 of the FMEA-chapter);
3. Determine intermediate GZ-curve and righting moment;
4. Calculate external heeling moments due to wind, waves, water on deck, etc. (Chapter 8.4). Apply these as combined moment to the GZ-curve calculated in 3;
5. Determine the *final* GZ-curve and remaining righting moment;
6. Extract the following results:
    - A. The remaining righting moment as percentage of the righting moment of the *basic loading condition* (see 1);
    - B. The remaining righting moment as percentage of the required righting moment from the regulations.

The calculation is performed for a number of vessels at once (details of vessels used are found in chapter 9.2.1), for the basic loading condition derived from the stability booklet (explained in more detail in chapter 8.2).

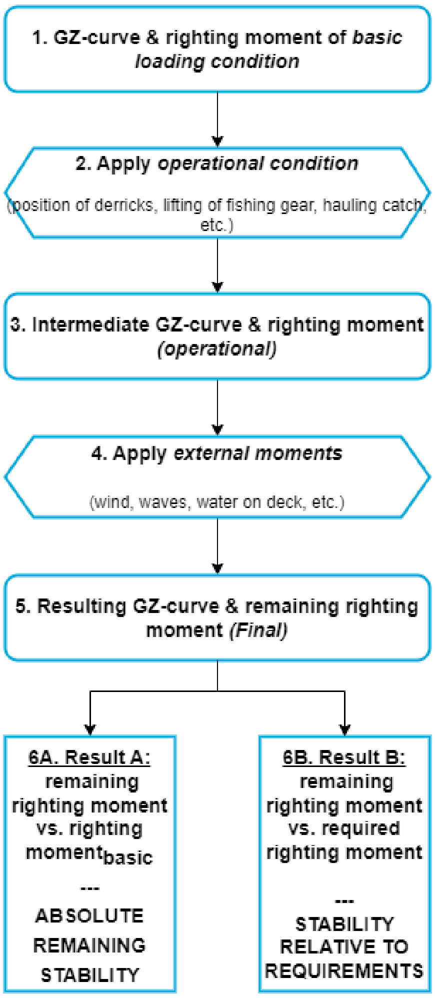

Figure 16: Flowchart showing the steps of the calculation method.

The results of the calculation are twofold:

1. Absolute remaining stability;
2. Stability relative to the Dutch regulations for beam trawlers. (NSI, 1989) (MIWM, 2002)

An important difference with most previous studies is that the focus is not on compliance with the regulations, but on the actual and absolute stability performance of the vessels. As is shown in 0, when the vessel in a certain condition does not comply with the stability criteria, this does necessarily mean that its stability is insufficient; the vessel may still have sufficient ability and righting moment to withstand certain external heeling moments like wind or waves, or a combination of them.

Furthermore, the following is to be noted on the calculation method:

- It is a statical calculation. Dynamical effects are not taken into account.
- It has been validated with PIAS randomly throughout the study. Details can be found in Appendix XVII.

The calculation steps described above are elaborated in the following paragraphs. Details on the formulas used can also be found in Appendix XVII.

8.2 Basic loading condition

It is chosen to use one of the standard and mandatory loading conditions for beam trawlers, which is also present in the stability booklets. The following condition is considered as a worst-case but realistic fishing condition, and is used as basis for all calculations:

Departure from fishing grounds, 100% Catch, 50% Consumables

By default, all standard loading conditions in the stability booklets are calculated with the derricks in horizontal position (NSI, 1989). For this investigation this is not considered to be accurate, as the store position of the derricks is with the derricks topped up. Therefore, the derricks in store position (Code *8080* in the calculations) are used as basis for the basic loading condition. Thus, the above-mentioned loading condition is converted to a condition with the derricks in store position.

8.3 Calculation of the operational condition

The operational condition of the vessel is composed from the following elements. It corresponds to a combination of the elements from 7.4.2 to 0 of the FMEA-analysis:

- Position of derricks PS (00 degrees - 45 degrees - 80degrees (=store position));
- Position of derrick SB (idem);
- Beam trawl gear hanging in derrick PS or acting at bulwark (when safety system is activated);
- Beam trawl gear hanging in derrick SB or acting at bulwark (idem);
- Stern trawl (twin rig, or other) on board;
- Hauling net PS (can be catch, debris or both catch + debris);
- Hauling net SB (can be catch, debris or both catch + debris);
- Catch or debris or both catch + debris in net PS (acting at derrick or bulwark);
- Catch or debris or both catch + debris in net SB (acting at derrick or bulwark);

For each of these elements, the effect on the vessel's VCG and TCG is calculated and this results in a change in the stability of the vessel. Figure 17 shows an example in which the stability of the vessel with a specific operational condition is decreased compared to the basic loading condition.

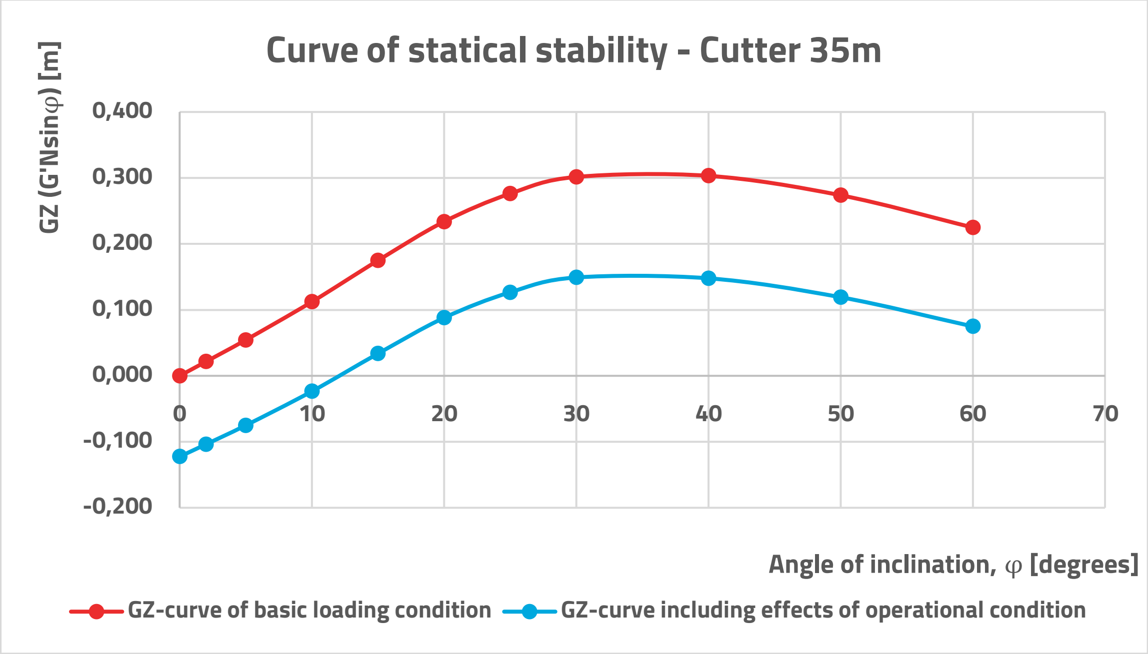

Figure 17 GZ-curves showing the effect on stability of a certain operational condition.

8.4 Calculation of external moments.

The following external factors have been considered:

- Steady wind (from 5 to 10 on the scale of Beaufort);
- Wind gust (factor 1.5);
- Waves
    - Longitudinal;
    - Transverse;
- Water on deck;
- Gear + catch/debris PS skipped to SB-side.

Each of the factors is described in detail in the following paragraphs.

8.4.1 Steady wind

The occurring wind moment due to wind blowing transversely on the vessel with wind forces of 5 up to 10 Beaufort can be applied. This is considered to be realistic. If the weather forecast indicates higher wind forces than 10 Beaufort, it is assumed that the vessel is not leaving port, or returning to a safe haven when already at sea.

When examining the used wind contours and corresponding wind levers in the stability booklets, it was noted that in all cases the wind contour is incomplete and lacking parts such as the derricks, mast rigging, radars, and all of the wires.

Thorough analysis of the wind contour of one of the reference vessels resulted in an increase of both the lateral area as the wind lever with approximately 15% compared to the original values. Details of this calculation are found in Appendix XVII. Still excluded are parts like the pulleys, but also the fishing gear because this is not always hanging above the water. Furthermore, estimates of other reference vessels yielded similar values. Based on these arguments, 15% increase on the *lateral area* and *wind lever* has been applied to all vessels considered.

8.4.2 Wind gust

A wind gust is taken into account by multiplying the external moment due to steady wind (as described in chapter 8.4.1 with a *wind gust factor* of 1.5. This is based on the IMO Weather Criterion (IMO, 2022) and means that in a steady wind of force 6 Bft, gusts of wind force 7 Bft are applied.

8.4.3 Waves

Two different types of waves are considered: longitudinal waves and transverse waves. A third relevant type is considered to broaching waves: waves coming from abaft. However, the statical effect on the stability of this type of wave was in most cases found to be less than that of longitudinal and transverse waves, and therefore has not been considered. The dynamical effects of broaching however are significant and can even lead capsizing of the vessel.

Broaching was the cause of capsize of fishing vessel *Catrina* (MAIB, 1999). She capsized in moderate weather (windforce 5 bft, 2-meter waveheight) in stern quartering waves which caused her to heel heavily before being pushed over by one big wave. But as dynamical effects are not considered in this study, broaching is left out of the analysis. It shall however be investigated in subsequent studies.

The implementation of longitudinal and transverse waves is described in the following paragraphs.

8.4.3.1 Longitudinal waves

The most unfavorable wave considering waves in longitudinal direction are waves with a wavelength of about the length of the vessel and with the vessel lying on the wave crest. This situation is called *Pure Loss of Stability* and if the vessel is in such situation its stability can be dramatically decreased due to the decrease of waterplane area. This can lead to instant capsize of the vessel and is considered a high-risk situation (Gonzalez, Casas, Rojas, Agras, & Ocampo, 2015). This is especially the case when the vessel is sailing in following waves, what is often daily practice with beam trawlers. See Figure 18 for an illustration of this phenomenon.

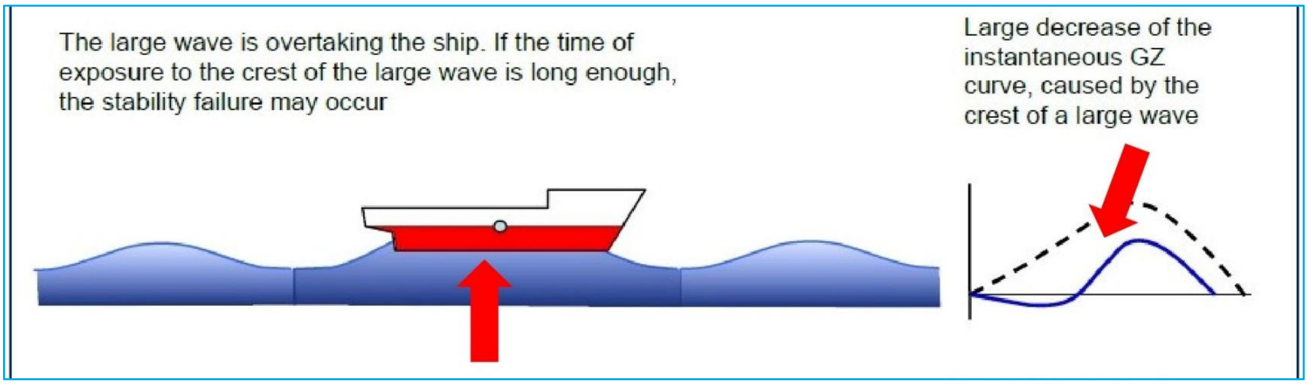

Figure 18: Illustration showing the possible effect of *pure loss of stability* in longitudinal waves. (Source: IMO SDC 7/INF.2_26 November 2019, "FINALIZATION OF SECOND GENERATION INTACT STABILITY CRITERIA.......", ANNEX – "DRAFT CONSOLIDATED EXPLANATORY NOTES OF INTERIM GUIDELINES ON SECOND GENERATION INTACT STABILITY CRITERIA", page 27)

Based on a number of reference ships, and a calculation of the most unfavorable, but actually occurring, wave steepness in the North Sea, the *decrease in righting moment* was determined by means of PIAS. The result was a decrease of stability between 60% and 90%. A relation was found between displacement and the decrease in righting moment. These results were then translated into a general formula, which was used in the calculation model. The trendline and formula are shown in Figure 19.

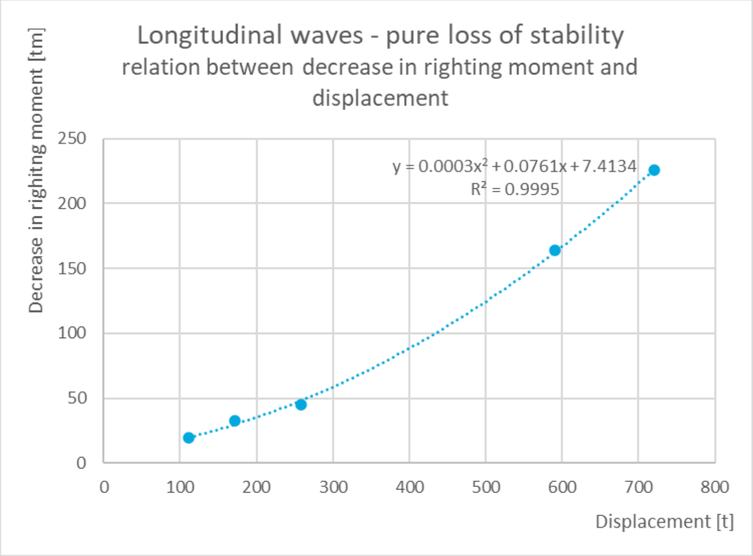

Figure 19: Relation between decrease in righting moment and displacement for a vessel in a longitudinal wave crest.

Other important considerations for marking longitudinal waves as a substantial risk are:

- The limited maneuverability during fishing operations. If the crew experiences problems or feels that the situation is getting unsafe, they have very little or no possibility of instantly changing the course of the vessel. Reference is made to chapter 7.4.6.

- Current training and education of fishermen does not cover this phenomenon and the risks involved at all. This subject is covered in more detail in chapter 7.4.7.

8.4.3.2 Transverse waves

An attempt has been made to translate the effect of the vessel being hit by a transverse wave, or lying on a transverse wave, into a heeling moment. However, it was concluded that this is almost impossible due to the following:

- Speed of wave compared to the vessel; because the vessel has almost no speed compared to the transverse wave, the wave always passes the ship, so the movement of the wave, its speed and thus the time factor plays a role, thus making it a dynamical phenomenon.
- Position of vessel on the wave matters and has a significant effect. This has been discovered by applying a transverse wave to one of the reference vessels in PIAS and varying the position of the top of the wave along the breadth direction of the vessel. As reference the same wave as used for the longitudinal wave was used. Most reference vessels feature a negative stability at the position halfway between the wave crest and wave through. So only considering transverse waves in a statical way, would lead to default capsize of the vessel. This is not what happens in reality.

To be able to judge the possible sensitivity / vulnerability for transverse waves to some extent, an example calculation was performed in PIAS. For both the basic loading condition and the final stage with 10% righting moment remaining (orange category as described in chapter 8.5), the boundaries of positive stability along the wavelength were determined.

In the latter condition, the part of the wavelength in which the vessel has a negative stability is much larger than the part in which it has a positive stability. In the basic loading condition, the vessel has a positive stability for a large part of the wavelength, so one can argue that the time factor and the passing of the wave will right the vessel again when the ‘dead point’ has passed. This is illustrated in Figure 20. The vertical red line indicates the position of the centreline of the vessel at the wave.

This shows that with a decrease in stability due to operational condition and/or external moments, vessels can be very vulnerable to capsize in transverse waves. The effect of the fishing gear in the water could not be included in this calculation but is considerable. Therefore, it has been chosen to include transverse waves in the qualitative analysis; in the FMEA-analysis (see chapter 7).

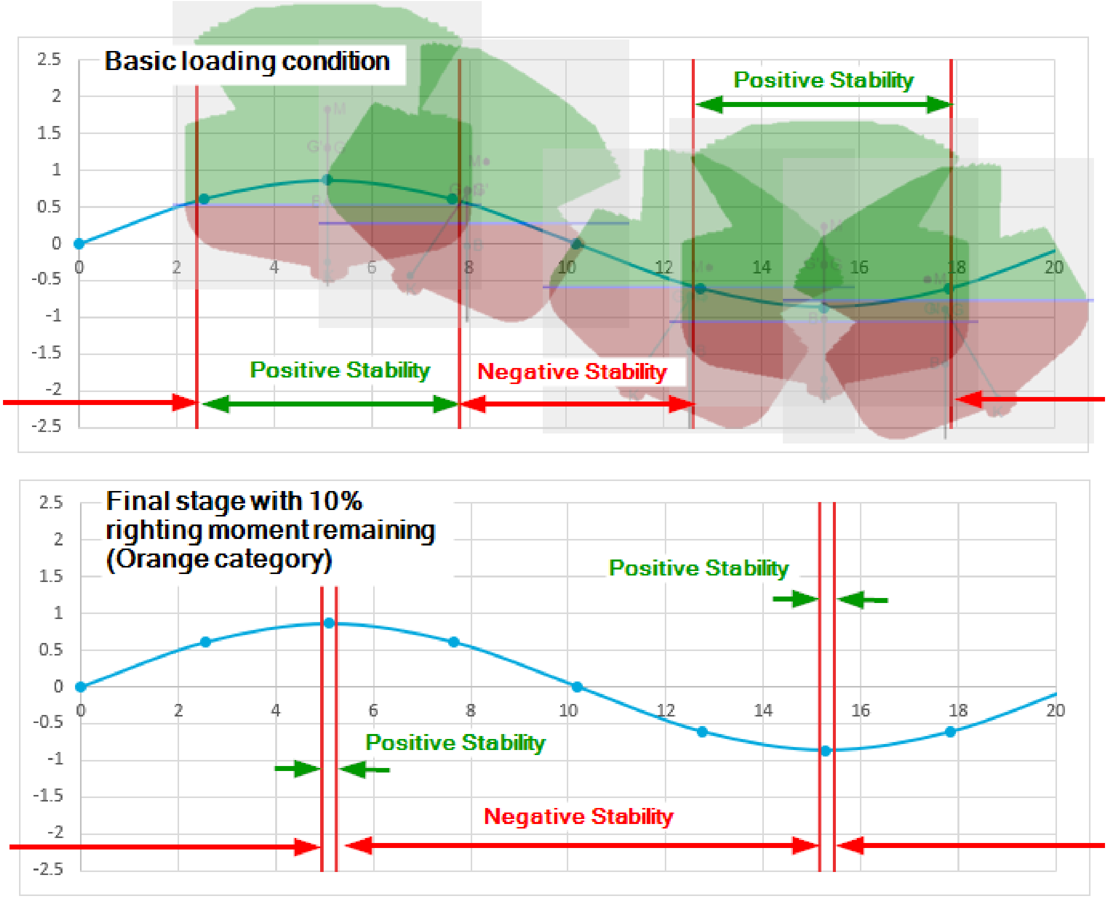

Figure 20: Example calculation of vessel stability in transverse waves (statical). A decrease in stability can make a vessel very vulnerable to capsize in transverse waves

8.4.4 Water on deck

The influence of water on deck has been approximated by determining a default amount of water on deck in relation to the vessel's open deck area.

This default amount of water is determined based on a reference vessel: Z-19 Sonja of which an accident report is available (FEBIMA, 2018). In this report, calculations were made with 1m^3, 3m^3 and 5m^3 of water on deck. These amounts of water were translated to a level of water on deck and for 3m^3 this resulted in a water level of 4cm. This is considered to be a reasonable level and was used in the calculation model.

Furthermore, for Z-19 Sonja and two of the reference vessels used in the calculations, the deck area ratio versus *length * breadth of the vessel* was determined. This ratio ranged from 0.39 to 0.46. See the table in Appendix XIX for an overview of this calculation. A ratio of 0.40 was taken as default value.

With both the default water level and deck area ratio, for every vessel in the calculation, the amount of water and thus the weight can be calculated. To get to a heeling moment, also a lever is needed. The lever is determined by means of modelling moving water on deck in PIAS. For a heeling angle of 10 and 20 degrees, the movement and center of gravity of the water was determined and this distance was translated to a factor related to the half breadth of the vessel. The resulting factor for the lever is *0.75 * half breadth*.

8.4.5 Gear + catch/debris PS skipped to SB-side

This option is illustrating the event of fishing gear plus any catch at PS skipping over to SB and then acting at SB-side. Either by the 'fishing wire' pulling underneath or overhead of the vessel in an event where the vessel is (uncontrollably) turning. After talking to fishermen, it became clear that many of them have experienced this event, where the fishing line of one of the nets flipped over or underneath the aftship. Figure 21 shows this situation.

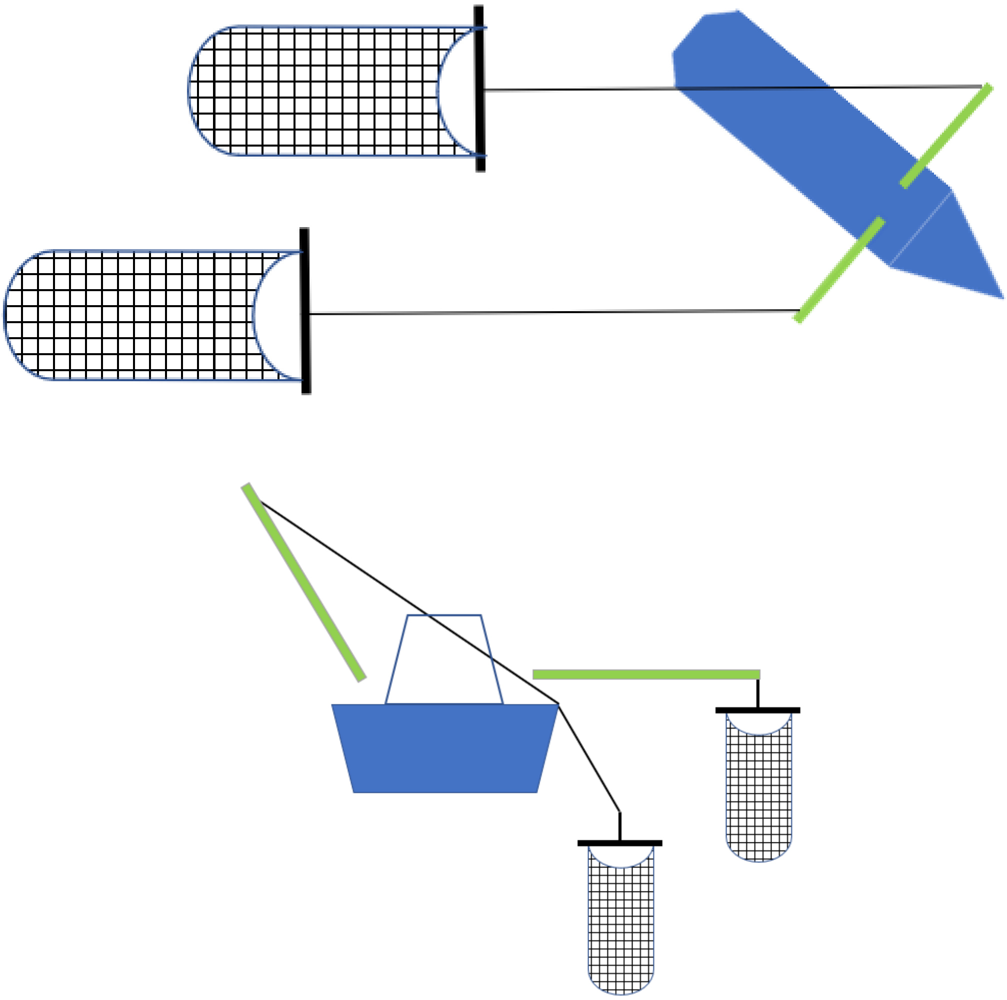

Figure 21: Gear skipped to SB-side

In many cases this was solved, but it has also led to capsizing of the vessel.

One fisherman explained in detail how the beam trawler he sailed on had capsized in the mid-sixties after such an event. The accident with the UK-171 'Spes Salutis' (Dutch Safety Board, 2021) was also caused by this event. Therefore, it is considered to be a worst case, but realistic scenario.

This event is implemented in a simplified way by subtracting the weight, and thus heeling moment, on PS and adding it to the SB side at the point where the fishing gear is acting in that particular scenario. This can either be the top of the derrick or the bulwark when the safety release system is activated (see chapter 7.4.5).

8.5 Remaining righting moment

After subtracting the applied external heeling moments (described in detail in the previous paragraphs), the result is a remaining righting moment or a negative righting moment. It is obvious that in the latter case the vessel has capsized; it does not have any remaining righting moment to overcome the heeling moment.

The remaining righting moment is compared to the *righting moment*$_{basic}$ and converted to a percentage of this value. These percentages are categorized as presented in Table 8:

Remaining righting moment / Righting moment$_{basic}$	**Category**	**Notes**
<0%	🟥	Due to this combination of operational condition and external moments the vessel will have no remaining righting moment
<10%	🟧	Very critical, with a very large probability of the loss of righting moment due to one added external moment (event) or dynamical effects.

Table 8: Categorization of remaining righting moment vs. righting moment of basic loading condition

To provide some order of magnitude, the limit of 10% of the orange category is chosen based on the amount of heeling moment induced by *steady wind of 6 Bft* + *wind gust*, or *water on deck.* Based on the vessels investigated, it was concluded that in general both events induce a heeling moment of about 10% of the *righting moment*$_{basic}$.

8.6 Check against the stability requirements

For the final stage of stability, *basic loading condition* + *operational condition* + *external heeling moments*, compliance with the Dutch beam trawler regulations are checked (See chapter 4.1.2 for the criteria).

Therefore, the GZ-curve of *basic loading condition* + *operational condition* is updated with the effects of the applied external heeling moments by subtracting the lever of the total external heeling moments from the GZ-values. This is illustrated in Figure 22 below.

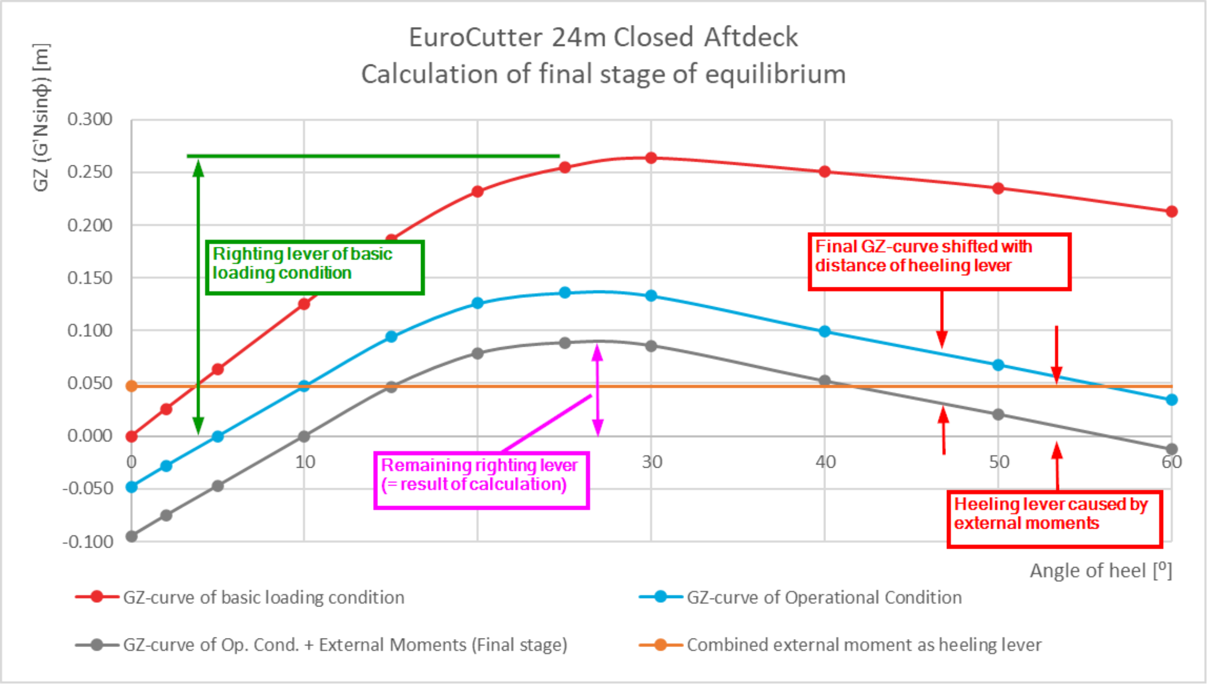

Figure 22: Different parts of the calculation of stability of combination of operational condition and external moments.

The final resulting GZ-curve (grey curve in Figure 22) is checked against minimum required righting lever (GZ-value at top of the curve) as required by the regulations. The remaining righting lever is expressed as a percentage of the minimum required righting lever and is categorized as shown in Table 9.

Remaining righting moment / Required righting moment	Category	Notes
<0%	🟥	This combination of operational condition and external moments results in loss of righting moment and thus of compliance to none of the requirements
0-20%	🟪	20% is the allowance on the stability requirements for beam trawlers. Thus, this category indicates that if this allowance did not exist, the vessel would lose its righting moment in this condition.
20-80%	🟦	In this category, the vessel does not comply to the requirements for fishing vessels at all.
80-100%	🟦	80% is a 20% decrease, which is equal to the allowance for beam trawlers. Thus, in this category, the vessel in this condition does not comply to the requirements for beam trawlers[10], but still does comply with the general requirements for fishing vessels.
>100%	🟩	Complies to all the requirements, including the 20% allowance for beam trawlers.

Table 9: Categorization of remaining righting moment vs. required righting moment from regulations.

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[10] There are a number of other requirements besides the GZ-value that feature the 20% allowance, which may still be met, but in this study the GZ-value is taken as measure.

8.7 Assumptions

The following assumptions in the calculation method and calculations have been made:

- The vessel’s hull and LSW are assumed to be symmetrical;
- In calculations of asymmetrical conditions, heel is calculated to SB side only;
- Fishing gear and net are free hanging; no part is in the water;
- The acting point when hauling the catch is in the top of the mast at centreline.
- Beam trawl gear is on board by default;
- Stern trawl gear is not on board by default (as required by ILT for most vessels). This is optionally added in the operational condition;
- LCG is not taken into account; level trim is assumed. Cross curves at level trim are used.
- When hauling catch, the weight of both catch and/or debris is taken into account as extra displacement and considered acting at the hauling point;
- Cross curves are not corrected for increase in displacement due to lifted weights of catch etc. The effect of this is very limited and is considered to be in the margin;
- When catch and/or debris is in a net and acting at either the top of the derricks or at the bulwark, it is assumed that the cod-end is in the water, so the catch is hydrostatically ‘neutral’ and no weight and additional displacement is taken into account. Only the weight of debris is accounted for.

9 Analysis

9.1 FMEA based risk analysis

As mentioned in chapter 7.1 the risk analysis of the fishing conditions of beam trawlers was based on the FMEA risk analysis method. In this chapter the method of the analysis and the results of it are presented.

The fishing conditions were based on every day fishing activities, derived from the information on the website of Vistikhetmaar (https://vistikhetmaar.nl/onderwijs/), the situations of the vessels discussed in the stability appendix E of the investigation report on the capsizing and sinking of beam trawlers (Dutch Safety Board, 2021) and discussions with fishermen.

9.1.1 Set up of the analysis

In chapter 7 the FMEA-based analysis was shown for various separate failure modes. The failure modes were subdivided in categories and for each failure mode de risk rating was assessed. The results can be found in the following chapters:

- 7.4.1 External factors;
- 7.4.2 Internal factors;
- 7.4.3 Loads on derricks;
- 7.4.4 Hauling catch;
- 7.4.5 Fishing net to the side of the vessel;
- 7.4.6 Maneuverability;
- 7.4.7 Crew;
- 7.4.8 Authorities;
- 7.4.9 Stability information.

The failure modes can be divided in two main categories:

- failure modes that can be included in the stability calculations, the sailing and fishing conditions, described in chapters 7.4.1 – 7.4.5, the ‘hard factors’;
- failure modes with the origin in other factors, such as crew, described in chapters 7.4.6 – 7.4.9, the ‘soft factors’.

In the following two chapters the risk ratings for both categories are presented.

9.1.1.1 Risk ratings codes

The fishing conditions that were used for the stability calculations, the internal conditions, were coded. First the angle of the derricks is mentioned by two numbers, the first for the PS derrick and the second for the SB derrick. They are followed by codes for the condition of the fishing gear.

In Figure 23 examples are given for two of the codes. The codes for the situations observed for this investigation are given in Appendix IV. Codes for the external factors like wind and waves are given in Appendix V.

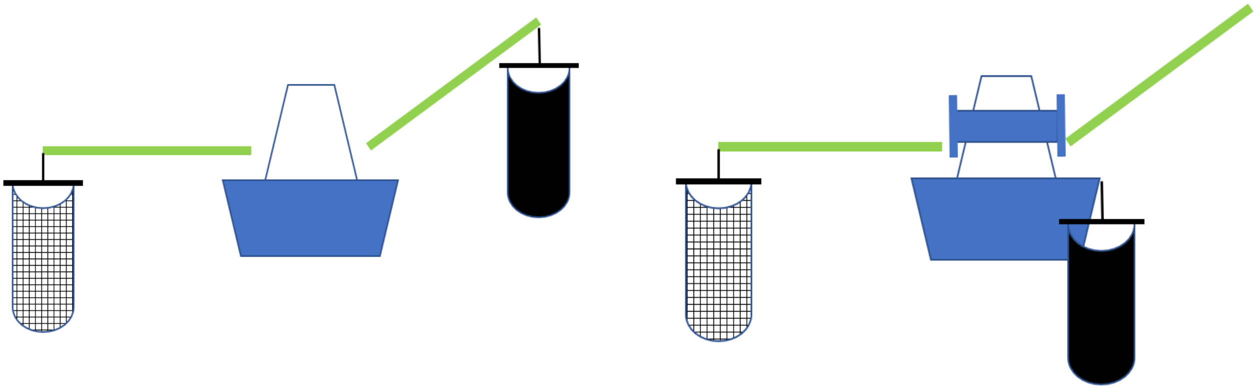

Figure 23: Situation with code 0045-BDP-NDS (PS derrick horizontal with empty net, SB derrick at 45 degrees and debris) and code 0045-BDP-NDS-GRD1-BBS-STG (PS net emtpy, SB safety system activated: net with debris lowered to the side of the vessel and Stern Trawl Gear stored on net drums)

9.1.1.2 Combined risk ratings

The effect of combinations of failure modes is expressed in the sum of the risk ratings of each separate failure mode. For example: The risk for broaching at wind force 9 Bft can be obtained from the sum of both failure modes: 1.1.1.2 ‘Waves coming at 45 degrees from aft’ + 1.1.2.3.1 ‘Wind force 9 Bft without gust’ gives a risk rating of 315 + 245 = 560.

9.1.2 Risk rating of combined failure modes for ‘hard factors’

To determine the set of conditions, that could be used in the calculations of the remaining heeling moment for each vessel, a risk rating matrix was made with combinations of internal and external factors, the ‘hard factors’ as mentioned in chapter 9.1.1. These factors were used to calculate the stability of all vessels included in the investigation, as can be seen in chapter 8. Examples of observed fishing conditions, with their codes, are given in Figure 24 and Figure 25. Condition 8080 is the basic condition, 8080-BDP-BDS is the basic condition with nets hoisted from deck, suspended from the derricks.

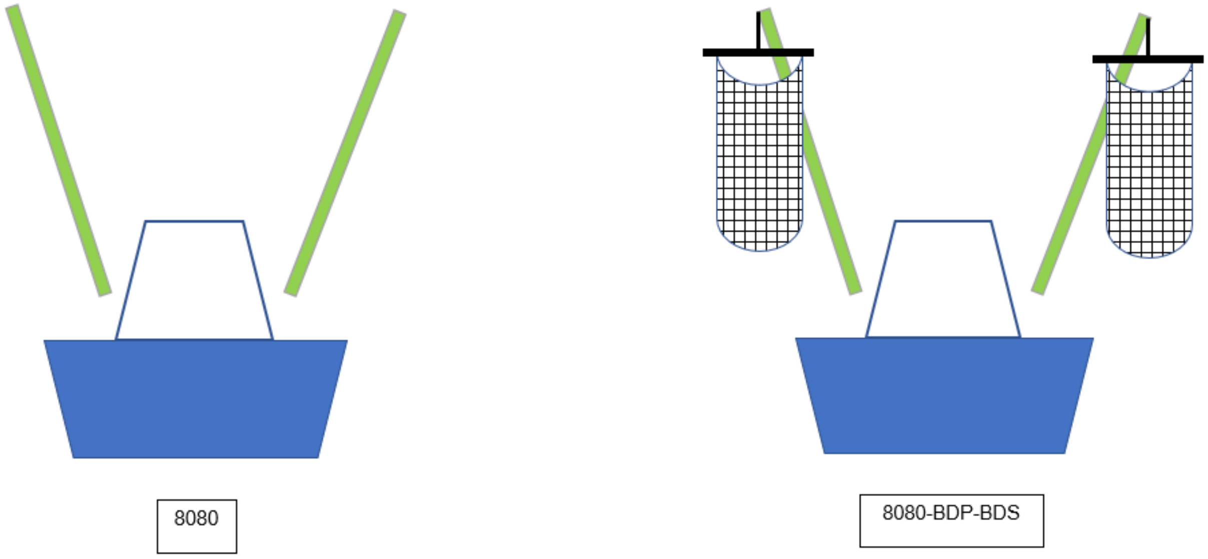

Figure 24: Combined situations for fishing conditions with codes 8080: Derricks fully topped in transit position and 8080-BDP-BDS: Same situation, with fishing gear hoisted free from deck

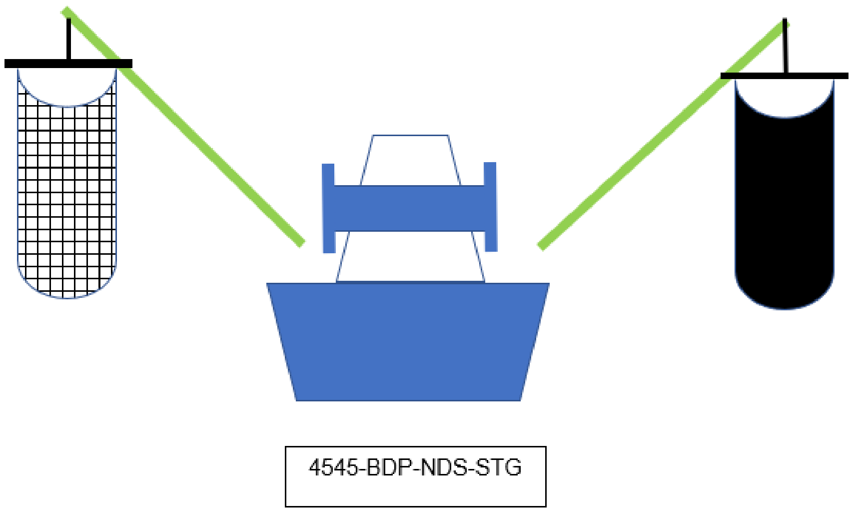

Figure 25: Explanation of code 4545-BDP-NDS-STG

4545-BDP-NDS-STG (Figure 25) shows the vessel with derricks at 45 degrees, net at PS, net with debris at SB and stern trawl gear stored at the net drums.

Appendix XVI shows the score chart for risk ratings for the combined effect of various operating conditions and wind, waves and water on deck. The operating conditions were chosen as indicated in chapter 9.1.1.1. The colouring of the cells is based on the value ranges as described in chapter 7.4.

This combined risk rating matrix demonstrates that:

- The risk ratings for the vessels' condition during sailing to and from the fishing grounds, as required for the stability booklet, are not representative for the risk ratings during fishing. The 8080 conditions have almost no orange and red markings and many of the fishing conditions have a much higher risk rating;
- The stern trawl gear remaining on the net drums on the aft ship has a serious effect on the risk rating. For example: Compared to the 8080 condition the risk ratings for the 8080 – STG condition turn to orange and even red. For all conditions where the stern trawl gear is still on the vessel while beam trawling, the risk ratings are seriously increased;
- Asymmetrical loads on the derricks increase the risk rating considerably;
- In conditions where heavy loads are caught in the nets, mitigation by means of a functioning safety system reduce the risk rating, whereas a not-functioning system can lead to extreme risky situations and even capsizing. Maintenance and regular testing of the safety systems is crucial.
- The effect of longitudinal waves with a wavelength equal to the ship's length lead to a drastic reduction of the vessel's stability. Since for these vessels this wavelength can already occur at the North Sea (Appendix XVIII) during conditions with winds force 5 – 6 Bft, this situation is a serious risk for vessels up till 24 m.
- When one fishing line flips over to the other side of the vessel, the risk rating increases, as can be seen in the column 'W6GuGs'. The risk rating for the net switching over to the other side is relatively low, because the occurrence is low, as can be seen in chapter 7.4.5. However, the impact on stability and thus the severity is very high. It was the cause of the capsizing and sinking of the UK-171 'Spes Salutis'. (Dutch Safety Board, 2021) Therefore, for a proper interpretation of the risks, the risk rating score chart must be combined with the righting moment score chart.

9.1.3 Risk ratings of failure modes including ‘soft factors’

For the combined risk ratings not only the effect of the factors, for which the effect can be calculated in a stability calculation, the ‘hard factors’ have to be taken in account, but also the effect of the failure modes that cannot be calculated, the ‘soft factors’. The risk ratings for these factors were given in chapters 7.4.7 – 7.4.10. These risk ratings must be added to those presented in Appendix XVI to assess the combined effect.

For example: The effect of fatigue of the crew has a risk rating of 294, so this is to be added to all combined risk ratings.

As a consequence, mitigating the issues of the ‘soft factors’ will have an immediate positive effect on risk ratings of **all** the sailing and fishing conditions of the fishing vessels.

9.2 Risk analysis based on stability calculations

As mentioned in chapter 7 there are numerous combinations of conditions for beam trawlers that can be calculated. To select the most relevant situations, the FMEA-based analysis was used.

The results of these calculations are presented in a score card, in which the effects of the various conditions added to the base condition is shown.

9.2.1 Analysed vessels

In Table 10, an overview is given of the vessels that have been analysed. It shows that a complete range of vessel sizes has been considered: ranging from 20m in length to over 40m.

Vessel no	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Name	EuroCutter 20m			EuroCutter 24m Open Aftdeck	EuroCutter 24m Closed aft deck	Cutter 35m	Cutter 2000hp		Cutter 44m 2975hp
variant	Original	Heavy Gear (HG)	Lengthened Derricks (DE)				Original	Light Gear (LG)	
LOA [m]	19.99			23.10	23.97	37.15	42.90		44.60
Stability factor[11]	1.00			1.00	1.00	1.00	1.15		1.67

Table 10: Overview of the vessels that have been considered and analysed.

In Table 11, the variations of vessel 1 and 7 are explained:

Vessel no.	**Name**	**Variant**	**Weight**	**Explanation**
1	EuroCutter 20m	Original	1350 kg	Original shrimps fishing gear.
2	EuroCutter 20m	Heavy Gear (HG)	1950 kg	Fishing gear for Sole, including chains etc.
3	EuroCutter 20m	Lengthened Derricks	+50 kg per derrick	Original, with 1-meter extra derrick length.
7	Cutter 2000hp	Original	8500 kg	Original heavy fishing gear.
8	Cutter 2000hp	Light Gear (LG)	6000 kg	Light fishing gear based on limited power[12] and SumWing.

Table 11: Explanation of vessel variations considered in the calculations and analysis.

The input data of the vessels for the calculations is found in Appendix XX. Furthermore, the data which the fishing gear weights of the variants are based on, is found in Appendix XXI

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[11] Stability factor based on installed engine power. See chapter 4.1.2.1 for an explanation.

[12] Nowadays, power is limited in many cases, allowing for sailing with lighter fishing gear.

9.2.2 Results

9.2.2.1 Basic stability compared to the length of the beam trawler

Except for one vessel, all investigated capsizing accidents happened to beam trawlers of 24 m or less, as can be seen in Figure 26. See also chapter 3.

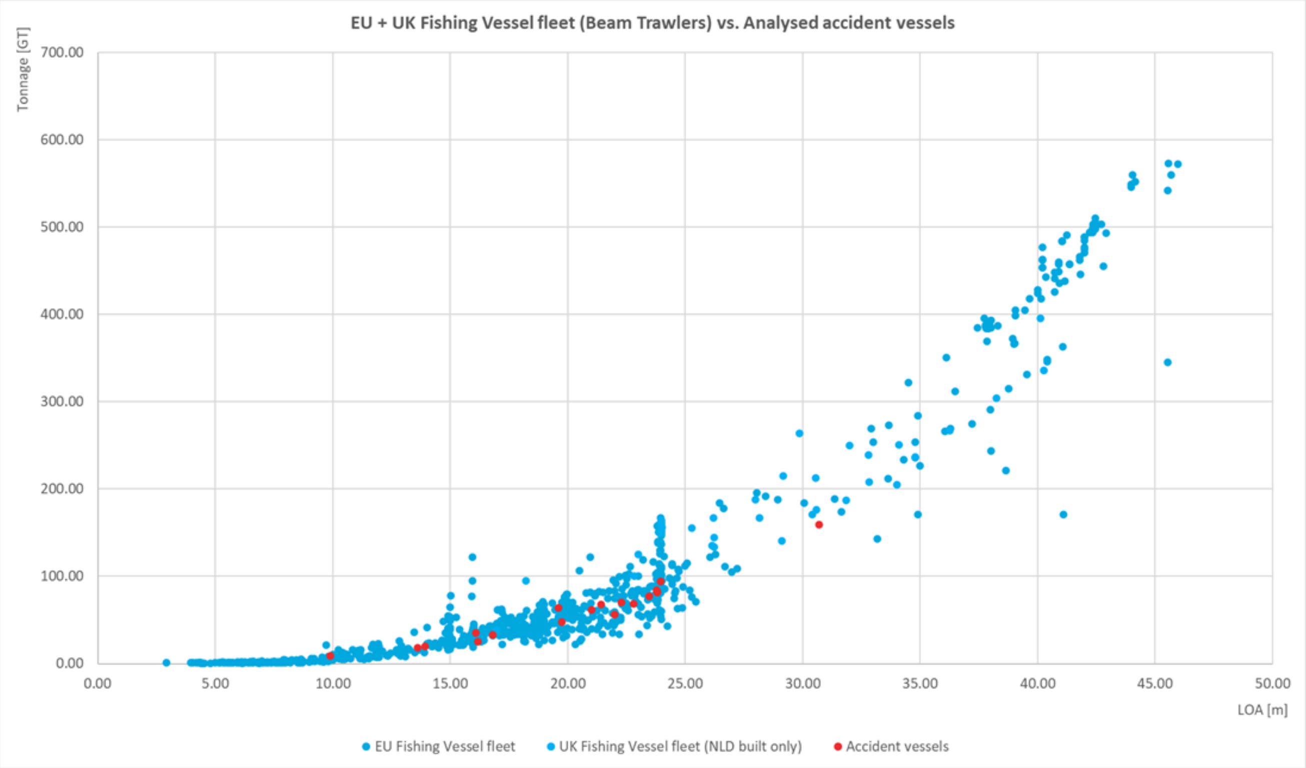


Figure 26: Accident vessels compared to the entire beam trawler fleet

For this investigation the remaining righting moments for the different sizes of vessels were compared. To be able to do so, they were calculated for various operating conditions for the vessels used in our stability investigation. Table 12 gives an overview of the results for the remaining righting moments in the basic condition as described in chapter 8.2 This shows that the larger cutters have considerable more remaining righting moment and also shows the vulnerability of the beam trawlers < 24 m.

Vessel nr.	Type of vessel	Vessel and Operational Condition	NoExternal [tm]
1	EuroCutter 20m	8080	28
2	EuroCutter 20m HG	8080	28
3	EuroCutter 20m DE	8080	28
4	EuroCutter 24m v1	8080	45
5	EuroCutter 24m v2	8080	68
6	Cutter 35m	8080	179
7	Cutter 2000hp	8080	244
8	Cutter 2000hp LG	8080	247
9	Cutter 44m 2975hp	8080	317

Table 12: Remaining righting moments in the basic condition

9.2.2.2 The effect of asymmetrical loads

For the investigation the remaining righting moment for various asymmetrical conditions were calculated. For example: When fishing starts, both fishing gears are hoisted in the derricks, in the 8080-BDP-BDS condition. Then one of the derricks is lowered to 45 degrees, creating an asymmetrical condition with empty nets. Figure 27 shows both situations.

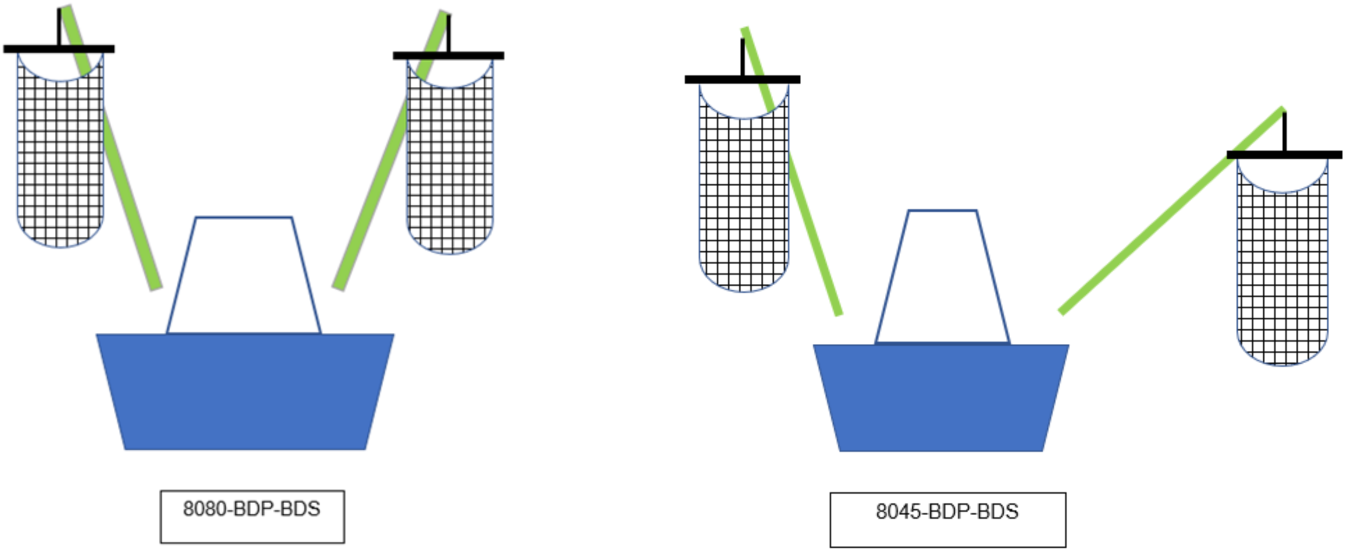


Figure 27: Sketches of the first stages of fishing

This example condition is considered to be a normal practice condition, occurring several times a day. The effect of this situation on the remaining righting moments, without the influence of waves and wind, is given Table 13. The orange marking shows that the remaining heeling moment is reduced to 10% or less of the required righting moment.

Vessel nr.	Type of vessel	Vessel and Operational Condition	NoExternal [tm]	Decrease
1	EuroCutter 20m	8080-BDP-BDS	15	
		8045-BDP-BDS	9	43%
2	EuroCutter 20m HG	8080-BDP-BDS	10	
		8045-BDP-BDS	1	89%
3	EuroCutter 20m DE	8080-BDP-BDS	12	
		8045-BDP-BDS	4	67%
4	EuroCutter 24m v1	8080-BDP-BDS	32	
		8045-BDP-BDS	21	33%
5	EuroCutter 24m v2	8080-BDP-BDS	45	
		8045-BDP-BDS	34	25%
6	Cutter 35m	8080-BDP-BDS	104	
		8045-BDP-BDS	76	27%
7	Cutter 2000hp	8080-BDP-BDS	100	
		8045-BDP-BDS	51	49%
8	Cutter 2000hp LG	8080-BDP-BDS	141	
		8045-BDP-BDS	102	28%
9	Cutter 44m 2975hp	8080-BDP-BDS	163	
		8045-BDP-BDS	102	37%

Table 13: The decrease of remaining righting moment when creating an asymmetrical condition

Table 13 shows the following:

- The decrease of righting moment 20 m beam trawler vessel nr. 1 (with shrimp gear) is significantly higher than the larger vessels, except for vessel 7. This vessel has a heavy fishing gear (Sole gear). The lighter version of the gear, shown in vessel 8, reduces the decrease significantly: 28% instead of 49%;
- The 20 m beam trawler vessel 2 with heavy gear (sole gear) has the largest decrease of the righting moment;
- On the 20 m beam trawler vessel 3, with shrimp gear and lengthened derricks, the effect of asymmetrical loads is far greater than on Vessel 1, with the original derricks;
- Vessel 4 has an open aftschip and vessel 5 a closed one. This has a notable effect on the decrease of the righting moment in the asymmetrical condition.

This table clearly shows that the larger vessels have more remaining righting moment when a derrick is lowered to 45 degrees than the beam trawlers of 24 meter and less. An explanation could be the scale effect, since the larger vessels are almost twice the size of the smaller ones and the heeling effect of the gear is relatively greater for the smaller ones because of the scale effect. Another factor to be considered is the stability factor, see chapter 9.2.2.6.

9.2.2.3 The effect of loss of one fishing gear

As part of this investigation, the remaining righting moments for the vessels when one fishing gear is lost, while the other remains at the end of its derrick, have been calculated. In the observed situation the PS fishing gear was lost, resulting in the derrick moving to the upright condition as shown in Figure 28.

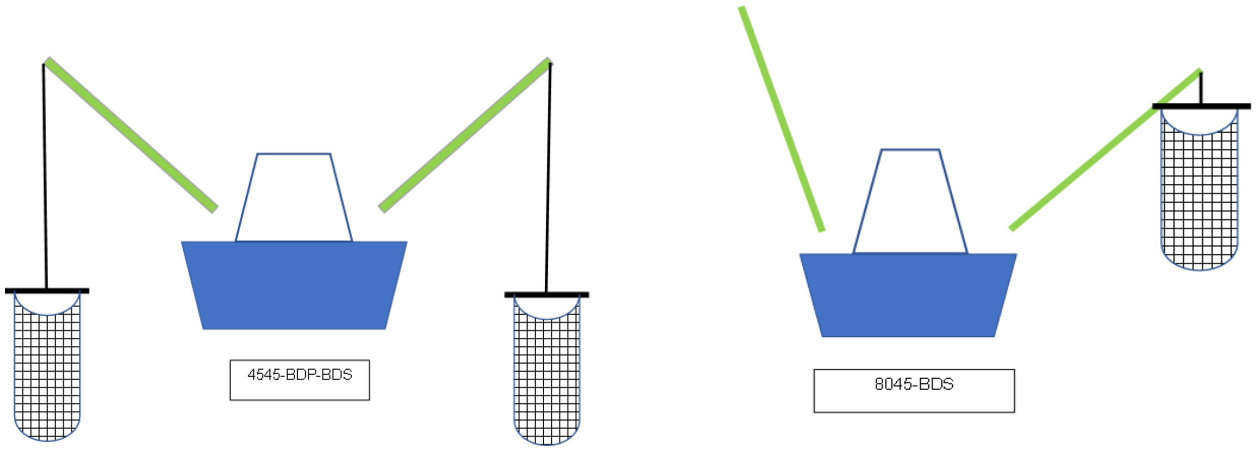


Figure 28: The effect of losing one fishing gear

Both UK-165 “Lummetje” and UK-171 “Spes Salutis” (Dutch Safety Board, 2021) experienced comparable situations, with this respect that with both vessels there was an additional substantial dynamic effect resulting from the loss of the gear. In our calculation only the static stability is investigated. The calculated remaining righting moments with no external factors like wind or waves are given in Table 14.

Vessel nr.	Type of vessel	Vessel and Operational Condition	NoExternal [tm]	Decrease
1	EuroCutter 20m	4545-BDP-BDS	20	
		8045-BDS	16	20%
2	EuroCutter 20m HG	4545-BDP-BDS	15	
		8045-BDS	11	29%
3	EuroCutter 20m DE	4545-BDP-BDS	17	
		8045-BDS	12	30%
4	EuroCutter 24m v1	4545-BDP-BDS	37	
		8045-BDS	28	23%
5	EuroCutter 24m v2	4545-BDP-BDS	52	
		8045-BDS	44	15%
6	Cutter 35m	4545-BDP-BDS	128	
		8045-BDS	107	17%
7	Cutter 2000hp	4545-BDP-BDS	143	
		8045-BDS	118	17%
8	Cutter 2000hp LG	4545-BDP-BDS	174	
		8045-BDS	155	11%
9	Cutter 44m 2975hp	4545-BDP-BDS	215	
		8045-BDS	168	22%

Table 14: Decrease of remaining righting moments when the PS fishing gear is lost

9.2.2.4 The effect of external factors

For the operational conditions from chapter 9.2.2.2 the remaining righting moments with different external factors were calculated. Table 15 shows the remaining righting moments for two vessels for three situations: without external factors, for wind force 6 Bft. and 8 Bft.

Vessel nr.	Type of vessel	Vessel and Operational Condition	NoExternal [tm]	W6 [tm]	W8 [tm]
1	EuroCutter 20m	8080-BDP-BDS	15	13	9
		8045-BDP-BDS	9	6	3
9	Cutter 44m 2975hp	8080-BDP-BDS	163	135	98
		8045-BDP-BDS	102	74	37

Table 15: Remaining righting moments with external factors

As can be seen in Table 15, the remaining righting moments for the 44 m beam trawler are significantly greater than those for the 20 m beam trawler. The smaller beam trawler has a remaining righting moment of about 10 % of that of the larger vessel. The effect of asymmetrical loads on the stability is even greater for more extreme asymmetrical loads.

Appendix XXII shows the score card with the righting moments for all operational conditions for the vessels.

The score card demonstrates that in many situations the vessels have a considerable decrease of the remaining righting moment and do not comply with the criteria anymore (see also chapter 9.2.2.5), but still have a remaining righting moment.

However, the appendix shows that in 25% of the examined operational conditions the vessels have **no remaining righting moment**. Examples of these conditions are:

- Most operational conditions in wind force 6 Bft. with a longitudinal wave, for all beam trawlers except for the 43 m trawler with light gear;
- All situations where a one fishing gear skips over to the other side, for all vessels;
- For most vessels < 24 m: wind force 10, with wind gust and water on deck in most operational conditions.

The score card shows also that the EuroCutter with the lengthened derricks has a serious decrease of the remaining righting moment.

9.2.2.5 Remaining righting moments compared to the criteria

The remaining righting moments were compared to the righting moments required by the criteria. They are expressed as a percentage, as described in chapter 8.6. Table 16 shows the combination of the effect of lowering one derrick to 45 degrees and the effects of wind force 6 Bft. and 8 Bft, expressed in the remaining percentage of the righting moment required by the criteria. As stated in chapter 8.6, the light blue marking indicates maximum 20% decrease compared to the required stability, dark blue 20 – 80% decrease and purple 90 – 100% decrease.

Vessel nr.	Type of vessel	Vessel and Operational Condition	RNoExternal	RW6	RW8
1	EuroCutter 20m	1-8080-BDP-BDS	58%	48%	35%
		1-8045-BDP-BDS	33%	23%	10%
9	Cutter 44m 2975hp	9-8080-BDP-BDS	82%	68%	49%
		9-8045-BDP-BDS	51%	37%	18%

Table 16: Remaining righting moments in percentages of requested righting moments

Table 16 shows that the decrease of remaining righting moment is only less than 20% (light blue marking) for the 44 m Cutter, in all other situations the decrease of the righting moment is more than 20%.

Would the 20% not have been requested, both vessels would not survive wind force 8 Bft. in fishing conditions.

A complete overview of the results can be found Appendix XXIII. The score card in this appendix cleary shows the fishing conditions with less than 20% of the required stability reamining (purple marking) and those were no righting moment is left (red marking). It must be noted that in many situations, although the remaining righting moment does not comply with the criteria, the vessel still has it. Only when the conditions are marked red, there is no righting moment left.

Examples of fishing conditions marked red, having an absolute safety risk are:

- Most of the conditions were the fishing gear is switched to the other side;
- Conditions were stern trawl gear is stored on the net drums;
- Conditions in waves that equal the ship’s length, together with asymmetrical loads.

The 20 m EuroCutter with heavy gear is extra vulnerable, compared to the same vessel with normal gear, as is the same vessel with lengthened derricks.

The 35 m beam trawler has significantly less purple and red marked values, as have the 43 m and 44 m vessels (vessels 6 – 9).

9.2.2.6 Stability factor

The larger beam trawlers, especially those of 40 m and more, have been fitted with relatively powerful engines. Because of that, extra stability is required by the stability factor in the rules, as explained in chapter 4.1.2.1. In the beam trawler fleet, the stability factor for those ships added up till 50 % to the stability. The beam trawlers with a length of 24 and less do not benefit from this rule, as can be seen in Figure 10 in chapter 5.5.

9.2.2.7 Threshold heeling moment from Lifting Code (IMO MSC.415(97))

In the Lifting Code (IMO, 2016), a threshold value is calculated based on displacement and GM', resulting in a threshold lifting moment (M_L). The part of the regulation covering the applicability of the code is included in Appendix XXIV. If a vessel is (designed for) lifting larger weights than this threshold, the Lifting Code is mandatory to comply with. However, at this moment it is not applied to fishing vessels, not even to fishing vessels larger than 24m.

Table 17 shows for each of the analyzed vessels the threshold lifting moment. It also includes the moment induced by lifting the fishing gear on one side of the vessel with the derrick in horizontal position. All reference vessels exceed the threshold value with this common operation. Thus, looking at this application criterium, beam trawlers are also subject to these regulations, which include phenomena like *sudden loss of hook load*. Particular stability criteria have to be met in these conditions.

Vessel no	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Name	EuroCutter 20m			EuroCutter 24m Open Aftdeck	EuroCutter 24m Closed aft deck	Cutter 35m	Cutter 2000hp		Cutter 44m 2975hp
variant	Original	Heavy Gear (HG)	Lengthened Derricks (DE)				Original	Light Gear (LG)	
M_L [tonm]	5.96	5.99	5.97	11.59	13.71	28.93	27.03	26.93	34.18
Mgear (hor. Derricks) [tonm]	13.50	19.5	14.85	16.90	24.84	76.50	133.45	94.20	163.40

Table 17: Moment induced by lifting fishing gear on one side, compared to the threshold lifting moment from the Lifting Code.

10 Conclusions

The main purpose of the investigations was to establish the risks of capsizing and sinking induced by asymmetrical loads, for fishing vessels within the Dutch beam trawler fleet. The risks were analyzed in the same order the activities of beam trawling are carried out. In this way the risks were built up step by step, giving insight in each situation.

In the next chapters the conclusions of this investigation are presented. It has become clear that vessels of 24 m length and less are very vulnerable to the stability risks of the fishing conditions. They encounter serious risks on a daily basis, and the fact that these vessels are over represented in the number of capsizes is comprehendible. Better stability information, education and training of the crew and more focused supervision by the authorities is vital.

The larger vessels face considerable less risks. However, also for these vessels better stability information, education and training of the crew and focused supervision by the authorities will upgrade the safety level.

10.1 Stability in basic condition

In the basic loading condition (chapter 8.2), the difference between the remaining righting moments of vessels of less than 24 m and those of more than 24 m is huge: The smaller vessels have only 10% of the remaining righting moments of the larger vessels. (Chapter 9.2.2.1) Since the same criteria apply for both vessels, the difference can be explained by two factors:

- The scale effect: the smaller vessels are half the size of the larger ones, which leads to a relative decrease of righting moment;
- The stability factor: The installed engine power on vessels of 24 m and less is not enough to benefit from the stability factor.

Not only do the vessels < 24 m have considerably less remaining righting moments in the basic condition, they are also more vulnerable to the weather and fishing conditions, as can be seen in the following chapters.

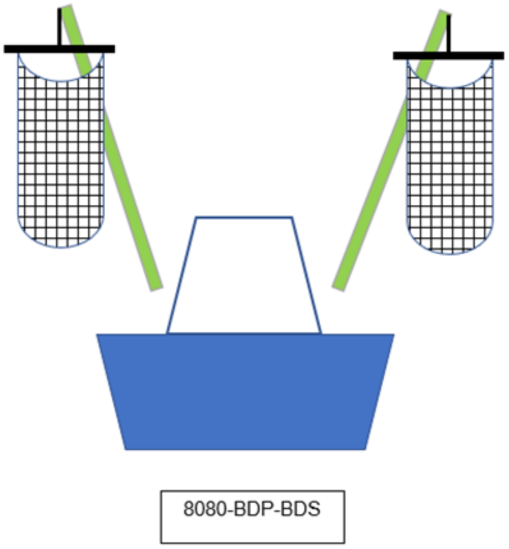
10.2 Asymmetrical loads

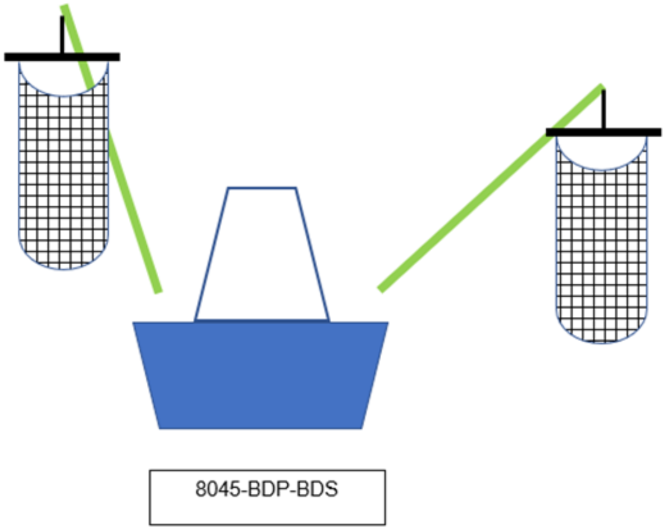
The effect of asymmetrical loads during fishing is substantial and can even lead to capsizing. It was the direct cause of 47% of the accidents investigated and played a role in 74% of the accidents. Not only the factors mentioned in 10.1 influence this effect, but also:

- Whether or not the derricks have been lengthened;
- The safety system installed: An active system such as the Marelec system can help to mitigate excessive (a)symmetric loads;
- The type of fishing gear: A gear for Sole-fishing is considerably heavier than a gear for shrimp-fishing. Also, the length of the boom and the type (pipe or SumWing).

The danger of asymmetrical loads depends on the exact configuration of the beam trawler and the gear, but from the score cards (Appendix XXII and Appendix XXIII) can be concluded that:

- Without any influence from wind or waves the stability with empty nets in both derricks is reduced by 25 – 67% for the vessels in the investigation, when one derrick is lowered to 45 degrees shown in the sketch below.





- A heavy load in one net reduces the remaining righting moment considerably, especially with both derricks at 45 degrees. Then all vessels < 24 m have in most conditions little till no remaining righting moment. In that situation a wind with a force of 6 Bft. will reduce the remaining righting moment to a dangerous level. In this situation a well-functioning (automatic) safety system can be a life-saver.
- The danger of one fishing gear skipping over to the other side (Figure 29) is obvious from the score cards: In most of the operating conditions the vessels have no remaining righting moment.

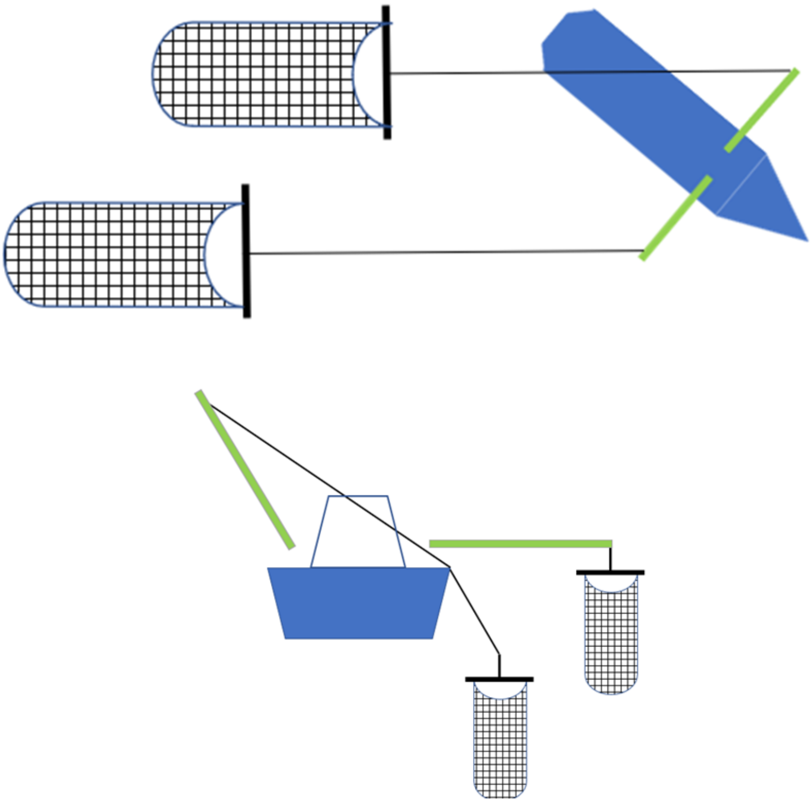
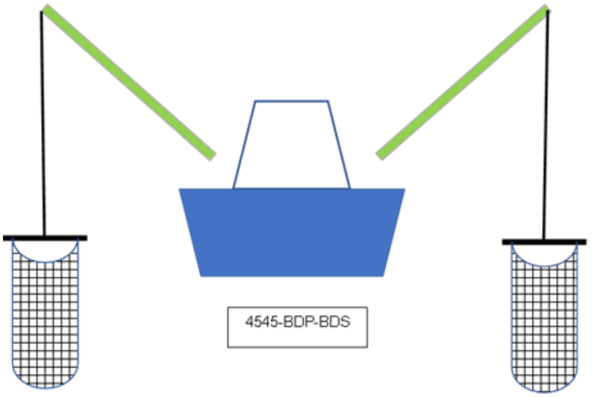


Figure 29: One net skipping over to the other side

10.3 The effect of the loss of one fishing net on the stability

The remaining righting moments were calculated for all vessels in the investigation for the situation given in Figure 31. The remaining righting moments decreased by 20 – 30% for the beam trawlers < 24 m and 11 – 22% for the beam trawlers > 24 m. The EuroCutters are much more vulnerable to this phenomenon. The calculations show only the results on the static stability, but there is a significant dynamic effect as well. This effect could not be quantified with the calculation methods used and needs more research.



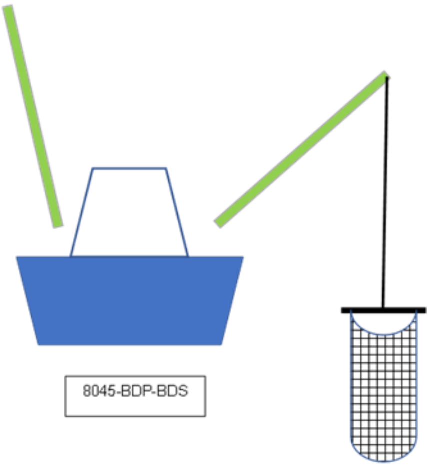


Figure 31: Loss of the PS fishing gear

10.4 The effect of 20% extra stability for beam trawlers

Firstly, the origin of the additional 20% stability required for beam trawlers has not been found. Documents of the year 1972 mention this extra margin, but not when it was established.

Figure 30: PS Fishing gear skipping over to SB

When calculating the remaining heeling moments for several fishing conditions of the beam trawlers, it became clear that as soon as the fishing gear is lifted from the deck and hoisted overboard, the stability of the vessel is reduced rapidly below the extra 20%.

The score card for remaining heeling moments compared to the regulations (Appendix XXIII) shows that 11% of the calculated situations have a remaining heeling moment between 20 and 0 % of the required stability. 25 % of the cases have less than 0%. Would the extra 20% not have been included in the regulations, 36% of the cases would have no remaining heeling moment. Table 18 gives an overview.

Criteria	Count	Percentage
More than 80%	632	24%
Between 80 and 20%	1082	40%
Between 20% and 0	286	11%
Less than 0%	673	25%
Total	2673	

Table 18: Results for calculated situations

10.5 Stability in waves

During the investigation the effects of waves were assessed. Waves with a wavelength of 20 – 24 meters with a wave height of approximately 1,6 meter are part of the normal spectrum for the North Sea at winds of 3 – 6 Bft, as indicated in Appendix XVIII.

Longitudinal waves with a wavelength equal to the length of the vessel can cause ‘pure loss of stability’, when the vessel is on top of the wave. Appendix XXII shows the effect in the column ‘W6WI’. Especially for smaller vessels (<24 meters) the most unfavorable wave heights (attributed to the wave steepness) occur at relatively smooth seas.

Because their complexity, dynamic effects on the vessel and its submerged fishing gear were not included in this investigation.

The effect on the stability of transverse waves was investigated and static stability calculations were made. However, it was not possible to fully take the dynamic effect of a vessel and its (submerged) fishing gear in transverse waves into account. The risks induced by the dynamic effects need more research, most likely by MARIN. This applies also to broaching, the situation where a waves acts on a vessel at an angle from abaft, forcing the vessel to a transverse position related to the waves.

10.6 Stability information for conditions during fishing

At the moment, the stability information on board is limited to the required four free sailing conditions. (IMO, 2022) (NSI, 1989) Conditions during fishing operations (lifting of nets, moving of derricks etc.) are not included.

The results of this research project, as well as those from earlier ones, demonstrate the urgent need for stability information during fishing. Like dredgers and vessels engaged in lifting operations, stability during fishing must be assessed and included in the stability information available to the skipper and crew.

10.7 Differences in scope of national regulations

During this investigation it was found that the national regulations differ substantially from one nation to another. For example: the extra 20% stability required for Dutch beam trawlers is not required for German flag vessels. The cause for this difference lies in the fact that vessels < 24 m are not covered by IMO-regulations. This leads to a disturbed playing field.

10.8 Risk mitigating measures

For the categories of failure modes as mentioned in chapter 7 risk mitigating actions have been determined. In the next chapters give an overview.

10.8.1 External factors

For the external factors, the course related to the waves can be adjusted to the weather conditions as much as possible, but since the course is highly depending on the fishing activities, this cannot be done always. However, the risk of e.g. longitudinal waves with a wavelength equal to the ship’s length is considerable and at the moment not a part of the training. More knowledge of the risks of waves on the stability will help to make more risk-based decisions during fishing.

The risk rating of water on deck demonstrates the necessity of water being able to be drained from the deck. Therefore, freeing ports have to be kept free and operable to ensure that the water on deck is kept to a minimum. This must also be one of the topics during inspections by ILT and crew trainings.

The risk of a net skipping to the other side of the vessel, as shown in Figure 32 is serious and mitigation is difficult, because of the combination of vessel's speed and course related to the waves and the current. Training of students and crew, preferably in a bridge simulator, will help by acknowledging the risk and mitigating the risk.

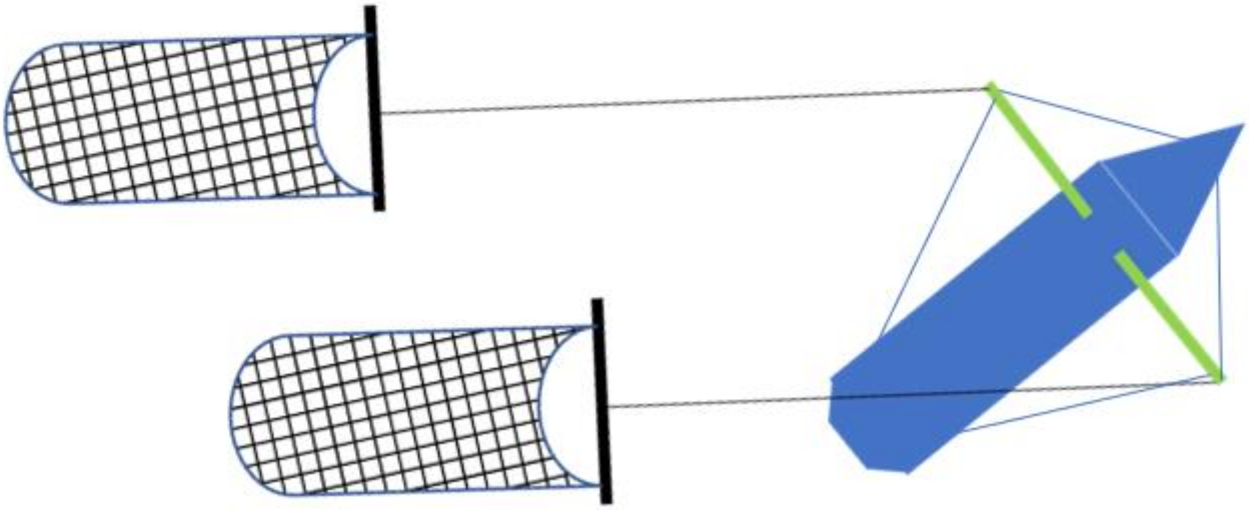


Figure 32: Fishing net skipping to the other side of the vessel

10.8.2 The effect of lengthened derricks and the storage of stern trawl gear

Two internal factors were considered, that require extra attention from both the fishermen and the Authorities: The lengthening of derricks and the storage of the stern trawl gear on the net drums.

When a fishing gear is changed, the derricks are sometimes lengthened. An example is given in the picture below. Not always the stability information is updated for the derricks. Also, the effect of the longer derricks on the fishing conditions is not considered at all. Fishing conditions are not part of the stability information available to the master in the stability booklet.

Often a combination of two fishing methods is used on a beam trawler: beam trawling and stern trawling (e.g. Twin rigging, Flyshooting) are alternated. When the vessel is beam trawling, the stern trawl gear is stored on net drums on the aftship, (Figure 33) or left ashore. The storage of the stern trawl gear is a topic mentioned in the stability booklet: For most vessels this gear must be removed when beam trawling and in some cases even the net drums have to be removed. This is not always done. Report on the capsizing and sinking of fishing vessels (Dutch Safety Board, 2021).

Figure 33: Stern trawl gear on the net drums

Table 19 clearly shows the decreased remaining righting moment for the vessel with lengthened derricks (DE) and the influence of the storage of the stern trawl gear (STG). It shows clearly that both factors decrease the remaining heeling moment of a vessel considerably, thus attributing to the safety risk of the vessel.

Both lengthened derricks and the storage of the stern trawl gear must be topics for inspections by ILT and are to be included in trainings of students and crew.

Vessel nr.	Type of vessel	Vessel and Operational Condition	NoExternal [tm]	W6 [tm]
1	EuroCutter 20m	4545-BDP-BDS-NDS	4,5	1,9
1	EuroCutter 20m	4545-BDP-BDS-NDS-STG	3,8	1,2
3	EuroCutter 20m DE	4545- BDP-BDS-NDS	0,9	-1,7
3	EuroCutter 20m DE	4545-BDP-BDS-NDS-STG	0,2	-2,4

Table 19: The effect of lengthened derricks (DE) and the storage of stern trawl gear (STG) on the remaining righting moment

11 Recommendations

Based on the findings of this investigation recommendations can be made. They are described in the next chapters.

11.1 Wind force or sea state limitation during fishing operations

From the score card of remaining heeling moments Appendix XXII can be concluded that the risks for stability during fishing operations increase substantially in conditions with wind forces exceeding wind force 6 Bft.

Therefore, it is recommended to develop a wind force limit for fishing operations, that can be included in the approved stability information. When the wind exceeds the limit, the vessel can remain at sea, or sail to a safe port. This wind force limit must be calculated for each individual beam trawler.

11.2 Guidelines for stability criteria for fishing operations

The Federale Overheidsdienst Mobiliteit & Vervoer of Belgium issued an investigation on additional stability criteria for beam trawlers. *Studie voor het bepalen van aanvullende stabiliteitscriteria voor boomkor-vissersschepen* (FOD Mobiliteit & Vervoer, 2022) The report of this investigation was issued on August 2nd, 2022. For this investigation stability criteria were drawn up for conditions during fishing. The results of the Conoship investigation can be used in addition with the Belgian study to develop specific stability criteria for fishing operations with beam trawlers.

For vessels engaged in lifting operations the lifting code has been developed. (Res.MSC.415(97) - Amendments to part B of the International Code on Intact Stability, 2008) The principle of this code could be applied while setting up guidelines for stability during fishing operations.

The effect of the water on deck can be compared to the effect of water in the hold of a dredger, as described in the IMO Guidelines for the assignment of reduced freeboards for dredgers, DR-68. This guideline can be used as an example when setting up the guidelines. There are also other methods for calculating the effect of water on deck, such as the Torremolinos 2002 rules, but those are very hard to use because of their complexity.

It is recommended to set up a dialogue with international partners (flag state Authorities) to develop these specific guidelines for the stability of beam trawlers during fishing.

11.3 Stability training and education

From interviews with teachers and people in the field it became clear that there is a need for training methods for stability, that are better suited for the level of the students at the MBO fishery schools than the current method, which is theoretically challenging for most students.

Some of the stability topics during fishing operations, such as putting one net in a derrick or a fishing net getting caught, are already included the stability lessons. However, using a bridge simulator showing the effects of changing position of the derricks and asymmetrical loads can be helpful. Especially training mitigating actions against capsizing risks will boost the insight in the specific stability risks of the fishing operations.

At this moment there is no bridge simulator that is able to fully show the effects of the fishing operations. However, MARIN is developing a bridge simulator, in which fishing conditions can be simulated, including the effects of changing derrick positions. Figure 34 shows a screenshot of the simulator.

Figure 34: Screenshot of the MARIN-simulator

VSTEP-Simulations is a supplier of bridge simulators, who has installed the bridge simulator at ROC Friese Poort at Urk. The simulation features a beam trawler, with limited simulation of a fishing net getting caught at a wreck. During discussions with VSTEP it became clear that an interactive simulation showing the full effects of asymmetrical loads on the stability of a beam trawler is technically challenging and has not been done by VSTEP before. Whether or not an animation of these effects can be done remains to be investigated.

11.4 Marelec system

At this moment various emergency release systems are fitted on the derricks of beam trawlers, enabling the crew to release the fishing line in case of emergency. The Marelec system is an active system based on the constant measuring of the tension in the fishing line, mainly installed on the bigger and more modern beam trawlers.

The Belgian Authorities have supported the Belgian fleet by issuing this system for all beam trawlers, to enhance the safety of the vessels. Apart from the enhanced safety, the Marelec system supplies a lot of real time data on the behaviour of the fishing gear. More and more Belgian fishermen use this data in combination with ship’s data, such as real time monitoring of the fuel consumption, to make fishing more cost-efficient.

It is recommended that the Marelec system is installed on all Dutch beam trawlers as well. Because of its costs, Dutch fishermen are reluctant to install the Marelec system. Support from the authorities, like in Belgium, is likely to help.

11.5 Stability information presentation

From various accident reports and interviews with fishermen, lecturers and Authorities it became clear that the stability booklet is of very limited use to the skipper and crew of beam trawlers. In most cases it is put in a drawer on the bridge and never looked at again. The reason is that a beam trawler's skipper is trained to MBO-level 2 and generally has a very practical approach to stability. The stability information on board of a beam trawler, as required by the Authorities, does not meet the needs of the skipper, not only because it is very hard to comprehend, but also because it only contains free sailing conditions. Once the vessel starts fishing, no specific information is given on the influence of moving derricks, hoisting nets etc. on the stability of the vessel.

Stability information for the conditions during fishing operations must be made available to the skipper in an easy comprehensible way. It is recommended to decide on the best way to present the stability information in close cooperation with Conoship, the schools, fishery organizations, ILT and Ministry of I&W.

11.6 Enforcement of the regulations

Apart from developing specific guidelines for fishing operations, more emphasis can be given on the enforcement of the existing regulations. Inspections of fishing vessels checking the storage of stern trawl gear during beam trawling and alterations to the vessel effecting the stability, such as enlarged derricks, freeing ports or added V-SAT masts must be intensified, to ensure the safety of the beam trawlers.

During the review of the stability information ILT must give extra attention to the accuracy of the wind contour

11.7 Design factors

More emphasis on assessment of fishing conditions during design of the beam trawler. The risk-based design method identifies the risks for the vessel and mitigates this in the design phase. For beam trawlers, identifying the risks during fishing operations will help to design safer ships.

11.8 Dynamic effect in (transverse) waves

More investigation must be done on the energy, with focus on beam trawlers with a length of 24 m and less, in cooperation between MARIN and Conoship

Effect can be very severe as shown in chapter 9.2. But the probability of occurrence needs more thorough investigation. This is an important element in the total risk rating.

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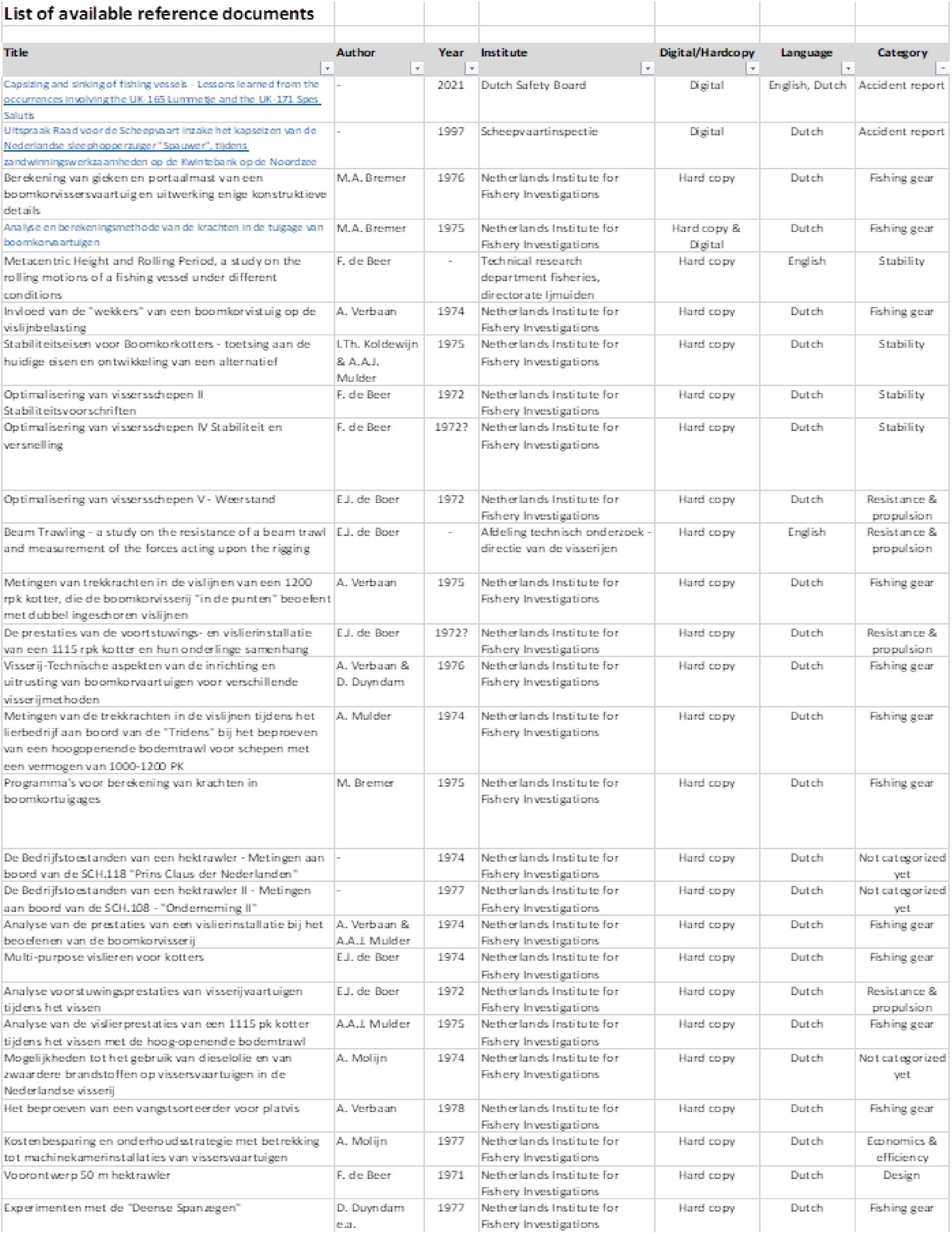
APPENDIX

Appendix I. Overview of reference documents



List of available reference documents

Title	Author	Year	Institute	Digital/Hardcopy	Language	Category
Capsizing and sinking of fishing vessels - Lessons learned from the occurrences involving the UK-165 Lummetje and the UK-171 Spes Salutis	-	2021	Dutch Safety Board	Digital	English, Dutch	Accident report
Uitspraak Raad voor de Scheepvaart inzake het kapseizen van de Nederlandse sleephopperzuiger "Spauwer", tijdens zandwinningswerkzaamheden op de Kwintebank op de Noordzee	-	1997	Scheepvaartinspectie	Digital	Dutch	Accident report
Berekening van gieken en portaalmast van een boomkorvissersvaartuigen uitwerking enige konstruktieve details	M.A. Bremer	1976	Netherlands Institute for Fishery Investigations	Hard copy	Dutch	Fishing gear
Analyse en berekeningsmethode van de krachten in de tuigage van boomkorvaartuigen	M.A. Bremer	1975	Netherlands Institute for Fishery Investigations	Hard copy & Digital	Dutch	Fishing gear
Metacentric Height and Rolling Period, a study on the rolling motions of a fishing vessel under different conditions	F. de Beer	-	Technical research department fisheries, directorate Ijmuiden	Hard copy	English	Stability
Invloed van de "wekkers" van een boomkorvistuig op de vislijnbelasting	A. Verbaan	1974	Netherlands Institute for Fishery Investigations	Hard copy	Dutch	Fishing gear
Stabiliteitseisen voor Boomkorkotters - toetsing aan de huidige eisen en ontwikkeling van een alternatief	I.Th. Koldewijn & A.A.J. Mulder	1975	Netherlands Institute for Fishery Investigations	Hard copy	Dutch	Stability
Optimalisering van vissersschepen II Stabiliteitsvoorschriften	F. de Beer	1972	Netherlands Institute for Fishery Investigations	Hard copy	Dutch	Stability
Optimalisering van vissersschepen IV Stabiliteit en versnelling	F. de Beer	1972?	Netherlands Institute for Fishery Investigations	Hard copy	Dutch	Stability
Optimalisering van vissersschepen V - Weerstand	E.J. de Boer	1972	Netherlands Institute for Fishery Investigations	Hard copy	Dutch	Resistance & propulsion
Beam Trawling - a study on the resistance of a beam trawl and measurement of the forces acting upon the rigging	E.J. de Boer	-	Afdeling technisch onderzoek - directie van de visserijen	Hard copy	English	Resistance & propulsion
Metingen van trekkrachten in de vislijnen van een 1200 rpk kotter, die de boomkorvisserij "in de punten" beoefent met dubbel ingeschoren vislijnen	A. Verbaan	1975	Netherlands Institute for Fishery Investigations	Hard copy	Dutch	Fishing gear
De prestaties van de voortstuwings- en vislierinstallatie van een 1115 rpk kotter en hun onderlinge samenhang	E.J. de Boer	1972?	Netherlands Institute for Fishery Investigations	Hard copy	Dutch	Resistance & propulsion
Visserij-Technische aspekten van de inrichting en uitrusting van boomkorvaartuigen voor verschillende visserijmethoden	A. Verbaan & D. Duyndam	1976	Netherlands Institute for Fishery Investigations	Hard copy	Dutch	Fishing gear
Metingen van de trekkrachten in de vislijnen tijdens het lierbedrijf aan boord van de "Tridens" bij het beproeven van een hoogopenende bodemtrawl voor schepen met een vermogen van 1000-1200 PK	A. Mulder	1974	Netherlands Institute for Fishery Investigations	Hard copy	Dutch	Fishing gear
Programma's voor berekening van krachten in boomkortuigages	M. Bremer	1975	Netherlands Institute for Fishery Investigations	Hard copy	Dutch	Fishing gear
De Bedrijfstoestanden van een hektrawler - Metingen aan boord van de SCH.118 "Prins Claus der Nederlanden"	-	1974	Netherlands Institute for Fishery Investigations	Hard copy	Dutch	Not categorized yet
De Bedrijfstoestanden van een hektrawler II - Metingen aan boord van de SCH.108 - "Onderneming II"	-	1977	Netherlands Institute for Fishery Investigations	Hard copy	Dutch	Not categorized yet
Analyse van de prestaties van een vislierinstallatie bij het beoefenen van de boomkorvisserij	A. Verbaan & A.A.J. Mulder	1974	Netherlands Institute for Fishery Investigations	Hard copy	Dutch	Fishing gear
Multi-purpose vislieren voor kotters	E.J. de Boer	1974	Netherlands Institute for Fishery Investigations	Hard copy	Dutch	Fishing gear
Analyse voorstuwingsprestaties van visserijvaartuigen tijdens het vissen	E.J. de Boer	1972	Netherlands Institute for Fishery Investigations	Hard copy	Dutch	Resistance & propulsion
Analyse van de vislierprestaties van een 1115 pk kotter tijdens het vissen met de hoog-openende bodemtrawl	A.A.J. Mulder	1975	Netherlands Institute for Fishery Investigations	Hard copy	Dutch	Fishing gear
Mogelijkheden tot het gebruik van dieselolie en van zwaardere brandstoffen op vissersvaartuigen in de Nederlandse visserij	A. Molijn	1974	Netherlands Institute for Fishery Investigations	Hard copy	Dutch	Not categorized yet
Het beproeven van een vangstsorteerder voor platvis	A. Verbaan	1978	Netherlands Institute for Fishery Investigations	Hard copy	Dutch	Fishing gear
Kostenbesparing en onderhoudsstrategie met betrekking tot machinekamerinstallaties van vissersvaartuigen	A. Molijn	1977	Netherlands Institute for Fishery Investigations	Hard copy	Dutch	Economics & efficiency
Voorontwerp 50 m hektrawler	F. de Beer	1971	Netherlands Institute for Fishery Investigations	Hard copy	Dutch	Design
Experimenten met de "Deense Spanzegen"	D. Duyndam e.a.	1977	Netherlands Institute for Fishery Investigations	Hard copy	Dutch	Fishing gear

Appendix II. List of analysed accident reports

List of analysed accident reports

Author	External marking	Ship's name	Flag	Homeport	LOA [m]	B [m]	GT	Ship type	Fishing type	Engine power [kW]	Engine power [hp]	Year of construction	Date accident	Location accident	Weather conditions	Summary	Asymmetrical loading involved?	Fatal casualties
Onderzoeksraad voor Veiligheid	UK-165	Lummetje	Dutch	Urk	19.75	5.3	48		Shrimps	221	301	1986	28-11-2019			At least one of the nets got stuck on a ship's wreck and the ship capsized	Definitely	2
Onderzoeksraad voor Veiligheid	UK-171	Spes Salutis	Dutch	Urk	23.46	5.8	77		Shrimps	220	300	1963	9-12-2020			SB hit something, crew tried to hoist both nets, SB net tangled with PS net, ship capsized	Definitely	0
Febima, Belgium	Z-19	Sonja	Belgium	Zeebrugge	30.70	7.27	159.00			515	701	1974	25-8-2018	Off the British coast 25 nm ENE of	5 Bft, waves 1 - 1,5 m	PS net caught heavy sand, both nets raised, capsized	Possibly	2
Febima, Belgium	O-13	Morgenster	Belgium	Oostende	23.94	6.00	94.00			218	297	1989	7-11-2018	22 km SE of Eastbourne	7 Bft, waves > 2 m	Both empty nets were hoisted above water for repair after a fishing track. The vessel was hit by waves and capsized.	Not at all	0
Marine Accident Investigation Branch	FV	Flamingo	Belgium	Zeebrugge	23.82		82	Beam trawler		221	301	1988	7-7-2002	SE of Harwich	4 Bft, 1 m swell	Rocks and shells in portside net coused the weak link to break. This triggered the vessel to capsize.	Definitely	4
Nautische commissie Antwerpen	N-28	Mooie Meid	Belgium	Nieuwpoort	19.60	5.60	64.00			145	197	1989	2-3-2011	51 20.12 N 002 14.00 E	6 - 7 Bft, waves 1,7 - 2,5 m	Vessel had rudder problems, causing it to make three short circles and later one. After/during the latter circle it capsized.	Not sure	4
Federal Public Service of Mobility and Transport / MAIB	Z-122	Noordster	Belgium	Zeebrugge	23.78	6.08	84.00			220	300	1985	13-12-2005	11.5 miles S of Beachy Head		PS net got stuck, SB net hoisted until clear above the water, causing the vessel to heel to portside. The SB net swung over and the vessel capsized.	Definitely	3
Federal Public Service of Mobility and Transport / MAIB	Z-85	Morgenster	Belgium	Zeebrugge	23.82	6.00	82.00	Beam trawler / Twin Rig		210	286	1996	28-1-2015		Rough seas	Bad weather conditions, no survivors or witnesses. PS boom was out, the SB boom was topped, which decreased the stability drastically and the angle of heel (abt. 18 degrees). Rough seas will have increased the angle of heel, leading to capsizing of the vessel.	Definitely	4
Nautische commissie Antwerpen	Z-700	Rapke	Belgium	Zeebrugge	16.80	5.06	33			176	240	1996	20-4-2011		Calm	During hoisting of the nets, the vessel suddenly veered to starboard and capsized within seconds	Possibly	0
Febima, Belgium	Z-582	Assanat	Belgium	Zeebrugge	21	5.43	62			221	301	1961	27-12-2016	British coast near Margate	Favourable weather forecast		Not sure	2
Marine Accident Investigation Branch, UK	NN-194	Catrina	UK	Newhaven	13.92	4.84	20	dual purpose stern trawler/twin beam scallop dredger	Scallop	194	264	1991	13-10-1998	South of Newhaven	5 Bft, waves 2m steep	"Immediate cause: The capsize was caused by the impact of breaking wave when Catrina was heeled heavily to starboard following a broach" Speed of vessel was almost the same as incoming wave Autopilot was used, so helm response was insufficient to correct swing from broach Possibly low stability involved Downflooding points being low is also mentioned. Submerged before 'Angle of vanishing stability' See specific tab for more findings and key elements	Not at all	0
Marine Accident Investigation Branch, UK	SM-74	Sally Jane	UK		13.6	4.86	18.06	Multipurpose, Twin beam, scallop fishing, stern trawling	Scallop	201	274	1990	17-9-2013	Near Christchurch bay, England	4-5 Bft, moderate sea. Good visibility	Sally Jane capsized due to loss of transverse stability, probably caused by difference in the weight of contents of SB and PS nets. Asymmetrical loading most likely due to contents in SB net breaking free Hatches to fish hold and ER not secured, leading to downflooding Stability information was not used by the crew. See specific tab for more findings and key elements	Definitely	0
Marine Accident Investigation Branch, UK	PH-409	Pescado	UK	Plymouth	22	5.83	55.91	Twin beam	Scallop	400	545	1956	25-2-1991	Near south coast of Cornwall	5-6 Bft, visibility fair - good, waves 1.0 - 2.5m	Investigation revealed that Pescado was unsafely operated. FV Safety Certificate was withdrawn. Crew was not sufficiently qualified and experienced. Pescado's fishing gear became fast on sea bed. While trying to free it, she heeled excessively, flooded and sank	Possibly	6
Marine Accident Investigation Branch, UK	BM-148	Margaretha Maria	UK	Brixham	22.8	5.82	68.78	Twin beam		221	301	1958	11-11-1997	50 miles south-west-by-south of Lizard Point, England	2-3 Bft, slight seas, good weather	Capsize most probably caused by loss of stability resulting from derricks being topped with 3.5 to 4 tonne of debris in each net Factor that contributed to the capsize was also the ability of the winch to haul large weights of unknown size to the surface	Possibly	4

Appendix III. Overview of foreign criteria

	Criterium	Unit	IMO[13]	The Netherlands[14]	Belgium[15]	UK[16]	Spain[17]	Germany[18]
	Applicable to vessel length		>24 m	<24m & 24m - 75m	?	?	<24 m	<24 m
1	Minimum metacentric height (GM')	m	0.35	0.50	0.50	0.42	0.42	0.35
2	Righting arm at 30º angle of heel	m	0.20	0.24	0.24	0.24	0.24	0.20
3	Area under righting lever curve up to 30º angle of heel	mrad	0.055	0.066	0.066	0.066	0.066	0.055
4	Area under righting lever curve up to 40º angle of heel	mrad	0.090	0.108	0.108	0.108	0.108	0.090
5	Area under righting lever curve between 30º and 40º angle of heel	mrad	0.030	0.036	0.036	0.036	0.036	0.030
6	Maximum righting arm should occur at an angle of heel preferably exceeding 30º but not less than 25º	-	Yes	-	Yes	-	Yes	-
7	Range of positive righting arm	deg	-	-	-	-	-	60
8	Maximum angle due to wind moment (weather criterion)	-	IMO (areas)	50º or Φf	40º or Φf	-	IMO (areas)	-
	20% allowance on criterium 2 to 5 for Beam Trawlers.	-	No	Yes	Yes	Yes	Yes	No
	Power factor on criterium 2 to 5	-	No	0.6 – 0.7 L^2	1.0 L^2	No	No	No
	Additional criteria	-				Lifting	Lifting	
	Determination of VCG of LSW	-	-	Derricks horizontal	Derricks at 45º	-	-	-

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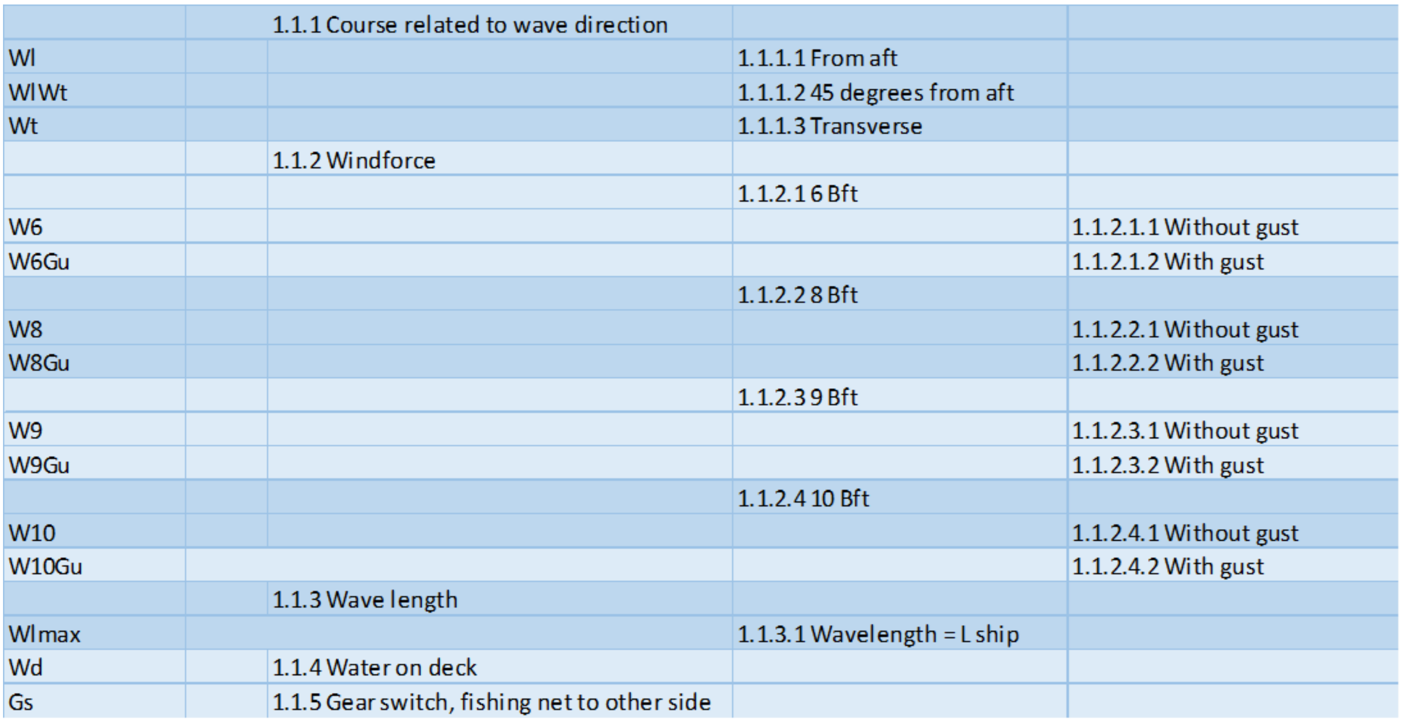
[13] (IMO, 2022)
[14] (NSI, 1989)
[15] (Federale Overheidsdienst Mobiliteit en Vervoer, 2015)
[16] Based on the Isle of Man regulations (Isle of Man Marine Administration, 2006) and (Wolfson, Unit, 2001)
[17] (Ministerio de Fomento, 2007)
[18] (German NSI, 2018)

Appendix IV. Codes used for external factors of fishing conditions

8080	Both derricks in seagoing position: fully topped
8080-STG	Same, with stern trawl gear on the net drums
8080-BDP-BDS	Both derricks fully topped, fishing gear in the top of the derricks
8045-BDP-BDS	Same situation, one derrick lowered to 45 degrees
4545-BDP-BDS	Same situation, now both derricks lowered to 45 degrees
0000-BDP-BDS	Same situation, now both derricks lowered horizontal
0000-BDP-BDS-NDS	Same, with debris in one net
0045-BDP-BDS-NDS	Same, with the net with debris hoisted until the derrick is at 45 degrees
0045-BDP-BDS-HBS	Same situation, now the net with debris is hauled in till above deck.
0045-BDP-BDS-NDS-GRD0	One derrick horizontal with the fishing gear in it, the other with debris hoisted to 45 degrees, malfunction of safety system
0045-BDP-BDS-NDS-GRD0-STG	Same situation, now with stern trawl gear on the net drums
0045-BDP-BBS-NDS-GRD1	One derrick horizontal with the fishing gear in it, the other with debris hoisted to 45 degrees, safety system releases fishing block from top of the derrick and net is shifted to the side of the vessel
0045-BDP-BBS-NDS-GRD1-STG	Same situation, now with stern trawl gear on the net drums
4545-BDP-BDS-NDS-GRD0	Both derricks at 45 degrees, starboard net with debris, malfunction of safety system
4545-BDP-BDS-NDS-GRD0-STG	Both derricks at 45 degrees, starboard net with debris, malfunction of safety system, stern trawl gear on the net drums.
4545-BDP-BBS-NDS-GRD1	Derricks at 45 degrees, debris in one net, safety system releases the fishing block from the top of the derrick and the net is shifted to the side of the vessel
4545-BDP-BBS-NDS-GRD1-STG	Same situation, stern trawl gear stored on the net drums
4545-BDP-BDS-HBS	Both derricks at 45 degrees, hauling catch and debris in starboard net
4545-BDP-BDS-HCP-HCS	Derricks at 45 degrees, hauling catch symmetrically
4545-BDP-BDS-HCP-HCS-STG	Same situation with stern trawl gear on net drums
4545-BDP-BDS-HBP-HBS-STG	Derricks at 45 degrees, hauling catch and debris symmetrically, stern trawl gear on drums
8045-BDS-STG	Derricks at 80 and 45 degrees, fishing gear at SB, PS net missing, stern trawl gear on net drums
8045-BDP-BDS-NDS	Derricks at 80 and 45 degrees, fishing gear at the top of the derricks and debris in one net
8045-BDP-BDS-HCP-HCS	Derricks at 80 and 45 degrees, hauling catch symmetrically
8045-BDP-BDS-HCP-HCS-STG	Same situation, with stern trawl gear stored on net drums
8045-BDP-BDS-HBP-NDS-STG	Derricks at 80 and 45 degrees, fishing gear at the top of the derricks, debris in one net, hauling catch and debris in the other, stern trawl gear on net drums

Appendix V. Codes for external factors



		1.1.1 Course related to wave direction		
Wl			1.1.1.1 From aft	
WlWt			1.1.1.2 45 degrees from aft	
Wt			1.1.1.3 Transverse	
		1.1.2 Windforce		
			1.1.2.1 6 Bft	
W6				1.1.2.1.1 Without gust
W6Gu				1.1.2.1.2 With gust
			1.1.2.2 8 Bft	
W8				1.1.2.2.1 Without gust
W8Gu				1.1.2.2.2 With gust
			1.1.2.3 9 Bft	
W9				1.1.2.3.1 Without gust
W9Gu				1.1.2.3.2 With gust
			1.1.2.4 10 Bft	
W10				1.1.2.4.1 Without gust
W10Gu				1.1.2.4.2 With gust
		1.1.3 Wave length		
Wlmax			1.1.3.1 Wavelength = L ship	
Wd		1.1.4 Water on deck		
Gs		1.1.5 Gear switch, fishing net to other side		

Appendix VI. Risk ratings of external factors

		Severity	Occurrence	Detection / Mitigation	Risk rating	Remarks
FMEA code	**1.1 External factors**					
	1.1.1 Course related to wave direction					
Wl	1.1.1.1 From aft	4	9	7	252	
WlWt	1.1.1.2 45 degrees from aft	5	9	7	315	
Wt	1.1.1.3 Transverse	4	9	5	180	Mitigation: Most of the time there is a possibility to change course.
	1.1.2 Windforce					
	1.1.2.1 6 Bft					
W6	1.1.2.1.1 Without gust	3	7	9	189	
W6Gu	1.1.2.1.2 With gust	4	7	9	252	
	1.1.2.2 8 Bft					
W8	1.1.2.2.1 Without gust	4	7	9	252	
W8Gu	1.1.2.2.2 With gust	5	7	9	315	
	1.1.2.3 9 Bft					
W9	1.1.2.3.1 Without gust	5	7	9	315	
W9Gu	1.1.2.3.2 With gust	6	7	9	378	
	1.1.2.4 10 Bft					
W10	1.1.2.4.1 Without gust	6	7	9	378	
W10Gu	1.1.2.4.2 With gust	7	7	9	441	
	1.1.3 Wave length					
Wlmax	1.1.3.1 Wavelength = L ship	7	7	10	490	
Wd	1.1.4 Water on deck	5	9	9	405	
Gs	1.1.5 Gear switch, fishing net to other side	9	3	9	243	

Appendix VII. Risk ratings of internal factors

		Severity	Occurrence	Detection / Mitigation	Risk rating	Remarks
	1.2 Internal factors					
	1.2.1 Position derricks					Severity depending on asymmetricallity, Occurrence: normal fishing operation,
8080	1.2.1.1 80/80 Degrees	3	10	7	210	
8045	1.2.1.2 80/45 Degrees	6	10	7	420	
8000	1.2.1.3 80/00 Degrees	7	9	7	441	
4545	1.2.1.4 45/45 Degrees	3	10	7	210	
4500	1.2.1.5 45/00 Degrees	6	10	7	420	
0000	1.2.1.6 00/00 Degrees	2	10	7	140	
	1.2.2 Net drums					Occurrence: once the vessel has sailed, the situation cannot be
STG 1	1.2.2.1 Net drums empty	5	10	10	500	
STG 2	1.2.2.2 Net drums filled with stern trawl gear	7	10	10	700	For most of the beamtrawlers carrying the stern trawl gear while beam trawling is not allowed.
STG 3	1.2.2.3 Net drums removed	1	10	10	100	
De	1.2.3 Derricks enlarged	8	10	10	800	The effect of enlarging derricks and not adjusting the stability information is permanent and cannot be mitigated during sailing.

Appendix VIII. Risk ratings for loads on derricks

					Severity	Occurrence	Detection / Mitigation	Risk rating	Remarks
	1.3 Asymmetrical loads on derricks								
		1.3.1 Above water							Part of normal fishing operations, occurrence 10
BDP/BDS			1.3.1.1 Empty		4	10	10	400	
BDPC/BDSC			1.3.1.2 Catch		6	10	9	540	
NDS			1.3.1.3 Catch + debris		9	7	10	630	
		1.3.2 Below water							
GRD			1.3.2.1 Stuck to ground						Occurrence of getting stuck is the same, difference is made by whether or not the system is maintained and tested on a regular basis.
GRD1				1.3.2.1.1 Safety system functioning	5	9	3	135	Regular testing and maintenance
GRD0				1.3.2.1.2 Safety system malfunction	8	7	10	560	No testing or maintenance
	1.4 Derrick loaded symmetrical								
		1.4.1 Above water							
BDP-BDS			1.4.1.1 Empty		3	10	7	210	
BDPC-BDSC			1.4.1.2 Catch		5	10	9	450	
NDS-NDS			1.4.1.3 Catch + debris		8	7	10	560	
		1.4.2 Below water							
GRD			1.4.2.1 Stuck to ground						Occurrence of getting stuck is the same, difference is made by whether or not the system is maintained and tested on a regular basis.
GRD1				1.4.2.1.1 Safety system functioning	3	7	3	63	Regular testing and maintenance
GRD0				1.4.2.1.2 Safety system malfunction	8	7	10	560	No testing or maintenance

Appendix IX. Risk ratings for hauling catch

	1.5 Hauling catch								The cod-end is hoisted on board, while the rest of the fishing gear remains at the derrick ends.
HCP/HCS		1.5.1 Hauling catch asymmetrical			5	10	7	350	
HCP-HCS		1.5.2 Hauling catch symmetrical			4	10	7	280	
HBP/HBS		1.5.3 Hauling catch + debris asymmetrical			7	8	7	392	
HBP-HBS		1.5.4 Hauling catch + debris symmetrical			6	8	7	336	

Appendix X. Risk ratings for fishing net to side of vessel

					Severity	Occurrence	Detection / Mitigation	Risk rating	Remarks
	1.6 Fishing net to side of vessel								In case of overload of the derricks the safety system is activated
BBP-BBS		1.6.1 Safety system symmetrically activated			3	7	9	189	Not normal practice, but asymmetrical load can be prevented.
BBP/BBS		1.6.2 Safety system asymmetrically activated			8	7	7	392	

Appendix XI. Risk ratings for manoeuvrability

	Severity	Occurrence	Detection / Mitigation	Risk rating	Remarks
1.7 Maneuvrability					Loss of maneuvrability during fishing is a high risk
1.7.1 No propulsion	7	1	5	35	
1.7.2 Ruddersystem malfunction	7	1	5	35	

Appendix XII. Risk ratings for crew

	Severity	Occurrence	Detection / Mitigation	Risk rating	Remarks
1.8 Crew					
1.8.1 Knowledge stability					
1.8.1.1 Training	5	10	8	400	Kennisniveau is een permanent risico
1.8.2 Risk assessment	5	10	7	350	
1.8.3 Fatigue	6	7	7	294	
1.8.4 Economical considerations					
1.8.4.1 Fishing gear insured	6	5	9	270	
1.8.4.2 Fishing gear not insured	9	5	9	405	

Appendix XIII. Risk ratings of the Authorities

	Severity	Occurrence	Detection / Mitigation	Risk rating	Remarks
1.9 Authorities					
1.9.1 Rules and legislations	6	9	9	486	Clear rules and guidelines on the stability of beam trawlers during operation will significantly contribute to the safety of the vessel and crew
1.9.2 Inspection and rule enforcement lacking	8	9	7	504	When a net drum is not detected by IL&T and remains on board, it has a severe inpact on the stability of the vessel

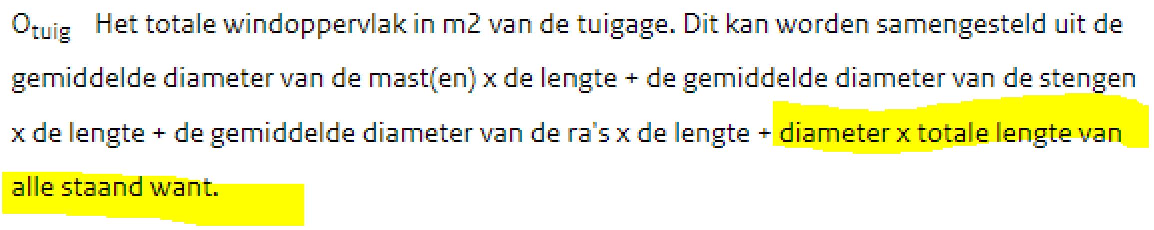
Appendix XIV. Risk ratings of stability information

	Severity	Occurrence	Detection / Mitigation	Risk rating	Remarks
1.10 Stability information					
1.10.1 Windcontour not correct	7	10	10	700	Radarmasts added, derricks and their stays not taken into account
1.10.2 VCG not accurate	7	10	10	700	Alterations that haven't been reported and adjusted in the stability booklet
1.10.3 Fishing conditions not included	9	10	10	900	Only the free-sailing conditions are included in the stability information.

Appendix XV. Increase of wind contour area and lever

As mentioned in chapter 8.4.1, the wind contours found in the stability booklets were lacking several important parts such as the derricks, wires etc.

The wind contour of one of the reference vessels was thoroughly analysed and missing parts were added. Wires were added based on the Dutch regulations for Commercial Sailing vessels (MIWM, 2022, p. Ch.4), which for example state that the length and lateral area of all standing rigging, ('staand want') shall be included in the total lateral area. See Figure 35.



O_{tuig} Het totale windoppervlak in m2 van de tuigage. Dit kan worden samengesteld uit de gemiddelde diameter van de mast(en) x de lengte + de gemiddelde diameter van de stengen x de lengte + de gemiddelde diameter van de ra's x de lengte + diameter x totale lengte van alle staand want.

Figure 35: Article from Dutch regulations on commercial sailing vessels on the wind area of the rigging.

The calculation of the increased lateral area and wind lever is shown in the first table below. The other two tables show in detail the effect of including the wires.

Contour	Draft	Displacement	Moment	Lever	Lateral area	Wind pressure	Wind force	Wind lever	Difference with original	
	[m]	[kg]	[kgm]	[m]	[m2]	[kg/m2]	[kg]	[m]	Lateral area	Wind lever
Original	1.75	108345	9191	0.085	61.0	51.4	3135	2.93		
Contour incl. missing parts	1.75	108345	11597	0.107	68.7	51.4	3532	3.28	113%	112%
Updated contour incl. wires	1.75	108345	12357	0.114	70.6	51.4	3630	3.40	116%	116%
Contour with derricks at 45 degrees	1.75	108345	11279	0.104	68.2	51.4	3507	3.22	112%	110%
Contour - derricks at 45 degrees incl. wires	1.75	108345	11956	0.110	70.0	51.4	3601	3.32	115%	113%

Wire data - derricks in store position

			Lateral				From base	From COG of underwater body	
Wire	**Length**	**Number**	**Length total**	**Diameter**	**Lateral area**		**Height COG**	**Height COG**	**Moment**
	[m]	[#]	[m]	[m]	[m2]		[m]	[m]	[kgm]
Aft stay (aft mast-fore mast)	8.8	1	8.8	0.02	0.18		9.12	8.22	74.4
Fore stay	6.2	1	6.2	0.02	0.12		7.55	6.65	42.4
Aft wires derricks	11.7	2	23.4	0.02	0.47		9.60	8.70	209.3
Front wires derricks	11.5	2	23.0	0.02	0.46		8.95	8.05	190.3
Winch wires (wheelhouse-mast)	7.3	4	29.0	0.02	0.58		7.30	6.40	190.8
Wire between top of aft mast and front mast	9.7	1	9.7	0.01	0.10		11.45	10.55	52.6
Total			100.1		1.91				759.8

Wire data - derricks at 45 degrees

			Lateral				From base	From COG of underwater body	
Wire	**Length**	**Number**	**Length total**	**Diameter**	**Lateral area**		**Height COG**	**Height COG**	**Moment**
	[m]	**[#]**	**[m]**	**[m]**	**[m2]**		**[m]**	**[m]**	**[kgm]**
Aft stay (aft mast-fore mast)	8.8	1	8.8	0.02	0.18		9.12	8.22	74.4
Fore stay	6.2	1	6.2	0.02	0.12		7.55	6.65	42.4
Aft wires derricks	11.3	2	22.6	0.02	0.45		8.57	7.67	178.2
Front wires derricks	9.6	2	19.1	0.02	0.38		7.95	7.05	138.4
Winch wires (wheelhouse-mast)	7.3	4	29	0.02	0.58		7.30	6.40	190.8
Wire between top of aft mast and front mast	9.7	1	9.7	0.01	0.10		11.45	10.55	52.6
Total			95.4		1.81				676.8

Appendix XVI. Combined risk ratings score card

In the column ‘No External’ for each operational row the basic condition of the vessel as described in chapter 8.2 is updated with the risk rating of the condition mentioned in the row. In the next column, ‘Wd, the effect of water on deck is added and so on.

For this matrix a selection has been made from the failure modes that have been considered. Wind force 6 was selected as an example, to demonstrate the effect of the operational conditions during moderate winds. It is clear that the circumstances at wind force 9 are much more severe, but that was not considered to contribute to the purpose of this matrix and therefore not shown.

In the column ‘NoExternal’ the effect of adding failure modes can be seen, without the influence of external factors. In the first row the vessel is in transit mode, with both derricks topped up and no fishing gear fitted. In the second row the effect of the stern trawl gear left on the net drums is shown. In Appendix IV the codes of the vessels’ operation conditions are explained.

For each row the colour indication as described in 7.4 shows the height of the risk rating. For example: when looking at the column W6 (Wind force 6 Bft. without gusts) and W6Wlmax (Wind force 6 Bft. with longitudinal waves with wavelength = vessel length), it is clear that longitudinal waves increase the risk rating. For example: For the vessel in transit condition with the stern trawl gear on the net drums (8080-STG) it turns from orange to red.

Vessel and Operational Condition	NoExternal	Wd	Wt	W6	W6Gu	W6Gu Gs	W6Gu Wd	W6Gu WdWt	W6Wl max	W8	W8Gu	W8Gu Wd	W8Gu WdWt	W8GuWd WtDe	W10Gu WdWt
Value	**0**	**405**	**180**	**189**	**252**	**495**	**504**	**909**	**420**	**252**	**315**	**720**	**900**	**800**	**1026**
8080	210	615	390	399	462		804	984	819	462	525	930	1110	1910	1236
8080-STG	910	1315	1090	1099	1162		1504	1684	1519	1162	1225	1630	1810	2610	1936
8080-BDP-BDS	1120	1525	1300	1309	1372		1714	1894	1729	1372	1435	1840	2020	2820	2146
8045-BDP-BDS	630	1035	810	819	882	1125	1224	1404	1239	882	945	1350	1530	2330	1656
4545-BDP-BDS	420	825	600	609	672	915	1014	1194	1029	672	735	1140	1320	2120	1446
0000-BDP-BDS	350	755	530	539	602	845	944	1124	959	602	665	1070	1250	2050	1376
0000-BDP-BDS-NDS	980	1385	1160	1169	1232	1475	1574	1754	1589	1232	1295	1700	1880	2680	2006
0045-BDP-BDS-NDS	1260	1665	1440	1449	1512	1755	1854	2034	1869	1512	1575	1980	2160	2960	2286
0045-BDP-BDS-HBS	812	1217	992	1001	1064	1307	1406	1586	1421	1064	1127	1532	1712	2512	1838
0045-BDP-BDS-NDS-GRD0	1820	2225	2000	2009	2072	2315	2414	2594	2429	2072	2135	2540	2720	3520	2846
0045-BDP-BBS-NDS-GRD1	1185	1590	1365	1374	1437	1680	1779	1959	1794	1437	1500	1905	2085	2885	2211
0045-BDP-BDS-NDS-GRD0-STG	2520	2925	2700	2709	2772	3015	3114	3294	3129	2772	2835	3240	3420	4220	3546
0045-BDP-BBS-NDS-GRD1-STG	1885	2290	2065	2074	2137	2380	2479	2659	2494	2137	2200	2605	2785	3585	2911
4545-BDP-BDS-NDS	1050	1455	1230	1239	1302	1545	1644	1824	1659	1302	1365	1770	1950	2750	2076
4545-BDP-BDS-HBS	812	1217	992	1001	1064	1307	1406	1586	1421	1064	1127	1532	1712	2512	1838
4545-BDP-BDS-NDS-GRD0	1610	2015	1790	1799	1862	2105	2204	2384	2219	1862	1925	2330	2510	3310	2636
4545-BDP-BBS-NDS-GRD1	1367	1772	1547	1556	1619	1862	1961	2141	1976	1619	1682	2087	2267	3067	2393
4545-BDP-BDS-NDS-GRD0-STG	2310	2715	2490	2499	2562	2805	2904	3084	2919	2562	2625	3030	3210	4010	3336
4545-BDP-BBS-NDS-GRD1-STG	2067	2472	2247	2256	2319	2562	2661	2841	2676	2319	2382	2787	2967	3767	3093
4545-BDP-BDS-HCS	770	1175	950	959	1022	1265	1364	1544	1379	1022	1085	1490	1670	2470	1796
4545-BDP-BDS-HCP-HCS	700	1105	880	889	952	1195	1294	1474	1309	952	1015	1420	1600	2400	1726
4545-BDP-BDS-HCP-HCS-STG	1400	1805	1580	1589	1652	1895	1994	2174	2009	1652	1715	2120	2300	3100	2426
4545-BDP-BDS-HBP-HBS-STG	1470	1875	1650	1659	1722	1965	2064	2244	2079	1722	1785	2190	2370	3170	2496
8045-BDS-STG	1520	1925	1700	1709	1772	2015	2114	2294	2129	1772	1835	2240	2420	3220	2546
8045-BDP-BDS-NDS	1260	1665	1440	1449	1512	1755	1854	2034	1869	1512	1575	1980	2160	2960	2286
8045-BDP-BDS-HCP-HCS	910	1315	1090	1099	1162	1405	1504	1684	1519	1162	1225	1630	1810	2610	1936
8045-BDP-BDS-HCP-HCS-STG	1610	2015	1790	1799	1862	2105	2204	2384	2219	1862	1925	2330	2510	3310	2636
8045-BDP-BDS-HBP-NDS-STG	1960	2365	2140	2149	2212	2455	2554	2734	2569	2212	2275	2680	2860	3660	2986

Appendix XVII. Details of calculation method

The calculation method consists of the following steps:

1. Determine GZ-curve and righting moment of *basic loading condition*;
2. Calculate the change in stability of the vessel due to the *operational condition* considered; position of the derricks, the lifting of fishing gear, weight of catch and debris, etc.(paragraphs 7.4.2 –0 of the FMEA-chapter);
3. Determine intermediate GZ-curve and righting moment;
4. Calculate external heeling moments due to wind, waves, water on deck, etc. (Chapter 8.4). Apply these as combined moment to the GZ-curve calculated in 3;
5. Determine the *final* GZ-curve and remaining righting moment;
6. Extract the following results:
   A. The remaining righting moment as percentage of the righting moment of the *basic loading condition* (see 1);
   B. The remaining righting moment as percentage of the required righting moment from the regulations.

Below, these calculation steps are described in detail.

Step 1: Determine GZ-curve and righting moment of *basic loading condition*

For this step, the following parameters are used as input for the calculations:

- Displacement;
- VCG';
- TCG;
- GM';
- Cross Curves (KN*sin(Φ)) for this particular condition.

With these parameters, the GZ-curve (curve of statical stability, with GZ = G'N*sin(Φ) = righting lever) for the basic loading condition is calculated by means of the following formula:

$$G'N * sin\varphi = KN * sin\varphi - VCG' * sin\varphi - TCG * cos\varphi \qquad (1)$$

For a better understanding, Figure 36 shows these parameters (left) and the GZ-curve (right)

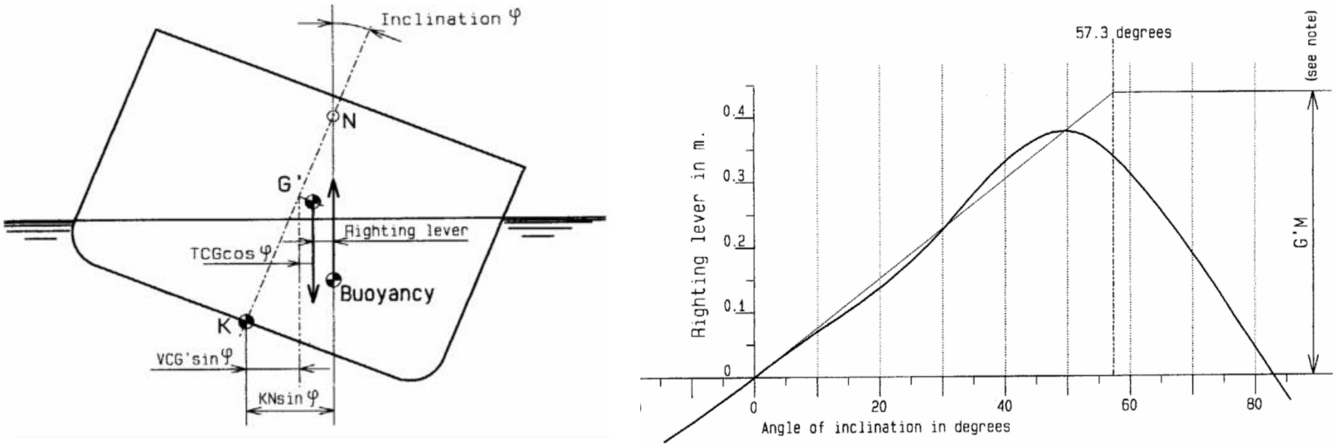


Figure 36: Parameters used in calculation of GZ (righting lever) [left] and GZ-curve [right]

From the GZ-curve, the maximum GZ-value is calculated. This is used to calculate the *maximum righting moment* by multiplying the maximum GZ-value with the displacement:

$$Maximum\ righting\ moment_{basic} = GZ_{max-basic} * Displacement_{basic} \quad (2)$$

Step 2: Calculate the change in stability of the vessel due to the *operational condition* considered

For each of the elements mentioned in chapter 8.3, if applied, the shift of the vessel's vertical center of gravity (VCG) and transverse center of gravity (TCG) is calculated by the following formula:

$$\Delta VCG' = \frac{w * d}{Displacement} \quad (3)$$

In which:

$$w = the\ weight\ of\ the\ element\ considered$$
$$d = distance\ over\ which\ the\ weight\ is\ shifted$$

This changed VCG and TCG results in a changed GZ-curve according to equation (3). Figure 17 shows an example in which the stability of the vessel with a specific operational condition is decreased compared to the basic loading condition.

Step 3: Determine intermediate GZ-curve and righting moment

From this resulting GZ-curve, the heeling angle (intersection with X-axis) and a new GZ-max is extracted and is used to calculate the new *maximum righting moment*:

$$Righting\ moment_{operational} = GZ_{max-operational} * Displacement_{operational} \quad (4)$$

Step 4: Calculate external heeling moments

Steady wind.

The external moment due to wind can be calculated with values that can be extracted from a stability booklet and is calculated according to the following formula:

$$External\ moment_{Steady\ wind} = Lateral\ area * Wind\ lever * Wind\ pressure \quad (5)$$

In which:

$$Lateral\ area = lateral\ area\ of\ the\ vessel\ above\ the\ waterline$$
$$Wind\ lever = wind\ lever\ at\ the\ draught\ under\ consideration$$
$$Wind\ pressure = wind\ pressure\ of\ the\ wind\ force\ under\ consideration$$

Step 5: Determine the *final* GZ-curve and remaining righting moment

From this Final GZ-curve, the heeling angle (intersection with X-axis) and a new GZ-max is extracted and is used to calculate the *remaining righting moment*:

$$Remaining\ righting\ moment_{Final} = GZ_{max-Final} * Displacement_{Final} \quad (6)$$

Step 6: Extract the results

Reference is made to the explanation in paragraph 8.5 and 8.6.

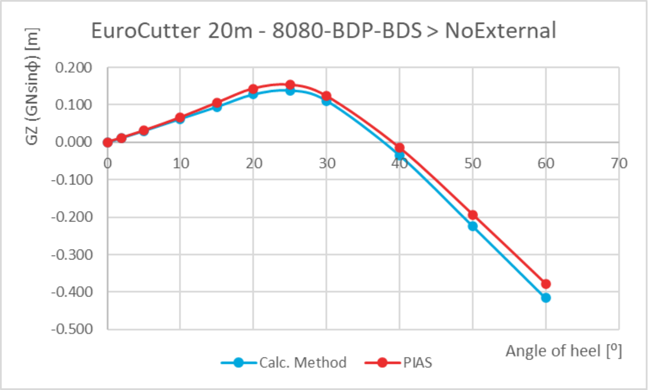
Validation with PIAS

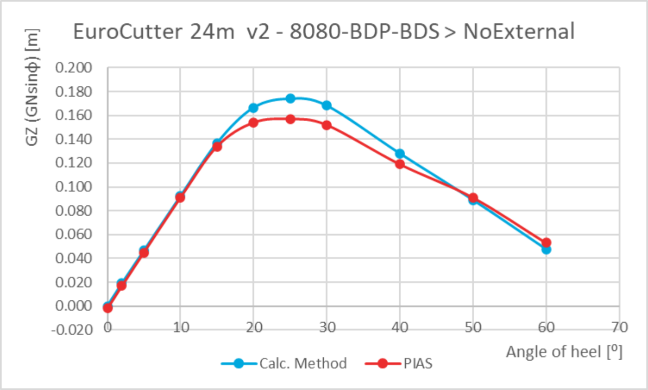
The developed calculation method in Excel has been validated with PIAS. Throughout the development and the study, several random checks were done. For this report, the following conditions have been checked for two of the reference vessels:

1. 8080-BDP-BDS > NoExternal (Symmetrical)
2. 8045-BDS > NoExternal (Asymmetrical)
3. 8045-BDS > W6Gu (with external moments)

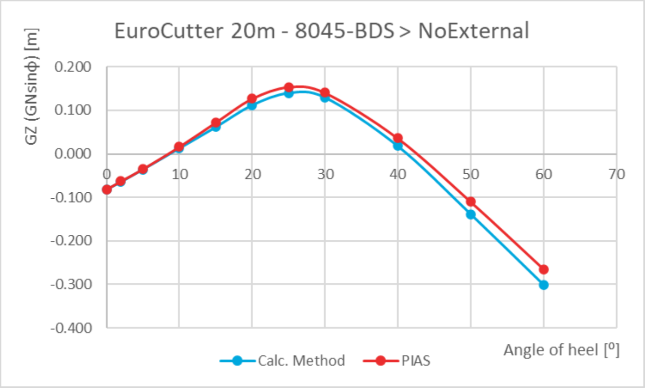
In the tables below, the results are summarized. Overall, there is a deviation at the top of the GZ-curve between the calculation method and PIAS. The deviation is approximately 10%, with one vessel on the negative side and the other one on the positive side. For the goals of this study, it is considered an acceptable deviation.

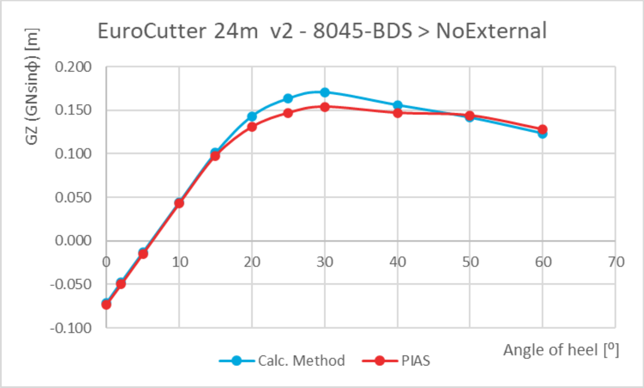
	EuroCutter 20m		**EuroCutter 24m v2 (Closed Aft deck)**	
Operational condition	**8080-BDP-BDS**		**8080-BDP-BDS**	
External moments	**NoExternal**		**NoExternal**	
	Calc. Method	**PIAS**	**Calc. Method**	**PIAS**
Resulting Displacement	111.3	111.3	257.9	257.9
Resulting VCG'	2.820	2.820	3.034	3.033
Resulting TCG	0.000	0.000	0.000	0.000
Resulting GM'	0.348	0.348	0.534	0.534
External moment	No	No	No	No
Resulting Max. GZ	0.138	0.153	0.174	0.157
Resulting angle of heel	0.0	0.0	0.0	0.0
Remaining Righting Moment	15.4	17.4	44.9	40.5





	EuroCutter 20m		EuroCutter 24m v2 (Closed Aft deck)	
Operational condition	**8045- BDS**		**8045- BDS**	
External moments	**NoExternal**		**NoExternal**	
	Calc. Method	**PIAS**	**Calc. Method**	**PIAS**
Resulting Displacement	111.3	111.3	257.9	257.9
Resulting VCG'	2.640	2.642	2.905	2.905
Resulting TCG	0.082	0.082	0.0710	0.0730
Resulting GM'	0.528	0.526	0.660	0.663
External moment	No	No	No	No
Resulting Max. GZ	0.140	0.154	0.171	0.154
Resulting angle of heel	8.7	8.5	6.2	6.3
Remaining Righting Moment	15.6	17.1	44.0	39.7





	EuroCutter 20m		EuroCutter 24m v2 (Closed Aft deck)	
Operational condition	**8045- BDS**		**8045- BDS**	
External moments	**W6Gu**		**W6Gu**	
	Calc. Method	**PIAS**	**Calc. Method**	**PIAS**
Resulting Displacement	111.3	111.3	257.9	257.9
Resulting VCG'	2.640	2.642	2.905	2.905
Resulting TCG	0.082	0.082	0.071	0.073
Resulting GM'	0.528	0.526	0.663	0.663
External moment	3.9	W6Gu Pias	7.5	W6Gu Pias
Resulting Max. GZ	0.105	0.121	0.142	0.126
Resulting angle of heel	12.3	11.6	8.7	8.8
Remaining Righting Moment	11.7	13.5	36.5	32.5

NOTE: No GZ-curves are plotted here because the external moments, in this case windforce 6 Bft with wind gust has been applied in PIAS, not by adding a fixed heeling moment, but by using the actual wind contour. In this case, no final GZ-curve is plotted by the program.

On the next page, for the EuroCutter 24m v2 vessel, the PIAS output of the 8045-BDS condition is printed as reference.

TRIM AND STABILITY CALCULATION

EuroCutter 24m v2 Closed Aftdeck

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Loading condition : 5-8045-BDS > NoExternal

Description	Filling %	Density ton/m³	Weight ton	VCG m	LCG m	TCG m	FSM tonm
leeg schip	-	-	226.306	2.960	9.796	0.000	-
Neg. derricks horizontal	-	-	-3.440	6.120	14.300	0.000	-
Derricks store position	-	-	3.440	12.130	13.287	0.000	-
Neg. derrick SB	-	-	-1.770	12.130	13.287	3.158	-
Derrick SB at 45 degrees (45	-	-	1.770	10.426	13.287	6.406	-
Neg. beam trawl gear SB	-	-	-2.300	4.000	12.430	2.750	-
BT gear SB derrick (BDS)	-	-	2.300	12.272	12.430	8.252	-
7. Dirty oil 15-18 SB	50.0	0.8500	0.532	0.792	7.815	2.177	0.220
8. Fuel 18-23 PS	50.0	0.8500	4.367	0.813	9.762	-1.642	0.375
9. Fuel 18-23 SB	50.0	0.8500	4.499	0.834	9.764	1.673	0.354
3. Hydr. oil 10-14 PS	0.0	0.8500	0.000	0.446	5.850	-1.710	0.000
5. Hydr. oil 14-17 PS	98.0	0.8500	1.194	1.022	7.462	-2.348	0.299
12. Freshwater 32-43 PS	50.0	1.0000	2.983	0.737	16.842	-0.523	0.468
13. Freshwater 32-43 SB	50.0	1.0000	2.983	0.737	16.842	0.523	0.468
4. Lubr. oil 10-13 SB	50.0	0.8500	0.270	0.914	5.761	2.039	0.086
6. Cooling fluid 13-15 SB	98.0	1.0000	0.760	1.033	6.775	2.283	0.037
14. Fuel oil daytank 19-20.5	80.0	0.8500	0.212	3.206	8.850	-2.350	0.014
Crew and provisions	-	-	0.750	5.000	4.000	0.000	-
Ice in hold	-	-	1.000	1.500	15.500	0.000	-
100% Catch in fishhold	-	-	12.000	1.650	12.520	0.000	-
TOTAL	**-**	**-**	**257.855**	**2.896**	**10.048**	**0.073**	**2.321**
Deadweight	-	-	31.549	2.434	11.852	0.599	2.321

Hydrostatics

Volume	249.571	m³
LCF	9.012	m
Mom. change trim	1.989	tonm/cm
Ton/cm immersion	1.332	ton/cm
Density	1.0250	ton/m³

Drafts and trim

Drafts above base :

Draft mean (Lpp/2)	2.972	m
Draft aft (App)	2.993	m
Draft fore (Fpp)	2.951	m
Trim	-0.041	m

Transverse stability

KM transverse	3.568	m
VCG	2.896	m
GM solid	0.672	m
GG' correction	0.009	m
G'M liquid	0.663	m

VCG' 2.905 m

The stability values are calculated for the actual trim.

TRIM AND STABILITY CALCULATION

EuroCutter 24m v2 Closed Aftdeck

24 Nov 2022   11:01:03

Loading condition : 5-8045-BDS > NoExternal

Statical stability, calculated with constant LCB :

Angle(SB) degrees	Draft mld. m	Trim m	KNsinφ m	VCG'sinφ m	TCGcosφ m	G'Nsinφ m	Area mrad
0.00	2.972	-0.041	0.000	0.000	0.073	-0.073	0.004
2.00	2.972	-0.041	0.125	0.101	0.073	-0.050	0.002
5.00	2.970	-0.039	0.311	0.253	0.073	-0.015	0.000
10.00	2.964	-0.032	0.620	0.504	0.072	0.043	0.001
15.00	2.955	-0.013	0.921	0.752	0.071	0.098	0.008
20.00	2.957	0.034	1.193	0.993	0.069	0.131	0.018
25.00	2.971	0.129	1.441	1.228	0.066	0.147	0.030
30.00	2.992	0.283	1.670	1.452	0.063	0.154	0.043
40.00	3.048	0.780	2.070	1.867	0.056	0.147	0.070
50.00	3.081	1.495	2.416	2.225	0.047	0.144	0.095
60.00	3.098	2.456	2.681	2.515	0.037	0.128	0.119
70.00	3.154	4.147	2.844	2.729	0.025	0.089	0.138

Statical angle of inclination is 6.30 degrees to starboard

Verification against the stability criteria "NSI boomkorkotters"

Hydrostatics

Draft mld.	2.972 m
Trim	-0.041 m
Statical angle of inclination	6.30 degrees SB
Flooding angle	>70.00 degrees

Calculated to SB	Criterion	Value	
Minimum metacentrumhoogte G'M	0.500	0.663	meter
Maximum GZ bij 30 graden	0.240	0.154	meter
Maximum GZ bij 30 graden of meer	0.240	0.154	meter
Top van de GZ kromme bij minstens	25.000	30.888	degrees SB
Oppervlak onder de GZ kromme tot 30 graden	0.066	0.043	mrad
Oppervlak onder de GZ kromme tot 40 graden	0.108	0.070	mrad
Oppervlak onder de GZ kromme tussen 30 en 40 graden	0.036	0.026	mrad

VCG'

A non-zero statical angle of equilibrium occurs,
No maximum allowable VCG' is calculated.

Loading condition DOES NOT comply with the stated criteria.

TRIM AND STABILITY CALCULATION

EuroCutter 24m v2 Closed Aftdeck

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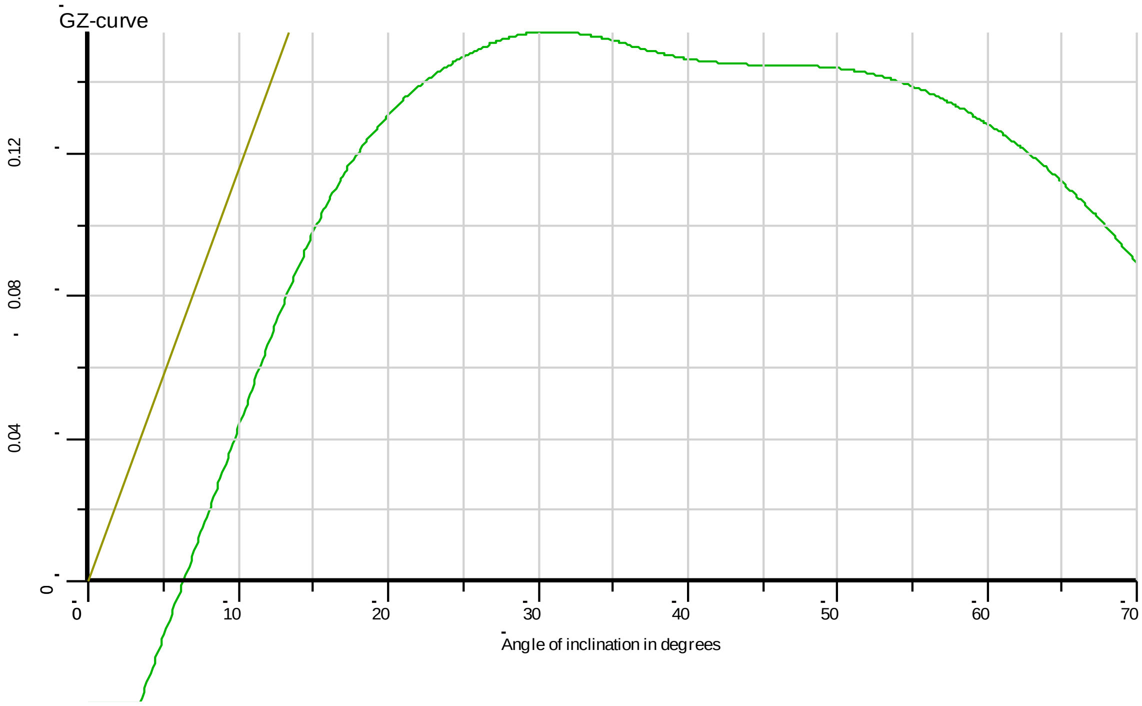
Loading condition : 5-8045-BDS > NoExternal



Appendix XVIII. Decrease in righting moment in longitudinal waves

For five reference ships, for a wave with a wavelength equal to the length of the vessel, the most unfavorable wave steepness has been assessed, with the theory of Pure loss of stability. This means the highest wave height attributing to the occurring waves at that vessel length in the North Sea (deep water) & Dutch shallow waters (Zeeland) have been calculated. The highest occurring wave steepnesses have been identified based on the measured wave scatters (Essen, van, 2016) (Global Wave Statistics, 2011). The wave steepness of the highest occurring wave is abt. 2 times as high as the most common occurring wave at that wavelength. However, the wave steepness on the North Sea and shallow waters in the Dutch Continental waters are typically higher than the general wave steepness factor as used for the IMO Pure loss of stability.

Typically, on the North Sea a 3 Bft gives waves of abt. 1-2 meters, a 5 bft 2-3 meters and a 6 Bft gives a wave height of over 3 meters. This indicates that, especially for the smaller vessels (<24m) the most unfavorable wave for pure loss of stability is found at relatively smooth seas. However, at shallower waters (higher wave steepness) the wind force will be higher to reach those wave heights.

The effect on the stability of these waves was determined for each reference ship at the basic loading condition by means of PIAS. The result was a decrease of stability (maximum GZ-value) between 60% and 90%. This means that when the vessel is in a wave crest, its stability decreases dramatically. This decrease in maximum GZ-value has been translated to a *decrease in righting moment* by multiplying the GZ-value with the displacement. Details are shown in the table below.

Furthermore, a quadratic relationship is found between the displacement of the vessel and the decrease in righting moment, which is shown in Figure 37. The trend line formula has been added to the calculation model. In this way, vessels of which no PIAS or other stability models are available, can also be added to the calculations. One of the reference vessels, “Cutter 44m 2975hp” is added in this way.

Basic loading condition is assumed						
		EuroCutter 20m	**EuroCutter 24m**	**EuroCutter 24m**	**Cutter 35m**	**Cutter 2000hp**
			Open aft deck	**Closed aft deck**		
Length between perpendiculars (Lpp)	[m]	17.81	20.40	21.09	32.86	38.10
Most unfavourable wave length (Lpp)	[m]	17.81	20.40	21.09	32.86	38.10
Max. wave height from wave calculation	[m]	1.45	1.72	1.79	2.64	3.00
At location	[-]	Zeeland	Zeeland	Zeeland	Zeeland	Zeeland
Water depth	[m]	5.00	5.00	5.00	10.00	10.00
Max. wave height possible in PIAS	[m]	1.78	2.04	2.11	3.29	3.81
Chosen wave height	[m]	1.45	1.72	1.79	2.64	3.00
Wave amplitude for input in PIAS	[m]	0.73	0.86	0.90	1.32	1.50
Displacement	[t]	111.3	172.2	257.9	591.1	721.1
Gzmax without wave	[m]	0.262	0.250	0.300	0.314	0.360
Gzmax with wave	[m]	0.089	0.062	0.124	0.036	0.047
Righting moment without wave	[tm]	29.2	43.1	77.4	185.6	259.6
Righting moment with wave	[tm]	9.9	10.7	32.0	21.3	33.9
Decrease in righting moment	[tm]	**19.2**	**32.4**	**45.4**	**164.3**	**225.7**
	[%]	**66%**	**75%**	**59%**	**89%**	**87%**

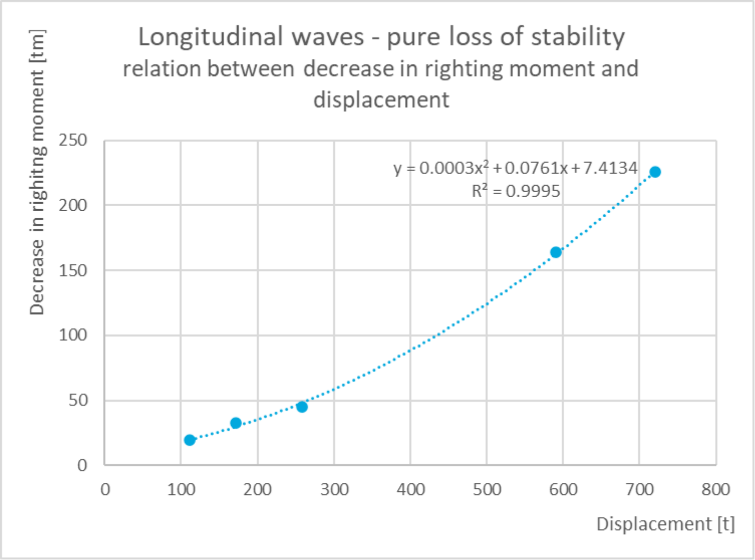
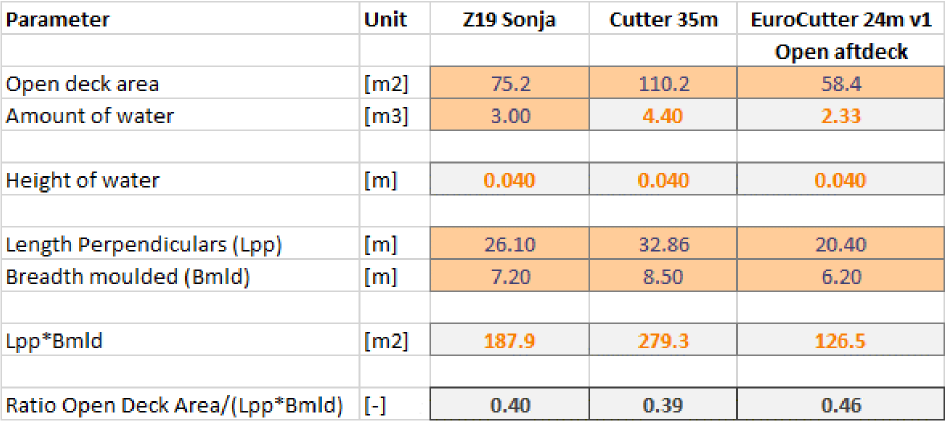


Figure 37: Relation between decrease in righting moment and displacement for a vessel in a longitudinal wave crest.

Appendix XIX. Water on deck



Parameter	Unit	Z19 Sonja	Cutter 35m	EuroCutter 24m v1
				Open aftdeck
Open deck area	[m2]	75.2	110.2	58.4
Amount of water	[m3]	3.00	4.40	2.33
Height of water	[m]	0.040	0.040	0.040
Length Perpendiculars (Lpp)	[m]	26.10	32.86	20.40
Breadth moulded (Bmld)	[m]	7.20	8.50	6.20
Lpp*Bmld	[m2]	187.9	279.3	126.5
Ratio Open Deck Area/(Lpp*Bmld)	[-]	0.40	0.39	0.46

Appendix XX. Vessel input data

Vessel Particulars		**EuroCutter 20m**	**EuroCutter 20m HG**	**EuroCutter 20m DE**	**EuroCutter 24m v1**	**EuroCutter 24m v2**	**Cutter 35m**	**Cutter 2000hp**	**Cutter 2000hp LG**	**Cutter 44m 2975hp**
					Open aft deck	**Closed aft deck**				
Parameter	**Unit**									
Length over all	[m]	19.99	19.99	19.99	23.10	23.97	37.15	42.90	42.90	44.60
Length between perpendiculars	[m]	17.81	17.81	17.81	20.40	21.09	32.86	38.10	38.10	39.10
Breadth moulded	[m]	5.80	5.80	5.80	6.20	6.85	8.50	8.50	8.50	9.00
Depth moulded (at 1/2 L)	[m]	2.60	2.60	2.60	2.71	3.65	4.70	5.30	5.30	5.10
Dimensions of fishing equipment										
Height of hauling point of catch (from base)	[m]	9.89	9.89	9.89	9.40	10.89	13.90	14.75	14.75	15.32
Height of rotation point of derrick (from base	[m]	4.98	4.98	4.98	5.30	6.12	7.70	8.35	8.35	7.78
Breadth of rotation point of derrick (from CL)	[m]	0.40	0.40	0.40	1.15	2.10	2.50	2.40	2.40	2.70
Length of derrick	[m]	9.50	9.50	10.50	8.50	8.70	12.80	13.30	13.30	14.50
COG of derrick to length ratio	[%]	70%	70%	70%	70%	70%	70%	70%	70%	70%
Store position of derrick	[deg]	80	80	80	80	80	80	80	80	80
Weight of one derrick	[t]	0.78	0.78	0.83	1.77	1.77	2.60	4.29	4.29	5.04
Weight of beam trawl gear (one side)	[t]	1.35	1.95	1.55	1.75	2.30	5.00	8.50	6.00	9.50
VCG of beam trawl gear in store position	[m]	3.20	3.20	3.20	3.25	4.00	5.50	6.20	6.20	5.85
TCG of Beam trawl gear in store position	[m]	2.40	2.40	2.40	2.50	2.75	3.30	3.60	3.60	3.85
Weight of stern trawl gear	[t]	0.95	0.95	0.95	2.70	5.30	0.00	0.00	0.00	0.00
VCG of stern trawl gear	[m]	4.90	4.90	4.90	4.56	7.00	0.00	0.00	0.00	0.00
Height at safety release acting point	[m]	5.55	5.55	5.55	5.80	6.20	8.60	9.30	9.30	8.10
Breadth at safety release acting point	[m]	2.72	2.72	2.72	2.90	3.15	4.21	4.10	4.10	4.50
Details of basic loading condition										
Base loading condition		**FISHING 100% Catch, 50% Consumables (Derricks in store position)**								
Displacement	[t]	111.280	111.880	111.480	172.228	257.855	591.064	721.135	718.635	831.860
VCG'	[m]	2.550	2.553	2.551	2.498	2.843	3.679	3.900	3.892	3.680
TCG'	[m]	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GM'	[m]	0.618	0.618	0.618	0.830	0.725	0.621	0.634	0.634	0.736
Maximum GZ value	[m]	0.262	0.262	0.262	0.249	0.247	0.314	0.360	0.360	0.400
Top of GZ curve at (approx.)	[deg]	25	25	25	20	30	35	40	40	35
Cross curves at basic loading condition draught (Trim is considered to be level trim)										
Heeling angle [degrees]		**KNsin(phi)**	**KNsin(phi)**	**KNsin(phi)**	**KNsin(phi)**	**KNsin(phi)**	**KNsin(phi)**	**KNsin(phi)**	**KNsin(phi)**	**KNsin(phi)**
0	[m]	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	[m]	0.110	0.110	0.110	0.117	0.125	0.150	0.157	0.157	0.154
5	[m]	0.276	0.276	0.276	0.292	0.311	0.375	0.392	0.392	0.385
10	[m]	0.552	0.552	0.552	0.581	0.619	0.751	0.784	0.784	0.771
15	[m]	0.824	0.824	0.824	0.863	0.922	1.127	1.176	1.176	1.156
20	[m]	1.092	1.092	1.092	1.111	1.204	1.492	1.564	1.564	1.541
25	[m]	1.330	1.330	1.330	1.319	1.456	1.831	1.931	1.931	1.902
30	[m]	1.521	1.521	1.521	1.500	1.685	2.141	2.269	2.269	2.221
40	[m]	1.778	1.778	1.778	1.790	2.078	2.668	2.845	2.845	2.729
50	[m]	1.937	1.937	1.937	2.023	2.413	3.092	3.303	3.303	3.096
60	[m]	2.027	2.027	2.027	2.219	2.675	3.411	3.652	3.652	3.366
Details considering wind heeling moment (at basic loading condition)										
Lateral area	[m2]	70.15	70.15	70.15	82.47	99.04	196.15	233.66	233.66	401.50
Wind lever	[m]	3.37	3.37	3.37	3.62	4.58	5.78	5.91	5.91	6.25
Details of external events										
Weights of catch (one side)										
Heavy catch	[t]	0.35	0.35	0.40	0.45	0.72	2.95	1.80	1.80	1.80
Weights of debris in nets (one side)										
Debris	[t]	1.5	1.5	1.5	1.5	1.5	3	3	3	3
Water on deck										
Free deck area (40% of Lpp * Bmld)	[m2]	41.3	41.3	41.3	50.6	57.8	111.7	129.5	129.5	140.8
Height of water on deck	[m]	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Amount of water on deck	[m3]	1.65	1.65	1.65	2.02	2.31	4.47	5.18	5.18	5.63
Stability factor	[-]	1.00	1.00	1.00	1.00	1.00	1.00	1.15	1.15	1.67
ML from lifting code	[tonm]	5.96	5.99	5.97	11.59	13.71	28.93	27.03	26.93	34.18

Appendix XXI. Details on fishing gear weights

The table below provides an overview of the fishing gear weight variations as used in the calculations.

Fishing gear weight variations

EuroCutter 20m			
Fishing gear light (shrimps)	[kg]	1350	= Original
Fishing gear heavy (Sole)	[kg]	1929	Based on weight distribution of chains vs. Boom+net etc.: 30%/70%
Cutter 2000hp			
Fishing gear heavy (standard gear)	[kg]	8500	= Original. Based on data from RIVO 82-03 report and other sources
Fishing gear light	[kg]	6000	Light gear, based on reduced power and SumWing instead of steel pipe/boom

The 30%/70% weight distribution is based on the analysis of fishing gear weights as mentioned in (Blom, 1982), summarized in the table below. The vessel -ex-IJM44 – is coming closest to the reference vessel (EuroCutter 20m) considered, taking into account length and installed power. Besides, it is assumed that this ratio is not changing much further towards a larger ratio with smaller vessels.

Weights of fishing gear from report RIVO 82-03

Parameter	**Unit**	**SCH 28**	**ex-IJM 44**	**ex-TX 8**	**KW 189**	**GO 1**	**ex-ARM 22**
Length Over All (LOA)	[m]	26.1	26.2	34.0	33.0	36.7	35.8
Installed power	[hp]	800	540	1200	1350	1760	1760
Part							
Spruit (of + boom + sloffen)	[kg]	200	1950	300	2800	550	400
Boom	[kg]	550		1350		1800	3100
Sloffen	[kg]	840		1100		1170	
Kettingmat	[kg]						2400
Wekkers	[kg]	1420	660	1470	1600	2540	1140
Kietelaars	[kg]	290	110	100	200	210	
Kettingpees	[kg]	200	130	200	350	330	160
Net	[kg]	200	200	300	350	350	400
Total	[kg]	3700	3050	4820	5300	6950	7600
Alleen Boom compleet + net		48%	70%	63%	59%	56%	51%
Wekkerkettingen etc.		52%	30%	37%	41%	44%	49%

Appendix XXII. Score card of remaining righting moments

Vessel nr.	Type of vessel	Vessel and Operational Condition	NoExternal [tm]	Wd [tm]	W6 [tm]	W6Gu [tm]	W6GuGs [tm]	W6GuWd [tm]	W6Wl [tm]	W8 [tm]	W8Gu [tm]	W8GuWd [tm]	W10GuWd [tm]
1	EuroCutter 20m	8080	28,1	24,4	25,5	24,2	18,6	20,5	5,9	21,9	18,9	15,2	6,7
1	EuroCutter 20m	0000-BDP-BDS	30,4	26,7	27,8	26,5	-0,2	22,8	8,2	24,2	21,2	17,5	9,0
1	EuroCutter 20m	0000-BDP-BDS-NDS	15,8	12,1	13,2	11,9	-14,8	8,2	-6,4	9,6	6,6	2,9	-5,6
1	EuroCutter 20m	0045-BDP-BBS-NDS	33,4	29,8	30,8	29,5	12,5	25,9	11,2	27,3	24,2	20,5	12,0
1	EuroCutter 20m	0045-BDP-BBS-NDS-STG	32,7	29,1	30,1	28,8	11,8	25,2	10,5	26,6	23,5	19,8	11,3
1	EuroCutter 20m	0045-BDP-BDS-HBS	24,5	20,8	21,9	20,6	-2,4	16,9	2,3	18,4	15,3	11,6	3,1
1	EuroCutter 20m	0045-BDP-BDS-NDS	14,7	11,0	12,1	10,8	-12,2	7,1	-7,5	8,5	5,5	1,8	-6,7
1	EuroCutter 20m	0045-BDP-BDS-NDS	14,7	11,0	12,1	10,8	-12,2	7,1	-7,5	8,5	5,5	1,8	-6,7
1	EuroCutter 20m	0045-BDP-BDS-NDS-STG	14,0	10,3	11,4	10,1	-12,9	6,4	-8,2	7,8	4,8	1,1	-7,4
1	EuroCutter 20m	4545-BDP-BBS-NDS	23,3	19,6	20,7	19,4	6,1	15,7	1,1	17,1	14,1	10,4	1,9
1	EuroCutter 20m	4545-BDP-BBS-NDS-STG	22,6	18,9	20,0	18,7	5,4	15,0	0,4	16,4	13,4	9,7	1,2
1	EuroCutter 20m	4545-BDP-BDS	19,6	15,9	17,0	15,7	-3,5	12,0	-2,6	13,5	10,4	6,7	-1,8
1	EuroCutter 20m	4545-BDP-BDS-HBP-HBS-STG	8,6	4,9	6,0	4,7	-14,5	1,0	-13,6	2,4	-0,6	-4,3	-12,8
1	EuroCutter 20m	4545-BDP-BDS-HBS	14,3	10,7	11,7	10,4	-8,8	6,8	-7,9	8,2	5,1	1,4	-7,1
1	EuroCutter 20m	4545-BDP-BDS-HCP-HCS	17,6	13,9	15,0	13,7	-5,5	10,0	-4,6	11,5	8,4	4,7	-3,8
1	EuroCutter 20m	4545-BDP-BDS-HCP-HCS-STG	16,9	13,2	14,3	13,0	-6,2	9,3	-5,3	10,8	7,7	4,0	-4,5
1	EuroCutter 20m	4545-BDP-BDS-HCS	18,6	14,9	16,0	14,7	-4,5	11,0	-3,6	12,5	9,4	5,7	-2,8
1	EuroCutter 20m	4545-BDP-BDS-NDS	4,5	0,8	1,9	0,6	-18,6	-3,1	-17,7	-1,6	-4,7	-8,4	-16,9
1	EuroCutter 20m	4545-BDP-BDS-NDS-STG	3,8	0,1	1,2	-0,1	-19,3	-3,8	-18,4	-2,3	-5,4	-9,1	-17,6
1	EuroCutter 20m	8045-BDP-BDS	8,8	5,1	6,2	4,9	-7,5	1,2	-13,4	2,6	-0,4	-4,1	-12,6
1	EuroCutter 20m	8045-BDP-BDS-HBP-NDS-STG	-12,3	-16,0	-14,9	-16,2	-28,6	-19,9	-34,5	-18,4	-21,5	-25,2	-33,7
1	EuroCutter 20m	8045-BDP-BDS-HCP-HCS	6,8	3,1	4,2	2,9	-9,5	-0,8	-15,4	0,6	-2,4	-6,1	-14,6
1	EuroCutter 20m	8045-BDP-BDS-HCP-HCS-STG	6,1	2,4	3,5	2,2	-10,2	-1,5	-16,1	-0,1	-3,1	-6,8	-15,3
1	EuroCutter 20m	8045-BDP-BDS-NDS	-6,3	-10,0	-8,9	-10,2	-22,6	-13,9	-28,5	-12,5	-15,5	-19,2	-27,7
1	EuroCutter 20m	8045-BDS-STG	14,9	11,2	12,3	11,0	-1,4	7,3	-7,3	8,7	5,6	2,0	-6,6
1	EuroCutter 20m	8080-BDP-BDS	15,4	11,7	12,8	11,5	5,9	7,8	-6,8	9,2	6,2	2,5	-6,0
1	EuroCutter 20m	8080-STG	27,4	23,7	24,8	23,5	17,9	19,8	5,2	21,2	18,2	14,5	6,0
2	EuroCutter 20m HG	8080	28,1	24,4	25,5	24,2	16,2	20,5	5,8	21,9	18,8	15,2	6,7
2	EuroCutter 20m HG	0000-BDP-BDS	29,5	25,8	26,9	25,6	-13,0	21,9	7,2	23,3	20,2	16,6	8,1
2	EuroCutter 20m HG	0000-BDP-BDS-NDS	14,9	11,2	12,3	11,0	-27,7	7,3	-7,4	8,7	5,6	1,9	-6,6
2	EuroCutter 20m HG	0045-BDP-BBS-NDS	36,3	32,6	33,7	32,4	7,8	28,7	14,0	30,1	27,1	23,4	14,9
2	EuroCutter 20m HG	0045-BDP-BBS-NDS-STG	35,6	31,9	33,0	31,7	7,1	28,0	13,3	29,4	26,4	22,7	14,2
2	EuroCutter 20m HG	0045-BDP-BDS-HBS	23,4	19,7	20,8	19,5	-13,7	15,8	1,1	17,3	14,2	10,5	2,0
2	EuroCutter 20m HG	0045-BDP-BDS-NDS	13,6	9,9	11,0	9,7	-23,5	6,0	-8,7	7,4	4,4	0,7	-7,8
2	EuroCutter 20m HG	0045-BDP-BDS-NDS	13,6	9,9	11,0	9,7	-23,5	6,0	-8,7	7,4	4,4	0,7	-7,8
2	EuroCutter 20m HG	0045-BDP-BDS-NDS-STG	12,9	9,2	10,3	9,0	-24,2	5,3	-9,4	6,7	3,7	0,0	-8,5
2	EuroCutter 20m HG	4545-BDP-BBS-NDS	22,9	19,2	20,3	19,0	-0,2	15,3	0,6	16,8	13,7	10,0	1,5
2	EuroCutter 20m HG	4545-BDP-BBS-NDS-STG	22,2	18,5	19,6	18,3	-0,9	14,6	-0,1	16,1	13,0	9,3	0,8
2	EuroCutter 20m HG	4545-BDP-BDS	15,3	11,6	12,7	11,4	-16,4	7,7	-7,0	9,1	6,1	2,4	-6,1
2	EuroCutter 20m HG	4545-BDP-BDS-HBP-HBS-STG	5,1	1,4	2,5	1,2	-26,6	-2,5	-17,2	-1,0	-4,1	-7,8	-16,3
2	EuroCutter 20m HG	4545-BDP-BDS-HBS	10,0	6,3	7,4	6,1	-21,6	2,4	-12,3	3,9	0,8	-2,9	-11,4
2	EuroCutter 20m HG	4545-BDP-BDS-HCP-HCS	13,3	9,6	10,7	9,4	-18,4	5,7	-9,0	7,1	4,1	0,4	-8,1
2	EuroCutter 20m HG	4545-BDP-BDS-HCP-HCS-STG	12,6	8,9	10,0	8,7	-19,1	5,0	-9,7	6,4	3,4	-0,3	-8,8
2	EuroCutter 20m HG	4545-BDP-BDS-HCS	14,3	10,6	11,7	10,4	-17,4	6,7	-8,0	8,1	5,1	1,4	-7,1
2	EuroCutter 20m HG	4545-BDP-BDS-NDS	0,2	-3,5	-2,4	-3,7	-31,5	-7,4	-22,1	-6,0	-9,0	-12,7	-21,2
2	EuroCutter 20m HG	4545-BDP-BDS-NDS-STG	-0,5	-4,2	-3,1	-4,4	-32,2	-8,1	-22,8	-6,7	-9,7	-13,4	-21,9
2	EuroCutter 20m HG	8045-BDP-BDS	1,0	-2,7	-1,6	-2,9	-20,7	-6,6	-21,2	-5,1	-8,2	-11,9	-20,4
2	EuroCutter 20m HG	8045-BDP-BDS-HBP-NDS-STG	-19,2	-22,9	-21,8	-23,1	-41,0	-26,8	-41,5	-25,4	-28,4	-32,1	-40,6
2	EuroCutter 20m HG	8045-BDP-BDS-HCP-HCS	-1,0	-4,6	-3,6	-4,9	-22,7	-8,5	-23,2	-7,1	-10,2	-13,9	-22,4
2	EuroCutter 20m HG	8045-BDP-BDS-HCP-HCS-STG	-1,7	-5,3	-4,3	-5,6	-23,4	-9,2	-23,9	-7,8	-10,9	-14,6	-23,1
2	EuroCutter 20m HG	8045-BDP-BDS-NDS	-14,1	-17,7	-16,7	-18,0	-35,8	-21,6	-36,3	-20,2	-23,3	-27,0	-35,5
2	EuroCutter 20m HG	8045-BDS-STG	10,1	6,4	7,5	6,2	-11,7	2,5	-12,2	4,0	0,9	-2,8	-11,3
2	EuroCutter 20m HG	8080-BDP-BDS	9,7	6,0	7,1	5,8	-2,2	2,1	-12,6	3,6	0,5	-3,2	-11,7
2	EuroCutter 20m HG	8080-STG	27,4	23,7	24,8	23,5	15,5	19,8	5,1	21,2	18,1	14,5	5,9
3	EuroCutter 20m DE	8080	28,1	24,4	25,5	24,2	17,3	20,5	5,8	21,9	18,9	15,2	6,7
3	EuroCutter 20m DE	0000-BDP-BDS	30,8	27,1	28,2	26,9	-6,9	23,2	8,6	24,7	21,6	17,9	9,4
3	EuroCutter 20m DE	0000-BDP-BDS-NDS	15,0	11,3	12,4	11,1	-22,7	7,4	-7,2	8,8	5,8	2,1	-6,4
3	EuroCutter 20m DE	0045-BDP-BBS-NDS	36,5	32,8	33,9	32,6	11,5	28,9	14,3	30,4	27,3	23,6	15,1
3	EuroCutter 20m DE	0045-BDP-BBS-NDS-STG	35,8	32,1	33,2	31,9	10,8	28,2	13,6	29,7	26,6	22,9	14,4
3	EuroCutter 20m DE	0045-BDP-BDS-HBS	24,7	21,0	22,1	20,8	-8,3	17,1	2,4	18,5	15,4	11,8	3,2
3	EuroCutter 20m DE	0045-BDP-BDS-NDS	13,6	9,9	11,0	9,7	-19,4	6,0	-8,7	7,4	4,3	0,7	-7,8
3	EuroCutter 20m DE	0045-BDP-BDS-NDS	13,6	9,9	11,0	9,7	-19,4	6,0	-8,7	7,4	4,3	0,7	-7,8
3	EuroCutter 20m DE	0045-BDP-BDS-NDS-STG	12,9	9,2	10,3	9,0	-20,1	5,3	-9,4	6,7	3,6	0,0	-8,5
3	EuroCutter 20m DE	4545-BDP-BBS-NDS	23,9	20,2	21,3	20,0	3,6	16,3	1,7	17,7	14,7	11,0	2,5
3	EuroCutter 20m DE	4545-BDP-BBS-NDS-STG	23,2	19,5	20,6	19,3	2,9	15,6	1,0	17,0	14,0	10,3	1,8
3	EuroCutter 20m DE	4545-BDP-BDS	17,5	13,8	14,9	13,6	-10,7	9,9	-4,8	11,3	8,2	4,5	-4,0
3	EuroCutter 20m DE	4545-BDP-BDS-HBP-HBS-STG	6,6	2,9	4,0	2,7	-21,5	-1,0	-15,6	0,5	-2,6	-6,3	-14,8
3	EuroCutter 20m DE	4545-BDP-BDS-HBS	12,0	8,4	9,4	8,1	-16,1	4,5	-10,2	5,9	2,8	-0,9	-9,4
3	EuroCutter 20m DE	4545-BDP-BDS-HCP-HCS	15,2	11,5	12,6	11,3	-13,0	7,6	-7,1	9,0	6,0	2,3	-6,2
3	EuroCutter 20m DE	4545-BDP-BDS-HCP-HCS-STG	14,5	10,8	11,9	10,6	-13,7	6,9	-7,8	8,3	5,2	1,6	-6,9
3	EuroCutter 20m DE	4545-BDP-BDS-HCS	16,3	12,6	13,7	12,4	-11,8	8,7	-5,9	10,2	7,1	3,4	-5,1
3	EuroCutter 20m DE	4545-BDP-BDS-NDS	0,9	-2,7	-1,7	-3,0	-27,2	-6,6	-21,3	-5,2	-8,3	-12,0	-20,5
3	EuroCutter 20m DE	4545-BDP-BDS-NDS-STG	0,2	-3,4	-2,4	-3,7	-27,9	-7,3	-22,0	-5,9	-9,0	-12,7	-21,2
3	EuroCutter 20m DE	8045-BDP-BDS	4,0	0,3	1,4	0,1	-15,5	-3,6	-18,2	-2,1	-5,2	-8,9	-17,4
3	EuroCutter 20m DE	8045-BDP-BDS-HBP-NDS-STG	-18,1	-21,8	-20,7	-22,0	-37,6	-25,7	-40,4	-24,3	-27,3	-31,0	-39,5
3	EuroCutter 20m DE	8045-BDP-BDS-HCP-HCS	1,7	-1,9	-0,9	-2,2	-17,7	-5,8	-20,5	-4,4	-7,5	-11,2	-19,7
3	EuroCutter 20m DE	8045-BDP-BDS-HCP-HCS-STG	1,0	-2,7	-1,6	-2,9	-18,4	-6,6	-21,2	-5,1	-8,2	-11,9	-20,4
3	EuroCutter 20m DE	8045-BDP-BDS-NDS	-12,5	-16,2	-15,1	-16,4	-32,0	-20,1	-34,7	-18,6	-21,7	-25,4	-33,9
3	EuroCutter 20m DE	8045-BDS-STG	11,5	7,8	8,9	7,6	-8,0	3,9	-10,7	5,3	2,3	-1,4	-9,9
3	EuroCutter 20m DE	8080-BDP-BDS	12,2	8,5	9,6	8,3	1,4	4,6	-10,0	6,1	3,0	-0,7	-9,2
3	EuroCutter 20m DE	8080-STG	27,4	23,7	24,8	23,5	16,6	19,8	5,1	21,2	18,2	14,5	6,0

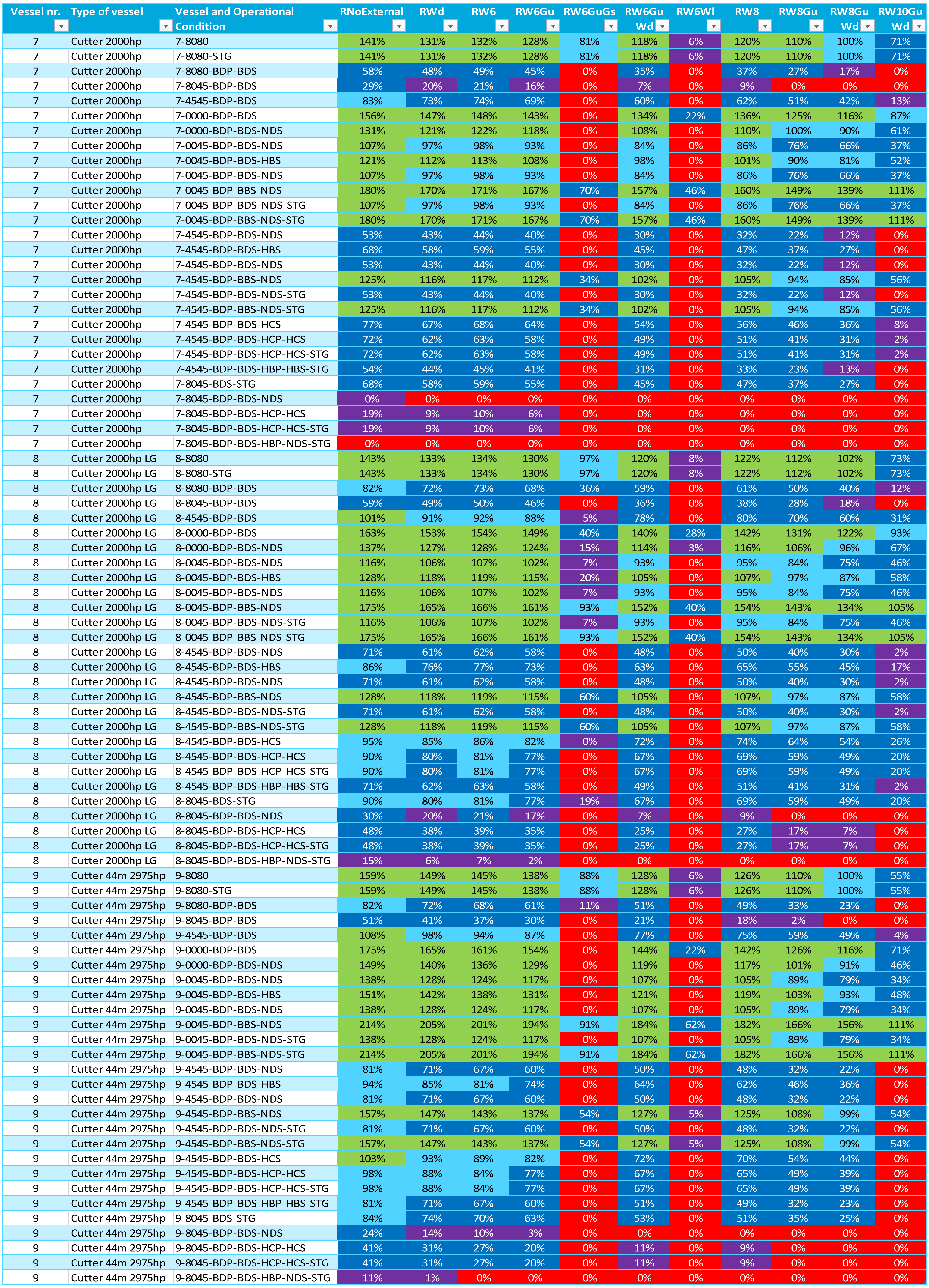
Vessel nr.	Type of vessel	Vessel and Operational Condition	NoExternal [tm]	Wd [tm]	W6 [tm]	W6Gu [tm]	W6GuGs [tm]	W6GuWd [tm]	W6Wl [tm]	W8 [tm]	W8Gu [tm]	W8GuWd [tm]	W10GuWd [tm]
4	EuroCutter 24m v1	8080	45,3	40,5	42,1	40,4	31,2	35,6	12,6	37,6	33,7	28,9	18,1
4	EuroCutter 24m v1	0000-BDP-BDS	51,1	46,2	47,8	46,1	12,4	41,3	18,4	43,3	39,4	34,6	23,9
4	EuroCutter 24m v1	0000-BDP-BDS-NDS	36,6	31,7	33,3	31,6	-2,1	26,8	3,9	28,8	24,9	20,1	9,4
4	EuroCutter 24m v1	0045-BDP-BBS-NDS	55,4	50,6	52,1	50,5	28,5	45,7	22,7	47,6	43,8	38,9	28,2
4	EuroCutter 24m v1	0045-BDP-BBS-NDS-STG	53,8	48,9	50,5	48,8	26,9	44,0	21,1	46,0	42,1	37,3	26,6
4	EuroCutter 24m v1	0045-BDP-BDS-HBS	45,6	40,7	42,3	40,6	11,2	35,8	12,9	37,8	33,9	29,1	18,4
4	EuroCutter 24m v1	0045-BDP-BDS-NDS	35,4	30,6	32,2	30,5	1,1	25,7	2,7	27,7	23,8	19,0	8,2
4	EuroCutter 24m v1	0045-BDP-BDS-NDS	35,4	30,6	32,2	30,5	1,1	25,7	2,7	27,7	23,8	19,0	8,2
4	EuroCutter 24m v1	0045-BDP-BDS-NDS-STG	34,2	29,4	30,9	29,3	-0,1	24,5	1,5	26,5	22,6	17,8	7,0
4	EuroCutter 24m v1	4545-BDP-BBS-NDS	41,5	36,6	38,2	36,5	18,9	31,7	8,8	33,7	29,8	25,0	14,2
4	EuroCutter 24m v1	4545-BDP-BBS-NDS-STG	40,2	35,4	37,0	35,3	17,7	30,5	7,5	32,5	28,6	23,8	13,0
4	EuroCutter 24m v1	4545-BDP-BDS	36,5	31,7	33,3	31,6	6,6	26,8	3,8	28,8	24,9	20,1	9,3
4	EuroCutter 24m v1	4545-BDP-BDS-HBP-HBS-STG	27,1	22,3	23,8	22,2	-2,9	17,4	-5,6	19,4	15,5	10,7	-0,1
4	EuroCutter 24m v1	4545-BDP-BDS-HBS	32,4	27,6	29,2	27,5	2,5	22,7	-0,3	24,7	20,8	16,0	5,2
4	EuroCutter 24m v1	4545-BDP-BDS-HCP-HCS	34,7	29,8	31,4	29,7	4,7	24,9	2,0	26,9	23,0	18,2	7,4
4	EuroCutter 24m v1	4545-BDP-BDS-HCP-HCS-STG	33,4	28,6	30,2	28,5	3,5	23,7	0,7	25,7	21,8	17,0	6,2
4	EuroCutter 24m v1	4545-BDP-BDS-HCS	35,6	30,8	32,3	30,7	5,6	25,9	2,9	27,8	24,0	19,1	8,4
4	EuroCutter 24m v1	4545-BDP-BDS-NDS	22,3	17,5	19,0	17,4	-7,7	12,6	-10,4	14,6	10,7	5,9	-4,9
4	EuroCutter 24m v1	4545-BDP-BDS-NDS-STG	21,1	16,3	17,8	16,2	-8,9	11,4	-11,6	13,3	9,5	4,6	-6,1
4	EuroCutter 24m v1	8045-BDP-BDS	21,4	16,6	18,1	16,5	-0,6	11,7	-11,3	13,7	9,8	5,0	-5,8
4	EuroCutter 24m v1	8045-BDP-BDS-HBP-NDS-STG	1,9	-3,0	-1,4	-3,1	-20,2	-7,9	-30,8	-5,9	-9,8	-14,6	-25,3
4	EuroCutter 24m v1	8045-BDP-BDS-HCP-HCS	19,5	14,7	16,2	14,6	-2,5	9,8	-13,2	11,8	7,9	3,1	-7,7
4	EuroCutter 24m v1	8045-BDP-BDS-HCP-HCS-STG	18,3	13,5	15,0	13,4	-3,7	8,6	-14,4	10,6	6,7	1,8	-8,9
4	EuroCutter 24m v1	8045-BDP-BDS-NDS	7,2	2,4	3,9	2,3	-14,9	-2,6	-25,5	-0,6	-4,5	-9,3	-20,0
4	EuroCutter 24m v1	8045-BDS-STG	26,5	21,7	23,2	21,6	4,5	16,8	-6,2	18,7	14,9	10,0	-0,7
4	EuroCutter 24m v1	8080-BDP-BDS	31,7	26,9	28,4	26,8	17,6	22,0	-1,0	24,0	20,1	15,3	4,5
4	EuroCutter 24m v1	8080-STG	43,7	38,9	40,4	38,8	29,6	34,0	11,0	35,9	32,1	27,2	16,5
5	EuroCutter 24m v2	8080	67,9	61,9	63,0	60,5	43,8	54,4	16,0	56,1	50,2	44,2	27,8
5	EuroCutter 24m v2	0000-BDP-BDS	73,7	67,6	68,7	66,2	16,5	60,1	21,7	61,8	55,9	49,9	33,5
5	EuroCutter 24m v2	0000-BDP-BDS-NDS	57,6	51,5	52,6	50,1	0,4	44,0	5,6	45,8	39,9	33,8	17,4
5	EuroCutter 24m v2	0045-BDP-BBS-NDS	81,5	75,4	76,5	74,0	41,9	67,9	29,5	69,7	63,8	57,7	41,4
5	EuroCutter 24m v2	0045-BDP-BBS-NDS-STG	72,0	65,9	67,0	64,5	32,4	58,4	20,0	60,2	54,3	48,2	31,8
5	EuroCutter 24m v2	0045-BDP-BDS-HBS	62,4	56,4	57,4	54,9	11,1	48,9	10,5	50,6	44,7	38,6	22,3
5	EuroCutter 24m v2	0045-BDP-BDS-NDS	53,2	47,1	48,2	45,7	1,9	39,6	1,2	41,4	35,5	29,4	13,0
5	EuroCutter 24m v2	0045-BDP-BDS-NDS	53,2	47,1	48,2	45,7	1,9	39,6	1,2	41,4	35,5	29,4	13,0
5	EuroCutter 24m v2	0045-BDP-BDS-NDS-STG	44,6	38,6	39,7	37,2	-6,7	31,1	-7,3	32,8	26,9	20,9	4,5
5	EuroCutter 24m v2	4545-BDP-BBS-NDS	62,8	56,7	57,8	55,3	29,1	49,3	10,9	51,0	45,1	39,0	22,7
5	EuroCutter 24m v2	4545-BDP-BBS-NDS-STG	54,6	48,5	49,6	47,1	20,9	41,0	2,6	42,8	36,9	30,8	14,5
5	EuroCutter 24m v2	4545-BDP-BDS	52,1	46,0	47,1	44,6	6,6	38,5	0,1	40,3	34,4	28,3	11,9
5	EuroCutter 24m v2	4545-BDP-BDS-HBP-HBS-STG	31,3	25,2	26,3	23,8	-14,2	17,7	-20,7	19,5	13,6	7,5	-8,9
5	EuroCutter 24m v2	4545-BDP-BDS-HBS	45,1	39,0	40,1	37,6	-0,4	31,5	-6,9	33,3	27,4	21,3	4,9
5	EuroCutter 24m v2	4545-BDP-BDS-HCP-HCS	47,5	41,4	42,5	40,0	2,1	34,0	-4,4	35,7	29,8	23,7	7,4
5	EuroCutter 24m v2	4545-BDP-BDS-HCP-HCS-STG	39,6	33,5	34,6	32,1	-5,9	26,0	-12,4	27,8	21,9	15,8	-0,6
5	EuroCutter 24m v2	4545-BDP-BDS-HCS	49,8	43,7	44,8	42,3	4,4	36,2	-2,2	38,0	32,1	26,0	9,7
5	EuroCutter 24m v2	4545-BDP-BDS-NDS	35,3	29,2	30,3	27,8	-10,2	21,7	-16,7	23,4	17,5	11,5	-4,9
5	EuroCutter 24m v2	4545-BDP-BDS-NDS-STG	27,3	21,2	22,3	19,8	-18,2	13,7	-24,7	15,5	9,6	3,5	-12,8
5	EuroCutter 24m v2	8045-BDP-BDS	33,6	27,5	28,6	26,1	-1,2	20,0	-18,4	21,8	15,9	9,8	-6,6
5	EuroCutter 24m v2	8045-BDP-BDS-HBP-NDS-STG	2,4	-3,7	-2,6	-5,1	-32,4	-11,2	-49,6	-9,4	-15,3	-21,4	-37,7
5	EuroCutter 24m v2	8045-BDP-BDS-HCP-HCS	29,1	23,0	24,1	21,6	-5,7	15,5	-22,9	17,2	11,3	5,3	-11,1
5	EuroCutter 24m v2	8045-BDP-BDS-HCP-HCS-STG	21,1	15,0	16,1	13,6	-13,7	7,5	-30,9	9,3	3,4	-2,7	-19,0
5	EuroCutter 24m v2	8045-BDP-BDS-NDS	16,8	10,7	11,8	9,3	-18,0	3,2	-35,2	5,0	-0,9	-7,0	-23,4
5	EuroCutter 24m v2	8045-BDS-STG	34,4	28,3	29,4	26,9	-0,4	20,8	-17,6	22,6	16,7	10,6	-5,8
5	EuroCutter 24m v2	8080-BDP-BDS	44,8	38,8	39,9	37,4	20,7	31,3	-7,1	33,0	27,1	21,1	4,7
5	EuroCutter 24m v2	8080-STG	58,3	52,2	53,3	50,8	34,2	44,7	6,3	46,5	40,6	34,5	18,2
6	Cutter 35m	8080	179,2	164,6	166,7	160,5	113,3	145,9	9,5	149,7	135,0	120,4	79,6
6	Cutter 35m	0000-BDP-BDS	194,6	180,0	182,1	175,9	22,9	161,3	24,9	165,1	150,3	135,7	94,9
6	Cutter 35m	0000-BDP-BDS-NDS	152,5	137,9	140,1	133,8	-19,2	119,2	-17,1	123,1	108,3	93,7	52,9
6	Cutter 35m	0045-BDP-BBS-NDS	216,2	201,6	203,7	197,5	99,9	182,9	46,5	186,7	172,0	157,4	116,6
6	Cutter 35m	0045-BDP-BBS-NDS-STG	216,2	201,6	203,7	197,5	99,9	182,9	46,5	186,7	172,0	157,4	116,6
6	Cutter 35m	0045-BDP-BDS-HBS	152,8	138,2	140,3	134,1	-0,1	119,5	-16,9	123,3	108,6	94,0	53,2
6	Cutter 35m	0045-BDP-BDS-NDS	132,7	118,1	120,2	114,0	-20,2	99,4	-37,0	103,2	88,5	73,9	33,1
6	Cutter 35m	0045-BDP-BDS-NDS	132,7	118,1	120,2	114,0	-20,2	99,4	-37,0	103,2	88,5	73,9	33,1
6	Cutter 35m	0045-BDP-BDS-NDS-STG	132,7	118,1	120,2	114,0	-20,2	99,4	-37,0	103,2	88,5	73,9	33,1
6	Cutter 35m	4545-BDP-BBS-NDS	163,2	148,6	150,7	144,5	65,7	129,9	-6,5	133,7	119,0	104,4	63,6
6	Cutter 35m	4545-BDP-BBS-NDS-STG	163,2	148,6	150,7	144,5	65,7	129,9	-6,5	133,7	119,0	104,4	63,6
6	Cutter 35m	4545-BDP-BDS	128,4	113,8	116,0	109,7	-5,8	95,1	-41,2	98,9	84,2	69,6	28,8
6	Cutter 35m	4545-BDP-BDS-HBP-HBS-STG	73,0	58,4	60,6	54,3	-61,2	39,7	-96,6	43,6	28,8	14,2	-26,6
6	Cutter 35m	4545-BDP-BDS-HBS	99,8	85,2	87,3	81,1	-34,4	66,5	-69,9	70,3	55,6	41,0	0,2
6	Cutter 35m	4545-BDP-BDS-HCP-HCS	100,0	85,4	87,6	81,3	-34,2	66,7	-69,6	70,6	55,8	41,2	0,4
6	Cutter 35m	4545-BDP-BDS-HCP-HCS-STG	100,0	85,4	87,6	81,3	-34,2	66,7	-69,6	70,6	55,8	41,2	0,4
6	Cutter 35m	4545-BDP-BDS-HCS	114,2	99,6	101,8	95,5	-20,0	80,9	-55,4	84,8	70,0	55,4	14,6
6	Cutter 35m	4545-BDP-BDS-NDS	79,7	65,1	67,2	61,0	-54,5	46,4	-90,0	50,2	35,5	20,9	-19,9
6	Cutter 35m	4545-BDP-BDS-NDS-STG	79,7	65,1	67,2	61,0	-54,5	46,4	-90,0	50,2	35,5	20,9	-19,9
6	Cutter 35m	8045-BDP-BDS	76,0	61,4	63,5	57,3	-24,1	42,7	-93,7	46,5	31,8	17,2	-23,6
6	Cutter 35m	8045-BDP-BDS-HBP-NDS-STG	-1,4	-16,0	-13,8	-20,1	-101,4	-34,7	-171,0	-30,8	-45,6	-60,2	-101,0
6	Cutter 35m	8045-BDP-BDS-HCP-HCS	47,6	33,0	35,1	28,9	-52,5	14,3	-122,1	18,1	3,4	-11,2	-52,0
6	Cutter 35m	8045-BDP-BDS-HCP-HCS-STG	47,6	33,0	35,1	28,9	-52,5	14,3	-122,1	18,1	3,4	-11,2	-52,0
6	Cutter 35m	8045-BDP-BDS-NDS	27,3	12,7	14,8	8,6	-72,8	-6,0	-142,4	-2,2	-17,0	-31,6	-72,4
6	Cutter 35m	8045-BDS-STG	106,8	92,2	94,4	88,1	6,8	73,5	-62,8	77,4	62,6	48,0	7,2
6	Cutter 35m	8080-BDP-BDS	104,2	89,6	91,7	85,5	38,2	70,9	-65,5	74,7	60,0	45,4	4,6
6	Cutter 35m	8080-STG	179,2	164,6	166,7	160,5	113,3	145,9	9,5	149,7	135,0	120,4	79,6

Vessel nr.	Type of vessel	Vessel and Operational Condition	NoExternal [tm]	Wd [tm]	W6 [tm]	W6Gu [tm]	W6GuGs [tm]	W6GuWd [tm]	W6Wl [tm]	W8 [tm]	W8Gu [tm]	W8GuWd [tm]	W10GuWd [tm]
7	Cutter 2000hp	8080	243,8	226,9	228,6	221,0	141,0	204,1	10,3	207,9	189,9	173,0	123,3
7	Cutter 2000hp	0000-BDP-BDS	270,8	253,9	255,6	248,0	-18,9	231,1	37,3	234,9	217,0	200,0	150,3
7	Cutter 2000hp	0000-BDP-BDS-NDS	227,2	210,3	212,0	204,4	-62,5	187,5	-6,3	191,3	173,3	156,4	106,6
7	Cutter 2000hp	0045-BDP-BBS-NDS	313,2	296,3	298,0	290,4	122,1	273,5	79,7	277,3	259,3	242,4	192,6
7	Cutter 2000hp	0045-BDP-BBS-NDS-STG	313,2	296,3	298,0	290,4	122,1	273,5	79,7	277,3	259,3	242,4	192,6
7	Cutter 2000hp	0045-BDP-BDS-HBS	211,3	194,3	196,1	188,5	-45,3	171,5	-22,2	175,3	157,4	140,4	90,7
7	Cutter 2000hp	0045-BDP-BDS-NDS	185,3	168,4	170,1	162,5	-71,3	145,5	-48,2	149,3	131,4	114,5	64,7
7	Cutter 2000hp	0045-BDP-BDS-NDS	185,3	168,4	170,1	162,5	-71,3	145,5	-48,2	149,3	131,4	114,5	64,7
7	Cutter 2000hp	0045-BDP-BDS-NDS-STG	185,3	168,4	170,1	162,5	-71,3	145,5	-48,2	149,3	131,4	114,5	64,7
7	Cutter 2000hp	4545-BDP-BBS-NDS	217,8	200,8	202,6	195,0	59,8	178,0	-15,7	181,8	163,9	146,9	97,2
7	Cutter 2000hp	4545-BDP-BBS-NDS-STG	217,8	200,8	202,6	195,0	59,8	178,0	-15,7	181,8	163,9	146,9	97,2
7	Cutter 2000hp	4545-BDP-BDS	142,9	126,0	127,7	120,1	-80,6	103,2	-90,6	107,0	89,0	72,1	22,3
7	Cutter 2000hp	4545-BDP-BDS-HBP-HBS-STG	93,9	77,0	78,7	71,1	-129,6	54,2	-139,6	58,0	40,0	23,1	-26,7
7	Cutter 2000hp	4545-BDP-BDS-HBS	118,4	101,5	103,2	95,6	-105,1	78,7	-115,1	82,5	64,5	47,6	-2,2
7	Cutter 2000hp	4545-BDP-BDS-HCP-HCS	124,5	107,6	109,3	101,7	-99,0	84,8	-109,0	88,6	70,6	53,7	3,9
7	Cutter 2000hp	4545-BDP-BDS-HCP-HCS-STG	124,5	107,6	109,3	101,7	-99,0	84,8	-109,0	88,6	70,6	53,7	3,9
7	Cutter 2000hp	4545-BDP-BDS-HCS	133,7	116,8	118,5	110,9	-89,8	94,0	-99,8	97,8	79,8	62,9	13,1
7	Cutter 2000hp	4545-BDP-BDS-NDS	92,4	75,5	77,2	69,6	-131,1	52,7	-141,1	56,5	38,5	21,6	-28,2
7	Cutter 2000hp	4545-BDP-BDS-NDS-STG	92,4	75,5	77,2	69,6	-131,1	52,7	-141,1	56,5	38,5	21,6	-28,2
7	Cutter 2000hp	8045-BDP-BDS	51,0	34,1	35,8	28,2	-112,2	11,3	-182,5	15,1	-2,9	-19,8	-69,6
7	Cutter 2000hp	8045-BDP-BDS-HBP-NDS-STG	-24,0	-40,9	-39,2	-46,8	-187,2	-63,7	-257,5	-59,9	-77,9	-94,8	-144,6
7	Cutter 2000hp	8045-BDP-BDS-HCP-HCS	32,6	15,7	17,4	9,8	-130,5	-7,1	-200,9	-3,3	-21,3	-38,2	-87,9
7	Cutter 2000hp	8045-BDP-BDS-HCP-HCS-STG	32,6	15,7	17,4	9,8	-130,5	-7,1	-200,9	-3,3	-21,3	-38,2	-87,9
7	Cutter 2000hp	8045-BDP-BDS-NDS	0,5	-16,4	-14,7	-22,3	-162,7	-39,2	-233,0	-35,4	-53,4	-70,3	-120,1
7	Cutter 2000hp	8045-BDS-STG	118,1	101,2	102,9	95,3	-45,1	78,4	-115,4	82,2	64,2	47,3	-2,5
7	Cutter 2000hp	8080-BDP-BDS	100,4	83,5	85,2	77,6	-2,4	60,7	-133,1	64,5	46,5	29,6	-20,1
7	Cutter 2000hp	8080-STG	243,8	226,9	228,6	221,0	141,0	204,1	10,3	207,9	189,9	173,0	123,3
8	Cutter 2000hp LG	8080	246,7	229,8	231,5	223,9	167,4	207,0	14,5	210,8	192,8	175,9	126,1
8	Cutter 2000hp LG	0000-BDP-BDS	280,6	263,7	265,4	257,8	69,4	240,9	48,4	244,7	226,7	209,8	160,0
8	Cutter 2000hp LG	0000-BDP-BDS-NDS	237,0	220,0	221,8	214,2	25,8	197,2	4,7	201,0	183,1	166,1	116,4
8	Cutter 2000hp LG	0045-BDP-BBS-NDS	302,3	285,3	287,1	279,5	160,7	262,5	70,0	266,3	248,4	231,4	181,7
8	Cutter 2000hp LG	0045-BDP-BBS-NDS-STG	302,3	285,3	287,1	279,5	160,7	262,5	70,0	266,3	248,4	231,4	181,7
8	Cutter 2000hp LG	0045-BDP-BDS-HBS	222,0	205,1	206,8	199,2	34,2	182,3	-10,2	186,1	168,1	151,2	101,5
8	Cutter 2000hp LG	0045-BDP-BDS-NDS	200,2	183,3	185,0	177,4	12,4	160,5	-32,0	164,3	146,3	129,4	79,7
8	Cutter 2000hp LG	0045-BDP-BDS-NDS	200,2	183,3	185,0	177,4	12,4	160,5	-32,0	164,3	146,3	129,4	79,7
8	Cutter 2000hp LG	0045-BDP-BDS-NDS-STG	200,2	183,3	185,0	177,4	12,4	160,5	-32,0	164,3	146,3	129,4	79,7
8	Cutter 2000hp LG	4545-BDP-BBS-NDS	221,5	204,5	206,3	198,7	103,2	181,7	-10,8	185,5	167,6	150,6	100,9
8	Cutter 2000hp LG	4545-BDP-BBS-NDS-STG	221,5	204,5	206,3	198,7	103,2	181,7	-10,8	185,5	167,6	150,6	100,9
8	Cutter 2000hp LG	4545-BDP-BDS	173,9	156,9	158,7	151,1	9,4	134,1	-58,4	137,9	120,0	103,0	53,3
8	Cutter 2000hp LG	4545-BDP-BDS-HBP-HBS-STG	124,9	107,9	109,7	102,0	-39,6	85,1	-107,4	88,9	71,0	54,0	4,3
8	Cutter 2000hp LG	4545-BDP-BDS-HBS	149,4	132,4	134,2	126,6	-15,1	109,6	-82,9	113,4	95,5	78,5	28,8
8	Cutter 2000hp LG	4545-BDP-BDS-HCP-HCS	155,5	138,6	140,3	132,7	-9,0	115,8	-76,7	119,6	101,6	84,7	34,9
8	Cutter 2000hp LG	4545-BDP-BDS-HCP-HCS-STG	155,5	138,6	140,3	132,7	-9,0	115,8	-76,7	119,6	101,6	84,7	34,9
8	Cutter 2000hp LG	4545-BDP-BDS-HCS	164,7	147,8	149,5	141,9	0,2	124,9	-67,6	128,7	110,8	93,9	44,1
8	Cutter 2000hp LG	4545-BDP-BDS-NDS	123,4	106,4	108,2	100,6	-41,1	83,6	-108,9	87,4	69,5	52,5	2,8
8	Cutter 2000hp LG	4545-BDP-BDS-NDS-STG	123,4	106,4	108,2	100,6	-41,1	83,6	-108,9	87,4	69,5	52,5	2,8
8	Cutter 2000hp LG	8045-BDP-BDS	102,0	85,0	86,8	79,2	-19,9	62,2	-130,3	66,0	48,1	31,1	-18,6
8	Cutter 2000hp LG	8045-BDP-BDS-HBP-NDS-STG	27,0	10,0	11,7	4,1	-94,9	-12,8	-205,3	-9,0	-26,9	-43,9	-93,6
8	Cutter 2000hp LG	8045-BDP-BDS-HCP-HCS	83,6	66,6	68,4	60,8	-38,3	43,8	-148,7	47,6	29,7	12,7	-37,0
8	Cutter 2000hp LG	8045-BDP-BDS-HCP-HCS-STG	83,6	66,6	68,4	60,8	-38,3	43,8	-148,7	47,6	29,7	12,7	-37,0
8	Cutter 2000hp LG	8045-BDP-BDS-NDS	51,5	34,5	36,3	28,7	-70,4	11,7	-180,8	15,5	-2,4	-19,4	-69,1
8	Cutter 2000hp LG	8045-BDS-STG	155,2	138,3	140,0	132,4	33,3	115,5	-77,0	119,3	101,3	84,4	34,7
8	Cutter 2000hp LG	8080-BDP-BDS	140,6	123,7	125,4	117,8	61,3	100,9	-91,6	104,7	86,7	69,8	20,1
8	Cutter 2000hp LG	8080-STG	246,7	229,8	231,5	223,9	167,4	207,0	14,5	210,8	192,8	175,9	126,1
9	Cutter 44m 2975hp	8080	316,9	297,5	289,3	275,5	176,4	256,1	11,0	251,7	219,1	199,6	109,3
9	Cutter 44m 2975hp	0000-BDP-BDS	348,9	329,5	321,3	307,5	-19,3	288,1	43,0	283,7	251,1	231,6	141,3
9	Cutter 44m 2975hp	0000-BDP-BDS-NDS	299,2	279,8	271,6	257,8	-69,0	238,4	-6,7	234,0	201,4	181,9	91,6
9	Cutter 44m 2975hp	0045-BDP-BBS-NDS	429,6	410,1	402,0	388,2	182,1	368,7	123,7	364,4	331,8	312,3	222,0
9	Cutter 44m 2975hp	0045-BDP-BBS-NDS-STG	429,6	410,1	402,0	388,2	182,1	368,7	123,7	364,4	331,8	312,3	222,0
9	Cutter 44m 2975hp	0045-BDP-BDS-HBS	304,0	284,5	276,4	262,6	-23,9	243,1	-2,0	238,7	206,1	186,6	96,3
9	Cutter 44m 2975hp	0045-BDP-BDS-NDS	276,0	256,5	248,4	234,6	-51,8	215,2	-29,9	210,8	178,2	158,7	68,4
9	Cutter 44m 2975hp	0045-BDP-BDS-NDS	276,0	256,5	248,4	234,6	-51,8	215,2	-29,9	210,8	178,2	158,7	68,4
9	Cutter 44m 2975hp	0045-BDP-BDS-NDS-STG	276,0	256,5	248,4	234,6	-51,8	215,2	-29,9	210,8	178,2	158,7	68,4
9	Cutter 44m 2975hp	4545-BDP-BBS-NDS	314,9	295,5	287,3	273,5	107,7	254,1	9,0	249,7	217,1	197,6	107,3
9	Cutter 44m 2975hp	4545-BDP-BBS-NDS-STG	314,9	295,5	287,3	273,5	107,7	254,1	9,0	249,7	217,1	197,6	107,3
9	Cutter 44m 2975hp	4545-BDP-BDS	215,4	195,9	187,8	174,0	-72,1	154,5	-90,5	150,2	117,6	98,1	7,8
9	Cutter 44m 2975hp	4545-BDP-BDS-HBP-HBS-STG	163,2	143,7	135,6	121,8	-124,3	102,3	-142,7	98,0	65,3	45,9	-44,4
9	Cutter 44m 2975hp	4545-BDP-BDS-HBS	189,3	169,8	161,7	147,9	-98,2	128,4	-116,6	124,1	91,5	72,0	-18,3
9	Cutter 44m 2975hp	4545-BDP-BDS-HCP-HCS	195,8	176,3	168,2	154,4	-91,7	134,9	-110,1	130,6	98,0	78,5	-11,8
9	Cutter 44m 2975hp	4545-BDP-BDS-HCP-HCS-STG	195,8	176,3	168,2	154,4	-91,7	134,9	-110,1	130,6	98,0	78,5	-11,8
9	Cutter 44m 2975hp	4545-BDP-BDS-HCS	205,6	186,1	178,0	164,2	-81,9	144,7	-100,3	140,4	107,8	88,3	-2,0
9	Cutter 44m 2975hp	4545-BDP-BDS-NDS	161,4	141,9	133,8	120,0	-126,1	100,5	-144,6	96,1	63,5	44,0	-46,3
9	Cutter 44m 2975hp	4545-BDP-BDS-NDS-STG	161,4	141,9	133,8	120,0	-126,1	100,5	-144,6	96,1	63,5	44,0	-46,3
9	Cutter 44m 2975hp	8045-BDP-BDS	101,9	82,4	74,3	60,5	-112,1	41,1	-204,0	36,7	4,1	-15,4	-105,7
9	Cutter 44m 2975hp	8045-BDP-BDS-HBP-NDS-STG	21,8	2,3	-5,8	-19,6	-192,2	-39,1	-284,1	-43,4	-76,1	-95,5	-185,8
9	Cutter 44m 2975hp	8045-BDP-BDS-HCP-HCS	82,3	62,9	54,7	40,9	-131,7	21,5	-223,6	17,1	-15,5	-35,0	-125,3
9	Cutter 44m 2975hp	8045-BDP-BDS-HCP-HCS-STG	82,3	62,9	54,7	40,9	-131,7	21,5	-223,6	17,1	-15,5	-35,0	-125,3
9	Cutter 44m 2975hp	8045-BDP-BDS-NDS	47,9	28,4	20,3	6,5	-166,1	-13,0	-258,0	-17,3	-50,0	-69,4	-159,7
9	Cutter 44m 2975hp	8045-BDS-STG	167,7	148,2	140,1	126,3	-46,4	106,8	-138,2	102,4	69,8	50,4	-40,0
9	Cutter 44m 2975hp	8080-BDP-BDS	162,9	143,5	135,4	121,6	22,4	102,1	-143,0	97,7	65,1	45,6	-44,7
9	Cutter 44m 2975hp	8080-STG	316,9	297,5	289,3	275,5	176,4	256,1	11,0	251,7	219,1	199,6	109,3

Appendix XXIII. Score card for remaining righting moments compared to the regulations

Vessel nr.	Type of vessel	Vessel and Operational Condition	RNoExternal	RWd	RW6	RW6Gu	RW6GuGs	RW6Gu Wd	RW6Wl	RW8	RW8Gu	RW8Gu Wd	RW10Gu Wd
1	EuroCutter 20m	1-8080	105%	91%	95%	91%	70%	77%	22%	82%	71%	57%	25%
1	EuroCutter 20m	1-8080-STG	102%	88%	92%	87%	67%	73%	19%	79%	67%	54%	22%
1	EuroCutter 20m	1-8080-BDP-BDS	58%	44%	48%	43%	22%	29%	0%	35%	23%	9%	0%
1	EuroCutter 20m	1-8045-BDP-BDS	33%	19%	23%	18%	0%	4%	0%	10%	0%	0%	0%
1	EuroCutter 20m	1-4545-BDP-BDS	73%	60%	64%	59%	0%	45%	0%	50%	39%	25%	0%
1	EuroCutter 20m	1-0000-BDP-BDS	114%	100%	104%	99%	0%	85%	31%	91%	79%	65%	34%
1	EuroCutter 20m	1-0000-BDP-BDS-NDS	58%	45%	49%	44%	0%	30%	0%	36%	24%	11%	0%
1	EuroCutter 20m	1-0045-BDP-BDS-NDS	54%	41%	45%	40%	0%	26%	0%	32%	20%	7%	0%
1	EuroCutter 20m	1-0045-BDP-BDS-HBS	90%	77%	81%	76%	0%	62%	9%	68%	56%	43%	11%
1	EuroCutter 20m	1-0045-BDP-BDS-NDS	54%	41%	45%	40%	0%	26%	0%	32%	20%	7%	0%
1	EuroCutter 20m	1-0045-BDP-BBS-NDS	124%	110%	114%	109%	46%	96%	42%	101%	90%	76%	44%
1	EuroCutter 20m	1-0045-BDP-BDS-NDS-STG	51%	38%	42%	37%	0%	23%	0%	29%	17%	4%	0%
1	EuroCutter 20m	1-0045-BDP-BBS-NDS-STG	120%	106%	110%	106%	43%	92%	39%	97%	86%	73%	42%
1	EuroCutter 20m	1-4545-BDP-BDS-NDS	17%	3%	7%	2%	0%	0%	0%	0%	0%	0%	0%
1	EuroCutter 20m	1-4545-BDP-BDS-HBS	53%	39%	43%	38%	0%	25%	0%	30%	19%	5%	0%
1	EuroCutter 20m	1-4545-BDP-BDS-NDS	17%	3%	7%	2%	0%	0%	0%	0%	0%	0%	0%
1	EuroCutter 20m	1-4545-BDP-BBS-NDS	86%	72%	76%	72%	23%	58%	4%	63%	52%	38%	7%
1	EuroCutter 20m	1-4545-BDP-BDS-NDS-STG	14%	0%	4%	0%	0%	0%	0%	0%	0%	0%	0%
1	EuroCutter 20m	1-4545-BDP-BBS-NDS-STG	83%	69%	73%	68%	20%	55%	1%	60%	49%	35%	4%
1	EuroCutter 20m	1-4545-BDP-BDS-HCS	69%	56%	60%	55%	0%	41%	0%	47%	35%	21%	0%
1	EuroCutter 20m	1-4545-BDP-BDS-HCP-HCS	66%	52%	56%	51%	0%	37%	0%	43%	31%	18%	0%
1	EuroCutter 20m	1-4545-BDP-BDS-HCP-HCS-STG	62%	49%	53%	48%	0%	34%	0%	40%	28%	15%	0%
1	EuroCutter 20m	1-4545-BDP-BDS-HBP-HBS-STG	31%	18%	22%	17%	0%	4%	0%	9%	0%	0%	0%
1	EuroCutter 20m	1-8045-BDS-STG	55%	41%	45%	41%	0%	27%	0%	32%	21%	7%	0%
1	EuroCutter 20m	1-8045-BDP-BDS-NDS	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
1	EuroCutter 20m	1-8045-BDP-BDS-HCP-HCS	25%	12%	16%	11%	0%	0%	0%	2%	0%	0%	0%
1	EuroCutter 20m	1-8045-BDP-BDS-HCP-HCS-STG	22%	9%	13%	8%	0%	0%	0%	0%	0%	0%	0%
1	EuroCutter 20m	1-8045-BDP-BDS-HBP-NDS-STG	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2	EuroCutter 20m HG	2-8080	105%	91%	95%	90%	60%	76%	22%	82%	70%	56%	25%
2	EuroCutter 20m HG	2-8080-STG	101%	87%	91%	87%	57%	73%	19%	78%	67%	53%	22%
2	EuroCutter 20m HG	2-8080-BDP-BDS	36%	22%	27%	22%	0%	8%	0%	13%	2%	0%	0%
2	EuroCutter 20m HG	2-8045-BDP-BDS	4%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2	EuroCutter 20m HG	2-4545-BDP-BDS	57%	43%	47%	42%	0%	29%	0%	34%	23%	9%	0%
2	EuroCutter 20m HG	2-0000-BDP-BDS	110%	96%	100%	95%	0%	81%	27%	87%	75%	62%	30%
2	EuroCutter 20m HG	2-0000-BDP-BDS-NDS	55%	41%	45%	40%	0%	27%	0%	32%	21%	7%	0%
2	EuroCutter 20m HG	2-0045-BDP-BDS-NDS	50%	36%	40%	36%	0%	22%	0%	27%	16%	2%	0%
2	EuroCutter 20m HG	2-0045-BDP-BDS-HBS	86%	72%	76%	71%	0%	58%	4%	63%	52%	38%	7%
2	EuroCutter 20m HG	2-0045-BDP-BDS-NDS	50%	36%	40%	36%	0%	22%	0%	27%	16%	2%	0%
2	EuroCutter 20m HG	2-0045-BDP-BBS-NDS	133%	120%	124%	119%	29%	105%	51%	111%	99%	86%	55%
2	EuroCutter 20m HG	2-0045-BDP-BDS-NDS-STG	47%	34%	37%	33%	0%	19%	0%	25%	13%	0%	0%
2	EuroCutter 20m HG	2-0045-BDP-BBS-NDS-STG	130%	116%	120%	115%	26%	102%	48%	107%	96%	83%	52%
2	EuroCutter 20m HG	2-4545-BDP-BDS-NDS	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2	EuroCutter 20m HG	2-4545-BDP-BDS-HBS	37%	23%	27%	22%	0%	9%	0%	14%	3%	0%	0%
2	EuroCutter 20m HG	2-4545-BDP-BDS-NDS	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2	EuroCutter 20m HG	2-4545-BDP-BBS-NDS	84%	71%	75%	70%	0%	56%	2%	62%	50%	37%	5%
2	EuroCutter 20m HG	2-4545-BDP-BDS-NDS-STG	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2	EuroCutter 20m HG	2-4545-BDP-BBS-NDS-STG	81%	67%	71%	67%	0%	53%	0%	58%	47%	34%	3%
2	EuroCutter 20m HG	2-4545-BDP-BDS-HCS	53%	39%	43%	39%	0%	25%	0%	30%	19%	5%	0%
2	EuroCutter 20m HG	2-4545-BDP-BDS-HCP-HCS	49%	36%	40%	35%	0%	21%	0%	26%	15%	1%	0%
2	EuroCutter 20m HG	2-4545-BDP-BDS-HCP-HCS-STG	46%	33%	37%	32%	0%	18%	0%	24%	12%	0%	0%
2	EuroCutter 20m HG	2-4545-BDP-BDS-HBP-HBS-STG	18%	5%	9%	4%	0%	0%	0%	0%	0%	0%	0%
2	EuroCutter 20m HG	2-8045-BDS-STG	37%	24%	28%	23%	0%	9%	0%	15%	3%	0%	0%
2	EuroCutter 20m HG	2-8045-BDP-BDS-NDS	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2	EuroCutter 20m HG	2-8045-BDP-BDS-HCP-HCS	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2	EuroCutter 20m HG	2-8045-BDP-BDS-HCP-HCS-STG	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
2	EuroCutter 20m HG	2-8045-BDP-BDS-HBP-NDS-STG	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3	EuroCutter 20m DE	3-8080	105%	91%	95%	90%	65%	77%	22%	82%	70%	57%	25%
3	EuroCutter 20m DE	3-8080-STG	101%	88%	92%	87%	61%	73%	19%	79%	67%	54%	22%
3	EuroCutter 20m DE	3-8080-BDP-BDS	46%	32%	36%	31%	5%	17%	0%	23%	11%	0%	0%
3	EuroCutter 20m DE	3-8045-BDP-BDS	15%	1%	5%	0%	0%	0%	0%	0%	0%	0%	0%
3	EuroCutter 20m DE	3-4545-BDP-BDS	65%	51%	56%	51%	0%	37%	0%	42%	31%	17%	0%
3	EuroCutter 20m DE	3-0000-BDP-BDS	115%	101%	105%	101%	0%	87%	32%	92%	81%	67%	35%
3	EuroCutter 20m DE	3-0000-BDP-BDS-NDS	55%	42%	46%	41%	0%	27%	0%	33%	21%	8%	0%
3	EuroCutter 20m DE	3-0045-BDP-BDS-NDS	50%	36%	40%	36%	0%	22%	0%	27%	16%	2%	0%
3	EuroCutter 20m DE	3-0045-BDP-BDS-HBS	91%	77%	81%	76%	0%	63%	9%	68%	57%	43%	12%
3	EuroCutter 20m DE	3-0045-BDP-BDS-NDS	50%	36%	40%	36%	0%	22%	0%	27%	16%	2%	0%
3	EuroCutter 20m DE	3-0045-BDP-BBS-NDS	135%	121%	125%	120%	42%	107%	53%	112%	101%	87%	56%
3	EuroCutter 20m DE	3-0045-BDP-BDS-NDS-STG	47%	34%	38%	33%	0%	19%	0%	25%	13%	0%	0%
3	EuroCutter 20m DE	3-0045-BDP-BBS-NDS-STG	131%	117%	121%	117%	39%	103%	50%	108%	97%	84%	53%
3	EuroCutter 20m DE	3-4545-BDP-BDS-NDS	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3	EuroCutter 20m DE	3-4545-BDP-BDS-HBS	44%	31%	35%	30%	0%	16%	0%	22%	10%	0%	0%
3	EuroCutter 20m DE	3-4545-BDP-BDS-NDS	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3	EuroCutter 20m DE	3-4545-BDP-BBS-NDS	88%	75%	79%	74%	13%	60%	6%	65%	54%	41%	9%
3	EuroCutter 20m DE	3-4545-BDP-BDS-NDS-STG	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3	EuroCutter 20m DE	3-4545-BDP-BBS-NDS-STG	85%	71%	75%	71%	11%	57%	4%	62%	51%	38%	6%
3	EuroCutter 20m DE	3-4545-BDP-BDS-HCS	61%	47%	51%	46%	0%	32%	0%	38%	26%	13%	0%
3	EuroCutter 20m DE	3-4545-BDP-BDS-HCP-HCS	56%	43%	47%	42%	0%	28%	0%	33%	22%	8%	0%
3	EuroCutter 20m DE	3-4545-BDP-BDS-HCP-HCS-STG	53%	40%	44%	39%	0%	25%	0%	31%	19%	6%	0%
3	EuroCutter 20m DE	3-4545-BDP-BDS-HBP-HBS-STG	24%	10%	14%	10%	0%	0%	0%	2%	0%	0%	0%
3	EuroCutter 20m DE	3-8045-BDS-STG	43%	29%	33%	28%	0%	14%	0%	20%	8%	0%	0%
3	EuroCutter 20m DE	3-8045-BDP-BDS-NDS	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3	EuroCutter 20m DE	3-8045-BDP-BDS-HCP-HCS	6%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3	EuroCutter 20m DE	3-8045-BDP-BDS-HCP-HCS-STG	4%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
3	EuroCutter 20m DE	3-8045-BDP-BDS-HBP-NDS-STG	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

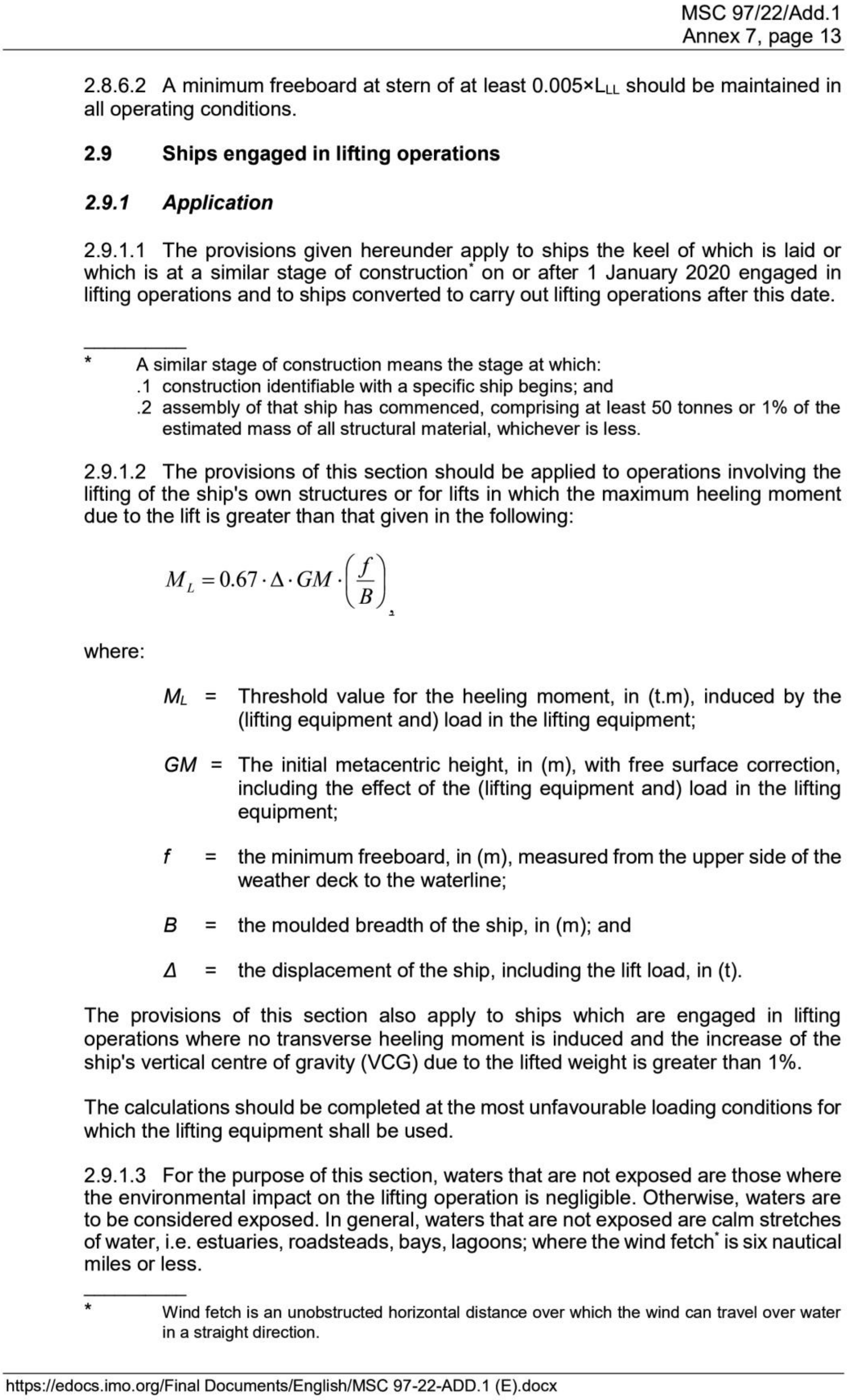
Vessel nr.	Type of vessel	Vessel and Operational Condition	RNoExternal	RWd	RW6	RW6Gu	RW6GuGs	RW6Gu Wd	RW6Wl	RW8	RW8Gu	RW8Gu Wd	RW10Gu Wd
4	EuroCutter 24m v1	4-8080	110%	98%	102%	98%	76%	86%	31%	91%	82%	70%	44%
4	EuroCutter 24m v1	4-8080-STG	104%	93%	96%	92%	70%	81%	26%	86%	76%	65%	39%
4	EuroCutter 24m v1	4-8080-BDP-BDS	77%	65%	69%	65%	43%	53%	0%	58%	49%	37%	11%
4	EuroCutter 24m v1	4-8045-BDP-BDS	52%	40%	44%	40%	0%	28%	0%	33%	24%	12%	0%
4	EuroCutter 24m v1	4-4545-BDP-BDS	88%	77%	80%	76%	16%	65%	9%	70%	60%	49%	23%
4	EuroCutter 24m v1	4-0000-BDP-BDS	124%	112%	116%	112%	30%	100%	44%	105%	95%	84%	58%
4	EuroCutter 24m v1	4-0000-BDP-BDS-NDS	88%	76%	80%	76%	0%	64%	9%	69%	60%	48%	22%
4	EuroCutter 24m v1	4-0045-BDP-BDS-NDS	85%	73%	77%	73%	3%	62%	7%	66%	57%	46%	20%
4	EuroCutter 24m v1	4-0045-BDP-BDS-HBS	109%	97%	101%	97%	27%	86%	31%	90%	81%	70%	44%
4	EuroCutter 24m v1	4-0045-BDP-BDS-NDS	85%	73%	77%	73%	3%	62%	7%	66%	57%	46%	20%
4	EuroCutter 24m v1	4-0045-BDP-BBS-NDS	133%	121%	125%	121%	68%	109%	54%	114%	105%	93%	68%
4	EuroCutter 24m v1	4-0045-BDP-BDS-NDS-STG	81%	69%	73%	69%	0%	58%	4%	63%	53%	42%	17%
4	EuroCutter 24m v1	4-0045-BDP-BBS-NDS-STG	127%	116%	119%	115%	63%	104%	50%	109%	99%	88%	63%
4	EuroCutter 24m v1	4-4545-BDP-BDS-NDS	54%	42%	46%	42%	0%	30%	0%	35%	26%	14%	0%
4	EuroCutter 24m v1	4-4545-BDP-BDS-HBS	78%	66%	70%	66%	6%	54%	0%	59%	50%	38%	13%
4	EuroCutter 24m v1	4-4545-BDP-BDS-NDS	54%	42%	46%	42%	0%	30%	0%	35%	26%	14%	0%
4	EuroCutter 24m v1	4-4545-BDP-BBS-NDS	99%	88%	92%	88%	45%	76%	21%	81%	72%	60%	34%
4	EuroCutter 24m v1	4-4545-BDP-BDS-NDS-STG	50%	38%	42%	38%	0%	27%	0%	32%	22%	11%	0%
4	EuroCutter 24m v1	4-4545-BDP-BBS-NDS-STG	95%	84%	87%	83%	42%	72%	18%	77%	68%	56%	31%
4	EuroCutter 24m v1	4-4545-BDP-BDS-HCS	86%	74%	78%	74%	14%	62%	7%	67%	58%	46%	20%
4	EuroCutter 24m v1	4-4545-BDP-BDS-HCP-HCS	83%	72%	75%	72%	11%	60%	5%	65%	55%	44%	18%
4	EuroCutter 24m v1	4-4545-BDP-BDS-HCP-HCS-STG	79%	68%	71%	68%	8%	56%	2%	61%	52%	40%	15%
4	EuroCutter 24m v1	4-4545-BDP-BDS-HBP-HBS-STG	63%	52%	56%	52%	0%	40%	0%	45%	36%	25%	0%
4	EuroCutter 24m v1	4-8045-BDS-STG	63%	52%	55%	51%	11%	40%	0%	45%	35%	24%	0%
4	EuroCutter 24m v1	4-8045-BDP-BDS-NDS	17%	6%	9%	5%	0%	0%	0%	0%	0%	0%	0%
4	EuroCutter 24m v1	4-8045-BDP-BDS-HCP-HCS	47%	35%	39%	35%	0%	24%	0%	28%	19%	7%	0%
4	EuroCutter 24m v1	4-8045-BDP-BDS-HCP-HCS-STG	43%	32%	36%	32%	0%	20%	0%	25%	16%	4%	0%
4	EuroCutter 24m v1	4-8045-BDP-BDS-HBP-NDS-STG	4%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
5	EuroCutter 24m v2	5-8080	110%	100%	102%	98%	71%	88%	26%	91%	81%	71%	45%
5	EuroCutter 24m v2	5-8080-STG	92%	83%	84%	80%	54%	71%	10%	74%	64%	55%	29%
5	EuroCutter 24m v2	5-8080-BDP-BDS	72%	63%	64%	60%	34%	51%	0%	53%	44%	34%	8%
5	EuroCutter 24m v2	5-8045-BDP-BDS	54%	44%	46%	42%	0%	32%	0%	35%	26%	16%	0%
5	EuroCutter 24m v2	5-4545-BDP-BDS	84%	74%	76%	72%	11%	62%	0%	65%	56%	46%	19%
5	EuroCutter 24m v2	5-0000-BDP-BDS	119%	109%	111%	107%	27%	97%	35%	100%	90%	81%	54%
5	EuroCutter 24m v2	5-0000-BDP-BDS-NDS	92%	83%	84%	80%	1%	71%	9%	74%	64%	54%	28%
5	EuroCutter 24m v2	5-0045-BDP-BDS-NDS	85%	76%	77%	73%	3%	64%	2%	66%	57%	47%	21%
5	EuroCutter 24m v2	5-0045-BDP-BDS-HBS	100%	90%	92%	88%	18%	78%	17%	81%	72%	62%	36%
5	EuroCutter 24m v2	5-0045-BDP-BDS-NDS	85%	76%	77%	73%	3%	64%	2%	66%	57%	47%	21%
5	EuroCutter 24m v2	5-0045-BDP-BBS-NDS	131%	121%	123%	119%	67%	109%	47%	112%	103%	93%	66%
5	EuroCutter 24m v2	5-0045-BDP-BDS-NDS-STG	70%	61%	62%	58%	0%	49%	0%	52%	42%	33%	7%
5	EuroCutter 24m v2	5-0045-BDP-BBS-NDS-STG	113%	104%	105%	102%	51%	92%	31%	95%	85%	76%	50%
5	EuroCutter 24m v2	5-4545-BDP-BDS-NDS	57%	47%	49%	45%	0%	35%	0%	38%	28%	18%	0%
5	EuroCutter 24m v2	5-4545-BDP-BDS-HBS	72%	62%	64%	60%	0%	50%	0%	53%	44%	34%	8%
5	EuroCutter 24m v2	5-4545-BDP-BDS-NDS	57%	47%	49%	45%	0%	35%	0%	38%	28%	18%	0%
5	EuroCutter 24m v2	5-4545-BDP-BBS-NDS	101%	91%	93%	89%	47%	79%	17%	82%	73%	63%	36%
5	EuroCutter 24m v2	5-4545-BDP-BDS-NDS-STG	43%	33%	35%	31%	0%	22%	0%	24%	15%	6%	0%
5	EuroCutter 24m v2	5-4545-BDP-BBS-NDS-STG	86%	76%	78%	74%	33%	65%	4%	67%	58%	49%	23%
5	EuroCutter 24m v2	5-4545-BDP-BDS-HCS	80%	70%	72%	68%	7%	58%	0%	61%	52%	42%	16%
5	EuroCutter 24m v2	5-4545-BDP-BDS-HCP-HCS	76%	67%	68%	64%	3%	55%	0%	57%	48%	38%	12%
5	EuroCutter 24m v2	5-4545-BDP-BDS-HCP-HCS-STG	62%	53%	54%	51%	0%	41%	0%	44%	34%	25%	0%
5	EuroCutter 24m v2	5-4545-BDP-BDS-HBP-HBS-STG	49%	39%	41%	37%	0%	28%	0%	30%	21%	12%	0%
5	EuroCutter 24m v2	5-8045-BDS-STG	54%	45%	47%	43%	0%	33%	0%	36%	26%	17%	0%
5	EuroCutter 24m v2	5-8045-BDP-BDS-NDS	27%	17%	19%	15%	0%	5%	0%	8%	0%	0%	0%
5	EuroCutter 24m v2	5-8045-BDP-BDS-HCP-HCS	47%	37%	39%	35%	0%	25%	0%	28%	18%	8%	0%
5	EuroCutter 24m v2	5-8045-BDP-BDS-HCP-HCS-STG	33%	24%	25%	21%	0%	12%	0%	15%	5%	0%	0%
5	EuroCutter 24m v2	5-8045-BDP-BDS-HBP-NDS-STG	4%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
6	Cutter 35m	6-8080	126%	116%	118%	113%	80%	103%	7%	106%	95%	85%	56%
6	Cutter 35m	6-8080-STG	126%	116%	118%	113%	80%	103%	7%	106%	95%	85%	56%
6	Cutter 35m	6-8080-BDP-BDS	73%	63%	65%	60%	27%	50%	0%	53%	42%	32%	3%
6	Cutter 35m	6-8045-BDP-BDS	54%	43%	45%	40%	0%	30%	0%	33%	22%	12%	0%
6	Cutter 35m	6-4545-BDP-BDS	91%	80%	82%	77%	0%	67%	0%	70%	59%	49%	20%
6	Cutter 35m	6-0000-BDP-BDS	137%	127%	128%	124%	16%	114%	18%	116%	106%	96%	67%
6	Cutter 35m	6-0000-BDP-BDS-NDS	107%	97%	98%	94%	0%	84%	0%	86%	76%	66%	37%
6	Cutter 35m	6-0045-BDP-BDS-NDS	93%	83%	84%	80%	0%	70%	0%	72%	62%	52%	23%
6	Cutter 35m	6-0045-BDP-BDS-HBS	107%	96%	98%	94%	0%	83%	0%	86%	76%	66%	37%
6	Cutter 35m	6-0045-BDP-BDS-NDS	93%	83%	84%	80%	0%	70%	0%	72%	62%	52%	23%
6	Cutter 35m	6-0045-BDP-BBS-NDS	152%	141%	143%	139%	70%	128%	33%	131%	121%	110%	82%
6	Cutter 35m	6-0045-BDP-BDS-NDS-STG	93%	83%	84%	80%	0%	70%	0%	72%	62%	52%	23%
6	Cutter 35m	6-0045-BDP-BBS-NDS-STG	152%	141%	143%	139%	70%	128%	33%	131%	121%	110%	82%
6	Cutter 35m	6-4545-BDP-BDS-NDS	56%	46%	47%	43%	0%	33%	0%	35%	25%	15%	0%
6	Cutter 35m	6-4545-BDP-BDS-HBS	70%	59%	61%	57%	0%	46%	0%	49%	39%	29%	0%
6	Cutter 35m	6-4545-BDP-BDS-NDS	56%	46%	47%	43%	0%	33%	0%	35%	25%	15%	0%
6	Cutter 35m	6-4545-BDP-BBS-NDS	114%	104%	106%	101%	46%	91%	0%	94%	83%	73%	45%
6	Cutter 35m	6-4545-BDP-BDS-NDS-STG	56%	46%	47%	43%	0%	33%	0%	35%	25%	15%	0%
6	Cutter 35m	6-4545-BDP-BBS-NDS-STG	114%	104%	106%	101%	46%	91%	0%	94%	83%	73%	45%
6	Cutter 35m	6-4545-BDP-BDS-HCS	80%	70%	71%	67%	0%	57%	0%	59%	49%	39%	10%
6	Cutter 35m	6-4545-BDP-BDS-HCP-HCS	70%	60%	61%	57%	0%	47%	0%	49%	39%	29%	0%
6	Cutter 35m	6-4545-BDP-BDS-HCP-HCS-STG	70%	60%	61%	57%	0%	47%	0%	49%	39%	29%	0%
6	Cutter 35m	6-4545-BDP-BDS-HBP-HBS-STG	50%	40%	42%	38%	0%	27%	0%	30%	20%	10%	0%
6	Cutter 35m	6-8045-BDS-STG	75%	65%	67%	62%	5%	52%	0%	55%	44%	34%	5%
6	Cutter 35m	6-8045-BDP-BDS-NDS	19%	9%	10%	6%	0%	0%	0%	0%	0%	0%	0%
6	Cutter 35m	6-8045-BDP-BDS-HCP-HCS	33%	23%	25%	20%	0%	10%	0%	13%	2%	0%	0%
6	Cutter 35m	6-8045-BDP-BDS-HCP-HCS-STG	33%	23%	25%	20%	0%	10%	0%	13%	2%	0%	0%
6	Cutter 35m	6-8045-BDP-BDS-HBP-NDS-STG	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%



Vessel nr.	Type of vessel	Vessel and Operational Condition	RNoExternal	RWd	RW6	RW6Gu	RW6GuGs	RW6Gu Wd	RW6Wl	RW8	RW8Gu	RW8Gu Wd	RW10Gu Wd
7	Cutter 2000hp	7-8080	141%	131%	132%	128%	81%	118%	6%	120%	110%	100%	71%
7	Cutter 2000hp	7-8080-STG	141%	131%	132%	128%	81%	118%	6%	120%	110%	100%	71%
7	Cutter 2000hp	7-8080-BDP-BDS	58%	48%	49%	45%	0%	35%	0%	37%	27%	17%	0%
7	Cutter 2000hp	7-8045-BDP-BDS	29%	20%	21%	16%	0%	7%	0%	9%	0%	0%	0%
7	Cutter 2000hp	7-4545-BDP-BDS	83%	73%	74%	69%	0%	60%	0%	62%	51%	42%	13%
7	Cutter 2000hp	7-0000-BDP-BDS	156%	147%	148%	143%	0%	134%	22%	136%	125%	116%	87%
7	Cutter 2000hp	7-0000-BDP-BDS-NDS	131%	121%	122%	118%	0%	108%	0%	110%	100%	90%	61%
7	Cutter 2000hp	7-0045-BDP-BDS-NDS	107%	97%	98%	93%	0%	84%	0%	86%	76%	66%	37%
7	Cutter 2000hp	7-0045-BDP-BDS-HBS	121%	112%	113%	108%	0%	98%	0%	101%	90%	81%	52%
7	Cutter 2000hp	7-0045-BDP-BDS-NDS	107%	97%	98%	93%	0%	84%	0%	86%	76%	66%	37%
7	Cutter 2000hp	7-0045-BDP-BBS-NDS	180%	170%	171%	167%	70%	157%	46%	160%	149%	139%	111%
7	Cutter 2000hp	7-0045-BDP-BDS-NDS-STG	107%	97%	98%	93%	0%	84%	0%	86%	76%	66%	37%
7	Cutter 2000hp	7-0045-BDP-BBS-NDS-STG	180%	170%	171%	167%	70%	157%	46%	160%	149%	139%	111%
7	Cutter 2000hp	7-4545-BDP-BDS-NDS	53%	43%	44%	40%	0%	30%	0%	32%	22%	12%	0%
7	Cutter 2000hp	7-4545-BDP-BDS-HBS	68%	58%	59%	55%	0%	45%	0%	47%	37%	27%	0%
7	Cutter 2000hp	7-4545-BDP-BDS-NDS	53%	43%	44%	40%	0%	30%	0%	32%	22%	12%	0%
7	Cutter 2000hp	7-4545-BDP-BBS-NDS	125%	116%	117%	112%	34%	102%	0%	105%	94%	85%	56%
7	Cutter 2000hp	7-4545-BDP-BDS-NDS-STG	53%	43%	44%	40%	0%	30%	0%	32%	22%	12%	0%
7	Cutter 2000hp	7-4545-BDP-BBS-NDS-STG	125%	116%	117%	112%	34%	102%	0%	105%	94%	85%	56%
7	Cutter 2000hp	7-4545-BDP-BDS-HCS	77%	67%	68%	64%	0%	54%	0%	56%	46%	36%	8%
7	Cutter 2000hp	7-4545-BDP-BDS-HCP-HCS	72%	62%	63%	58%	0%	49%	0%	51%	41%	31%	2%
7	Cutter 2000hp	7-4545-BDP-BDS-HCP-HCS-STG	72%	62%	63%	58%	0%	49%	0%	51%	41%	31%	2%
7	Cutter 2000hp	7-4545-BDP-BDS-HBP-HBS-STG	54%	44%	45%	41%	0%	31%	0%	33%	23%	13%	0%
7	Cutter 2000hp	7-8045-BDS-STG	68%	58%	59%	55%	0%	45%	0%	47%	37%	27%	0%
7	Cutter 2000hp	7-8045-BDP-BDS-NDS	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
7	Cutter 2000hp	7-8045-BDP-BDS-HCP-HCS	19%	9%	10%	6%	0%	0%	0%	0%	0%	0%	0%
7	Cutter 2000hp	7-8045-BDP-BDS-HCP-HCS-STG	19%	9%	10%	6%	0%	0%	0%	0%	0%	0%	0%
7	Cutter 2000hp	7-8045-BDP-BDS-HBP-NDS-STG	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
8	Cutter 2000hp LG	8-8080	143%	133%	134%	130%	97%	120%	8%	122%	112%	102%	73%
8	Cutter 2000hp LG	8-8080-STG	143%	133%	134%	130%	97%	120%	8%	122%	112%	102%	73%
8	Cutter 2000hp LG	8-8080-BDP-BDS	82%	72%	73%	68%	36%	59%	0%	61%	50%	40%	12%
8	Cutter 2000hp LG	8-8045-BDP-BDS	59%	49%	50%	46%	0%	36%	0%	38%	28%	18%	0%
8	Cutter 2000hp LG	8-4545-BDP-BDS	101%	91%	92%	88%	5%	78%	0%	80%	70%	60%	31%
8	Cutter 2000hp LG	8-0000-BDP-BDS	163%	153%	154%	149%	40%	140%	28%	142%	131%	122%	93%
8	Cutter 2000hp LG	8-0000-BDP-BDS-NDS	137%	127%	128%	124%	15%	114%	3%	116%	106%	96%	67%
8	Cutter 2000hp LG	8-0045-BDP-BDS-NDS	116%	106%	107%	102%	7%	93%	0%	95%	84%	75%	46%
8	Cutter 2000hp LG	8-0045-BDP-BDS-HBS	128%	118%	119%	115%	20%	105%	0%	107%	97%	87%	58%
8	Cutter 2000hp LG	8-0045-BDP-BDS-NDS	116%	106%	107%	102%	7%	93%	0%	95%	84%	75%	46%
8	Cutter 2000hp LG	8-0045-BDP-BBS-NDS	175%	165%	166%	161%	93%	152%	40%	154%	143%	134%	105%
8	Cutter 2000hp LG	8-0045-BDP-BDS-NDS-STG	116%	106%	107%	102%	7%	93%	0%	95%	84%	75%	46%
8	Cutter 2000hp LG	8-0045-BDP-BBS-NDS-STG	175%	165%	166%	161%	93%	152%	40%	154%	143%	134%	105%
8	Cutter 2000hp LG	8-4545-BDP-BDS-NDS	71%	61%	62%	58%	0%	48%	0%	50%	40%	30%	2%
8	Cutter 2000hp LG	8-4545-BDP-BDS-HBS	86%	76%	77%	73%	0%	63%	0%	65%	55%	45%	17%
8	Cutter 2000hp LG	8-4545-BDP-BDS-NDS	71%	61%	62%	58%	0%	48%	0%	50%	40%	30%	2%
8	Cutter 2000hp LG	8-4545-BDP-BBS-NDS	128%	118%	119%	115%	60%	105%	0%	107%	97%	87%	58%
8	Cutter 2000hp LG	8-4545-BDP-BDS-NDS-STG	71%	61%	62%	58%	0%	48%	0%	50%	40%	30%	2%
8	Cutter 2000hp LG	8-4545-BDP-BBS-NDS-STG	128%	118%	119%	115%	60%	105%	0%	107%	97%	87%	58%
8	Cutter 2000hp LG	8-4545-BDP-BDS-HCS	95%	85%	86%	82%	0%	72%	0%	74%	64%	54%	26%
8	Cutter 2000hp LG	8-4545-BDP-BDS-HCP-HCS	90%	80%	81%	77%	0%	67%	0%	69%	59%	49%	20%
8	Cutter 2000hp LG	8-4545-BDP-BDS-HCP-HCS-STG	90%	80%	81%	77%	0%	67%	0%	69%	59%	49%	20%
8	Cutter 2000hp LG	8-4545-BDP-BDS-HBP-HBS-STG	71%	62%	63%	58%	0%	49%	0%	51%	41%	31%	2%
8	Cutter 2000hp LG	8-8045-BDS-STG	90%	80%	81%	77%	19%	67%	0%	69%	59%	49%	20%
8	Cutter 2000hp LG	8-8045-BDP-BDS-NDS	30%	20%	21%	17%	0%	7%	0%	9%	0%	0%	0%
8	Cutter 2000hp LG	8-8045-BDP-BDS-HCP-HCS	48%	38%	39%	35%	0%	25%	0%	27%	17%	7%	0%
8	Cutter 2000hp LG	8-8045-BDP-BDS-HCP-HCS-STG	48%	38%	39%	35%	0%	25%	0%	27%	17%	7%	0%
8	Cutter 2000hp LG	8-8045-BDP-BDS-HBP-NDS-STG	15%	6%	7%	2%	0%	0%	0%	0%	0%	0%	0%
9	Cutter 44m 2975hp	9-8080	159%	149%	145%	138%	88%	128%	6%	126%	110%	100%	55%
9	Cutter 44m 2975hp	9-8080-STG	159%	149%	145%	138%	88%	128%	6%	126%	110%	100%	55%
9	Cutter 44m 2975hp	9-8080-BDP-BDS	82%	72%	68%	61%	11%	51%	0%	49%	33%	23%	0%
9	Cutter 44m 2975hp	9-8045-BDP-BDS	51%	41%	37%	30%	0%	21%	0%	18%	2%	0%	0%
9	Cutter 44m 2975hp	9-4545-BDP-BDS	108%	98%	94%	87%	0%	77%	0%	75%	59%	49%	4%
9	Cutter 44m 2975hp	9-0000-BDP-BDS	175%	165%	161%	154%	0%	144%	22%	142%	126%	116%	71%
9	Cutter 44m 2975hp	9-0000-BDP-BDS-NDS	149%	140%	136%	129%	0%	119%	0%	117%	101%	91%	46%
9	Cutter 44m 2975hp	9-0045-BDP-BDS-NDS	138%	128%	124%	117%	0%	107%	0%	105%	89%	79%	34%
9	Cutter 44m 2975hp	9-0045-BDP-BDS-HBS	151%	142%	138%	131%	0%	121%	0%	119%	103%	93%	48%
9	Cutter 44m 2975hp	9-0045-BDP-BDS-NDS	138%	128%	124%	117%	0%	107%	0%	105%	89%	79%	34%
9	Cutter 44m 2975hp	9-0045-BDP-BBS-NDS	214%	205%	201%	194%	91%	184%	62%	182%	166%	156%	111%
9	Cutter 44m 2975hp	9-0045-BDP-BDS-NDS-STG	138%	128%	124%	117%	0%	107%	0%	105%	89%	79%	34%
9	Cutter 44m 2975hp	9-0045-BDP-BBS-NDS-STG	214%	205%	201%	194%	91%	184%	62%	182%	166%	156%	111%
9	Cutter 44m 2975hp	9-4545-BDP-BDS-NDS	81%	71%	67%	60%	0%	50%	0%	48%	32%	22%	0%
9	Cutter 44m 2975hp	9-4545-BDP-BDS-HBS	94%	85%	81%	74%	0%	64%	0%	62%	46%	36%	0%
9	Cutter 44m 2975hp	9-4545-BDP-BDS-NDS	81%	71%	67%	60%	0%	50%	0%	48%	32%	22%	0%
9	Cutter 44m 2975hp	9-4545-BDP-BBS-NDS	157%	147%	143%	137%	54%	127%	5%	125%	108%	99%	54%
9	Cutter 44m 2975hp	9-4545-BDP-BDS-NDS-STG	81%	71%	67%	60%	0%	50%	0%	48%	32%	22%	0%
9	Cutter 44m 2975hp	9-4545-BDP-BBS-NDS-STG	157%	147%	143%	137%	54%	127%	5%	125%	108%	99%	54%
9	Cutter 44m 2975hp	9-4545-BDP-BDS-HCS	103%	93%	89%	82%	0%	72%	0%	70%	54%	44%	0%
9	Cutter 44m 2975hp	9-4545-BDP-BDS-HCP-HCS	98%	88%	84%	77%	0%	67%	0%	65%	49%	39%	0%
9	Cutter 44m 2975hp	9-4545-BDP-BDS-HCP-HCS-STG	98%	88%	84%	77%	0%	67%	0%	65%	49%	39%	0%
9	Cutter 44m 2975hp	9-4545-BDP-BDS-HBP-HBS-STG	81%	71%	67%	60%	0%	51%	0%	49%	32%	23%	0%
9	Cutter 44m 2975hp	9-8045-BDS-STG	84%	74%	70%	63%	0%	53%	0%	51%	35%	25%	0%
9	Cutter 44m 2975hp	9-8045-BDP-BDS-NDS	24%	14%	10%	3%	0%	0%	0%	0%	0%	0%	0%
9	Cutter 44m 2975hp	9-8045-BDP-BDS-HCP-HCS	41%	31%	27%	20%	0%	11%	0%	9%	0%	0%	0%
9	Cutter 44m 2975hp	9-8045-BDP-BDS-HCP-HCS-STG	41%	31%	27%	20%	0%	11%	0%	9%	0%	0%	0%
9	Cutter 44m 2975hp	9-8045-BDP-BDS-HBP-NDS-STG	11%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Appendix XXIV. Application of Lifting Code

Page featuring details on the application of the criteria from the Lifting Code, taken from IMO MSC.415(97) AMENDMENTS TO PART B OF THE INTERNATIONAL CODE ON INTACT STABILITY, 2008 (2008 IS CODE)



2.8.6.2 A minimum freeboard at stern of at least $0.005 \times L_{LL}$ should be maintained in all operating conditions.

2.9 Ships engaged in lifting operations

2.9.1 Application

2.9.1.1 The provisions given hereunder apply to ships the keel of which is laid or which is at a similar stage of construction* on or after 1 January 2020 engaged in lifting operations and to ships converted to carry out lifting operations after this date.

2.9.1.2 The provisions of this section should be applied to operations involving the lifting of the ship's own structures or for lifts in which the maximum heeling moment due to the lift is greater than that given in the following:

$$M_L = 0.67 \cdot \Delta \cdot GM \cdot \left(\frac{f}{B}\right)$$

where:

M_L = Threshold value for the heeling moment, in (t.m), induced by the (lifting equipment and) load in the lifting equipment;

GM = The initial metacentric height, in (m), with free surface correction, including the effect of the (lifting equipment and) load in the lifting equipment;

f = the minimum freeboard, in (m), measured from the upper side of the weather deck to the waterline;

B = the moulded breadth of the ship, in (m); and

Δ = the displacement of the ship, including the lift load, in (t).

The provisions of this section also apply to ships which are engaged in lifting operations where no transverse heeling moment is induced and the increase of the ship's vertical centre of gravity (VCG) due to the lifted weight is greater than 1%.

The calculations should be completed at the most unfavourable loading conditions for which the lifting equipment shall be used.

2.9.1.3 For the purpose of this section, waters that are not exposed are those where the environmental impact on the lifting operation is negligible. Otherwise, waters are to be considered exposed. In general, waters that are not exposed are calm stretches of water, i.e. estuaries, roadsteads, bays, lagoons; where the wind fetch* is six nautical miles or less.

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* A similar stage of construction means the stage at which:
.1 construction identifiable with a specific ship begins; and
.2 assembly of that ship has commenced, comprising at least 50 tonnes or 1% of the estimated mass of all structural material, whichever is less.

* Wind fetch is an unobstructed horizontal distance over which the wind can travel over water in a straight direction.

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