Theme A

Case Stories of Recent Ship Collision Accidents
Rapports d'accidents de collisions de bateaux
Fälle von neueren Schiffskollisionen

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Accidents Involving Bridges

Accidents impliquant des ponts

Brückenunfälle

Aksel G. FRANDSEN
Consulting Engineer
Cowiconsult
Copenhagen, Denmark

Aksel G. Frandsen, born 1924, got his M.Sc.C.E. degree at the Technical University of Denmark. In Cowiconsult since 1949 he has been responsible for some of the firm's advanced bridge projects. The New Little Belt Bridge started his ship collision work in 1964. He is now head of Cowiconsult's research and computer section.

SUMMARY
The paper gives a summarized systematic account of 22 serious accidents, from the period 1960-1982, in which ships have interrupted bridge connections. The available data are far from complete. This fact, together with the small number of cases and the varying conditions, makes it impossible to draw general conclusions from the material. How the material can be utilized, and how the data sources should be improved is discussed in the paper.

RÉSUMÉ
L'article donne un résumé systématique de 22 accidents graves, de la période 1960-1982, dans lesquels des bateaux ont endommagé des ponts en les rompant. Les informations disponibles sont loin d'être complètes. Il est impossible de tirer des conclusions générales de ces informations étant donné le petit nombre de cas et les conditions variées. L'article indique cependant la manière d'utiliser les informations disponibles et d'améliorer les sources d'information.

ZUSAMMENFASSUNG
Der Artikel zeigt eine systematische Zusammenfassung von 22 schweren Unfällen, im Zeitraum 1960-1982, in denen Schiffe Brückenverbindungen unterbrochen haben. Die zugänglichen Daten sind bei weitem nicht vollständig. Dies, in Verbindung mit der geringen Anzahl von Fällen sowie die variierenden Umstände, macht es unmöglich, aus dem Material allgemeine Schlüsse zu ziehen. Wie das Material angewendet werden kann und wie die Data-Vorlagen verbessert werden sollten, wird in dem Artikel diskutiert.

0. INTRODUCTION.

In connection with the preparation of the present paper an attempt has been made to extract information from actual ship collision accidents, regarding the subjects treated under the different themes of this colloquium.

It was decided to limit the investigation to "serious accidents", in this context defined as the cases in which bridge traffic has been interrupted for a period. This because these cases were believed to be rather well described in the literature.

Although it was found, that the annual rate of such accidents has increased from 0.5 in the period 1960-1970 to 1.5 in the period 1971-1982, it must be realized, that the total number is small, seen from a statistical point of view. Also, the conditions at the different bridge sites vary considerably. Therefore general statistical results could not be obtained. A further difficulty has been, that the data at hand was often incomplete on important points.

The author found it nevertheless useful to accomplish the investigation, to report the results and to give an account of the shortcomings found. In the next chapter the available data sources are discussed, and the form in which the case records are presented, appendix A, is introduced. The following chapters then discuss the information found in the case records. These chapters are arranged according to the themes of the colloquium. Finally, the author gives his concluding remarks.

1. DATA SOURCES. LIST OF SERIOUS SHIP COLLISION ACCIDENTS.

The cases considered are those in which a ship hits a bridge structure resulting in the interruption of the bridge connection. Information on these kind of accidents has been found in newspapers and technical magazines. Engineering News Record is one of the major sources. Often some kind of marine accident report is available. The latter - being very informative and reliable - have been obtained for as many of the serious ship collision accidents as possible. However, these reports have the goal of placing responsibility among the parties involved in the accident, and not that of establishing bases for future design. In a few cases the author has had access to special reports, treating all aspects of the ship collision problem for certain bridges. Other data has been obtained from the recent international ship collision enquiry made in connection with the Great Belt Bridge study, cf. Frandsen et al /3/, and the earlier enquiry made in connection with the Little Belt Bridge study, cf. Ostenfeld et al /1/.

Based on these sources a summarized, systematic list of information on all serious ship collision accidents known to the author, from 1960 and up to May 1982, has been prepared (see appendix A). The list contains information on 22 accidents involving 18 individual bridge connections, two of these being twin bridges. It is ordered chronologically, according to the dates of the accidents. In case of more accidents with the same bridge connection, the first accident determines the place in the list.

A natural question in connection with such a list is how complete it is. From the list one may get the possibly erroneous impression that accidents on North American rivers are much more frequent than accidents on other rivers, as rivers from other geographical areas are hardly represented in the list. This seemingly skew distribution may cover a reality, but may also be the result of differences in tradition for reporting accidents. The author should welcome contributions from participants in the colloquium, helping to clarify this problem.

In the preparation of the list, the scheme given in appendix B was used to structure the data. This scheme has been arranged in such a way, that the information needed in an elementary risk-analysis of the bridge-ship traffic situation could easily be indicated, if available.

This was done in order to facilitate the utilization of the statistically weak data. Optimally they should be used to check the validity of different types of risk analysis models, and to calibrate them. Such calibrations have, according to the author's knowledge, only been done in a very few cases, namely the Tasman bridge and the Sunshine Skyway. It is the authors opinion, that such calibrations should be carried out whenever possible. However, it was outside the author's possibilities to pursue this goal for the other serious accidents at this occasion. The lack of data on important points is sufficient explanation for this.

It is the authors hope, that appendix B will also be used as a check-list for the information needed in a typical, future case record description, and he welcomes all contributions from participants in the colloquium, that can make the "database" of serious accidents more complete.

Finally it should be mentioned, that the condensed form in appendix A did not always allow the author to give full account for the complexity of real life. Therefore the basic sources should always be consulted, if the intended application is one of importance.

2. NAVIGATIONAL ASPECTS.

For the 18 individual bridge sites comprised in appendix A, the navigational conditions encompass almost all possibilities:

The bridges cross in 9 cases rivers, in 2 cases channels, in 1 case a narrow fjord, in 2 cases harbour areas, in 2 cases lakes and in 2 cases open ocean.

The conditions for the navigation are sometimes described in terms like "good" , "difficult" etc. These descriptions are not always quoted directly from the indicated sources, but stands for the authors interpretation of sometimes rather inconsistent indications.

The intensity of the ship traffic is only indicated in a very few cases.

Navigational aids are rarely mentioned in the sources at hand. In one case, the Pontchartrain Bridge, it is indicated that a supervisory and warning system has been installed. In the cases, in which marine accident reports exist, a waterway description with information on navigational aids is normally included. However, the author found it difficult to formulate general conclusions in this respect.

3. COLLISION PROBABILITIES. ACCIDENT CAUSES.

Collision probabilities, as such, can of course not be directly extracted from the few cases treated here. One thing that can be found, however, is a measure for the global frequency of serious accidents, with the above mentioned reservation that, on a world wide basis, some accidents may be missing in appendix A.

Fig. 1 shows the cumulated number of serious ship collisions since 1960. It can be seen, that the annual rate of such collisions has increased from 0.5 to 1.5 during the last two decades. It can also be seen from this figure, that collisions involving barges constitute about 55% of all the cases. This corresponds well with the above mentioned distribution of the accidents on rivers and channels, as one group, compared to the group of all the other navigable waters.

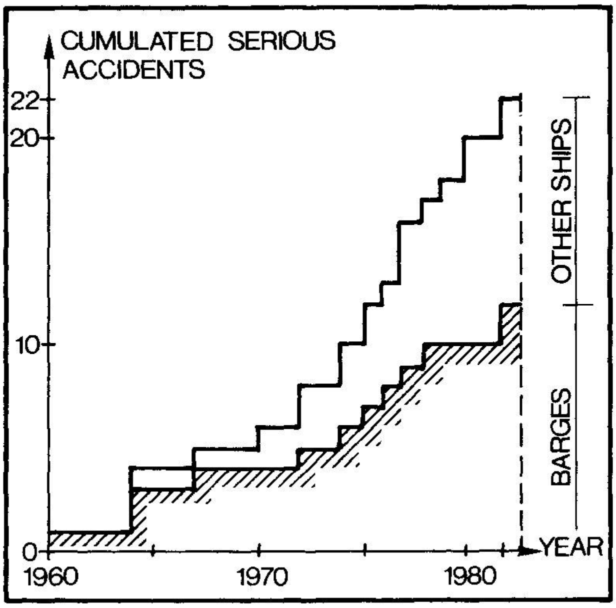

Fig. 1 Serious ship collisions with bridges 1960-1982.

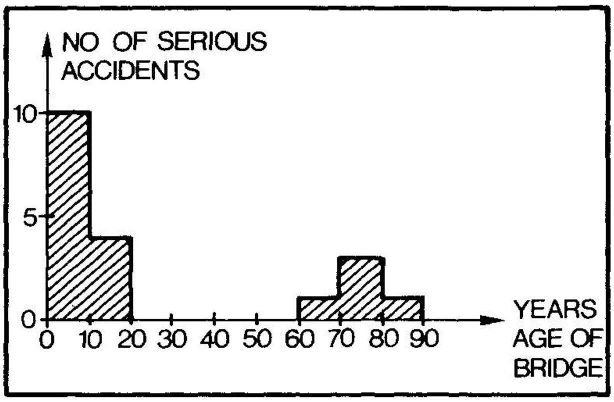

Fig. 2 No of serious accidents in relation to age of bridge.

In most of the cases it has been possible to establish how old the bridges are/were. Fig. 2 shows the number of serious accidents set in relation to the age of the bridge at the time of the accident. It is interesting to note, that most of the bridges were seriously hit while they were quite young - under 10 years of age, that no bridge between 20 and 60 years of age was hit, and that some very old bridges - between 60 and 90 years - were also hit. This pattern is known from many other areas, and is probably quite natural.

The number of near accidents must be much higher than the number of serious accidents, but near accidents are not reported in a consistent manner in the sources at disposal here. Dayton /2/ reports, that during the five year period 1970-74 a total of 811 accidents occurred on rivers and canals in the United States. From the same period and the same area appendix A has only one serious river accident. This relationship is perhaps not representative of all types of bridges.

If data on accident probabilities shall be transferred from other areas of experience, e.g. from strandings, a knowledge of the causes of accidents is important.

Information on causes of accidents, when barges are involved, may be obtained from the analysis of near accident data as given by Dayton /2/. On this basis it can be concluded, that barges are very sensitive to wind and current conditions, and that this is the main cause of accidents. This finding is, however, not confirmed by the data in appendix A. Of the 22 accidents 12 were caused by barges. Out of these 12 four have occured under abnormal wind and current conditions, and out of these again one is covered by Daytons results. The remaining three were caused by broken towlines (anchorlines). Two other cases occured during times of dense fog and were caused by careless navigation. The remaining 6 cases occurred under normal wind, current and visibility conditions and were in 4 cases caused by careless navigation and in 2 cases caused by mechanical failure. It thus seems that the conclusions from the near accident analysis by Dayton cannot be transferred to serious accidents.

Information on causes of collisions, including other ships than barges, may be based on the 10 cases in appendix A. Of these 10 cases, 5 happened during periods of time with normal wind, current and visibility conditions, and the causes of these accidents seem to be human error and mechanical failure. For four accidents happening under abnormal circumstances the same appears to be true. Only in one of these cases another cause is given: Environmental influence (ice-formations on the ships hull which affected the steering and could not be detected due to low visibility (Almö bridge, 1980)). For one case neither the environmental conditions nor the cause have been established yet.

It follows that in the evaluation of risk models it is unnecessary to distinguish between barges and other ships. The main causes for ship collisions appears to be human error and mechanical failure, whereas environmental influence (wind, weather, current, etc.) is only seldom the direct cause of the accident.

4. CONSEQUENCES OF COLLISIONS.

By definition, all the cases considered in appendix A entailed structural damage to such an extent, that the bridge connection was interrupted. The extent of the damage in each case has been governed mainly by the general arrangement of the bridge. None of the bridges were designed to resist important impact forces, and many of them had extremely low resistance capacity towards horizontal forces. The size of the damaged part of the bridge structure has therefore primarily been determined by the geometrical contact area between the ship and the bridge, and the damage normally stopped at dilatation joints or other, specially arranged, weak joints. Nothing can therefore be learned about impact forces etc. from the cases in appendix A.

The indicated costs for repair are not directly applicable as measure for the damage. This not only because of the changing values of the currencies through the two decades, but also because it is often uncertain what is included in the costs.

A better measure is perhaps the repair time needed. This also gives an impression of the general inconvenience which the society incurs as a result of the accident. It can be seen from appendix A, that - apart from very long causeways, where interruptions from ship collisions have become a routine matter to be dealt with within a week or so - the interruptions have lasted from 6 months up to almost 3 years. The importance of such a period of interruption depends on how indispensable the bridge has become for the daily traffic in the area, served by the bridge.

The number of fatalities is often considerable - up to 35 in a single accident - and totals almost 100 for the 22 accidents. Most of the fatalities are due to cars driving over the edge and falling into the water. Fatalities due to spill of hazardous cargoes have not been experienced in the accidents treated here, apart from the 7 persons killed by escaping CO-gas by the rupture of a gas pipe line in 1982.

5. ACCEPTANCE CRITERIA.

From the material at hand no direct conclusion on acceptance criteria could be drawn. However, some of the elements entering in an assesment of acceptable risk levels have been treated above in chapter 4.

6. INFLUENCE ON DESIGN.

The bridges dealt with here, have been designed and built over a very long period of time. It is therefore no wonder, that they differ quite a deal in respect of passage openings for the ship traffic.

Many of the older bridges are movable bridges, containing swing spans. The navigational openings, provided by such bridges, are normally very small - an example is found of openings only 16 m wide. Some swing spans have been replaced by vertical lift spans, thereby increasing the clear width of the opening by a factor of 2.5 - 3.

Newer movable bridges, from the period 1955 - 70, have lift spans of 60 - 150 m clear width, and up to 40 m clear height. Bridges from the same period, but with fixed navigaton spans, are found with horizontal clearance of 90 - 240 m and vertical clearance up to 45 m. Still from the same period the very long causeway over Lake Pontchartrain shows much more modest navigational openings, also after these openings were increased in connection with the construction of the second causeway.

Thus a general, but not uniform, tendency to provide larger openings for the ship traffic can be found in the bridge designs considered here. The way these bridges have been chosen, however, gives no guarantee, that they are representative for bridge design tendencies in general.

The main problem in the design of bridges over navigable waters seems however not to be the navigational openings, but all the vulnerable parts of the bridges far from the navigation spans where the ships are not supposed to sail. The experience from appendix A shows, that they often do sail here as a result of human error or mechanical failure. In some cases, as with the Almö bridge, there is a simple solution to the problem: place all the vulnerable parts of the bridge outside the possible reach of the ships, by taking advantage of the actual profile of the channel in question. However in most cases there is no such simple solution.

The material considered here gives no evidence on the usefulness of fenders because none of the accidents took place in areas where such structures were applied.

7. CONCLUDING REMARKS.

It is the authors opinion, that the study of actual collision cases is necessary if generally applicable, rational solutions to the problem of designing sufficiently safe bridges at reasonable costs are to be found.

However, the directly accessible material, as used here, is not always sufficiently detailed and reliable. There is a need for a complete and reliable database for serious collision accidents. As these accidents are rare events, even taken globally, such a database should preferably be managed by an independent, international body, e.g. like IABSE.

It is the authors hope, that the ship collision colloquium will give an opportunity to discuss the possibilities for establishment of such a database.

REFERENCES

1. OSTENFELD, CHR.: Ship Collisions against bridge piers. AIPC Memoires, 1965.
2. DAYTON, R.B.: Analysis of bridge collision accidents, Vol. I + II NTIS AD-A029 034 and AD-A036 732. U.S. Department of Transportation, 1976
3. FRANDSEN, A.G. and LANGSØ, H.: Ship collision problems. I: Great Belt Bridge, II: International enquiry. IABSE Proceedings P-31/80, May 1980.

APPENDIX A

List of serious accidents

Bridge:	SEVERN RAILWAY BRIDGE, Severn River, England.
Opening year:	1879.
Bridge struct.:	Steel truss supported by double columns. 21 bow string girder spans 135 ft to 170 ft, two 308 ft navigation spans. Max. clearance 65 ft above high water.
Navig. aspects:	Second highest tidal range in the world. Bridge considered real hazard to shipping out of control.
Date/accident:	1960-08-25. Two oil barges accidentally hooked up together collided broadside with pier.
Ship:	Steelbarges "Wastdale" 450 t total weight, length 136 ft, 130 dwt and "Arkendale" 408 t total weight, length 136 ft, 113 dwt.
Environment:	Dense fog.
Cause:	Tug pilot´s negligence.
Damage:	Two spans and one supporting pier fell down. 5 fatalities.
Remarks:	Estimated cost of repair £250,000. Bridge demolished in 1970.
Near accidents:	Piers frequently struck by vessels. Between 1939 and 1961 seven serious collisions resulting in fairly extensive damage.
References:	Peter Mason: "An investigation into the cause of damage to the Severn Railway Bridge" with discussion. The Structural Engineer, 1963, Vol.41, No.2 p.69 and No.10, p.327.

Bridge:	MARACAIBO BRIDGE, Lake Maracaibo, Venezuela.
Opening year:	1962.
Bridge struct.:	Concrete bridge, cantilever structure with suspended spans. Length 8678 m in 135 spans. Main bridge consisting of 5 cable-supported 235 m spans. Vertical navig. clearance 45 m. The A- and H-shaped piers rest on pile caps at water level, supported by deep, prefabricated vertical piles, extending through the water down in the bottom.
Navig. aspects:	Lake, with deep water navigation at main and flanking spans.
Date/accident:	1964-04-06. Ship collided broadside with two piers away from the navigation spans.
Ship:	"Esso Maracaibo" 36,000 dwt tanker, fully loaded.
Environment:	Normal. Predawn darkness.
Cause:	Electrical fault in steering gear.
Damage:	Three spans fell down, two piers destroyed.
Remarks:	Estimated damage \$5 - \$10 million. Repair time 6 months.
Near accidents:	-
References:	ENR 64-04-16, p.28, ENR 64-12-24, p.31. Civil Engineering 64-05, p.79.

Bridge:	PONTCHARTRAIN BRIDGE, Lake Pontchartrain near New Orleans, Louisiana, USA.
Opening year:	1957. Second bridge 1970.
Bridge struct.:	Prestressed concrete sections on pile bents, 56 ft apart. Vertical clearance 16 ft. Two bascule spans providing 75 ft clearance and three fixed humps providing 56 ft by 25 ft openings are the only passages on a length of 24 miles. The bridge was designed to sustain the normal load of boats hitting it, but not a "power collision". The sescond bridge has a similar structure as the first bridge, but spans increased to 84 ft and three-pile bents are used instead of two pile-bents. Increased navigation openings for easier passage. To minimize danger to navigation every second bent of the new structure is aligned with every third bent of the old.
Navig. aspects:	The lake is subject to sudden squalls and rough water.

Date/accident:	1964-06-16. Barge tow off-course swung in and hit the bridge.
Ship:	Loaded barges.
Environment:	Normal.
Cause:	Boat operators negligence. A Coast Guard hearing showed, that the captain, who was not at the wheel, was unable to plot a course and to define magnetic north.
Damage:	Four spans collapsed. 6 fatalities.
Remarks:	Estimated cost $125,000. 5 days repair time. The accident hapened in spite of the recently installed two radar stations, 88 warning signals and two-way radio communication.
Near accidents:	Fifth time in 8 years the bridge has been rammed by barges, but the first time it has caused fatalities.
References:	ENR 64-06-25, p.21.

Date/accident:	1964-07. Tug probably hit a pile bent.
Ship:	Tug towing two barges.
Environment:	Normal.
Cause:	Tug pilot's lack of attention, possibly asleep.
Damage:	Two 56 ft spans fell down, one pile bent destroyed.
Remarks:	Bridge hit so many times by barges, that repair has become routine. New sections are kept ready in store for replacement. Repair time less than 1 week.
Near accidents:	The sixth time the bridge has been hit in 8 years and the second within 1 month.
References:	ENR 64-07-30, p.7.

Date/accident:	1974-08 Tug hit an unprotected pier some way from the navigation span.
Ship:	Tug pulling 4 empty barges.
Environment:	Normal.
Cause:	The tugpilot had fallen asleep.
Damage:	A fourspan, 240 ft section, fell down. Two pile-bents demolished. 3 fatalities.
Remarks:	The new bridge was supposed to be more resistant to collisions "since one pile can be knocked out of a bent without collapsing spans". The ninth time the bridge was hit killing a total of nine.
Near accidents:	In 1969 a barge crane struck and damaged two 84 ft spans of the second 24-mile causeway, while it was under construction.
References:	ENR 68-04-18, p.38-41, ENR 69-02-27, p.7, ENR 74-08-08, p.20.

Bridge:	CHESAPEAKE BAY BRIDGE AND TUNNEL, Chesapeake bay, Virginia, USA.
Opening year:	1965.
Bridge struct.	Actual part of CBBT is a low level, 3 mile long concrete trestle. Prefab. 75 ft spans on pile bents, vertical clearance 25 ft. The 17.5 mile CBBT crossing consists of 6 concrete trestle bridges, 2 tunnels and 2 steel bridges. The tunnel sections provide navigation channels of 1700 ft and 2300 ft widths.
Navig. aspects:	Open ocean.
Date/accident:	1967-12. Ship thrown repeatedly against the bridge deck.
Ship:	Drifting, crewless coal barge.
Environment	Storm.
Cause:	Ship torn loose from it's moorings by the storm.
Damage:	One span moved 4 ft out of line. 5 other seriously damaged.
Remarks:	Cost $1.3 million (including lost revenue). Repair time 15 days.
References:	ENR 67-12-14, p.27, ENR 70-03-12, p.9
Date/accident:	1970-01-21. Ship thrown repeatedly against bridge deck.
Ship:	USS Yancey, navy cargo ship, approx. 10,000 dwt.
Environment:	Storm.
Cause:	Ship torn loose from its moorings by the storm.
Damage:	Fifteen piles supporting five 75 ft spans broke off. 11 other spans were seriously damaged.
Remarks:	Cost $2 million in repairs and $600.000 in revenues lost during 42 days shut-down.
References:	ENR 70-01-29, p.17, ENR 70-03-12, p.9.
Date/accident:	1972-09-21. Barge thrown repeatedly against the bridge deck.
Ship:	The tug "Carolyn" and "Weeks Barge 254".
Environment:	Heavy wind.
Cause:	Broken towline to tug.
Damage:	Two spans fell partly down, five 75 ft sections damaged.
Remarks:	Repair time approx. 1 month. Cost $1.1 million in repairs, $0.8 million in lost revenue.
Near accidents:	Rammed for the fifth time in seven years. Third time the bridge was closed down for repairs.
References:	ENR 72-09-28, p.22, ENR 72-11-23, p.56. Coast Guard: "Collision of the tug "Carolyn" and "Weeks Barge 254" with CBBT.... NTIS-AD 774-372.

Bridge:	SIDNEY LANIER BRIDGE, Brunswick River, Georgia, USA.
Opening year:	1957.
Bridge struct.:	4-lane bridge. Lift span, 250 ft, steel truss. Fixed spans divided by expansion joints in sections of 3 x 150 ft. Vertical clearance in lift span 139 ft/24 ft, in fixed spans 45 ft.
Navig. aspects:	River, 1250 yards wide. Bend in channel near bridge.
Date/accident:	1972-11-07. Ship hit the bridge next to the lift span.
Ship:	SS "African Neptune" 12,900 dwt freighter.
Environment:	Normal.
Cause:	The helmsman misunderstood the pilot's instructions.
Damage:	A three span section fell down. 10 fatalities.
Remarks:	Cost $1.3 million, repair time 6 months. NTSB recommends a study of the hazards of lift-span bridges with narrow openings, deepwater supports and curved channels.
References:	ENR 72-11-16, p.19, ENR 74-08-01, p.11. NTSB and US Coast Guard: SS African Neptune: Collision with the Sidney Lanier Bridge . ....NTIS AD-781 298.

Bridge:	WELLAND CANAL BRIDGE, Port Robinson, Ontario, Canada.
Opening year:	-
Bridge struct.:	Two lane, vertical-lift steel highway bridge. Length 214 ft. Steel towers atop concrete piers.
Navig. aspects:	-
Date/accident:	1974-08. Ship rammed lift span, while opening.
Ship:	670 ft ore carrier.
Environment:	-
Cause:	-
Damage:	Lift span fell into the canal. East tower toppled. West tower buckled. Demolition cost estimated at $775,000. Replacement cost estimated at $5-10 million.
Remarks:	-
Near accidents:	-
References:	ENR 74-08-29, p.3, ENR 74-09-12, p.21.

Bridge:	TASMAN BRIDGE, Derwent River, Hobart Tasmania, Australia.
Opening year:	1964.
Bridge struct.:	4-lane concrete bridge on double columns. Total length of viaducts 1025 m between abutments. Navigation span 94 m. Max vertical clearance 45.7 m, fenders at navigation span. Weak joints in superstructure to prevent progressive collapse. Piers supported by pile caps at water level, on deep-bored piles, extending to depths up to 265 ft, through the water down into the bottom.
Navig. aspects:	Good navigational conditions. Occasionally strong cross winds. 2500 vessels/year.
Date/accident:	1975-01-05. Ship collided head on with two piers, hitting the bridge at a relatively small angle more than 200 ft away from the navigation span.
Ship:	"SS Lake Illawara", 7,200 dwt bulkcarrier.
Environment:	Normal.
Cause:	Steering fault + captain's poor seamanship.
Damage:	Three 42 m bridge spans fell down, two piers totally destroyed. The ship sank. Approx. 15 fatalities.
Remarks:	Repair time 2 years and 9 months. Opportunity taken to widen the bridge to 5 lanes. Three fallen spans replaced by two spans - one steel - one concrete. The weak joint mechanism in superstructure performed well. The fenders of the main span had been designed to fend off a vessel of 15.000 t. It had been considered quite impracticable to design for impact against the other piers.
Near accidents:	-
References:	ENR 75-01-09, p.14, ENR 75-01-16, p.10. S.T.U.P. Bulletin of information Jan/Feb. 1975. Maunsell & Partners: Tasman Bridge - Risk of collision and methods of protection. September 1978. J.A. Leslie: Restoration of the Tasman Bridge following ship collision. FIP 8 Congr. May 1978.

Bridge: FRASER BRIDGE, Fraser River, New Westminster, Canada.
Opening year: 1904.
Bridge struc.: Railway swing bridge, steel truss, length 2.290 ft.
Navig. aspects: Navigation on river greatly restricted by the bridge.

Date/accident: 1975-12-26. Barge hit the bridge superstructure.
Ship: "Swiftsure Prince", 600 ft long barge in ballast.
Environment: Storm, heavy rain.
Cause: The unmanned barge tore loose from its moorings.
Damage: One 390 ft span fell down. Estimated cost $1.5 - $2 million.
Remarks: In 1968 extensively damaged by 10,000 t freighter, in 1957 struck by two bulk carriers, in 1952 struck by barge.
Near accidents: Since its opening the bridge has had repeated run-ins with tugs, barges and freighters.
References: Vancouver Sun 1975-12-27, and unidentified newspapers.

Bridge: PASS MANCHAC BRIDGE, Channel between Lake Pontchartrain and Lake Maurepas, Louisiana, USA.
Opening year: -
Bridge struct.: Two-lane bridge, concrete slab on steel girders supported by pile bents. Total length 3,012 ft. 51 spans, vertical clearance 50 ft.
Navig. aspects: -

Date/accident: 1976-09. Barge hit a pile bent, with 4 prestressed piles.
Ship: Barge towed by a tug.
Environment: Strong currents.
Cause: The barge off-course (tug pilot held responsible).
Damage: Pile bent destroyed, three spans 80, 107.5 and 70 ft long, fell down. At least one fatality.
Remarks: Repair time 4-6 months.
Near accidents: -
References: ENR 76-09-23, p.41.

Bridge: BENJAMIN HARRISON MEMORIAL BRIDGE, James River, Va, USA.
Opening year: 1967.
Bridge struct.: Two lane bridge with vertical-lift span, 363 ft long, and tower spans, 241 ft long, in steel truss. Adjacent spans in pc. Total length 4,463 ft. Clearance under tower spans 30 ft.
Navig. aspects: River with 300 ft wide and 34 ft deep dredged channel. Bends in channel upstream and downstream. Low current velocity.

Date/accident: 1977-02-24. Ship hit and destroyed the pier between tower span and adjacent span, after which the ship's hull passed under the tower span and the deck house hit the steel truss.
Ship: SS "Marine Floridian", 25,000 dwt tanker in ballast.
Environment: Normal.
Cause: Electrical fault in steering gear.
Damage: The northern tower span and its associated equipment were demolished. Support pier between tower span and approach causeway was destroyed. One section af causeway fell down. Center span and lift mechanism were damaged extensively. Cost of rebuilding estimated at $7,000,000. Repair time approx. 2 years.
Remarks: NTSB recommends warning signals and traffic control devices in accordance with FHA guidelines.
Near accidents: -
References: ENR 77-03-03, p.11, ENR 77-03-17, p.16
NTSB: Marine Accident Report US Tankship SS Marine Floridian, Collision with Benjamin Harrison Memorial Bridge. 1978 NTIS PB-293 237

Bridge: UNION AVENUE BRIDGE, Passaic River, New Jersey, USA.
Opening year: 1897.
Bridge struct.: Two lane bridge with swing span. Stone block pier on timber piles.
Navig. aspects: -

Date/accident: 1977-04. Barge hit pier at the navigation span.
Ship: Empty oil barge towed by tug.
Environment: Normal.
Cause: Broken towline to tug.
Damage: Pier and one end of 53 ft long side span fell into the river.
Remarks: Repair time 5-6 months. Damaged pier rebuilt in reinforced concrete. Cost estimate $600,000.
Near accidents: -
References: ENR 77-08-05, p.10.

Bridge: TINGSTAD BRIDGE, Gothenburg Harbour, Sweden.
Opening year: 1907.
Bridge struct.: Railway bridge, steel truss. Swing span 56.7 m, giving 2 navigation openings 15.7 m wide each. Side spans 31 m long.
Navig. aspects: Harbour area.

Date/accident: 1977-09-10. Ship hit the side spans of the bridge.
Ship: "Sørine Tholstrup", 1600 dwt gas tanker in ballast.
Environment: Normal.
Cause: Electrical fault in steering gear.
Damage Two side spans destroyed.
Remarks: Cost 2-3 million D.kr.
Near accidents: -
References: Politiken 77-09-11,12. Report from the Danish maritime inquiry.

Bridge: SOUTHERN PACIFIC RAILROAD BRIDGE, Atchafalaya River near Berwick, Lousisana, USA.
Opening year: 1907. Rebuilt 1971: Lift span replacing swing span.
Bridge struct.: Steel truss. 320 ft lift span. Vertical clearance 73 ft in open position. Piers protected by fenders.
Navig. aspects: Bend in channel in approach to bridge. Strong currents during high water make the downbound passage hazardous for many towing operations. Two other bridges in the immediate vicinity.

Date/accident: 1978-04-01. The lead barge hit the bridge superstructure in the side span of the railroad bridge, after having hit a bridge pier of the nearby highway bridge.
Ship: Tug pushing 4 barges.
Environment: Normal.
Cause: Tug pilot´s careless navigation (underpowered tow).
Damage: One 232 ft long steel truss span tumbled off the supporting piers and sank. Damage totalled $1.4 million, including costs of rerouting rail traffic.
Remarks: -
Near accidents: The bridge has been struck by vessels 534 times between 1946 and 1978.
References: NTSB Marine Accident Report: Collision of M/V "STUD" with the Southern Pacific Railroad Bridge ......, NTSB-MAR-80-5.
Dayton: Analysis of Bridge Collision Incidents. Vol I.
DOT USCG Report no CG-D-77-76.

Bridge locat: SECOND NARROWS RAILWAY BRIDGE, Vancouver Harbour, Canada.
Opening year: 1969.
Bridge struct.: Steel truss bridge, 152 m lift span. Piers protected by fenders.
Navig. aspects: Harbour area, strong tidal current.

Date/accident: 1979-01-12. Ship hit the superstructure near the navigation span.
Ship: Japan "ERICA" 22,000 dwt bulk carrier.
Environment: Dense fog. Visibility 100 m.
Cause: Captain´s misjudgement of land marks due to the fog.
Damage: One end of the 85 m long span closest to the lift span fell down. Lift span´s tower tilted 8 m out of vertical.
Remarks: Repair time 5 months.
Near accidents: The previous bridge in the same place suffered serious collision damage in the 1930´s.
References: The Financial Post Western Business, 1979-10-27, 1979-11-14, 1980-01-02 and 1980-01-03.
New Civil Engineer International, June 1980, p.42.

Bridge:	ALMÖ BRIDGE, Almösund, Sweden.
Opening year:	1960.
Bridge struct.:	Steel tubular arch bridge. Length 280 m. Navigation channel 50 m wide, 41 m high. Direct foundation on rock.
Navig. aspects:	Narrow fjord. Bends in channel in approach to bridge. Strong currents, occasionally ice. 3000 vessel passages in 1980
Date/accident:	1980-01-18. Gantry crane, mounted on ship, hit arch section near foundation on shore (approx. 100 m from navig. channel).
Ship:	"Star Clipper", 27,000 dwt product carrier in ballast.
Environment:	Darkness, reduced visibility, strong current, ice.
Cause:	Steering difficulties due to ice-formations on ship's hull.
Damage:	Total collapse of arch span. 8 fatalities.
Remarks:	Swedish Marine Accidents Commission states, that geometrical arrangement of a bridge in relation to water depths should be considered carefully, as increase in span may increase safety at reasonable price. Bridge rebuilt as cable-stayed bridge to prevent possibility of future collisions. Reopened 1981-11-09. Total cost 210 million Sw.kr. incl. 40 million Sw.kr. for temporary ferry connection, but excl. other implied costs.
Near accidents:	Bridge was hit, but not damaged, by cranes of a floating dock in 1974.
References:	Statens Haverikommission: Utredningsrapport beträffande .. ..."Star Clippers" påsegling av Almöbron ...... April 1981. Väg- och vattenbyggaren 11-12, 1981, p.29-32.

Bridge:	SUNSHINE SKYWAY, Tampa Bay, Florida, USA.
Opening year:	Eastern bridge 1954, western bridge 1971.
Bridge struct.:	Two identical bridges, separated 120 ft. Total length 22,424 ft, mainly concrete trestle spans. Central part: 3-span 1584 ft steel cantilever through truss, flanked by 2-span steel deck trusses. Clearance in main span 800 ft by 140 ft. Anchor pier: two column rc frame on rc shaft extending down to bay bottom, founded on pc piles.
Navig. aspects:	The ship traffic, about 11,000 passages per year, is concentrated in dredged main channel, 400 ft wide, 43 ft deep. Depths outside channel 25 - 30 ft. In approach from seaside channel has a 18 deg. bend approx. 0.7 nm before the bridge.
Date/accident:	1980-05-09. Stem of ship hit concrete portal legs on top of anchor pier 800 ft from navig. channel.
Ship:	SS "Summit Venture", 35,000 dwt bulk carrier in ballast.
Enviroment:	Rough weather with low visibility.
Cause:	Pilot's careless navigation in spite of the weather.
Damage:	Anchor pier destroyed and 1300 ft of 3 main steel truss spans fell into the bay. 35 fatalities.
Remarks:	No impact load codes for navigational structures in Florida. Bridge not designed for progressive collapse. NTSB recommends standards for bridge protection systems. Bridge not rebuilt. Cable-stayed bridge under planning to replace two existing bridges.
Near accidents:	At least 8 minor accidents since 1969. 2 major near accidents in 1980.
References:	ENR 80-05-15, p.12, NTSB: Marine Accident Report: Ramming of the Sunshine Skyway Bridge......NTSB-Mar-81-3

Bridge: RICHEMONT GAS PIPELINE, Mosel River, Lorraine, France.
Opening year: -
Bridge struct.: Gas pipeline river-crossing, two steel tubes 1500 mm diameter, supported by concrete piers, navigation channel approx. 25 m wide.
Navig. aspects: -

Date/accident: 1982-01-16. Barge hit pier.
Ship: Tug "METZ", pushing two barges.
Environment: Dense fog.
Cause: Tugpilot's careless navigation in spite of lack of visibility.
Damage: One pier was destroyed, the gas pipeline collapsed, causing damage to another pier. 7 fatalities, probably all due to escaping CO-gas from the pipeline.
Remarks: -
Near accidents: -
References: Le Figaro 82-01-18, Le Matin 82-01-18, L'Est Republicain 82-01-18.

Bridge: HANNIBAL - RAILROAD BRIDGE, Mississippi River, Hannibal, Missouri, USA.
Opening year: -
Bridge struct.: Low-level steel truss with swing span. Length 1580 ft.
Navig. aspects: -

Date/accident: 1982-05. Towboat rammed into a fixed span.
Ship: Towboat pushing 15 barges.
Environment: Normal.
Cause: Tow struck abutment, while passing swing span, barges broke loose, towboat lost control and swung around.
Damage: One span fell down.
Remarks: -
Near accidents: -
Reference: ENR 82-05-13, p.35.

APPENDIX B

Check list for use in case record description.

Location of bridge. Opening year. Dates for major changes.

Bridge:	- Type of bridge. Materials used. Foundation. - Geometrical layout (water depths, vertical clearance, width of navigation span and of side spans etc.). - Protective measures if any.
Navigational aspects:	- Waterway lay-out - Aids to navigation - Traffic intensity - Current - Wind - Visibility
Accident:	Date. Ship. Events, that lead to the collision, and events during and after the collision.
Ship:	- Name. - Type - Size (dwt). - Load factor: fully loaded, ballast or empty - Speed at time of impact.
Environment:	Traffic and weather conditions during accident.
Cause:	Assesment of the cause of the accident.
Damage:	Damage to the bridge. Damage to the ship. Number of fatalities.
Remarks:	Additional relevant information: - Solution of transport problems during time of repair. - Method of reconstruction. - Repair time and cost. - Alterations in the design due to the collision.
Other accidents:	Earlier accidents or near accidents if any.
References:	Marine accident report or other references.

Statistics on Collision Accidents Involving Offshore Structures

Statistiques d'accidents dus à des collisions avec les constructions maritimes

Statistiken über Kollisionsunfälle mit Offshore-Bauten

Per LAHELD
Senior Research Engineer
Det norske Veritas
Oslo, Norway

Per Laheld is a graduate from the Norwegian Naval Academy and holds a M.Sc., from the Norwegian Institute of Technology. He has worked in Det norske Veritas since 1967, presently within a group on marine collisions in the Research Department.

SUMMARY
The Norwegian Petroleum Directorate requests that the probability of ship collisions should not by best available estimate exceed 10^{-4} per year. The question at once arises whether there exists today a sufficient amount of relevant, reliable and enough detailed collision data so as to support a probability calculation based on methods which by the way in themselves are questionable. The paper summarizes in a statistical way the data available on offshore collisions world-wide. A discussion of the data sources and the data is made, and suggestions to improve the present situation are given.

RÉSUMÉ
La Direction norvégienne des pétroles recommande que la probabilité de collision de navires avec une plate-forme en mer ne dépasse pas 10^{-4} par an. La méthode de calcul proposée est discutée d'autant plus que les données disponibles sont très limitées. L'article récapitule les statistiques mondiales établies en Norvège. Les sources d'information sont discutées et des propositions sont faites pour améliorer l'état actuel.

ZUSAMMENFASSUNG
Das norwegische Oel-Direktorat empfiehlt, dass der Wert der Schiffs-Kollisionswahrscheinlichkeit bei best verfügbarer Schätzung, 10^{-4} pro Jahr nicht überschreiten sollte. Die Berechnungsmethode sowie die dafür benötigen Daten werden diskutiert. Statistische Daten von Offshore-Kollisionen aus der ganzen Welt werden vorgelegt. Datenquellen werden diskutiert und Anregungen zur Verbesserungen der gegenwärtigen Situation gegeben.

1. INTRODUCTION

The exploration for and production of "black gold" from the world's continental shelves has naturally also introduced new hazards into the old traditional seafaring activities. An increased risk of collisions is due to offshore platforms being positioned and installed "at random" in the open sea with accompanying ship traffic, is one such hazard.

Until recently the risk of collisions was not considered, neither in the design nor the operation of offshore platforms, the reason being the lack of data both on ship traffic and collisions experienced as well as lack of reliable methods for calculating probabilities and consequences of collisions.

In Norway, the question of offshore collisions was accentuated through the issue of a governmental order in 1981 entitled: "Guideline for Safety Evaluation of Platform Conceptual Design" where ship collisions are listed as one type of accident which should be evaluated. According to the Guidelines, the probability of occurrence "should not, by the best available estimate, exceed 10^{-4} per year".

Det Norske Veritas has, for several years, been involved in research projects on ship-ship and ship-platform collisions both on the probability and consequence side. These activities include, amongst other things, an Offshore Accident Databank containing data on 515 offshore accidents which have occurred since 1970.

2. INFORMATION SOURCES

Collisions usually involve claims for compensations and the question of guilt often leads to long legal disputes. Therefore, the parties involved will naturally prefer to keep all information confidential; at least the details of the collision until legal questions have been settled.

However, there are normally two sources through which information concerning a collision is made public, namely, the Press and National authorities. In both cases, the consequences of the collisions have normally been very severe, also involving fatal accidents.

According to Norwegian Maritime Law, an inquiry must be held when a fatal accident occurs, when two ships collide or when an incident is assumed to have occurred which causes substantial damage to the ship or property outside the ship. If the accident is not considered covered by this law, the parties involved are under no obligation to report it to the Norwegian authorities.

A similar system, for instance, applies to the Dutch shelf, whilst in the United Kingdom it is mandatory for operators to report all accidents to the authorities.

In order to obtain information concerning collisions, the following sources exist:

- national authorities,
- the Offshore Press,
- international non-governmental organizations,
- insurance companies,
- classification societies,
- oil companies,
- ship owners,
- ship repair yards.

The statistics on offshore collision accidents, presented in this paper, are partly based on the data presented by national authorities and partly on data presented by the Offshore Press. The above is supplemented with data from a project presently carried out for the SPS (Safety Offshore Programme) managed by the Royal Norwegian Council for Scientific and Industrial Research (NTNF). Most of these data are, however, proprietary to the operator and shipowner and, therefore, have to be presented on a statistical form.

3. EXISTING MOBILE AND FIXED PLATFORMS

Fig. 1 shows the yearly distribution of the total number of mobile units in various geographic locations. Table 1 shows the estimated total number of fixed platforms in various geographic locations.

As can be seen, there are today (1981), a total of about 500 mobile units and 2100 fixed major platforms worldwide. For the North Sea, corresponding figures are about 60 mobile units and 90 fixed major platforms.

The total number of rig-years (1.1.1970 to 31.12.1981) for mobile units worldwide is 1051. A corresponding number for the North Sea is 516 (according to "Ocean Industry").

Geographic location	Total number of Platforms		Note
	All platforms	Major platforms only	
North Sea		90	U.K., Norwegian, Danish and Dutch Sectors
U.S.A.	2930	1270	
Middle East		260	
Total Worldwide		2100	

Table 1. Estimated number of fixed platforms in 1982 (Source: VERITAS).

4. SHIP COLLISIONS

Definitions

Ship collision data may be divided into the following categories:

a. Drifting buoys and other objects.
b. Drifting ships and barges.
c. Drifting fishing vessels.
d. Infringements of 500 m safety zone around offshore installations.
e. Impacts and collisions from supply vessels and other offshore-related traffic.
f. Collisions and near-misses from non-offshore related ship traffic (mainly trawlers and merchant ships).

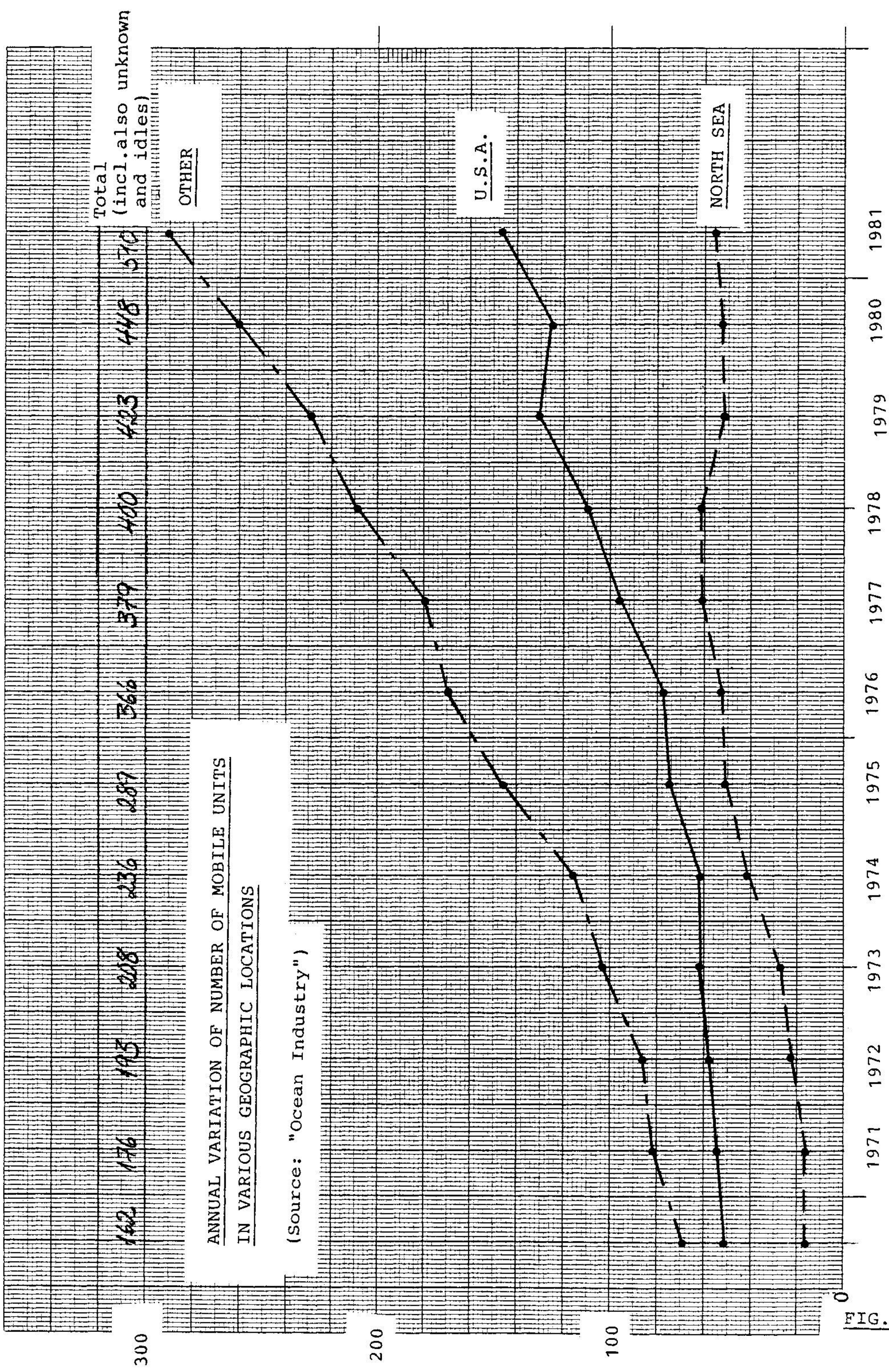
Total (incl.also unknown and idles)
142 176 193 208 236 287 366 379 400 423 448 570
OTHER
U.S.A.
NORTH SEA
ANNUAL VARIATION OF NUMBER OF MOBILE UNITS IN VARIOUS GEOGRAPHIC LOCATIONS
(Source: "Ocean Industry")
1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981
300
200
100
0

FIG.1.

An impact is defined as a type of collision causing only minor structural damage. No immediate repair is necessary. The accident is noted in the Captain's Journal with no further action taken. An impact is normally caused by the offshore-dedicated traffic (supply vessels, etc.).

A collision causes major structural damage usually necessitating immediate repair.

a. Drifting buoys and other objects - Norwegian sector

The main sources of information are the Main Rescue Centres in Stavanger and Bodø. Table 2 presents the monthly variation of reported drifting barges and other objects during 1979 and 1980. (Norwegian sector south of 65°N). As can be expected, there are concentrations in the Ekofisk, Frigg and Statfjord field areas. More complete information may be found in ref. [6].

MONTHLY VARIATION IN 1979

	Jan./ Feb.	March/ April	May/ June	July/ Aug.	Sept./ Oct.	Nov./ Dec.	Total 1979
BUOYS	31	22	9	0	14	18	94
OTHER OBJECTS	3	6	7	2	3	4	25
TOTAL	34	28	16	2	17	22	119
BUOYS AND OBJECTS IDENTIFIED BELONGING TO OFFSHORE INDUSTRY	11	8	3	1	4	7	34

(Included above)

MONTHLY VARIATION IN 1980

	Jan./ Feb.	March/ April	May/ June	July/ Aug.	Sept./ Oct.	Nov./ Dec.	Total 1980
BUOYS	21	25	4	1	13	15	79
OTHER OBJECTS	1	1	1	3	2	1	9
TOTAL	22	26	5	4	15	16	88
BUOYS AND OBJECTS IDENTIFIED BELONGING TO OFFSHORE INDUSTRY	10	4	0	0	5	4	23

(Included above)

Table 2. Ref. [5].

b. Drifting ships and barges - Norwegian section

Main sources of information are again the Main Rescue Centres. Reported incidents are presented in Table 3, ref. [7]

INCIDENT NO.	DATE	INCIDENT OCCURRED IN AREA	VESSEL/BARGE INVOLVED	INSTALLATION(S) THREATENED	
1.	Dec. 1971	Ekofisk	Barge with jacket platform	None on Norwegian side	
2.	18.12.74	Ekofisk	300 ft. barge	Ekofisk	Broke adrift while under tow German tug stood by in attendance. Weather: deteriorating force 10
3.	11.12.79	Outside Stavanger	Barge	None	
4.	12.12.79	Outside Lista	Barge	None	
5.	12.12.79	Frigg	10,000 ton barge H102	Frigg and later Statfjord, Brent	Tow parted 30 n.m. SE of Frigg. Tow re-established on 13.12. Weather: force 10-11, waves: 9 m.
6.	17.12.79	British sector	British ship "Manor Park" 480 on coaster	Ekofisk-Teeside pipeline booster platform 36/22A	Ship abandoned. Cargo of aluminium ingots shifted. Tow established on 18.12. Weather: force 10-12
7.	22.04.80	Outside Stadt	Barge	None	Reported drifting. Taken on tow.

Table 3. (contd.)

INCIDENT NO.	DATE	INCIDENT OCCURRED IN AREA	VESSEL/BARGE INVOLVED	INSTALLATION(S) THREATENED	
8.	01.01.81	Ekofisk	Accommodation vessel "Berge worker"	None on Norwegian side	Weather: Hurricane waves: 12 m.
9.	15.01.81	Statfjord	Fishing vessel "Harøyfjord"	3 mobile drilling rigs	Ship abandoned weather: full gale
10.	19.03.81	German sector	Dutch trawler	Ekofisk-Emden Pipeline booster platform GNSC/H-7	Drifting with no crew on deck 50 m. past platform "Near-miss" collision
11.	24.11.81	Ekofisk	Service platform "Phillips SS"	Ekofisk-Tor platform	Weather: Hurricane. Anchor lost

Table 3.

There are a number of features common to many of the incidents reported. Most of the incidents (about 90%) occurred during the months of December and January, usually during very severe weather conditions.

Most of the incidents threatening a major offshore field involved vessels which service the offshore oil industry (all incidents except one).

At an offshore field during the construction phase, towed barges present a great danger (half the total number of incidents). During the operation phase, anchored installations (accommodation-service platforms/vessels) are dangerous.

Pipeline booster platforms, which are isolated from other offshore traffic are particularly exposed to small drifting vessels, i.e. fishing vessels, trawlers and coasters, which are all, of course, vulnerable to extreme weather conditions.

As can be seen, a total of 11 incidents of drifting vessels and barges were reported in the Norwegian sector during the period 1.1.1971 to 1.1.1982. None of these incidents resulted in the vessel concerned colliding with an installation. Only one incident was a "near-miss" collision (No. 10), which, however, was a special case involving, it seems, a "sleeping crew". One can, therefore, say that with the above "exception" in no case did the drifting vessel/barge approach closer than some nautical miles of an installation. Thus, statistically and historically, one would only expect a small minority of drifting vessel incidents to lead to collisions.

c. Drifting fishing vessels - Norwegian sector

Fishing vessels which are temporarily or permanently out of control may also represent a threat to installations in the area. With the assistance of local VERITAS surveyors, a survey is presently being carried out registering such occurrences for about 326 Norwegian ocean-going fishing vessels with VERITAS classification. Results will be presented at the end of 1982.

d. Infringements of safety zones - Norwegian and U.K. sectors

In Tables 4a and 4b, the reported infringements of the 500 m safety zones in the Norwegian and U.K. sectors are presented.

Table 4a. Infringements in the Norwegian sector.

Total number

YEAR	1975	1976	1977	1978	1979	1980	1981***	TOTAL
NUMBER	4	15	13	10	39	13	7	101

Total number split on Offshore Fields

FIELD	1975	1976	1977	1978	1979*	1980	1981***	TOTAL
EKOFISK	4	15	13	5	34	13	7	91
FRIGG	0	0	0	4	0	0	0	5**
STATFJ.	0	0	0	1	3	0	0	4

* Gives a total number of 37 incidents while other sources give 39 incidents.

** Elf assumes total incidents since 1974 to be 5.
Elf informs that no incidents have been reported in the last two years.

*** No incidents have been reported after 31.3.81

Total number split on Type of Vessel

SHIP TYPE	TOTAL NUMBER	IN %
FISHING VESSEL	66	73
NAVAL SHIPS	11	13
CARGO SHIPS	3	3
YACHTS	2	2
UNIDENTIFIED SHIPS	4	4
AIRPLANES	5	5
TOTAL	91	100

Table 4 b. Infringements in the U.K. sector

Total number

Infringements Type of Vessel	1976	1977	1978	1979	1980	%
TRAWLERS	15+	15+	15	33+	45	< 79.0
COASTERS	2	2	2	3	1)	
NAVAL TUGS	1	2	0	0	0)	
TANKERS	1	0	1	0	0)	> 21.0
CARGO	0	1	3	3	1)	
UNKNOWN OR OTHER	2	1	3	1	1)	
FREIGHTERS	0	0	1	0	0)	
TOTAL	21+	22+	26	40	48	100.00

More complete information may be found in ref [8].

e. &
f. Worldwide statistics on offshore collision accidents

In the following, worldwide statistics on collision accidents are presented according to Lloyds´ List, extracted from the VERITAS Offshore Accidents Databank, ref [1].

Tables 5a to 5h are self-explanatory; however, some comments should be added.

As can be seen from Table 5a, the number of collision accidents ranks second to weather accidents. The total number of worldwide reported collisions during the 11 year period for all platforms (fixed and mobile) is 82.

From Table 5c, it can be seen that the average frequency of collisions per 100 mobile rig-years, as can be expected, is highest for the North Sea compared to the U.S.A. and worldwide.

From Table 5d, it can be seen that the great majority of collisions occur during the operating phase.

According to Table 5e, 15 out of 82 collisions have occurred in the North Sea since 1970.

Looking at Table 5f, we shall notice, however, that only 4 of these collisions have caused damage, the other 11 only caused minor or no damage at all. Corresponding figures for the USA (Tables 5e and 5g) are 22 and 8, respectively.

Though the number of collisions are high, the consequences are normally small and also the number of lives lost by collisions are relatively small, see Table 5h.

Type of Accident	Struc. Loss							RELATIVE FREQUENCY OF ACCIDENT TYPE (%)
	Tot. Loss	Sev. Dam.	Damage	Min. Dam.	No Dam.	Unknown	Sum	
WEATHER	5	10	23	17	9	-	(82)64	20(16)
CAPSIZING	11	4	1	1	-	1	18	
COLLISION	2	2	15	20	13	-	(82)52	16(16)
GROUNDING	1	6	2	3	1	-	13	
BLOWOUT	8	6	12	7	6	-	(80)39	12(16)
LEAKAGE	1	2	3	-	2	-	8	
MACHINE	-	1	5	6	-	-	12	
FIRE	1	3	12	8	-	1	25	8
EXPLOSION	-	2	5	6	-	1	14	
OUT OF P.	-	-	2	-	4	1	7	
FOUNDER.	3	-	-	-	-	1	4	
STR. DAM.	1	3	16	20	2	-	42	13
OTHER	-	1	3	8	15	1	28	9
UNKNOWN	-	-	-	-	-	-	-	
SUM	33	40	99	96	52	6	326	100

Table 5a. Collisions Worldwide.

Number of accidents distributed on "Type of Accident" and "Degree of Structural Loss", for mobile units only.

Period of occurrence: 01.01.70 - 31.12.81
Source: "Lloyd's List"

( ) Corresponding figure including also fixed platforms.

1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	SUM
4(5)	3(4)	3(4)	4(6)	1(3)	7(13)	4(9)	2(4)	8(11)	6(6)	7(13)	3(4)	52(82)

Table 5b. Yearly distribution of total number of collisions worldwide. (Source: "Lloyds List").

1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
2.5	1.7	1.6	1.9	0.42	2.4	1.1	0.53	2.0	1.43	1.58	0.59

Average
Worldwide: 1.39
North Sea: 1.55
U.S.A.: 1.05

Table 5c. Yearly distribution of total number of collisions worldwide per 100 rig-years for each year. (Source: "Lloyds List" and "Ocean Industry").

Type of Accident	OPERATION MODE					
	CONSTRUCTION	TRANSFER	MOBILIZE	OPERATING	UNKNOWN	SUM
WEATHER	2	24	1	37(50)	-	64(82)
CAPSIZING	-	6	3	7	2	18
COLLISION	5	7	-	31(57)	9	52(82)
GROUNDING	2	8	2	1	-	13
BLOWOUT	-	-	-	38	1	39
LEAKAGE	-	2	-	6	-	8
MACHINE	-	7	-	4	1	12
FIRE	2	2	1	16	4	25
EXPLOSION	6	1	-	6	1	14
OUT OF P.	-	5	-	1	1	7
FOUNDER.	-	4	-	-	-	4
STR. DAM.	4	6	9	20	3	42
OTHER	3	7	1	15	2	28
UNKNOWN	-	-	-	-	-	-
SUM	24	79	17	182	24	326

Table 5d. Collisions Worldwide.

Number of accidents distributed on "Type of Accident" and "Operation Mode", for mobile units only.

Period of occurrence: 01.01.70 - 31.12.81
Source: "Lloyd's List"

Type of Accident	SHELF		
	U.S.A	NORTH SEA	WORLDWIDE
WEATHER	10(16)	18(23)	64(82)
CAPSIZING	10	-	18
COLLISION	11(22)	8(15)	52(82)
GROUNDING	1	3	13
BLOWOUT	18	3	39
LEAKAGE	-	2	8
MACHINE	2	4	12
FIRE	8	5	25
EXPLOSION	2	5	14
OUT OF P.	-	1	7
FOUNDER.	1	-	4
STR. DAM.	10	7	42
OTHER	3	16	28
UNKNOWN	-	-	-
SUM	76	72	326

Table 5e . Collisions U.S.A. and North Sea

Number of accidents distributed on "Type of Accident" and "Geographic Location", for mobile units only.

Period of occurrence: 01.01.70 - 31.12.81
Source: "Lloyd´s List"

Type of Accident	Struc. Loss							RELATIVE FREQUENCY OF ACCIDENT TYPE (%)
	Tot. Loss	Sev. Dam.	Damage	Min. Dam.	No Dam.	Unknown	Sum	
WEATHER	1	1	8	5	3	-	18(23)	25(19
CAPSIZING	-	-	-	-	-	-	-	
COLLISION	-	-	2(4)	3(6)	3(5)	-	8(15)	11(12)
GROUNDING	-	2	-	1	-	-	3	
BLOWOUT	-	-	1	1	1	-	3	7(8)
LEAKAGE	-	-	-	-	2	-	2	
MACHINE	-	-	1	3	-	-	4	
FIRE	-	-	2	3	-	-	5	7(10)
EXPLOSION	-	1	1	2	-	1	5	
OUT OF P.	-	-	-	-	1	-	1	
FOUNDER.	-	-	-	-	-	-	-	
STR. DAM.	1	1	1	3	1	-	7	
OTHER	-	-	1	4	11	-	16	
UNKNOWN	-	-	-	-	-	-	-	
SUM	2	5	17	25	22	1	72	100

Table 5f. Collisions North Sea

North Sea accidents distributed on "Type of Accident" and "Degree of Structural Loss", for mobile units only.

Period of occurrence: 01.01.70 - 31.12.81
Source: "Lloyd´s List"

Type of Accident	Struc. Loss							RELATIVE FREQUENCY OF ACCIDENT TYPE (%)
	Tot. Loss	Sev. Dam.	Damage	Min. Dam.	No Dam.	Unknown	Sum	
WEATHER	1	4	1	3	1	-	10	13(11)
CAPSIZING	6	3	-	-	-	1	10	
COLLISION	-(1)	1(3)	2(4)	6(6)	2(8)	-	11(22)	14(15)
GROUNDING	-	-	-	-	1	-	1	
BLOWOUT	5	2	5	2	4	-	18(49)	24(33)
LEAKAGE	-	-	-	-	-	-	-	
MACHINE	-	-	1	1	-	-	2	
FIRE	1	2	3	2	-	-	8	10
EXPLOSION	-	-	2	-	-	-	2	
OUT OF P.	-	-	-	-	-	-	-	
FOUNDER.	-	-	-	-	-	1	1	
STR. DAM.	-	1	5	4	-	-	10	13
OTHER	-	1	-	2	-	-	3	
UNKNOWN	-	-	-	-	-	-	-	
SUM	13	14	19	20	8	2	76	100

Table 5g. Collisions U.S.A.

USA accidents distributed on "Type of Accident" and "Degree of Structural Loss", for mobile units only.

Period of occurrence: 01.01.70 - 31.12.81
Source: "Lloyd's List"

Type of Accident	Struc. Loss Tot. Loss	Sev. Dam.	Damage	Min. Dam.	No Dam.	Unknown	Sum	NUMBER OF LIVES LOST (%)
WEATHER	13	0	0	0	0	0	13(13)	3
CAPSIZING	21	6	0	0	0	1	28	
COLLISION	1	8	0	4	0	0	13(30)	3(5)
GROUNDING	0	6	0	0	0	0	6	
BLOWOUT	185 s	26	21	0	0	0	232 s(251)	45(42)
LEAKAGE	0	1	0	0	0	0	1	
MACHINE	0	0	1	0	0	0	1	
FIRE	0	0	0	0	0	0	0	
EXPLOSION	0	2	2	8	0	0	12	
OUT OF P.	0	0	0	0	0	0	0	
FOUNDER.	72 p	0	0	0	0	0	72 p(73)	
STR. DAM.	123 a	0	0	7	1	0	131 a(137)	26(23)
OTHER	0	0	0	2	0	0	2	
UNKNOWN	0	0	0	0	0	0	0	
SUM	415aps	49	24	21	1	1	511 aps (595)	100

Table 5h.

Number of lives lost distributed on "Type of Accident" and "Degree of Structural Loss", for mobile units only.

Period of occurrence: 01.01.70 - 31.12.81
Source: "Lloyd´s List"

a - "Alexander Kielland" included, 123 lives lost
p - "POHAI 2" included, 72 lives lost
s - "SEDCO 135-C" included, 180 lives lost

e. Impacts and Collisions from Offshore Dedicated Traffic - North Sea

In the U.K. sector, all impacts and collisions are required to be reported to the Department of Energy, Petroleum Engineering Division. In the Dutch and Norwegian sectors, however, no reporting system exists.

To our knowledge, no collisions causing serious damage have occurred as of today with offshore related traffic in the North Sea. Impacts, however, occur frequently. Table 6 presents some figures for the U.K. sector.

Table 6. Reported impacts and collisions in the U.K. sector. (Source: Department of Energy.)

(All impacts and collisions are between supply/standby vessels manoeuvring in the neighbourhood of fixed/mobile platforms).

1980		1981	
1.01 - 31.03.1980:	0	1.01 - 31.03.1981:	7
1.04 - 30.06.1980:	3	1.04 - 30.06.1981:	3
1.07 - 30.09.1980:	0	1.07 - 30.09.1981:	1
1.10 - 31.12.1980:	6	1.10 - 31.12.1981:	5
TOTAL 1980:	9	TOTAL 1981:	16

Most of the above occurrences can be characterized as impacts which caused very minor or no damage to ships and/or platforms.

For Norwegian waters, similar reports are not available for public use. A confidential investigation is presently being carried out by VERITAS in order to assess incidents of collisions and impacts which have occurred with supply ships and other offshore related traffic. 32 ship-owners have been contacted, who, together own 168 VERITAS classified ships. Also, 13 mobile rig-owners have been contacted. A few overall figures may be given; 17 ship-owners and 9 rig-owners have responded so far. During the period 1975-81, a total of 30 impacts have been reported by the ship masters.

f. Collisions and Near-misses from External Passing Traffic

North Sea

To our knowledge, only two collisions have been reported in the North Sea area between external passing traffic and an offshore platform. Both collisions involved trawlers en route; one occurred in the Dutch sector and one in the U.K. sector.

The fisherman in the Dutch sector collided with a platform in 1973. No further details are known.

The incident in the U.K. occurred in the autumn of 1981 when a trawler struck a fixed platform and stuck. It bent a 5′ section of deck upright.

As regards near-misses, we know only of one reported incident when a Dutch trawler with no crew on deck passed full speed 50 m away from the NORPIPE pipeline booster platform, GNSC/H-7. The incident was reported to the authorities as violation of the 500 m safety zone. Certainly, other near-misses must have occurred but it is often difficult to collect any kind of information since no written reports normally exist.

Other parts of the world

In other parts of the world, collisions certainly have occurred. We know, however, of only one incident which has been publicly reported. This occurred in August 1981, outside Louisiana in the Gulf of Mexico, involving a tanker running into a steel jacket platform at 18 knots. Contributing causes to the collision were that the existence of the platform was unknown to the ship's master, that a blind sector existed on the ship's radar due to the ship's foremast, and the decision of the master not to follow the recommended shipping lane through the area (ref. [8]).

5. CONCLUSIONS

We have, in this paper, presented some relevant statistics on collision accidents involving offshore structures. It remains to be seen, however, what use we can make of the available statistics in order to achieve our objective in gaining a better understanding of the problems and reducing the collision risk in the future.

Obviously, the probability for major offshore collisions in the North Sea is very small, making probability calculations rather uncertain. Based on the two collisions known today, an estimated collision frequency for passing trawlers may be established and applied to areas with varying passing trawler traffic. Similarly, this may be applied to impacts from offshore dedicated traffic. For other types of potential collision threats, however, where no collision has occurred in the North Sea, such as for instance, passing merchant ship traffic and drifting ships, etc. we are obliged to rely on other methods.

For collision consequence calculations, details of actual collisions would certainly be of great value. However, even in those few cases when such data are revealed, the initial ship data (course, speed, mass, etc.) are uncertain, and would only be known in cases of controlled test conditions.

Therefore, our main conclusion is that the available collision statistics today for the North Sea can only provide part of the input to a collision probability estimate. For collision consequence calculations, available collision data are of limited value.

Let us hope that our present situation of lack of offshore collision data from the North Sea will continue.

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