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THE CIRCUMSTANCES OF SEA COLLISIONS

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INTRODUCTION

Information relating to the circumstances of collisions is available from various sources but analysis of casualty information has usually been restricted to ships under one flag and been mainly applicable to accidents in restricted waters.

Collisions occurring within harbours, rivers, canals or inland waters almost invariably involve special circumstances or local factors. Investigations of such casualties are mainly of interest to the authorities responsible for maintaining safety of navigation in the area concerned and to mariners who are likely to navigate frequently through those waters. Collisions occurring in coastal waters and in the open sea are of international interest. Analysis of data relating to sea collisions may be relevant when considering possible changes to the International Regulations for Preventing Collisions at Sea and may have particular application to the establishment and revision of routeing schemes.

Collisions occurring outside port limits frequently involve ships of different flags, so no single national authority is likely to receive sufficient data from its own ships for a worthwhile analysis of casualties. There appears to be need for some organized system of pooling information. The Maritime Safety Committee of IMCO (**) has established an arrangement for receiving and circulating reports of serious marine casualties but such reports give insufficient information to be of much practical value. There is little prospect of setting up an official data bank of detailed cases in the near future.

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(**) Editor's note : Now IMO (International Maritime Organization) since May 1982.

Some results of a statistical survey of world-wide collisions carried out at the City of London Polytechnic were reported in the Proceedings of the Third International Symposium [1]. From an initial data bank of basic information relating to over 2,000 collisions that have occurred during the last 25 years it has been possible to obtain further details of over 700 cases. The Polytechnic computer is being used in their analysis. Before commenting on some of the preliminary results of this investigation it may be helpful to discuss the problems involved in obtaining satisfactory information.

SOURCES OF INFORMATION

When a ship is involved in a casualty the master is usually required to complete an accident report form, for submission to the appropriate national authority, giving a brief summary of the circumstances of the casualty. In the case of a collision the information required will normally include the time and position of the accident, visibility, initial course and speed, form of detection and equipment being used. The amount of additional information to be completed varies with different authorities. Space may be provided for further comments but masters are usually reluctant to supply information on such matters if this is not specifically required.

Upon the receipt of such information, if not before, the authorities may decide to hold an investigation into the circumstances of the casualty; some administrations apparently arrange for investigating boards to undertake an inquiry whenever a serious marine casualty occurs. Such a policy would result in official investigations of almost all collisions occurring outside port limits; other administrations hold more elaborate and costly court proceedings for a small proportion of casualties which merit special consideration, the majority of serious accidents being left for the attention of individual investigators who make a confidential report to the authorities concerned. Yet other national authorities appear to make little if any provision for a full investigation of serious marine casualties.

A major disadvantage of a government investigation into the causes of a collision, as a source of information about the circumstances, is that evidence will not usually be obtained from a foreign ship involved. Such evidence is likely to be withheld, as full disclosure may not be considered to be in the best interests of the parties concerned before the settlement of financial claims for damages and detention. This factor may be taken into account by some authorities when deciding whether to hold an investigation which involves a foreign ship.

Information concerning ship collisions may also become available as a result of civil actions between the parties concerned, to establish the degree of fault for the apportionment of damage costs. When such cases reach the courts the cross-examination of witnesses from both ships is likely to produce a detailed account of events preceding the collision. Unfortunately, there is usually a considerable delay before the court hearing takes place so that witnesses may be questioned on what happened three or more years ago. The majority of civil actions are settled out of court so that detailed information cannot readily be obtained.

It is, of course, widely appreciated that the evidence of witnesses cannot always be relied upon. This will apply particularly to the speed of the ship in restricted visibility and to the action taken to avoid collision. In some of the cases which come before the courts the evidence is so conflicting as to give the impression that it would be very difficult to determine what happened in the majority of collisions, but such cases are not typical. The few collisions which become the subject of court proceedings are usually those in which there is a wide discrepancy between the respective versions of how the situation developed so that a settlement cannot be agreed upon. In the course of this investigation into a large number of collisions separate reports have often been received from different sources for the two ships involved and it has usually been possible to match up the evidence to get a reasonably accurate indication of the situation preceding the collision.

ACQUIREMENT OF DATA

In view of the difficulties of obtaining full details of the circumstances of most collisions, and the necessity to minimize the amount of information to be requested from authorities and individuals supplying data from their own records, it was decided to restrict the investigation to the determination of the location, visibility, type of encounter situation and form of action taken. The form of questionnaire shows the amount of data requested for each case.

Data were first collected from published material such as court judgements, reports of government investigations and other accounts of casualties. From the initial data bank based on *Lloyd's Casualty Reports*, lists of ships involved in a collision were produced for each major flag and for each year, with the date of the accident given in each case. Alphabetical lists were also produced. Requests for assistance in obtaining the data were then made to various authorities, organizations and individuals in several maritime countries.

It has often proved difficult to obtain the data because of the confidential nature of the documents involved and the translating problems associated with reports from abroad. Very little information could be obtained for the earlier years, because the papers concerned had either been destroyed or become almost inaccessible. Information has not been sought for collisions which have occurred within the last two years as most of such cases are still the subject of investigations or civil actions. Nevertheless, there has been a very good response. For the years 1968-1977 it has been possible to obtain data from at least one ship in 50 per cent or more of known sea collisions.

Assistance has been received from numerous sources and this is very gratefully acknowledged. Particular gratitude is expressed to Captain BURGER of the University of Wales Institute of Science and Technology for providing a considerable amount of data from reports received from the Netherlands, and to Professor KANDORI of the Shimonoseki University of Fisheries for completing a large number of data forms from reports of investigations made in Japan. The Japanese data are of particular value because it becomes possible to give separate consideration to the two most congested coastal regions of Japan and North West Europe.

In cases where information could not be obtained for each of the two ships involved in a collision it was usually possible to obtain the voyage data for one vessel and to determine the probable form of encounter situation by reference to the chart. However, it has been possible to obtain data from both ships in over 500 cases.

RESULTS OF THE INVESTIGATION

This investigation has been restricted to collisions between vessels of over 100 tons gross, proceeding on passage and not engaged in special activities such as fishing, replenishment or naval exercises. It applies to collisions occurring world-wide in coastal waters or the open sea but does not apply to harbours, rivers, canals or inland waters. Narrow straits such as the Sound, the Bosphorus and the Strait of Messina have been excluded from consideration but collisions in the Straits of Gibraltar and Singapore have been included.

Data request form

Date of collision	
Local time	
Position	
Approximate visibility	

Ship names		
Radar fitted ?		
Radar in use ?		
At detection :		
Course		
Speed		
Detection method		
Relative bearing		
Range		
Helm action taken (with times or ranges)		
Engine movements (with times)		
Whether action restricted by 3rd ship, shoals, etc.		

Table 1
Annual incidence of collisions

Year	Reported by Lloyd's	Additional Japanese cases	Totals	Both ships over 1 000 tons	Detailed cases
1948-1955	–	–	–	–	18
1956	80	–	80	46	4
1957	68	–	68	46	6
1958	65	–	65	41	4
1959	76	–	76	45	11
1960	70	–	70	50	17
	359		359	228	
1961	77	–	77	51	25
1962	57	–	57	41	9
1963	87	–	87	48	19
1964	83	–	83	51	22
1965	94	–	94	41	21
	398		398	232	
1966	81	6	87	48	28
1967	63	10	73	36	30
1968	77	10	87	45	39
1969	94	11	105	55	52
1970	89	11	100	52	55
	404		452	236	
1971	80	25	105	41	60
1972	67	18	85	45	45
1973	68	9	77	34	44
1974	70	23	93	40	54
1975	77	17	94	57	57
	362		454	217	
1976	69	10	79	34	44
1977	61	20	81	36	43
1978	68	7	75	46	24
1979	71	–	71	43	1
1980	65 *	–	65 *	35 *	
	334 *		371 *	194 *	
Totals	1 857		2 034	1 107	732

* Estimates have been made for 1980 based on data obtained for 11 months.

Table 2

Regional totals and trends, showing numbers of collisions known to have occurred in restricted visibility (R. vis.)

Region	1956-1960		1961-1965		1966-1970		1971-1975		1976-1980		Totals	Percentage in restricted visibility
	(r. vis.)	total	(r. vis.)	total	(r. vis.)	total	(r. vis.)	total	(r. vis.)	total		
Baltic Sea	(16)	37	(23)	42	(18)	39	(17)	33	(9)	21	172	48
Southern North Sea	(35)	82	(42)	73	(40)	71	(14)	32	(12)	21	279	51
Dover Strait	(51)	62	(69)	80	(37)	48	(7)	21	(10)	16	227	77
English Channel	(17)	24	(22)	29	(13)	23	(15)	22	(6)	16	114	64
E. coast U.K.	(15)	33	(9)	16	(6)	14	(6)	10	(5)	9	82	50
W. coast Spain and Portugal	(5)	13	(11)	29	(10)	17	(6)	15	(8)	12	86	47
Gibraltar Strait	(6)	10	(8)	13	(8)	13	(3)	3	(8)	17	56	59
Mediterranean	(6)	22	(4)	19	(2)	15	(8)	29	(4)	31	116	21
E. coast N. America	(16)	27	(14)	22	(12)	20	(9)	18	(5)	11	98	54
Malacca and Singapore Straits	(0)	2	(1)	5	(0)	13	(4)	26	(3)	20	66	12
Korea and Japan	(3)	5	(10)	29	(81)	114	(88)	163	(48)	113	424	54
SW Pacific	(2)	2	(2)	6	(3)	11	(6)	24	(4)	17	60	28
Other regions	(17)	40	(17)	34	(15)	55	(24)	58	(17)	52	239	38
Proportion in restricted visibility	53 %		54 %		54 %		46 %		39 %			

Table 1 shows the annual incidence of collisions satisfying the above criteria. The incidence of collisions taken from *Lloyd's Weekly Casualty Reports* has remained fairly constant at between 57 and 94 per annum over the 25-year period. Data relating to collisions in Japanese waters, not reported by Lloyd's, has been received for the years 1966-1978. These additional cases are almost entirely restricted to collisions between Japanese coastal vessels of less than 500 tons gross. The numbers of cases for which additional information has been received are also shown for each year in Table 1.

Table 2 shows regional totals of collisions for 5-year periods. The figures for Japan and Korea include the additional collisions not reported by Lloyd's, which must be taken into account when assessing trends. Additional cases have not been reported for early and recent years.

Although collisions in restricted water areas such as Tokyo Bay, Shimonoseki Strait, Kobe approaches and much of the Inland Sea have not been included in the figures, the incidence is now much higher off Japan than for any other region. The improvement off North West Europe can be largely attributed to the introduction of traffic separation schemes and there appears to be an urgent need for IMCO-approved schemes to be established off the Japanese coast.

Restricted visibility (less than 2 miles) was reported for 501 of the 732 detailed cases (68.4 per cent) but for the remaining collisions reported by Lloyd's, restricted visibility was only indicated in just over 40 per cent of the cases. Some collisions receive only a brief mention in *Lloyd's Casualty Reports* and the presence of fog, or other conditions restricting visibility, would not necessarily be reported.

The number of collisions known to have occurred in restricted visibility are also indicated, in parentheses, in Table 2. The actual numbers will be higher, as explained in the previous paragraph. Before the introduction of traffic separation the proportion of collisions occurring in restricted visibility in the Dover Strait was over 80 per cent. This proportion has decreased, due partly to the effects of the traffic separation scheme and partly to a lower incidence of fog in the region during recent years. By contrast only 12 per cent of collisions in the Malacca and Singapore Straits have apparently taken place in restricted visibility and in each case this was due to heavy rain showers.

Table 3 shows the effect of darkness on the incidence of collisions. When the visibility was known to be 'clear' the number occurring in darkness was found to be three times the number occurring in daylight. During restricted visibility there was found to be no appreciable difference. It was not possible to determine the relative effect of twilight as the times of collisions are often imprecise.

Table 3

Effect of darkness on the incidence of collisions

	Daylight	Darkness	Marginal
Collisions in clear visibility....................	60	180	8
Collisions in restricted visibility................	427	401	80
Visibility not reported........................	116	260	29

The numbers of collisions known to have occurred for each hour are indicated in Table 4. As expected, the numbers are appreciably lower between 0600 and 1800 in clear visibility. During fog, collisions are found to be more frequent from midnight to noon in all areas, and least frequent during the afternoon. This appears to indicate that advection fog is more likely to be experienced during the first half of the day, although this is not suggested in the textbooks on meteorology.

Table 4
Numbers of collisions related to hour and visibility

Hour	All known cases	In clear visibility	In fog all areas	In fog NW Europe	In fog off Japan
01	103	14	53	37	13
02	104	21	45	20	18
03	101	20	50	32	10
04	114	20	47	26	10
05	91	12	61	32	19
06	78	7	48	20	16
07	73	1	45	27	8
08	75	3	53	28	19
09	66	10	44	23	12
10	54	6	38	33	3
11	54	5	36	22	6
12	61	4	40	29	5
13	44	7	27	17	7
14	36	3	24	18	3
15	32	4	23	12	6
16	31	5	15	12	2
17	35	3	18	13	1
18	35	6	21	9	6
19	50	14	21	15	3
20	51	10	18	13	2
21	63	25	20	11	6
22	51	15	22	16	4
23	76	22	27	15	7
24	56	11	20	11	8

ENCOUNTER SITUATIONS

One of the main purposes of seeking further information relating to sea collisions was to investigate the circumstances of collisions associated with different types of encounters for both clear and restricted visibility.

The frequency of encounter rates associated with different patterns of traffic flow has been considered in several papers, as for instance by BARRATT [2] and

GOODWIN [3]. An example of the practical use of this approach, by DEGRÉ and LEFÈVRE, has been the estimation of encounters likely to have been produced by alternative routing schemes proposed for the English Channel. LEWISON has recently [4][5] made an assessment of the risk of a ship encounter leading to a collision by calculating the number of potential encounters for ships approaching within half a mile of each other for a particular area of the Dover Strait over a period of several years, then comparing the number of encounters of each type with corresponding types of known collisions.

The difficulty of attempting to compare collisions with potential encounters over a small area, for which the traffic pattern is known, is that the numbers of collisions resulting from different types of encounter are likely to be too small to obtain valid results. A survey of collisions over a much wider area would provide sufficient numbers to enable a breakdown to be made with respct to both type of situation and visibility, but the results could not easily be related to the corresponding numbers of encounters. However, a comparison of results obtained for different regions, or for the same region under different conditions of visibility, may give a clear indication of the effect of restricted visibility on different types of encounter situation and provide a very approximate measure of the degree of risk associated with each type.

Categories of encounter situations may be related to the aspect of each vessel, or to the difference between the initial courses. The first method may be more appropriate for comparison with the Collision Regulations, which clearly define an overtaking situation in terms of the relative bearing from the overtaken ship and which impose practical limitations in terms of aspect on the meeting-end-on situation. Table 5 indicates the seven categories of encounter situation selected, according to aspect. The approximate ranges of course-difference which are associated with each category are also indicated.

Table 5

Categories of encounter situations

Category	Relative bearing	Course difference
1. Meeting	Each < 5° on the bow	170-180°
2. Fine crossing	Each < 15°, one > 5°	150-175°
3. Crossing	Each < 30°, one > 15°	120-165°
4. Broad crossing	Each < 60°, one > 30°	60-150°
5. Converging crossing	Each < 112 1/2°, one > 60°	0-120°
6. Converging overtaking	Each < 150°, one > 112 1/2°	0- 65°
7. Parallel overtaking	One > 150°	0- 30°

Table 6 shows the numbers of collisions in each category for both clear and restricted visibility. The results are shown separately for the two most congested coastal regions of NW Europe and Japan and compared with the residual figures for all other areas. It must be emphasised that the breakdown is not precise due to the limitations of the evidence when considering marginal cases. However, each case has been carefully considered for the purpose of this classification so the margin of error should be small.

Table 6

Numbers of collisions related to encounter situations and visibility

	Category of encounter situation						
	1 (M)	2 (FC)	3 (C)	4 (BC)	5 (CC)	6 (CO)	7 (PO)
Clear visibility							
NW Europe	8	12	6	10	13	6	17
Japan	3	13	10	25	14	5	18
Other areas	7	16	9	12	9	3	11
Totals	18	41	25	47	36	14	46
Restricted visibility							
NW Europe	65	99	33	16	3	1	13
Japan	52	72	32	12	7	0	2
Other areas	26	43	12	4	0	1	4
Totals	143	214	77	32	10	2	19

Clear visibility situations

Only 18 cases have been included in the category of meeting situations in clear visibility. The Crossing Rule would probably have been applicable to some of these collisions in which the angle on the bow was of the order of 5° for one or both ships. Some of these meeting-end-on collisions could be attributed to bad look-out on both ships, usually involving small vessels. In a few cases the close presence of a third ship was claimed to have prevented early action. A third important cause was a late starboard turn by one ship in a starboard-to-starboard passing situation, sometimes associated with port helm action by the other vessel.

Where traffic separation is not in force the number of meeting situations may be expected to be of the order of three times the number of overtaking situations [6]. The higher frequency of meeting or fine crossing situations compared with overtaking situations has been confirmed by actual counts made on voyages through different regions [7][8]. Broad crossing situations will generally be even less frequent than overtaking situations except in certain small areas where numerous ferry crossings occur. As the numbers of meeting or fine crossing collisions are approximately the same as the overtaking collisions for each area considered, and generally less than the broad crossing collisions, it would appear that meeting situations are associated with less risk than overtaking situations and that crossing situations present the greatest risk.

Such results were to be expected as the Collision Rules require both ships to keep out of the way in a meeting situation and specify the form of action to be taken. Helm action is particularly effective in an end-on situation; a relatively small change of course will usually be sufficient to avoid collision – even if made by only one ship. In crossing and overtaking situations only one vessel is expected to take early action, the other ship is required to keep her course and speed. Until recently, the stand-on ship was not permitted to take action until a very late stage. Crossing situations could be expected to be more dangerous than overtaking situations because of the higher rate of approach.

The predominant cause of collisions associated with crossing or overtaking situations in clear visibility is bad look-out in the give-way ship. An appreciable number of overtaking collisions (9 cases) were mainly attributed to a failure of the steering system of one ship when passing at close distance. Interaction sometimes contributed in the final stages but could not be regarded as an initial cause of collisions at sea.

Some crossing collisions could be, at least partly, attributed to course alterations made for navigational purposes, when rounding headlands or passing through areas of shoals. Several examples of these were noticed in the region of the Malacca and Singapore Straits. There would thus appear to be some justification for establishing traffic separation schemes in such areas even though the visibility is unlikely to be restricted by fog.

The frequency of encounters is normally considered to increase as the square of the traffic density, but the probability of collision associated with crossing and overtaking situations appears to decrease in regions of high traffic density due to the increased vigilance of the watchkeeping officers and, possibly, to the presence of the master on the bridge. Despite the high frequency of broad crossing situations in the narrow part of the Dover Strait, there seems to be no record of a collision resulting from a broad crossing encounter in clear visibility in the area now covered by the traffic separation scheme for the full period of 25 years.

Restricted visibility situations

Table 6 shows that in restricted visibility there is a considerable increase of collisions associated with meeting and fine crossing situations, although restricted visibility is only experienced for a very small percentage of the time. The numbers of collisions resulting from broad crossing and overtaking situations are less when the visibility is restricted. This indicates that in reduced visibility the probability of collision is increased by a factor of several hundred for meeting and fine crossing situations, but by a much smaller factor for broad crossing and overtaking situations.

Several of the overtaking collisions in restricted visibility occurred in traffic lanes of traffic separation schemes and in almost every case the accident could be at least partly attributed to a third ship. This is the type of situation which has been investigated by CURTIS [9][10] and the present results confirm the value of this line of research. A further major cause of such collisions was poor radar look-out. Only one case of an overtaking collision associated with failure of the steering system has been received for restricted visibility. The low speed of approach in overtaking situations gives more opportunity for avoiding action to be taken on visual sighting, compared to a meeting situation with the same range of visibility.

Most of the collisions resulting from broad crossing encounters in poor visibility occurred off the coast of Japan or in the southern part of the North Sea.

Small vessels were usually involved and in the majority of cases the initial radar detection range was less than 5 miles for at least one ship.

Meeting or fine crossing situations in restricted visibility account for over 50 per cent of the total number of collisions for which details have become available. The circumstances of such collisions have become familiar from several well-publicized cases. It is almost invariably found that no appreciable helm action was taken until a very late stage. The new regulations place more emphasis on the use of starboard helm action to avoid a close quarters situation, but there is little evidence to suggest that the early application of substantial port helm has proved dangerous. Several collisions of this type have resulted from starboard helm action by one ship in what would have been a starboard-to-starboard passing situation.

EFFECT OF COURSE DIFFERENCE

Figures 1 and 2 show a breakdown of numbers of collisions in terms of the difference between the initial courses, for both clear and restricted visibility. Once again it must be stressed that the number should not be assumed to be precise, due in some cases to the limitations of the available evidence.

This representation indicates more clearly that the risk of collision is greater for encounters between vessels proceeding in the same general direction than for vessels proceeding in opposite directions in good visibility, but that the situation is reversed in restricted visibility. The lowest incidence of collision is associated with a course difference of 30-90° in both clear and restricted visibility.

The breakdown does not show clear justification for the requirement that a traffic lane should be crossed as nearly as practicable at right angles. A right-angled crossing is made in the least time but the extra few minutes taken to cross at 70°, or even 60°, to the lane axis would be unlikely to result in additional encounters at normal rates of flow, except in the case of very slow craft.

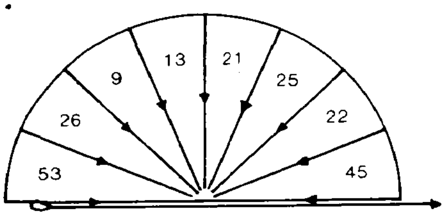

FIG. 1. – Numbers of collisions in clear visibility in relation to sector of course difference.

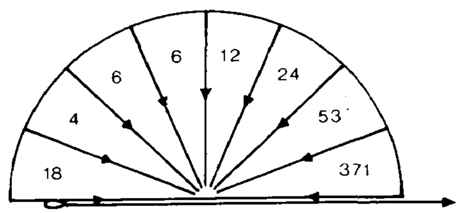

FIG. 2. – Numbers of collisions in restricted visibility in relation to sectors of course difference.

CONCLUDING REMARKS

This paper has summarized some of the preliminary results of an investigation of the circumstances of world-wide sea collisions. Additional data are being sought for more recent years in order to assess the effects of the changes to the Collision Rules which came into force in July 1977. A more detailed analysis of the results is being undertaken and it is hoped to maintain, and update, the data bank for a further period.

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THE SEA

Until recently the sea has been relatively free of many of the problems which have beset us on land : division of territories, pollution and endangered species, to cite a few. Once the high seas were considered the common property of all mankind, *res omnium communis* . Now we are in the process of dividing them into private reserves and privileged zones and adding another dispute to the already long list of international conflicts. At some locations, marine pollution, once almost insignificant, has recently increased to levels harmful to both marine life and man. There is now a growing and justifiable concern about overexploitation of several fish species and the mighty whale.

The magic formula sought by the teams of international lawyers and statesmen is how to divide the seas in an equitable way that will satisfy the territorial appetites of a multitude of nations – spurred, no doubt, by the promise of new-found riches, both real and imaginary. On the other hand, the primary effort of those entrusted by the public to assess the impact of man-induced changes in the environment on our lives has been toward developing a plan in which economic gains are balanced against physical health hazards. Conspicuously absent in all of these "grand schemes" is what effect the changes in the environment will have in our spiritual and aesthetic interaction with the sea. (*Interdiscip. Sci. Rev.* 5, (1980)).

It is imperative to emphasize that as long as history can recall, and probably even earlier, the sea has exerted a profound influence on human culture. It is not surprising that this has been so, for in addition to resources which she provides, her sublime beauty, her stateliness, and her ever-changing moods, the spectrum of which ranges from serene tranquility to awesome power, have been a source of spiritual and aesthetic experiences for man. The sea is the primordial mother in the cosmogonies of many of the ancient peoples – still is, according to current scientific thought – and there is no major branch of art that does not contain a multitude of works dealing with the sea. It was not only the aesthetic qualities of the sea which occupied the artistic mind, howewer. Using the sea either as an essential participant in a cosmic drama or as a worthy adversary for their seafaring heroes, artists such as Homer, Coleridge, Melville and Conrad went beyond the mere representation of concrete reality and gave us the themes which are universal : beauty of nature as reflected in the beauty and the dignity of human character; awareness of one's strengths and weaknesses when tested against the elements of nature; crime against God or God's creatures with resulting atonement and expiation; a voyage that not only leads to victory over the elements of nature, but also provides a cure for the pride that has over-reached itself.

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