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AN INVESTIGATION OF MARINE TRAFFIC IN SOUTH-EAST ASIAN WATERS AND IN THE CARIBBEAN

K. H. Kwik and W. Stecher

SUMMARY Knowledge of traffic behaviour is an essential pre-requisite for the determination of traffic safety and the finding of appropriate means for its preservation or enhancement. Subsequent to previous works, the authors in this paper present results of traffic surveys conducted in the Malacca Strait, Sunda Strait, South China Sea and in the Caribbean. The investigated areas are supposed to be much frequented. The surveys were conducted from a ship making a normal voyage. The results comprise numbers of meeting, crossing and overtaking encounters for certain periods of time, passing distances and courses and speeds of encountered ships. The results are given as graphs and in tabular form and are discussed.

INTRODUCTION A number of spectacular marine accidents at short intervals of time, including a midocean collision between two VLCCs off the South-East African coast, have caused much public concern about the status and trends of development of the safety of human life at sea and the protection of the marine environment against harmful pollution.

Substantial pressure of public opinion on the governments of practically all shipping nations has produced accellerated, sometimes even hectic moves towards new rulemaking by the national as well as the international legislators as e.g. IMCO. The International Conference on Tanker Safety and Pollution Prevention and the International Conference on Training and Certification of Seafarers which are to take place in 1978 may stand as examples for these endeavours.

Some doubts have been uttered, however, particularly by the shipping industry whether the proposed rulemaking will always produce the best available solution to the safety and pollution problem. There are rather reliable and in fact very impressive estimates of the costs involved with some of the proposed new construction and equipment regulations. At least in some cases there is very little reliable evidence available regarding the prospective benefits. This deplorable situation is mainly due to the fact that the science

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of marine traffic safety is only just coming off infantile age to take care of the many tasks of problem definition, problem description and problem solving which lie at the hands of the shipping industry, the governments of maritime nations and ultimately the community of mankind in general to maintain the safety at sea and the protection of the marine environment as a vital condition for the long-term survival of the human race.

It is our objective to contribute to this task in a field which has until recently been ploughed by personal, subjective opinion instead of scientific, objective evidence. It is the field of marine traffic safety which in turn may be defined as the accumulate safety of individual vessels if, when and as long as they participate in marine traffic. Reliable information on the characteristics of marine traffic is quite obviously urgently needed to determine whether and which specific measures, technical or organisational, voluntary or mandatory should be taken to maintain and promote marine traffic safety. Such reliable information is also needed as a basis for determining the risk of a casualty, the overall costs to the community if these risks materialize and consequently the acceptable costs to reduce or even to remove such risks.

Following previous works [1][2] the authors now present results of traffic surveys conducted in some areas in South-East Asia and in the Caribbean. The investigated areas are by general opinion of the shipping community believed to be much frequented. The surveys were made from a ship sailing through the areas. The objective was to collect data regarding the type, number, distribution, speed and course of all ships and other marine craft observed.

SCOPE OF INVESTIGATION The surveys were conducted from the container carrier "TOKIO EXPRESS" (speed 27 knots) during two round trips to the Far East in spring and summer 1976. This ship will be denoted as "own ship". Traffic scenes were preserved by cinematographing the radar picture and recording on a sheet of paper further details of the traffic. The method of recording and evaluating the data has already been given in [1] . The investigated areas were the areas swept by the radar range. In the present paper we would like to give results of traffic surveys conducted in the areas specified below. The areas are all restricted in the sense that coast lines, islands, banks and shoals confine the navigable waters. The clock times given are local times.

Malacca Strait The investigated area is the main fairway in the strait extending from latitude 3°03' N, longitude 100°47' E (16 n.m. northwest of One Fathom Bank lighthouse) to latitude 1°16' N, longitude 103°23' E (8 n.m. west of Tanjong Piai, see Fig. 1 a). The area represents the narrowest part of the Malacca Strait, where on many places due to numerous banks the fairway is only about 7 n.m. wide, and is about 189 n.m. long.

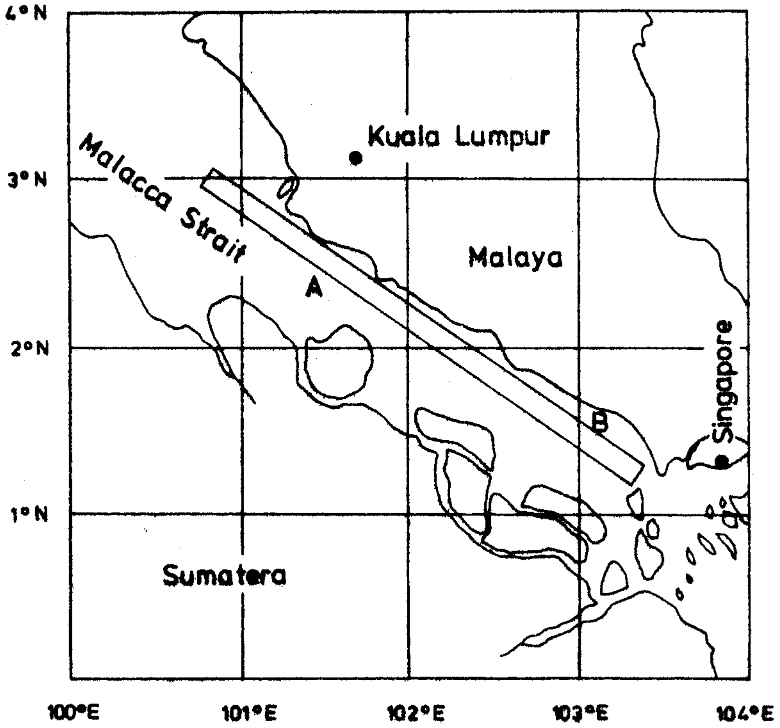

Fig. 1 a Investigated area in the Malacca Strait

One survey was conducted on Friday, March 19, 1976, from 6.55 to 14.06 o'clock while travelling in south-east direction. The survey time was 7 hours and 11 minutes. This survey is denoted "Survey A" in this paper.

A second survey was conducted on Saturday, April 3, 1976, from 0.40 to 8.29 o'clock while travelling in north-west direction. The survey time was 7 hours and 49 minutes. This survey is denoted "Survey B".

South China Sea The investigated areas comprise two shipping lanes. One of them is the lane usually used monsoon permitting from Singapore to Hongkong and vice versa and the other is the lane from the north of the Philippines to the entrance of Selat-Selat Gelasa (see Fig. 1 b). The first lane extends from lat. 1°27' N, long. 104°34' E (12 n.m. north-east of Horsburgh lighthouse) to lat. 21°53' N, long. 114°20' E (17 n.m. south of Wanglan lighthouse) and is about 1380 n.m. long.

One survey was conducted in this lane from Saturday, March 20, 1976, 20.45 o'clock, to Tuesday, March 23, 1976, 4.10 o'clock, while travelling northerly. The survey time with due regard to the time shift was 54 hours and 55 minutes. This survey is denoted "Survey C".

A second survey was conducted from Tuesday, March 30, 1976, 19.45 o'clock, to Friday, April 2, 1976, 2.23 o'clock, while travelling southerly. The survey time was 55 hours and 8 minutes. This survey is denoted "Survey D".

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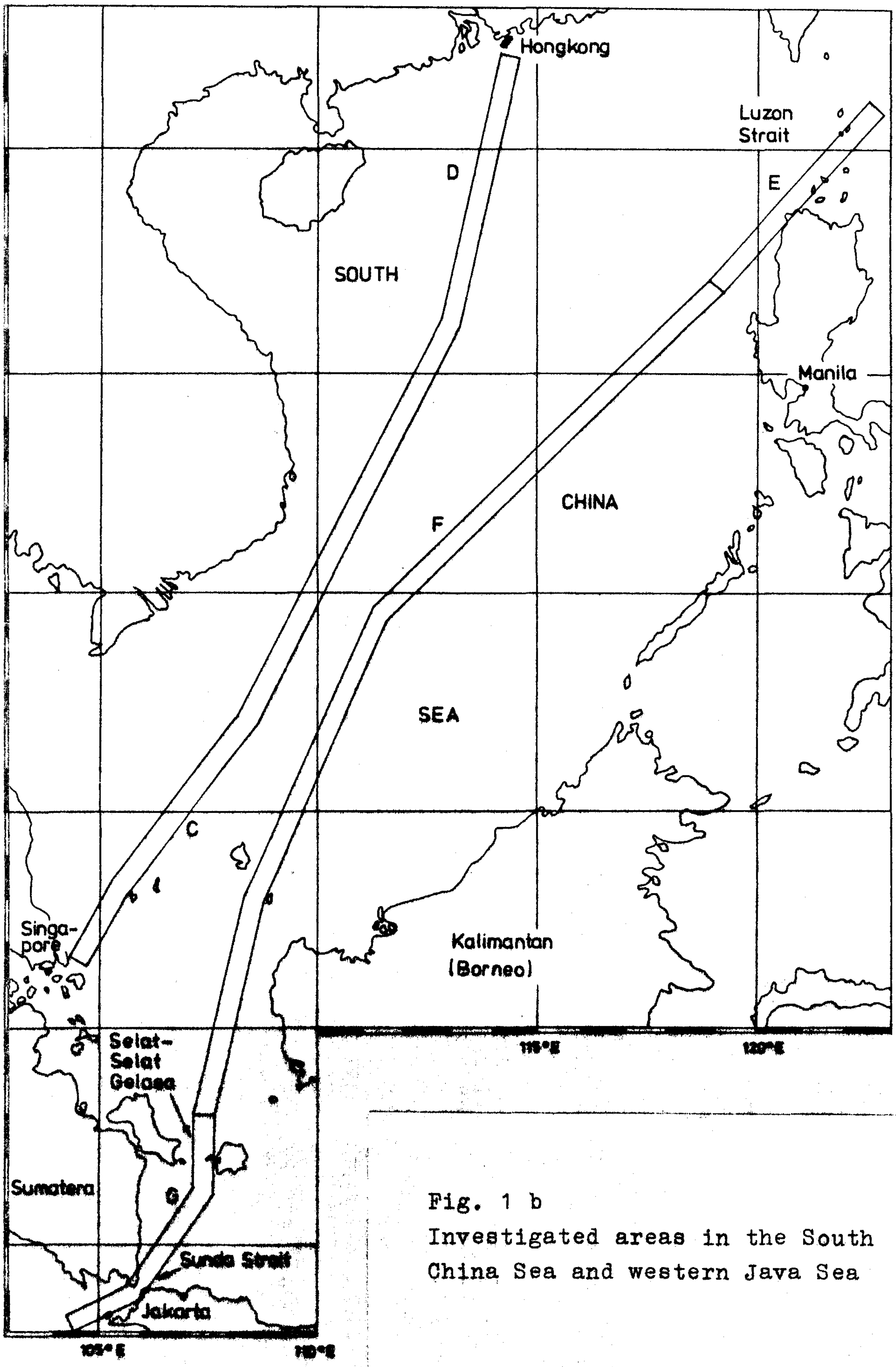

Fig. 1 b
Investigated areas in the South China Sea and western Java Sea

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The second lane extends from lat. 17°02' N, long. 119°01' E (80 n.m. north-westerly of San Fernando/Luzon) to lat. 2°00' S, long. 107°42' E (31 n.m. north of Langkuas/Belitung). It is about 1370 n.m. long.

A survey was conducted in this lane from Saturday, June 12, 1976, 0.00 o'clock, to Monday, June 14, 1976, 4.00 o'clock, while travelling southerly. The survey time was 53 hours and 10 minutes. This survey is denoted "Survey F".

Luzon Strait   The investigated area is the shipping lane through the Balintang Channel (see Fig. 1 b) extending from lat. 20°51' N, long. 122°39' E to lat. 17°02' N, long. 119° 01' E. It is about 308 n.m. long. The survey was conducted while travelling south-west on Friday, June 11, 1976, from 12.00 to 24.00 o'clock. The survey time with due regard to the time shift was 12 hours and 20 minutes. This survey is denoted "Survey E".

Selat-Selat Gelasa and Sunda Strait   The investigated area is the shipping lane extending from lat. 2°00' S, long. 107° 42' E through the Selat-Selat Gelasa, western Java Sea and the Sunda Strait to lat. 6°56' S, long. 104°27' E (see Fig. 1 b). It is about 364 n.m. long. The survey was conducted

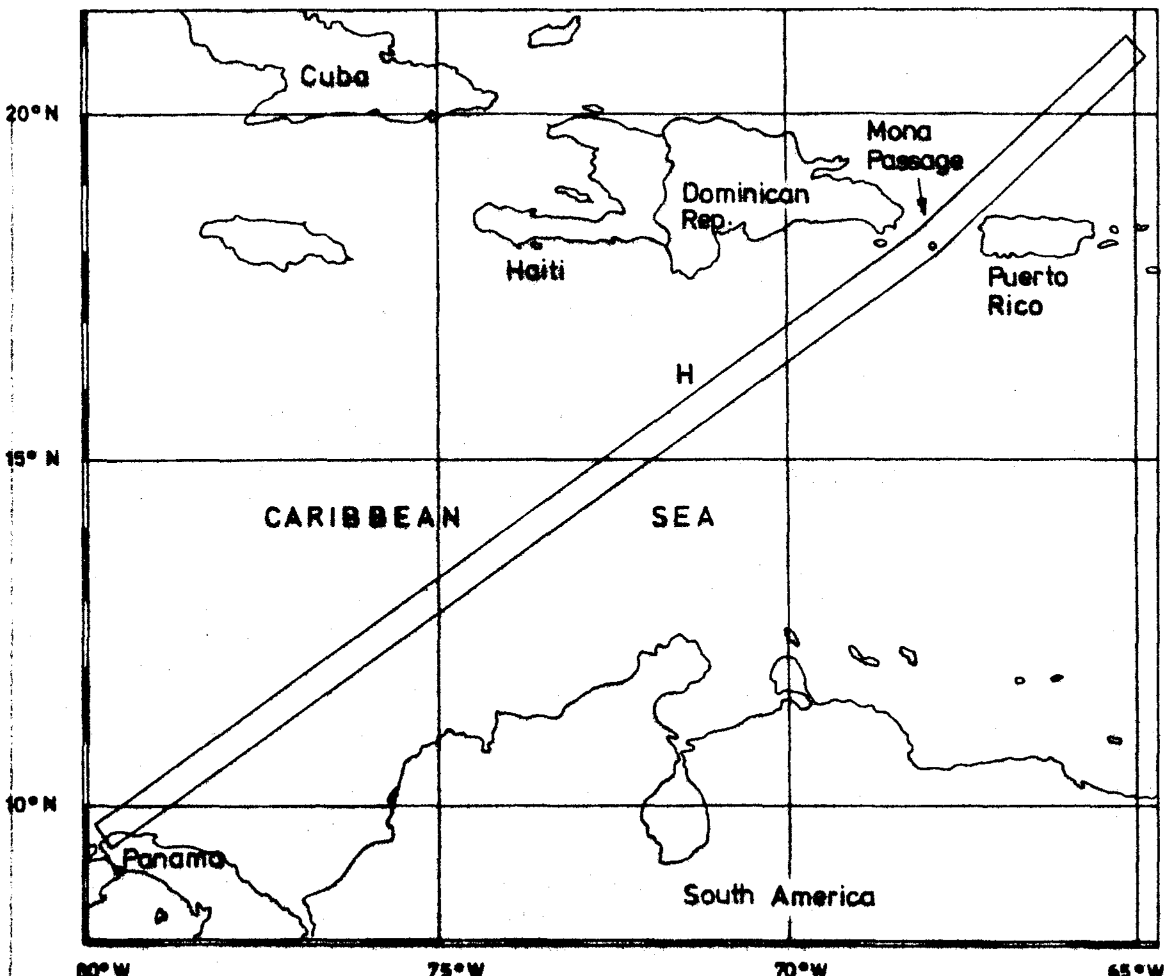

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Fig. 1 c   Investigated area in the Caribbean Sea while travelling southerly on Monday, June 14, 1976, from 4.00 to 20.00 o'clock. The survey time was 16 hours. This survey is denoted "Survey G".

Caribbean Sea   The investigated area is the shipping lane extending from lat. 21° 00' N, long. 65°00' W (160 n.m. north of the Virgin Islands) through the Mona Passage to lat. 9° 31' N, long. 79°50' W (9 n.m. north-east of the entrance to Limon Bay/north end of Panama Canal , see Fig. 1 c). It is about 1104 n.m. long. The survey was conducted while travelling south-west from Wednesday, May 12, 1976, 8.00 o'clock, to Friday, May 14, 1976, 16.00 o'clock. The survey time was 56 hours. On Thursday, May 13, 1976, own ship stopped her engines from 10.00 to 20.30 o'clock (the ship was then about in the middle of the distance stated above). During that time no encounter has occurred. This survey is denoted "Survey H".

DEFINITIONS   An encounter can arise in a meeting, overtaking or crossing situation. In this paper, only those encounters are considered whose passing distances to own ship are equal to or less than 12 nautical miles. Encounters at which the passing distances exceed 12 n.m. are not taken into account.

The number of encounters per unit of time is called encounter rate. The point of time of encounter is the moment at which the passing distance is reached.

Traffic density is defined as number of ships per unit of area.

For the sake of simplicity, meeting, overtaking and crossing encounters are defined slightly different from nautical custom. A meeting or head-on encounter is an encounter with an oncoming vessel. A vessel is called oncoming if it has a course reciprocal or, with an allowance of 15° to each side, nearly reciprocal to own ship's course.

An overtaking encounter is an encounter with a vessel having a course parallel or, again with an allowance of 15° to each side, nearly parallel to own ship's course. Own ship is overtaking if her speed is greater than that of the other ship, she is overtaken if her speed is less.

Encounters with vessels having courses other than reciprocal, nearly reciprocal, parallel or nearly parallel as defined above are called crossing encounters.

COMPLETE PRESENTATION OF DATA   Results of the traffic analyses are compiled in Tables 1 - 8. Whenever an encountered object was perceived as a vessel which, however, was not identified closer by the bridge personnel, the type of the object is given as "Vessel". The type is given as "Unknown" if the object was detected on the radar only.

Table 1 Traffic in the Malacca Strait - Survey A

Type of ship	Type of encounter	Passing distance (n.miles)	Local time	Other ship		Own ship		Date/Remarks
				Course (degrees)	Speed (knots)	Course (degrees)	Speed (knots)	
TANKER	MEETING	S 1.4	6.55	300	11.3	120	26.6	Fri 19.3.76
SUPERTANKER	OVERTAKING	S 0.2	6.57	120	11.7	120	26.6	
GENERAL CARGO	MEETING	S 0.3	7.10	300	12.4	120	26.6	
TANKER	MEETING	P 0.4	7.11	304	9.8	120	26.6	
TANKER	MEETING	S 0.8	7.36	300	12.1	120	26.6	* 17° P, 4.5 miles
TUG	MEETING	P 0.4	7.50	305	6.3	120	26.6	
BULK CARRIER	OVERTAKING	P 0.4	8.10	119	13.3	120	26.6	
CARGO SHIP	MEETING	P 6.9	8.19	303	16.9	120	26.6	
CARGO SHIP	MEETING	P 6.4	8.19	304	10.1	120	26.6	
CARGO SHIP	OVERTAKING	P 4.6	8.26	133	13.9	120	26.6	
CARGO SHIP	OVERTAKING	P 2.3	8.27	120	10.2	120	26.6	
TUG AND TOW	MEETING	P 2.1	8.32	300	2.3	120	26.6	
CARGO SHIP	MEETING	P 1.0	8.36	300	15.3	120	26.6	
COASTER	MEETING	P 3.5	8.45	300	4.3	120	26.6	
CARGO SHIP	MEETING	P 0.5	8.46	300	6.9	120	26.6	
BULK CARRIER	MEETING	P 0.6	8.48	300	10.6	120	26.6	
TUG AND TOW	MEETING	P 3.8	9.00	300	4.7	120	26.6	
BULK CARRIER	MEETING	P 2.2	9.05	300	12.4	120	26.6	
UNKNOWN	MEETING	P 4.9	9.10	300	6.9	120	26.6	
CARGO SHIP	MEETING	P 0.2	9.25	307	9.9	120	26.6	* 6° S, 3.4 miles
BULK CARRIER	OVERTAKING	S 1.7	9.27	120	13.3	120	26.6	
COASTER	OVERTAKING	S 0.2	9.28	120	9.8	120	26.6	
COASTER	MEETING	P 0.5	9.33	300	6.3	120	26.6	
COASTER	MEETING	S 0.9	9.35	300	6.3	120	26.6	
COASTER	MEETING	P 0.9	9.36	300	6.9	120	26.6	
PATROL BOAT	OVERTAKING	P 1.0	9.40	-	-	120	26.6	
TANKER	MEETING	P 0.2	10.04	307	14.7	127	26.6	* 6° S, 10 miles
UNKNOWN	MEETING	S 6.6	10.06	307	6.1	127	26.6	
CARGO SHIP	MEETING	S 1.5	10.10	307	11.2	127	26.6	
COASTER	OVERTAKING	P 0.6	10.12	127	10.2	127	26.6	
CARGO SHIP	MEETING	P 0.4	10.14	307	11.7	127	26.6	
COASTER	OVERTAKING	S 1.3	10.47	127	9.8	127	26.6	
COASTER	OVERTAKING	P 3.2	10.55	127	11.1	127	26.6	
COASTER	MEETING	P 2.6	11.00	307	10.0	127	26.6	
COASTER	MEETING	P 2.9	11.06	307	10.0	127	26.6	
COASTER	MEETING	P 2.0	11.15	307	9.3	127	26.6	
UNKNOWN	MEETING	P 2.6	11.30	307	12.1	127	26.6	
FISHING,SEVERAL	-	P -	11.40	-	-	124	25.8	
BULK CARRIER	MEETING	P 1.9	11.45	304	10.8	124	25.8	
TUG AND TOW	MEETING	P 2.6	11.50	304	4.2	124	25.8	
CARGO SHIP	MEETING	P 3.5	11.53	304	14.4	124	25.8	
SUPERTANKER	MEETING	P -	12.00	-	-	124	25.8	
TANKER	MEETING	P 0.7	12.13	304	16.1	124	25.8	
TANKER	MEETING	P 3.2	12.15	307	14.1	124	25.8	
GENERAL CARGO	MEETING	P 4.1	12.19	307	12.3	124	25.8	
BULK CARRIER	OVERTAKING	S 0.2	12.31	124	15.6	124	25.8	* 6° P, 2 miles
GENERAL CARGO	MEETING	P 4.1	12.40	307	14.1	124	25.8	
GENERAL CARGO	OVERTAKING	S 0.6	12.52	124	11.9	124	25.8	
OCEAN TUG	MEETING	P 1.7	12.53	304	10.8	124	25.8	
TANKER	MEETING	P 4.7	13.05	304	13.6	124	25.8	
TANKER	OVERTAKING	P 1.5	13.06	124	11.8	124	25.8	
GENERAL CARGO	MEETING	P 0.9	13.08	304	8.2	124	25.8	
BULK CARRIER	MEETING	P 0.6	13.15	304	11.4	124	25.8	
UNKNOWN	MEETING	P 2.6	13.15	304	13.2	124	25.8	
GENERAL CARGO	MEETING	P 0.1	13.22	304	12.9	124	25.8	
BULK CARRIER	MEETING	P 0.1	13.26	304	14.4	124	25.8	
FISHING	MEETING	P 0.9	13.33	304	6.1	124	25.8	
TANKER	MEETING	P 3.8	13.33	304	12.3	124	25.8	
TANKER	OVERTAKING	S 0.2	13.46	133	16.3	124	25.8	
TUG AND TOW	MEETING	S 2.6	13.48	304	4.1	124	25.8	
COASTER	MEETING	P 2.6	13.54	304	12.3	124	25.8	
GENERAL CARGO	OVERTAKING	P 0.2	14.02	124	5.8	124	25.8	
BULK CARRIER	OVERTAKING	S 0.8	14.06	124	15.6	124	25.8	

Table 2 Traffic in the Malacca Strait - Survey B

Type of ship	Type of encounter	Passing distance (n.miles)	Local time	Other ship Course (degrees)	Other ship Speed (knots)	Own ship Course (degrees)	Own ship Speed (knots)	Date/Remarks
SUPERTANKER	MEETING	P 1.8	0.40	108	10.6	288	24.4	Sat 3.4.76
VESSEL	MEETING	P 1.8	0.44	118	6.5	298	24.4	
VESSEL	MEETING	P 1.8	0.45	118	10.6	298	24.4	
UNKNOWN	MEETING	S 1.5	0.45	118	4.5	298	24.4	
VESSEL	MEETING	P 0.6	0.51	118	8.8	298	24.4	
CARGO SHIP	MEETING	S 0.4	0.52	118	11.0	298	24.4	
VESSEL	OVERTAKING	P 0.3	0.58	298	13.9	298	24.4	* 10° S, 0.5 miles
VESSEL	OVERTAKING	S 1.6	1.02	305	13.9	305	24.4	
FISHING	MEETING	S 0.6	1.04	125	8.8	305	24.4	
VESSEL	MEETING	S 1.1	1.08	-	-	305	24.4	
VESSEL	MEETING	S 1.5	1.26	-	-	305	24.4	
VESSEL	MEETING	S 1.6	1.26	-	-	305	24.4	
TUG AND TOW	MEETING	P 0.8	1.28	125	7.3	305	24.4	
CARGO SHIP	MEETING	S 0.3	1.31	125	13.4	305	24.4	
CARGO SHIP	MEETING	P 0.3	1.31	125	6.8	305	24.4	
CARGO SHIP	MEETING	P 0.7	1.35	125	13.6	305	24.4	
TANKER	OVERTAKING	S 4.1	1.43	308	14.5	305	24.4	
VESSEL	MEETING	P 0.3	1.51	125	12.5	305	24.4	
VESSEL	MEETING	S 0.4	1.52	125	10.2	305	24.4	
VESSEL	MEETING	S 1.7	1.53	125	12.5	305	24.4	
CARGO SHIP	MEETING	P 0.8	1.56	125	9.7	305	24.4	
OCEAN TUG	MEETING	S 0.2	1.58	125	8.8	305	24.4	
CARGO SHIP	MEETING	P 0.6	2.02	125	3.9	305	24.4	
CARGO SHIP	MEETING	S 1.3	2.05	125	8.8	305	24.4	
CARGO SHIP	MEETING	P 0.8	2.05	125	8.8	305	24.4	
CARGO SHIP	MEETING	S 1.9	2.13	125	2.8	305	24.4	
UNKNOWN	OVERTAKING	S 6.1	2.13	305	2.2	305	24.4	
CARGO SHIP	MEETING	S 1.4	2.20	125	7.6	305	24.4	
CARGO SHIP	MEETING	P 0.4	2.24	125	8.2	305	24.4	
VESSEL	MEETING	S 2.5	2.26	125	6.4	305	24.4	
SUPERTANKER	CROSSING	P 1.0	2.40	92	6.7	305	24.4	
CARGO SHIP	MEETING	P 0.2	2.44	125	11.0	305	24.4	
TUG AND TOW	OVERTAKING	S 1.0	2.58	305	7.6	305	24.4	
CARGO SHIP	MEETING	S 0.2	3.09	125	4.6	305	24.4	
CARGO SHIP	OVERTAKING	S 0.2	3.21	305	16.3	305	24.4	
TANKER	OVERTAKING	P 0.2	3.22	305	14.5	305	24.4	
CARGO SHIP	MEETING	P 1.0	3.24	122	13.4	305	24.4	
SUPERTANKER	OVERTAKING	P 1.0	3.45	306	14.0	305	24.4	
COASTER	OVERTAKING	S 1.2	3.47	305	8.7	305	24.4	
COASTER	MEETING	P 0.6	3.54	119	6.4	309	25.1	
SUPERTANKER	OVERTAKING	S 0.8	3.55	309	14.0	309	25.1	
PASSENGER SHIP	MEETING	P 1.8	4.17	129	11.9	309	25.1	
TANKER	OVERTAKING	P 3.5	4.26	309	14.0	309	25.1	
FISHING	-	P+S -	-	-	-	309	25.1	C.20 vessels within own ship's 2 miles range
GENERAL CARGO	MEETING	P 7.0	5.07	126	14.2	309	25.1	
GENERAL CARGO	MEETING	P 2.5	5.27	118	10.8	298	23.5	
GENERAL CARGO	MEETING	P 4.5	5.34	122	19.4	298	23.5	
TANKER	OVERTAKING	P 2.0	5.40	298	15.5	298	23.5	
TANKER	MEETING	P 0.8	5.40	113	14.3	298	23.5	
TANKER	MEETING	P 3.8	5.45	118	14.3	298	23.5	
TANKER	MEETING	P 4.8	5.45	123	14.3	298	23.5	
TANKER	MEETING	P 3.7	5.48	118	14.3	298	23.5	
VESSEL	OVERTAKING	P 0.9	5.56	301	9.9	298	23.5	
GENERAL CARGO	MEETING	P 2.0	6.06	118	13.5	298	23.5	
FISHING	MEETING	P -	6.07	-	-	298	23.5	
COASTER	OVERTAKING	S 1.1	6.12	298	10.2	298	23.5	
SUPERTANKER	MEETING	P 2.0	6.23	118	12.8	298	23.5	
BULK CARRIER	MEETING	S 2.3	6.23	123	14.3	298	23.5	
COASTER	CROSSING	S 2.8	6.41	317	13.1	298	23.5	
BULK CARRIER	MEETING	P 1.8	6.41	118	14.3	298	23.5	
COASTER	MEETING	P 2.5	6.41	122	8.5	298	23.5	
GENERAL CARGO	MEETING	P 0.7	6.50	118	13.5	298	23.5	
GENERAL CARGO	OVERTAKING	P 0.6	6.56	298	13.6	298	23.5	
GENERAL CARGO	MEETING	P 0.3	7.00	118	14.3	298	23.5	
OBO-CARRIER	MEETING	P 1.0	7.00	118	14.3	298	23.5	
TANKER	OVERTAKING	S 0.5	7.00	298	8.0	298	23.5	
COASTER	OVERTAKING	S 2.9	7.00	298	10.9	298	23.5	
COASTER	OVERTAKING	S 2.9	7.00	298	8.4	298	23.5	
GENERAL CARGO	OVERTAKING	S 0.6	7.28	301	10.9	298	23.5	
COASTER	CROSSING	S 0.2	7.35	113	3.7	315	23.5	
GENERAL CARGO	CROSSING	S 1.4	8.03	297	14.9	315	23.5	
LPG-CARRIER	MEETING	S 0.5	8.08	135	14.3	315	23.5	
TANKER	MEETING	P 1.5	8.29	130	13.6	315	23.5	

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Table 3 Traffic in the South China Sea between Singapore and Hongkong - Survey C

Type of ship	Type of encounter	Passing distance (n.miles)	Local time	Other ship		Own ship		Date/Remarks
				Course (degrees)	Speed (knots)	Course (degrees)	Speed (knots)	
TANKER	OVERTAKING	S 1.0	21.10	31	14.7	28	24.4	Sat 20.3.76
CARGO SHIP	CROSSING	P 4.3	21.15	6	12.2	28	24.4	
CARGO SHIP	CROSSING	S 2.8	21.20	61	10.5	28	24.4	
CARGO SHIP	OVERTAKING	S 0.2	21.22	28	7.8	20	24.4	* 5° P, 1.7 miles
CARGO SHIP	OVERTAKING	S 6.8	21.45	28	9.8	28	24.4	
CARGO SHIP	MEETING	S 4.8	21.55	208	11.9	28	24.4	
CARGO SHIP	MEETING	S 4.2	22.12	208	11.9	28	24.4	
CARGO SHIP	MEETING	P 2.2	22.18	208	17.2	28	24.4	
VESSEL	MEETING	P 1.1	22.30	208	11.7	28	24.4	
COASTER	MEETING	P 1.4	22.45	208	11.7	28	24.4	
COASTER	MEETING	S 1.4	22.49	208	14.7	28	24.4	
CARGO SHIP	MEETING	P 2.8	23.02	208	16.4	28	24.4	
CARGO SHIP	OVERTAKING	P 0.8	23.07	26	14.4	28	24.4	
UNKNOWN	MEETING	P 2.8	23.07	208	15.7	28	24.4	
CONTAINER FEEDER	MEETING	P 1.1	23.19	208	14.3	28	24.4	
TANKER	MEETING	P 0.8	23.33	208	11.4	28	24.4	
COASTER	OVERTAKING	P 2.0	23.42	25	9.5	28	24.4	
CARGO SHIP	MEETING	S 2.3	23.49	208	9.5	28	24.4	
UNKNOWN	OVERTAKING	S 7.6	0.19	28	2.9	28	25.8	Sun 21.3.76
VESSEL	MEETING	S 0.9	0.22	200	8.8	28	25.8	
TANKER	MEETING	S 4.0	0.46	208	14.3	28	25.8	
VESSEL	ONM	S 11.6	0.53	ONM	ONM	28	25.8	
BULK CARRIER	MEETING	S 0.4	0.55	208	9.8	28	25.8	* 5° P, 4 miles
GENERAL CARGO	MEETING	S 0.8	1.16	208	11.1	28	25.8	
GENERAL CARGO	MEETING	P 6.6	1.32	208	15.8	28	25.8	
COASTER	MEETING	S 2.0	1.35	211	12.6	20	25.8	
TANKER	MEETING	P 4.0	1.54	211	13.0	28	25.8	
TANKER	OVERTAKING	P 6.5	2.02	23	13.4	28	25.8	
VESSEL	MEETING	P 10.5	2.04	208	15.8	28	25.8	
GENERAL CARGO	MEETING	P 5.8	2.08	202	11.9	28	25.8	
GENERAL CARGO	MEETING	P 4.8	2.08	208	8.6	28	25.8	
TANKER	OVERTAKING	S 7.0	2.30	40	14.1	28	25.8	
VESSEL	OVERTAKING	S 8.0	2.32	37	11.3	28	25.8	
GENERAL CARGO	OVERTAKING	S 7.5	2.34	42	11.6	28	25.8	
GENERAL CARGO	MEETING	P 1.5	2.37	208	13.8	28	25.8	
VESSEL	MEETING	P 3.3	2.40	213	15.1	28	25.8	
TANKER	MEETING	P 1.7	2.56	208	11.1	28	25.8	
VESSEL	OVERTAKING	S 5.9	2.56	39	13.9	28	25.8	
GENERAL CARGO	MEETING	S 2.9	3.01	208	12.6	28	25.8	
GENERAL CARGO	MEETING	P 2.2	3.05	208	13.3	28	25.8	
SUPERTANKER	OVERTAKING	S 5.9	3.06	38	12.4	28	25.8	
GENERAL CARGO	MEETING	S 1.4	3.40	208	10.1	28	25.8	
COASTER	MEETING	P 0.6	3.43	208	8.6	28	25.8	
VESSEL	MEETING	P 8.4	3.56	216	6.8	36	25.8	
TANKER	MEETING	P 7.3	4.16	219	13.4	36	26.5	
SUPERTANKER	OVERTAKING	S 5.0	4.27	39	17.1	36	26.5	
TANKER	MEETING	S 2.8	4.45	216	9.1	36	26.5	
BULK CARRIER	MEETING	P 0.3	4.47	221	6.8	36	26.5	* 9° S, 2 miles
UNKNOWN	MEETING	S 5.0	5.10	216	11.9	36	26.5	
UNKNOWN	MEETING	P 10.8	5.34	216	8.9	36	26.5	
UNKNOWN	OVERTAKING	S 9.1	5.34	36	12.4	36	26.5	
CAR CARRIER	OVERTAKING	S 6.0	6.15	36	19.3	36	26.5	
UNKNOWN	MEETING	S 2.7	6.40	216	8.8	36	26.5	
BULK CARRIER	MEETING	S 2.8	6.55	216	12.9	36	26.5	
UNKNOWN	MEETING	S 8.9	7.06	216	12.3	36	26.5	
UNKNOWN	CROSSING	S 7.4	7.22	287	8.3	36	26.5	
GENERAL CARGO	MEETING	P 5.4	7.45	216	11.6	36	26.5	
CARGO SHIP	OVERTAKING	S 3.8	8.05	36	10.5	36	25.7	
CARGO SHIP	OVERTAKING	S 1.2	8.20	36	14.6	36	25.7	
FISHING	OVERTAKING	P 6.5	8.22	36	8.2	36	25.7	
CARGO SHIP	MEETING	S 1.5	8.30	204	13.3	36	25.7	
SUPERTANKER	MEETING	S 8.0	8.49	216	11.0	36	25.7	
CARGO SHIP	OVERTAKING	P 3.8	9.12	36	15.3	36	25.7	
COASTER	MEETING	S 0.4	9.38	216	6.0	36	25.7	** P, 5.5 miles
CARGO SHIP	MEETING	S 10.8	9.46	213	12.7	36	25.7	
TANKER	MEETING	S 2.0	10.14	216	12.7	36	25.7	
UNKNOWN	MEETING	S 10.5	10.14	216	14.2	36	25.7	
CARGO SHIP	MEETING	P 2.5	10.47	216	11.2	36	25.7	
CARGO SHIP	MEETING	P 4.8	11.12	216	12.1	36	25.7	
TANKER	OVERTAKING	P 3.7	11.30	35	14.0	36	25.7	
TANKER	MEETING	S 6.9	12.03	215	8.9	31	24.4	
TANKER	OVERTAKING	S 5.3	12.09	35	14.5	31	24.4	
FISHING	OVERTAKING	P 3.8	12.16	31	9.8	31	24.4	
GENERAL CARGO	MEETING	S 4.3	12.32	211	8.4	31	24.4	
TUG AND TOW	MEETING	P 0.4	13.01	211	5.1	31	24.4	
GENERAL CARGO	MEETING	S 11.5	13.14	211	14.4	31	24.4	
GENERAL CARGO	MEETING	S 4.3	13.54	211	14.4	31	24.4	
GENERAL CARGO	OVERTAKING	S 5.2	13.59	33	11.3	31	24.4	
UNKNOWN	MEETING	S 11.5	17.37	211	12.8	31	23.0	
GENERAL CARGO	MEETING	S 4.0	18.27	211	10.2	31	23.0	
CONTAINER SHIP	CROSSING	P 0.3	18.39	236	17.6	31	23.0	* 9° S, 4.5 miles
GENERAL CARGO	MEETING	S 6.3	19.55	211	8.4	31	23.0	
VESSEL	CROSSING	S 9.5	20.45	227	10.6	31	23.5	
CARGO SHIP	MEETING	P 3·2	21.21	224	10.5	31	23.5	

Table 3 (continued)

Type of ship	Type of encounter	Passing distance (n.miles)	Local time	Other ship Course (degrees)	Other ship Speed (knots)	Own ship Course (degrees)	Own ship Speed (knots)	Date/Remarks
TANKER	MEETING	S 7.4	1.14	211	12.3	31	23.5	Mon 22.3.76
COASTER	MEETING	S 6.6	3.20	211	10.9	31	23.5	
CONTAINER SHIP	MEETING	S 2.0	4.18	211	19.3	31	25.0	
UNKNOWN	OVERTAKING	P 11.4	4.53	31	11.0	31	25.0	
GAS CARRIER	MEETING	S 0.5	7.38	211	11.3	31	25.0	
CARGO SHIP	MEETING	S 9.6	10.24	211	15.8	31	25.0	
CONTAINER SHIP	MEETING	S 2.8	10.33	211	19.3	31	25.0	
CARGO SHIP	MEETING	P 9.2	10.52	211	10.8	31	25.0	
FISHING	-	S -	11.03	-	-	31	25.0	
CARGO SHIP	MEETING	P 5.0	11.35	211	12.5	31	25.0	
CONTAINER SHIP	MEETING	S 2.2	14.02	205	20.6	23	26.9	
GENERAL CARGO	OVERTAKING	P 0.3	17.35	5	17.8	5	26.9	
GENERAL CARGO	OVERTAKING	S 3.5	18.56	5	17.4	5	26.9	
TANKER	MEETING	S 2.7	0.17	197	16.1	17	23.8	Tue 23.3.76
GENERAL CARGO	MEETING	S 4.2	1.10	197	15.0	17	23.8	
FISHING	-	P 3.5	1.45	-	-	17	23.8	
FISHING	-	S 4.0	1.58	-	-	17	23.8	
FISHING,SEVERAL	-	S 9.3	2.11	-	-	17	23.8	
VESSEL	CROSSING	P 2.6	2.11	317	9.0	17	23.8	
VESSEL	MEETING	P 11.4	2.49	211	13.4	17	23.8	
FISHING,SEVERAL	-	P 5.5	3.57	-	-	17	23.8	
UNKNOWN	CROSSING	S 2.8	4.10	69	9.5	30	23.8	
UNKNOWN	CROSSING	P 4.0	4.10	193	12.8	30	23.8	

Fishing vessels and oil drilling rigs are included in these tables only. They are not considered in the calculations nor diagrams and other tables following, with exception of Table 12. In that table those fishing vessels also are considered whose speeds are known.

The letters ONM stand for "Object Not Moving". P stands for "Port" and S for "Starboard".

In the last column any manoeuvres that may have been executed to avoid a collision or a dangerous passing are listed. Data are given regarding amount of the turn, direction of the turn and distance at which the manoeuvre was initiated. One asterisk means that own ship has evaded, two asterisks mean that the other ship has evaded.

Due to measurement and read-off accuracies the data are restricted by the following allowances.

Passing distance	± 0.1	n. miles
Course	± 1	degree
Speed	± 0.2	knots

Table 4 Traffic in the South China Sea between Singapore and Hongkong - Survey D

Type of ship	Type of encounter	Passing distance (n.miles)	Local time	Other ship Course (degrees)	Other ship Speed (knots)	Own ship Course (degrees)	Own ship Speed (knots)	Date/Remarks
JUNK	CROSSING	S 1.8	19.45	310	5.1	197	24.6	Tue 30.3.76
JUNK	CROSSING	P 2.1	19.45	316	5.5	197	24.6	
UNKNOWN	CROSSING	P 11.5	19.55	244	9.5	197	24.6	
VESSEL	CROSSING	S 4.0	20.38	77	12.2	197	24.6	
VESSEL	OVERTAKING	P 5.5	21.02	190	13.0	197	24.6	
FISHING	CROSSING	S 0.2	21.28	312	8.3	197	24.6	
FISHING	-	S 7.5	22.07	-	-	197	24.6	
VESSEL	OVERTAKING	P 8.1	24.00	193	11.7	197	24.6	
COASTER	MEETING	S 1.1	0.41	17	11.2	197	24.6	Wed 31.3.76
VESSEL	CROSSING	P 2.8	1.16	132	6.5	197	24.6	
COASTER	MEETING	P 3.6	1.20	17	11.2	197	24.6	
GENERAL CARGO	MEETING	P 6.9	2.31	5	14.5	185	24.6	
GENERAL CARGO	OVERTAKING	S 1.4	3.24	185	15.5	185	24.6	
GENERAL CARGO	MEETING	P 8.0	3.55	5	14.5	185	24.6	
GENERAL CARGO	MEETING	P 1.8	5.45	5	14.7	185	25.6	
UNKNOWN	MEETING	P 9.4	7.55	5	7.6	185	25.6	
CARGO SHIP	MEETING	S 0.6	9.37	5	12.5	185	25.6	
UNKNOWN	OVERTAKING	P 4.1	11.20	185	5.7	185	25.6	
FISHING	OVERTAKING	P 8.6	13.37	208	2.3	208	25.1	
FISHING	OVERTAKING	P 3.4	13.38	208	2.3	208	25.1	
LPG-CARRIER	OVERTAKING	P 6.5	14.34	208	9.8	208	25.1	
GENERAL CARGO	OVERTAKING	S 10.3	14.43	209	16.2	208	25.1	
GENERAL CARGO	MEETING	P 2.9	16.07	28	7.1	208	24.8	
UNKNOWN	OVERTAKING	P 8.8	17.50	208	9.9	208	24.8	
GENERAL CARGO	OVERTAKING	P 1.5	18.55	206	13.2	208	24.8	
CONTAINER SHIP	MEETING	S 5.4	19.09	28	18.1	208	24.8	
GENERAL CARGO	OVERTAKING	P 2.9	19.37	208	13.0	208	24.8	
CARGO SHIP	OVERTAKING	P 1.6	21.32	206	14.0	208	24.8	
VESSEL	OVERTAKING	P 3.0	22.45	208	14.8	208	24.8	
VESSEL	OVERTAKING	P 9.9	23.17	208	13.8	208	24.8	
VESSEL	OVERTAKING	P 10.3	0.06	208	12.8	208	24.9	Thu 1.4.76
VESSEL	CROSSING	S 11.0	3.18	64	8.5	208	24.9	
COASTER	CROSSING	P 9.1	3.36	242	11.9	208	24.9	
GENERAL CARGO	MEETING	P 1.8	4.48	28	12.8	208	24.7	
FISHING	-	P 9.0	5.10	-	-	208	24.7	
CONTAINER SHIP	MEETING	S 1.8	5.37	32	25.5	208	24.7	
UNKNOWN	CROSSING	P 2.8	6.15	224	13.6	208	24.7	
UNKNOWN	MEETING	P 3.4	6.15	31	14.1	208	24.7	
UNKNOWN	OVERTAKING	P 7.0	7.30	214	11.0	214	24.7	
CARGO SHIP	MEETING	S 6.3	8.08	34	9.0	214	24.7	
TANKER	MEETING	S 7.5	10.47	34	12.8	214	24.7	
CARGO SHIP	MEETING	P 9.4	10.49	34	12.2	214	24.7	
COASTER	MEETING	S 5.0	10.53	34	9.5	214	24.7	
FISHING	-	S 0.6	11.09	-	-	214	24.7	
UNKNOWN	MEETING	P 10.1	11.30	34	9.5	214	24.7	
GENERAL CARGO	OVERTAKING	S 7.5	12.58	213	12.0	215	25.1	
VESSEL	MEETING	P 11.8	13.06	35	10.3	215	25.1	
TUG AND TOW	MEETING	P 4.8	13.20	35	2.3	215	25.1	
GENERAL CARGO	OVERTAKING	S 2.7	13.40	213	13.1	215	25.1	
TANKER	MEETING	P 8.5	13.47	35	12.4	215	25.1	
TANKER	MEETING	P 6.5	14.15	35	11.3	215	25.1	
LPG-CARRIER	OVERTAKING	P 7.9	14.59	215	13.9	215	25.1	
GENERAL CARGO	MEETING	P 11.2	15.09	35	17.2	215	25.1	
TANKER	MEETING	P 9.3	15.40	35	13.7	215	25.1	
TANKER	MEETING	P 1.8	15.40	35	13.3	215	25.1	
PASSENGER SHIP	MEETING	P 4.5	16.06	39	16.4	219	25.9	
GENERAL CARGO	MEETING	P 3.3	16.33	39	14.4	219	25.9	
UNKNOWN	MEETING	P 8.5	16.57	39	14.4	219	25.9	
GENERAL CARGO	MEETING	P 1.0	17.27	28	15.2	219	25.9	
GENERAL CARGO	MEETING	P 7.5	18.08	36	14.8	219	25.9	
GENERAL CARGO	MEETING	P 5.8	18.17	39	10.5	219	25.9	
TANKER	MEETING	P 10.0	18.20	39	12.9	219	25.9	
GENERAL CARGO	OVERTAKING	P 7.5	18.20	220	14.7	219	25.9	
GENERAL CARGO	MEETING	P 0.4	18.27	39	11.0	219	25.9	
CARGO SHIP	MEETING	P 8.4	20.18	29	16.6	209	25.7	
VESSEL	MEETING	P 10.6	20.55	29	8.0	209	25.7	
VESSEL	MEETING	P 5.8	22.27	22	13.3	202	24.7	
VESSEL	OVERTAKING	P 2.0	22.28	202	11.9	202	24.7	
TANKER	MEETING	P 2.1	22.39	22	11.7	202	24.7	
CARGO SHIP	MEETING	P 8.8	22.43	22	12.8	202	24.7	
VESSEL	MEETING	P 2.8	23.00	22	8.5	202	24.7	
CARGO SHIP	OVERTAKING	S 1.8	23.18	202	12.0	202	24.7	
TANKER	MEETING	P 4.2	23.32	22	14.1	202	24.7	
VESSEL	MEETING	P 2.3	23.38	22	9.4	202	24.7	
VESSEL	MEETING	P 3.8	23.43	22	12.2	202	24.7	
SUPERTANKER	MEETING	P 0.5	23.48	22	10.9	202	24.7	
VESSEL	MEETING	P 3.9	23.56	22	8.5	202	24.7	
VESSEL	MEETING	S 2.3	23.57	22	8.5	202	24.7	
TANKER	OVERTAKING	P 1.3	24.00	207	11.0	202	24.7	
TANKER	MEETING	S 6.3	0.40	19	12.8	202	24.7	Fri 2.4.76
TANKER	MEETING	P 3.3	0.41	22	10.3	202	24.7	
TANKER	MEETING	P 3.5	0.59	25	12.8	202	24.7	
COASTER	OVERTAKING	S 1.0	1.24	204	11.9	202	24.7	
GENERAL CARGO	CROSSING	S 8.8	1.31	187	13.5	202	24.7	
TANKER	MEETING	P 0.9	1.36	22	10.3	202	24.7	* 5° S, 10 miles
GENERAL CARGO	MEETING	S 2.5	1.46	17	12.2	197	24.7	* 10° P, 2.7 miles
SUPERTANKER	OVERTAKING	S 1.2	1.51	202	18.6	197	24.7	
VESSEL	-	S 3.6	1.54	-	-	202	24.7	
GENERAL CARGO	MEETING	P 2.9	2.12	22	4.5	202	24.7	
COASTER	CROSSING	S 0.4	2.23	76	10.1	202	24.7	

Table 5 Traffic in the Luzon Strait - Survey E

Type of ship	Type of encounter	Passing distance (n.miles)	Local time	Other ship Course (degrees)	Other ship Speed (knots)	Own ship Course (degrees)	Own ship Speed (knots)	Date/Remarks
CARGO SHIP	MEETING	P 7.5	13.13	38	12.7	218	24.6	Fri 11.6.76
SUPERTANKER	MEETING	S 4.2	14.39	53	12.8	218	24.6	
BULK CARRIER	MEETING	P 6.1	14.40	38	15.2	218	24.6	
SUPERTANKER	CROSSING	S 6.7	14.46	63	9.6	218	24.6	
CAR CARRIER	OVERTAKING	S 4.1	14.48	224	16.8	218	24.6	
TANKER	MEETING	S 1.0	14.50	38	11.3	218	24.6	
COASTER	CROSSING	P 1.1	14.59	140	8.5	218	24.6	
FISHING	CROSSING	P 0.5	15.10	119	9.6	218	24.6	
SUPERTANKER	CROSSING	S 7.6	15.12	55	13.5	218	24.6	
VESSEL	MEETING	P 0.5	15.25	52	12.3	220	24.6	* 7° S, 5 miles
TANKER	CROSSING	S 11.7	15.57	226	9.6	210	24.6	
CAR CARRIER	OVERTAKING	P 0.2	16.12	229	20.0	225	24.6	From 16.12 to 19.55
CARGO SHIP	MEETING	P 1.1	16.13	45	12.7	225	24.6	cluster of islands
CARGO SHIP	MEETING	P 0.6	16.19	45	12.0	225	24.6	P, c.5 miles
GENERAL CARGO	OVERTAKING	S 4.0	19.20	227	12.9	223	24.8	
VESSEL	OVERTAKING	S 9.2	19.55	224	15.0	223	24.8	
VESSEL	CROSSING	P 4.6	20.10	17	11.7	223	25.7	
VESSEL	CROSSING	S 3.6	20.11	16	9.1	223	25.7	
VESSEL	MEETING	S 7.8	20.35	43	10.8	223	25.7	
VESSEL	MEETING	S 11.2	21.29	43	11.8	223	25.7	
VESSEL	CROSSING	P 9.7	22.55	310	10.7	223	25.7	

Table 6 Traffic in the South China Sea between the north of the Philippines and Belitung (Indonesia) - Survey F

Type of ship	Type of encounter	Passing distance (n.miles)	Local time	Other ship Course (degrees)	Other ship Speed (knots)	Own ship Course (degrees)	Own ship Speed (knots)	Date/Remarks
SUPERTANKER	MEETING	S 11.0	0.30	42	11.9	222	25.6	Sat 12.6.76
VESSEL	MEETING	S 8.5	2.25	42	12.1	222	25.6	
TANKER	MEETING	S 10.8	8.37	43	14.0	223	25.8	
FISHING	OVERTAKING	S 0.5	14.23	223	1.6	223	25.8	
FISHING	OVERTAKING	S 6.3	14.27	223	6.4	223	25.8	
FISHING	OVERTAKING	P 6.5	14.45	223	1.6	223	25.8	
VESSEL	OVERTAKING	S 10.7	20.53	223	14.4	223	25.8	
TUG AND TOW	MEETING	S 11.4	9.50	26	2.9	206	25.8	Sun 13.6.76
UNKNOWN	OVERTAKING	S 8.4	14.05	208	3.9	208	25.4	
CARGO SHIP	MEETING	S 6.1	15.31	10	14.0	204	25.4	
SAILING YACHT	CROSSING	P 5.7	15.50	295	4.5	204	25.4	
SAILING YACHT	CROSSING	P 5.7	15.50	295	4.5	204	25.4	
SAILING YACHT	CROSSING	S -	17.08	-	-	180	25.4	
BULK CARRIER	MEETING	P 4.0	22.07	2	11.6	188	25.4	
CARGO SHIP	MEETING	P 1.7	0.22	9	11.4	189	25.9	Mon 14.6.76
TUG AND TOW	MEETING	S 0.2	1.46	9	4.2	189	25.9	
VESSEL	CROSSING	S 5.0	2.00	304	16.9	189	25.9	
UNKNOWN	CROSSING	P 6.5	2.10	143	5.4	189	25.9	

Table 7 Traffic in the western Java Sea and Sunda Strait - Survey G

Type of ship	Type of encounter	Passing distance (n.miles)	Local time	Other ship Course (degrees)	Other ship Speed (knots)	Own ship Course (degrees)	Own ship Speed (knots)	Date/Remarks
COASTER	OVERTAKING	S 1.0	4.40	185	4.6	185	21.3	Mon 14.6.76
FISHING	MEETING	P 1.3	5.28	32	0.2	212	21.3	From 5.28 to 7.48
FISHING	MEETING	P 1.3	5.28	32	0.2	212	21.3	cluster of islands
SAILER	MEETING	S 0.2	5.44	32	0.7	212	21.3	P, c.3 miles
UNKNOWN	CROSSING	S 7.5	5.46	16	7.4	212	21.3	
GENERAL CARGO	MEETING	P 0.3	6.10	32	14.6	212	21.3	* 8° S, 2.7 miles
CARGO SHIP	OVERTAKING	S 1.5	6.48	180	8.4	180	21.3	
FISHING, SEVERAL	-	S -	7.18	-	-	170	21.3	
COASTER	MEETING	S 2.2	7.35	338	6.9	170	21.3	
COASTER	MEETING	S 1.0	7.48	340	5.7	170	21.3	
FISHING	OVERTAKING	S 3.4	9.00	213	3.0	213	21.3	
SAILER	MEETING	P 1.8	9.25	33	0.2	213	21.3	
SAILER	OVERTAKING	P 4.1	9.55	213	1.1	213	21.3	
SAILER	MEETING	P 10.6	10.05	-	-	213	21.3	
SAILER	OVERTAKING	P 10.5	10.15	-	-	213	21.3	
COASTER	CROSSING	S 10.0	10.50	331	8.2	213	21.3	
UNKNOWN	OVERTAKING	P 2.5	11.20	213	0.5	213	21.3	
COASTER	CROSSING	S 9.0	11.40	165	5.8	213	21.3	
SAILER	CROSSING	S 4.3	11.47	358	6.5	213	21.3	
CARGO SHIP	CROSSING	P 4.0	11.49	350	18.7	213	21.3	
SAILER	MEETING	S 5.2	11.58	33	8.1	213	21.3	
SAILER	CROSSING	P 3.0	12.22	295	2.1	213	24.3	
SAILER	CROSSING	P 3.0	12.22	295	2.1	213	24.3	
SAILER	CROSSING	P 3.0	12.22	295	2.1	213	24.3	
COASTER	CROSSING	S 3.4	12.29	187	9.5	213	24.3	
COASTER	CROSSING	P 1.7	12.31	188	9.7	213	24.3	
UNKNOWN	OVERTAKING	S 6.9	12.50	213	0.4	213	24.3	
SAILER	OVERTAKING	S 1.7	13.43	207	5.3	207	24.3	
SAILER	OVERTAKING	S 2.4	13.49	207	3.6	207	24.3	
UNKNOWN	CROSSING	P 8.2	13.55	179	10.5	207	24.3	
C.15 OIL RIGS	-	P -	14.35	-	-	221	24.3	Several oil drilling
4 SAILERS	-	S 3.6	14.35	-	-	221	24.3	rigs, nearest
SAILER	OVERTAKING	S 3.6	14.40	221	4.5	221	24.3	0.6 miles
TANKER	ONM	S 1.1	14.43	ONM	ONM	221	24.3	
SAILER	OVERTAKING	S 3.9	14.44	221	2.8	221	24.3	
STORE SHIP	OVERTAKING	P 4.3	15.00	218	9.6	221	24.3	
TANKER	OVERTAKING	P 3.7	15.27	208	12.5	221	24.3	
TUG AND TOW	CROSSING	P 11.8	15.35	101	4.6	216	24.3	
SAILER	-	S 2.1	15.38	-	-	216	24.3	
UNKNOWN	MEETING	P 6.9	15.50	22	6.8	216	24.3	Own ship passes
BULK CARRIER	CROSSING	P 1.7	16.07	88	12.0	221	24.3	narrowest point of
VESSEL	MEETING	S 5.0	19.00	55	13.4	235	24.3	Sunda Strait

Table 8 Traffic in the Caribbean Sea - Survey H

Type of ship	Type of encounter	Passing distance (n.miles)	Local time	Other ship Course (degrees)	Other ship Speed (knots)	Own ship Course (degrees)	Own ship Speed (knots)	Date/Remarks
CARGO SHIP	MEETING	S 11.7	10.22	42	16.5	227	21.0	Wed 12.5.76
VESSEL	CROSSING	P 12.0	11.25	170	8.3	227	21.0	
CARGO SHIP	MEETING	P 10.9	11.25	47	13.0	227	21.0	
WAR SHIP	CROSSING	S 4.3	14.55	140	2.4	224	23.2	
FISHING	MEETING	S 1.1	16.26	44	4.5	224	24.1	
TANKER	CROSSING	P 6.6	18.04	354	13.0	224	24.1	
FISHING	MEETING	S 7.5	19.30	53	5.8	233	24.1	
TANKER	MEETING	S 1.0	4.56	53	11.8	233	25.1	Thu 13.5.76
UNKNOWN	MEETING	S 7.5	9.02	53	10.4	233	25.1	Own ship stops from
VESSEL	MEETING	S 9.0	22.02	51	6.8	231	25.5	10.00 to 20.30
VESSEL	CROSSING	S 11.0	23.14	126	7.7	231	25.5	
UNKNOWN	MEETING	P 4.1	1.30	51	14.2	231	24.8	Fri 14.5.76
COASTER	CROSSING	S 0.8	9.31	111	3.8	231	24.8	
CARGO SHIP	MEETING	S 3.0	9.35	44	9.3	231	24.8	
SAILING YACHT	CROSSING	P 2.9	12.32	246	2.4	229	23.3	
CARGO SHIP	MEETING	P 4.3	14.00	49	17.1	229	23.3	
VESSEL	CROSSING	S 12.0	14.04	24	6.0	229	23.3	
TIMBER CARRIER	MEETING	S 0.7	15.15	35	16.5	226	20.4	From 15.15 on coast-
SUPERTANKER	CROSSING	S 7.3	15.35	195	10.6	226	20.4	line, P, c.3 miles
TIMBER CARRIER	MEETING	P 0.4	15.48	46	12.6	226	20.4	* 4° S, 4.6 miles
TANKER	MEETING	S 0.5	15.55	37	10.8	226	20.4	
SMALL BOAT	CROSSING	P 0.7	15.58	29	2.8	226	20.4	

Cont
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Table 9 Summary on number and type of encounters

Survey	Number of encounters	Meeting	Overtaking	Crossing	Survey time (hours)	Encounter rate (1/hour)	Own ship's mean speed (knots)
A	61	45	16	0	7.18	8.49	26.3
B	70	47	19	4	7.82	8.95	24.1
C	100	68	24	8	54.92	1.82	25.1
D	84	51	23	10	55.13	1.52	25.0
E	20	9	4	7	12.33	1.62	25.0
F	15	8	2	5	53.17	0.28	25.7
G	40	12	14	14	16.00	2.50	22.8
H	20	11	0	9	56.00	0.36	19.7

Table 9 gives a summary on the number and type of encounters.

Note that there were only few crossing encounters in the Malacca Strait (Survey A and B) and that in the Luzon Strait, western Java Sea and the Caribbean (Survey E, G and H, respectively) the proportion of crossing encounters was relatively high. The number of encounters per survey hour was 8-9 for the Malacca Strait, about 2 for the lane between between Singapore and Hongkong and about 0.4 for the Caribbean. These figures should of course be seen in connexion with own ship's speed which was kept approximately constant during the surveys, except in Survey H where, as stated before, it was zero for about one-fifth of the survey time.

PASSING DISTANCES Distributions of passing distances of other ships to own ship for the various areas are shown in Figs. 2 a - c. It is reminded that only passing distances equal to or less than 12 n.miles are considered.

White bars refer to meeting encounters, hatched bars to overtaking encounters and black bars to crossing encounters. Each diagram is actually made up of two histograms: to the left of 0 for port side and to the right of 0 for starboard side. n is the total number of encounters.

The graphs also give indication of the ships' distributions.

No passing distance larger than 7 miles was observed in the Malacca Strait. The rapid drop of the number of encounters beyond own ship's close quarters is conspicuous. Obviously own ship went right through the densest part of the waterway. In the upper part of Fig. 2 a distributions for the close quarters encounters are also plotted. They allow the assumption of uniform distribution, that is an encounter is equally likely to occur at any passing distance within this short range.

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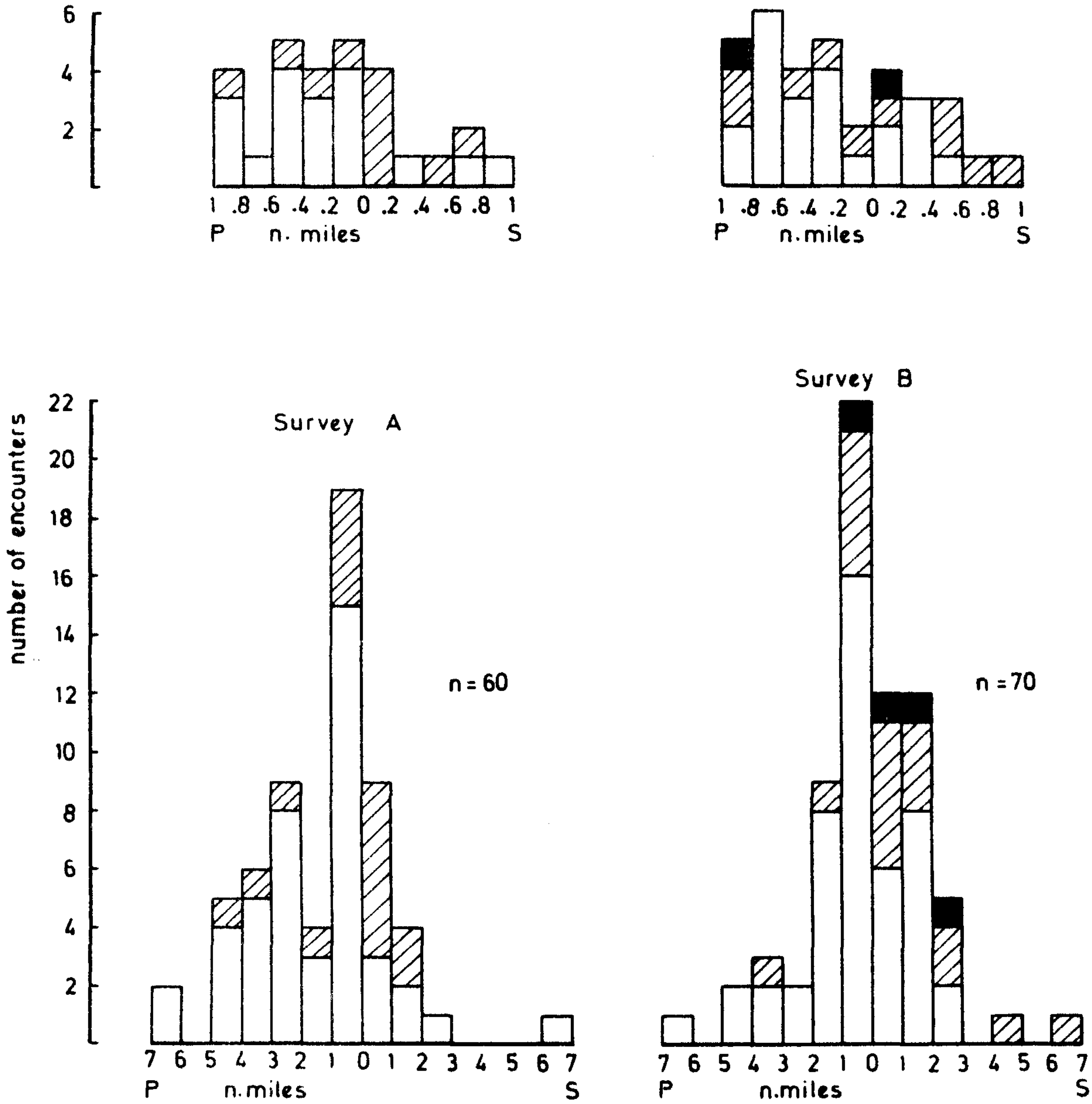

Fig. 2a

Distribution of passing distances in the Malacca Strait

Fig. 2 b shows distributions of passing distances in a main shipping lane but in a less restricted area. There is still a distinct peak visible which, however, lies beyond own ship's immediate vicinity. The diagrams depicted in Fig. 2 c would suggest uniform distributions. It is believed, however, that the sample number is too small to draw reliable conclusions from the graphs.

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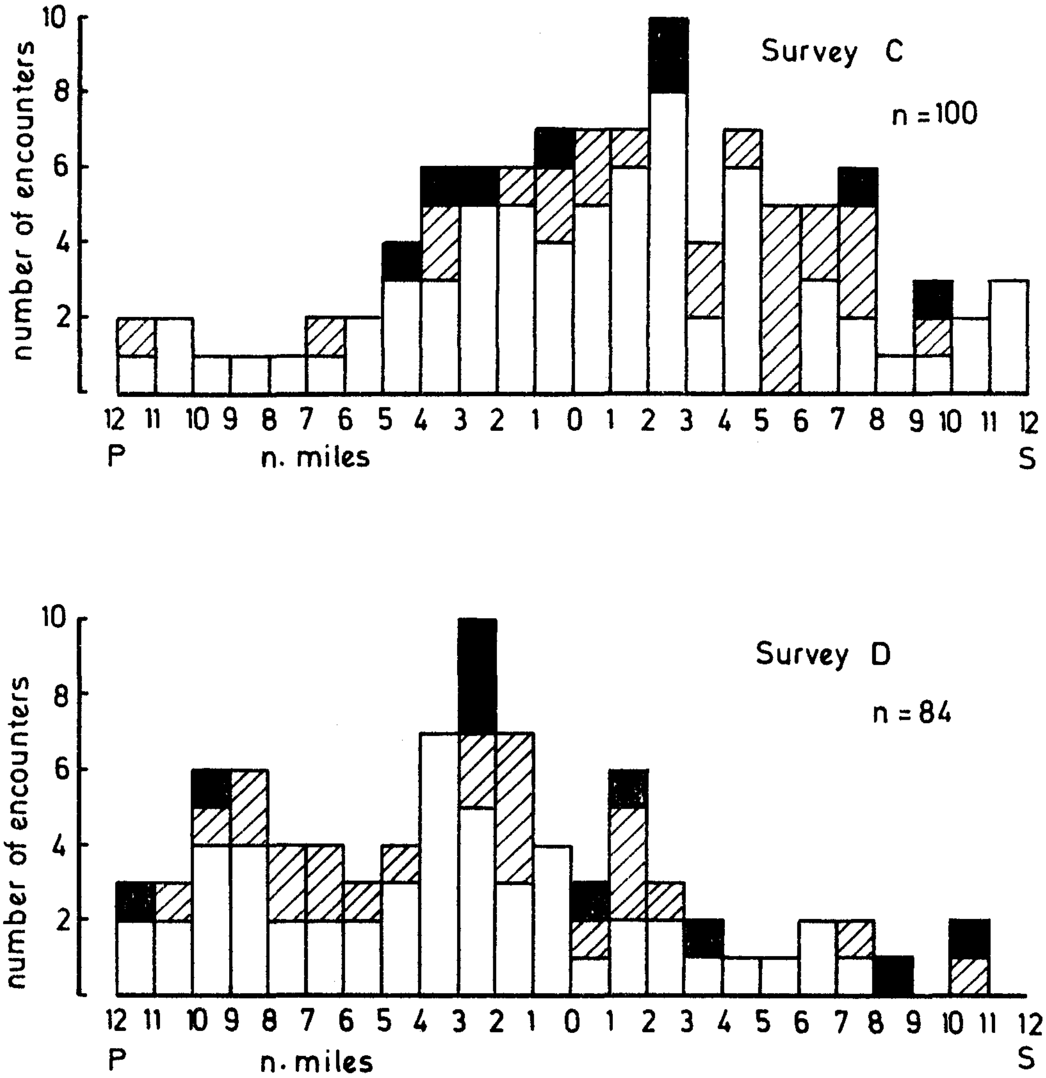

Fig. 2b

Distribution of passing distances in the lane between Singapore and Hongkong

Sometimes it is proper to look at the distribution on each ship side separately. It is seen that in many cases there is no simple model for the appropriate individual representation of the distribution of one ship side only. The sample means and standard deviations for either ship side are given in Table 10.

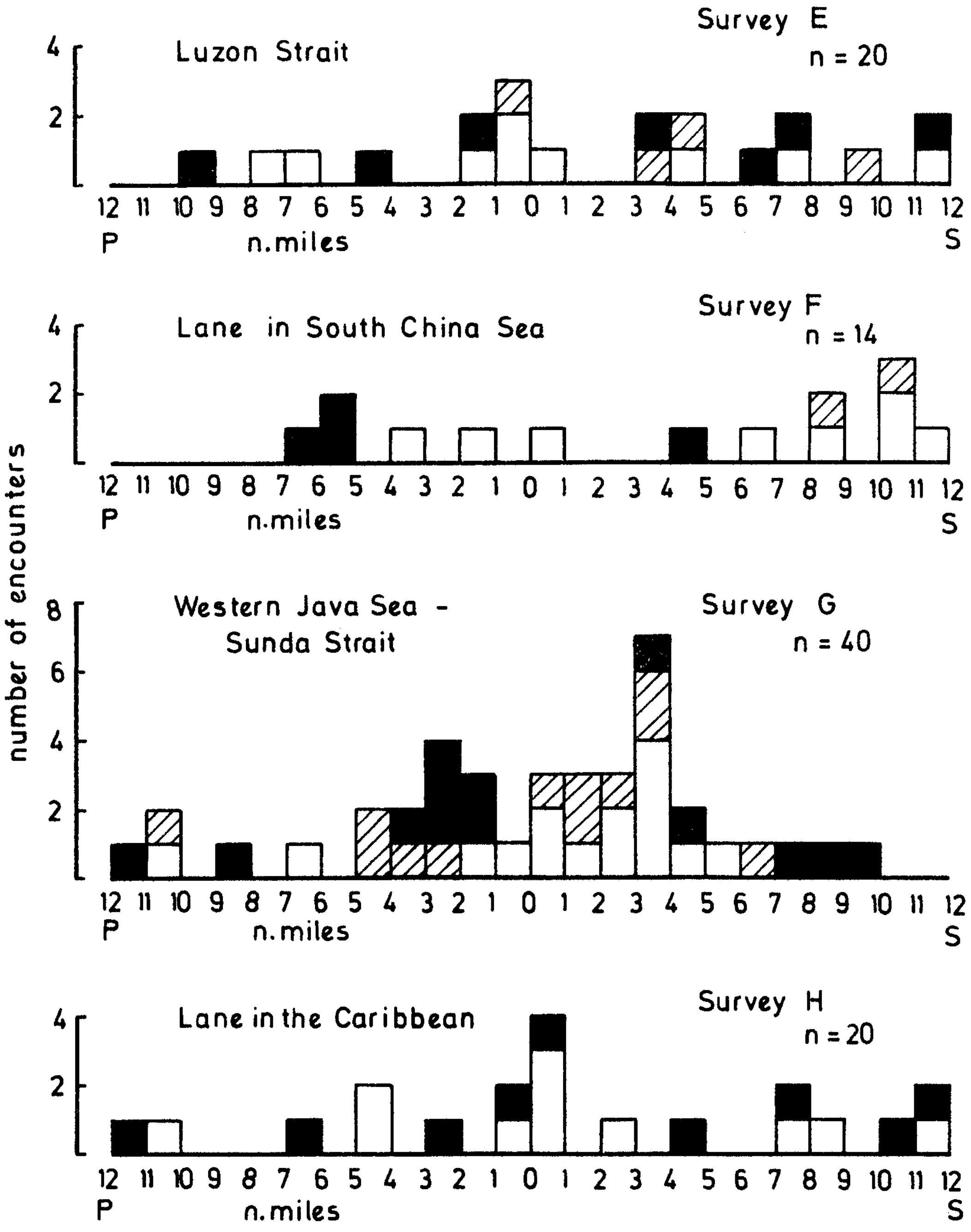

Fig. 2 c
Distribution of passing distances in various areas

Table 10 Mean and standard deviation of passing distances

Survey	Port			Starboard		
	Sample number	Mean (n.miles)	S.D. (n.miles)	Sample number	Mean (n.miles)	S.D. (n.miles)
A	45	2.1	1.7	15	1.3	1.6
B	39	1.4	1.4	31	1.5	1.3
C	40	4.0	3.3	60	4.7	3.2
D	61	5.4	3.4	23	4.0	3.2
E	9	3.6	3.5	11	6.4	3.5
F	5	4.5	2.0	9	7.9	3.6
G	17	4.6	3.6	23	3.7	2.5
H	8	5.1	4.1	12	5.5	4.5

<u>SPEED DISTRIBUTIONS</u> Speed distributions for ships sailing in opposite direction to own ship and for ships sailing in the same direction as own ship are plotted in Figs. 3 a - c. n is the number of observed ships.

There is a marked peak in each of the distributions for the Malacca Strait and the lane between Singapore and Hongkong. The graphs for the other areas are not so conclusive, it is believed that the sample number is too small. Means, standard deviations and confidence limits for the 95% confidence level are compiled in Tables 11 a - b. The confidence limits have been calculated under the assumption that the speed follows a normal distribution.

Table 11 a Mean and standard deviation of speeds of oncoming ships

Survey	Mean (knots)	S.D. (knots)	Confidence limits for the 95% confidence level			
			Mean		S.D.	
			Lower bound (knots)	Upper bound (knots)	Lower bound (knots)	Upper bound (knots)
A	10.6	3.6	9.5	11.7	3.0	4.6
B	11.0	3.7	9.9	12.1	3.1	4.7
C	12.2	3.1	11.4	13.0	2.6	3.7
D	12.3	3.7	11.2	13.4	3.1	4.6
E	12.3	1.4	11.2	13.4	0.9	2.7
F	10.0	3.9	6.7	13.3	2.6	7.9
G	6.6	5.2	2.6	10.6	3.5	10.0
H	12.8	3.4	10.5	15.1	2.4	6.0

Table 11 b Mean and standard deviation of speeds of overtaken ships

Survey	Mean (knots)	S.D. (knots)	Confidence limits for the 95% confidence level: Mean		S.D.	
			Lower bound (knots)	Upper bound (knots)	Lower bound (knots)	Upper bound (knots)
A	11.7	2.9	10.1	13.3	2.1	4.6
B	11.4	3.4	9.8	13.0	2.6	5.0
C	12.8	3.6	11.3	14.3	2.8	5.0
D	12.4	2.9	11.1	13.7	2.2	4.1
E	16.0	2.6	11.9	20.1	1.5	9.7
F	9.0	8.5	--	--	--	--
G	5.0	3.9	2.4	7.6	2.7	6.8

No ship faster than own ship was observed during the surveys.

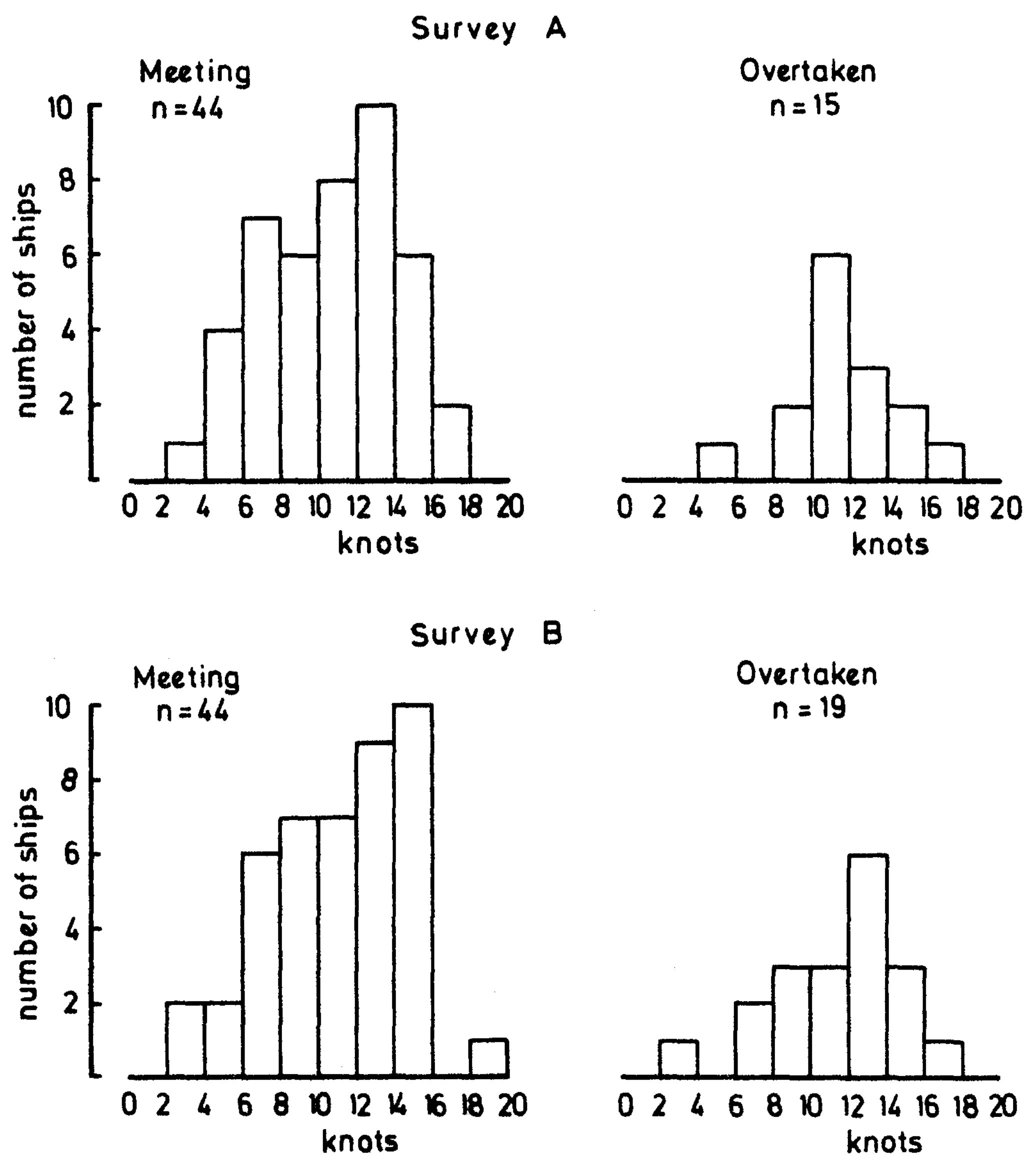

Fig. 3a

Speed distribution in the Malacca Strait

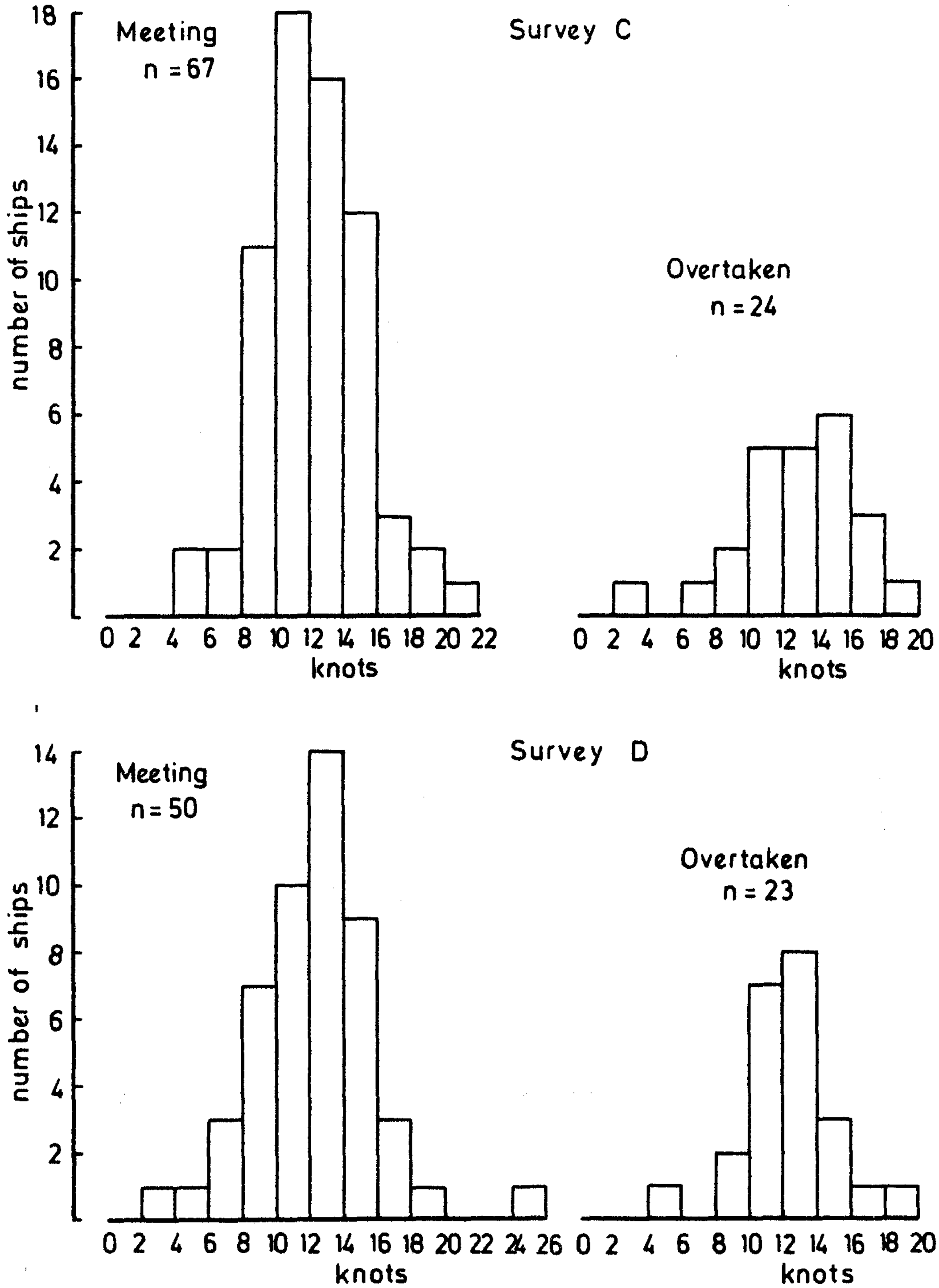

Fig. 3 b

Speed distribution in the lane between Singapore and Hongkong

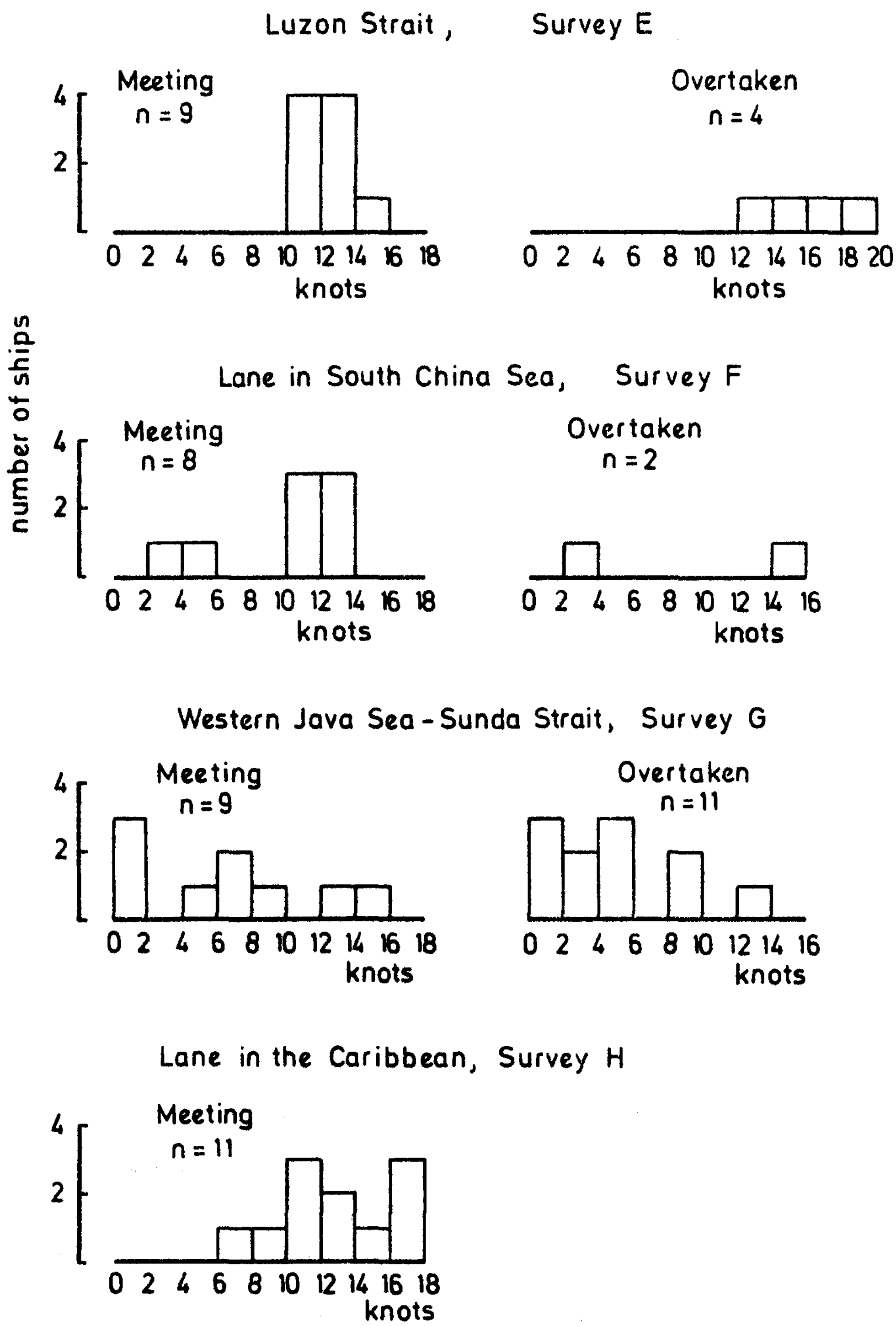

Fig. 3 c

Speed distribution in various areas

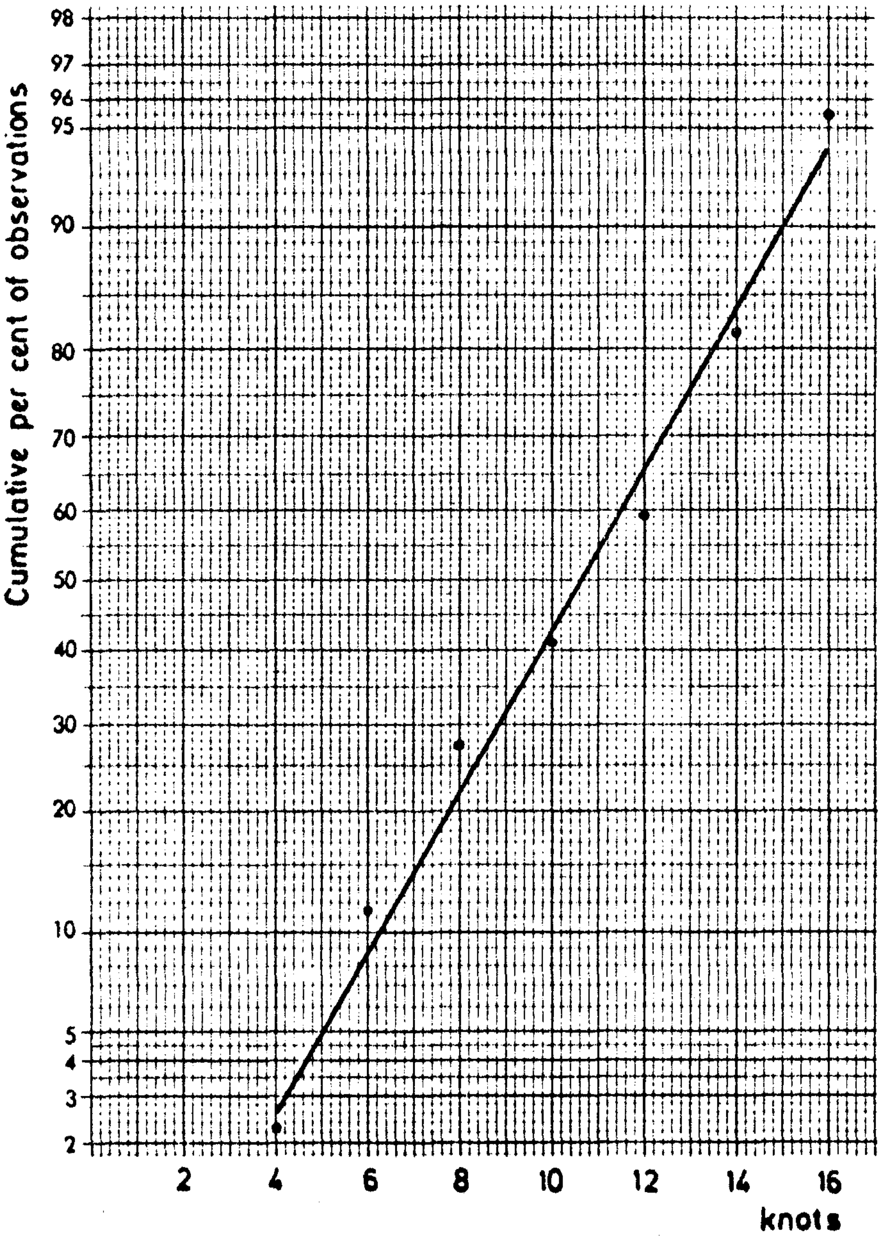

Fig. 4a
Probability plotting of speeds in the Malacca Strait (Survey A, meeting ships)

The observations give ship speeds ranging from 2 to 20 knots for the Malacca Strait as well as the lane between Singapore and Hongkong. They suggest that a mean speed of 11-12 knots is a good estimate. The confidence limits give the interval within which we may in the long run be 95% sure that the true value of the parameter is contained. For instance, we are 95% sure that in the long run the true value of the mean of speeds of the oncoming traffic in Survey C is between 11.4 and 13.0 knots and the true value of the standard deviation is between 2.6 and 3.7 knots.

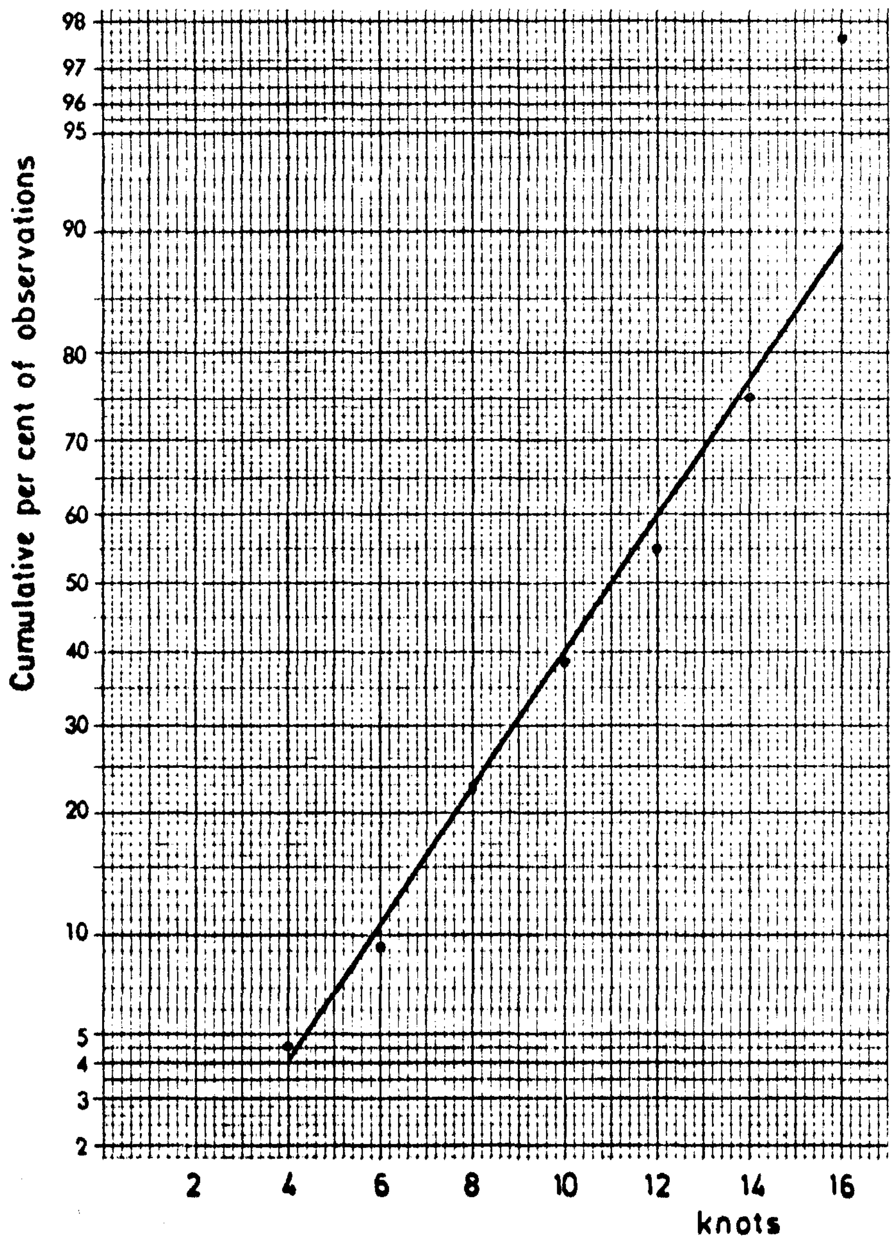

Fig. 4b
Probability plotting of speeds in the Malacca Strait (Survey B, meeting ships)

To see whether or not the observations contradict the assumption that speed follows a normal distribution, a probability plotting was carried out (Figs. 4 a - d). The method is subjective in the sense that the determination is based on a visual examination. If the chosen model is correct, the plotted points should cluster around a straight line. In Figs. 4 a - d the ordinate axis is scaled according to the values of the cumulative normal distribution. The plotted points tend to fall in a straight line. Thus we may conclude

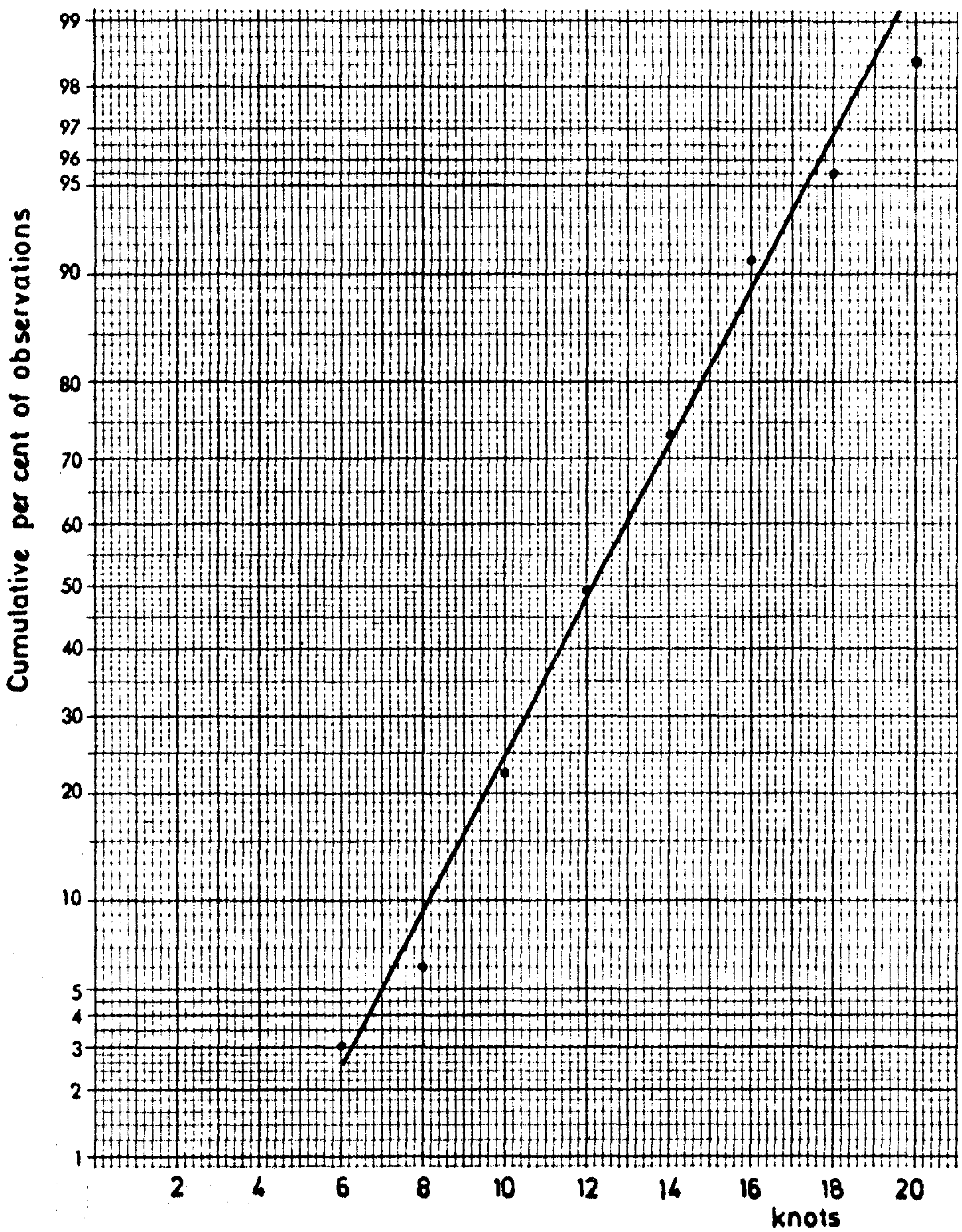

Fig. 4c

Probability plotting of speeds in the lane Singapore-Hongkong (Survey C, meeting ships)

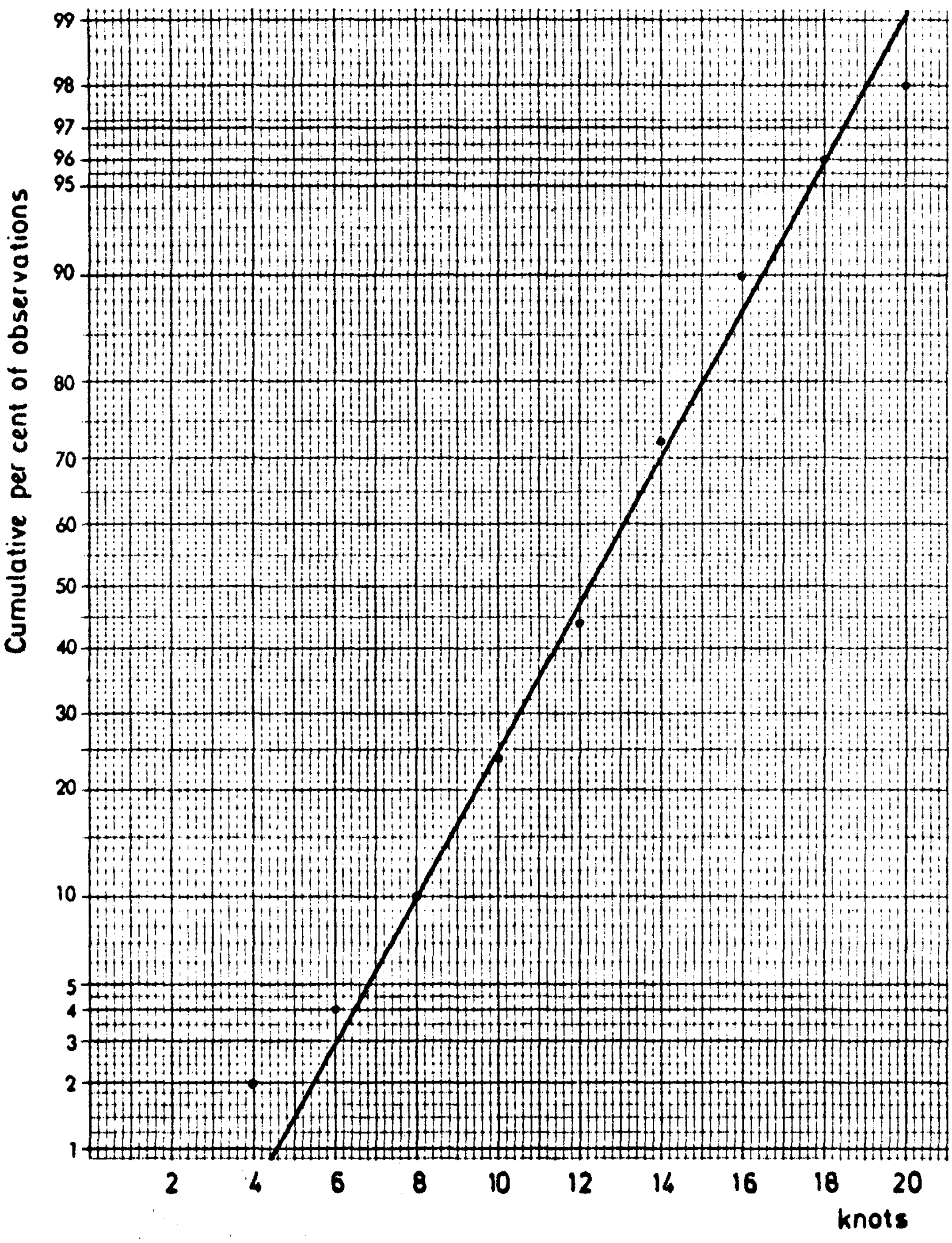

Fig. 4d
Probability plotting of speeds in the lane Singapore-Hongkong (Survey D, meeting ships)

that, on the basis of the data, the assumption of a normal distribution appears to be reasonable. Statistical tests giving numerical values on the adequacy of a model are also in use. They are not applied here.

CORRELATION BETWEEN SPEED AND PASSING DISTANCE We were also interested to know if there is a relationship between the passing distance and the speed of encountering ships. A standardized measure of the linear relationship between two variates is the coefficient of correlation. This coefficient can take on values between -1 and +1. The more the absolute value approaches to one, the greater the degree of relationship, and the more it approaches to zero, the less the degree of relationship.

The correlation coefficient for the various surveys has been calculated using the well-known formula. The results are compiled in Table 12.

Table 12 Coefficient of correlation between passing distance and speed of encountering ships

Survey	Sample number	Correlation coefficient
A	60	-0.0374
B	68	0.1584
C	102	-0.0963
D	86	0.0303
E	21	-0.1253
F	17	0.2532
G	36	0.1517
H	22	0.0900

To see whether the correlation really exists or whether it can be explained from the accidentalness of the sample, a test of significance according to R.A. Fisher was carried out. This test gives, for the 5% level of significance, values larger than those listed in Table 12. That means that our values do not differ significantly from zero and that, therefore, the hypothesis "correlation = 0" may not be rejected. Thus there is no evidence that there is a relationship between passing distance and speed in any of the surveys.

COURSE DISTRIBUTIONS The distributions of the courses of the encountered ships are depicted in Figs. 5 a - b. The distributions are given as polar diagrams. The circle representing all possible courses was subdivided in 36 class intervals of the same length. Thus the class length is 10°. The number of courses within a class length is given by the length of an arrow. The direction of an arrow indicates a class midpoint, that is approximately the mean of courses within the class length. An arrow is broken and the corresponding number of courses written beside it, if otherwise the arrow would be too long. Own ship's heading is always up. n is the number of observed ships.

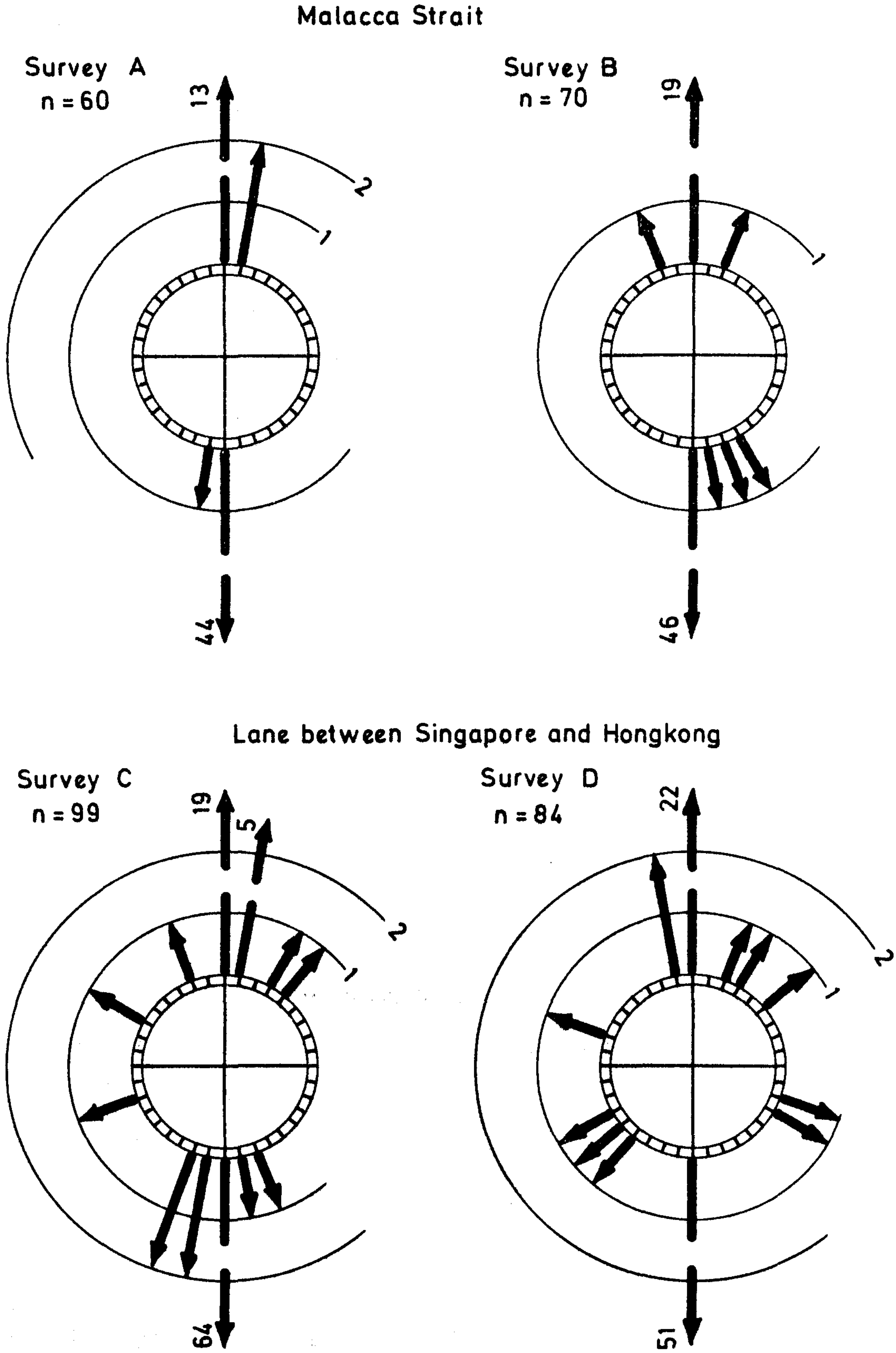

Fig. 5a

Course distribution in various areas

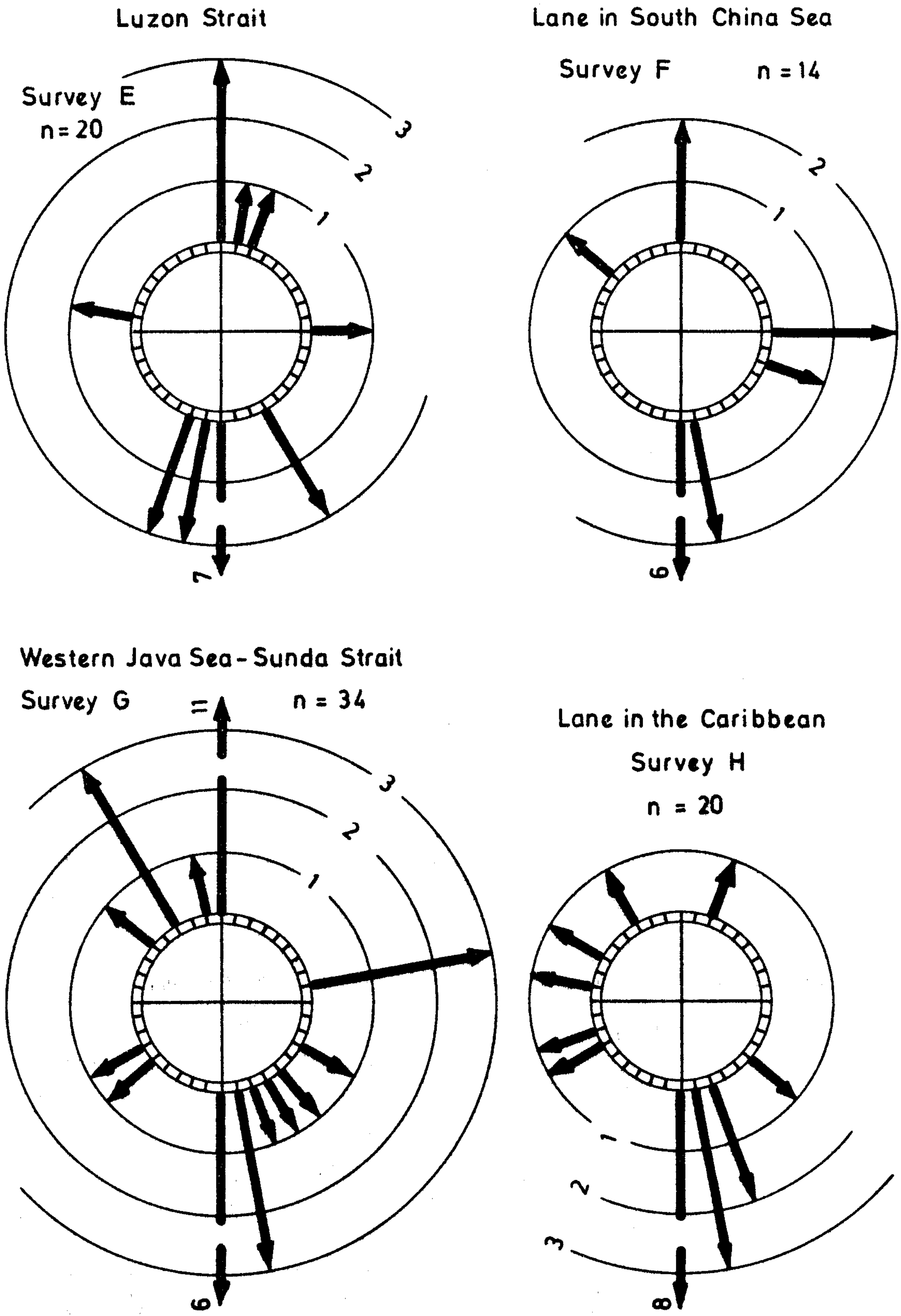

Fig. 5 b
Course distribution in various areas

As was already indicated in Table 9, by far most of the courses in the Malacca Strait and in the main lane between Singapore and Hongkong is parallel or reciprocal to own ship's heading. This is also true for the other investigated areas, although not in the same proportion. If crossing encounters did occur, then no specific crossing angle was preferred. In the Malacca Strait few ships crossed the main traffic with a very fine angle, in fact.

Theoretical reflections have shown that the encounter rate for a specific ship in crossing a two-way traffic is the lower the finer the traffic is crossed. The number of encounters per crossing, however, is the lower the more right-angled the traffic is crossed. A detailed discussion is omitted here. The interested reader is referred to [3] .

ENCOUNTER RATES Stress on the navigating officer while navigating his ship in much frequented areas is decisively given by the number of encounters occurred in a certain time period. The safety of the ship also depend on the encounter rate. In Figs. 6 a - b distributions of number of encounters occurred during certain time intervals are plotted (crosses). It can be seen that for a substantial part of the survey time there are two or less encounters every 10 minutes in Survey A and B, one or no encounter every 30 minutes in Survey E and G, two or less encounters every hour in Survey C and D, and one or no encounter every hour in Survey F and H. Clearly Survey A and B (Malacca Strait) give the highest encounter rates and Survey F and H (the second lane in the South China Sea and the lane in the Caribbean, respectively) the lowest.

The mean and variance of the number of encounters occurred in a certain time interval are compiled in Table 13. Although there are some theoretical objections to the general assumption that traffic is a Poisson process, the Poisson distribution has been used in the past to describe traffic.

Table 13 Mean and variance for the number of encounters during a certain time period

Survey	Time interval (minutes)	Mean	Variance	Confidence limits associated with the 95% confidence level: Mean, Lower bound	Mean, Upper bound	Variance, Lower bound	Variance, Upper bound
A	10	1.41	1.08	1.08	1.82	0.74	1.73
B	10	1.49	2.08	1.16	1.89	1.44	3.28
E	30	0.81	1.88	0.50	1.25	1.13	3.70
G	30	1.25	2.90	0.89	1.70	1.87	5.14
C	60	1.82	4.74	1.48	2.22	3.36	7.19
D	60	1.52	2.84	1.22	1.89	2.02	4.29
F	60	0.28	0.36	0.16	0.47	0.25	0.46
H	60	0.36	0.67	0.22	0.56	0.48	1.01

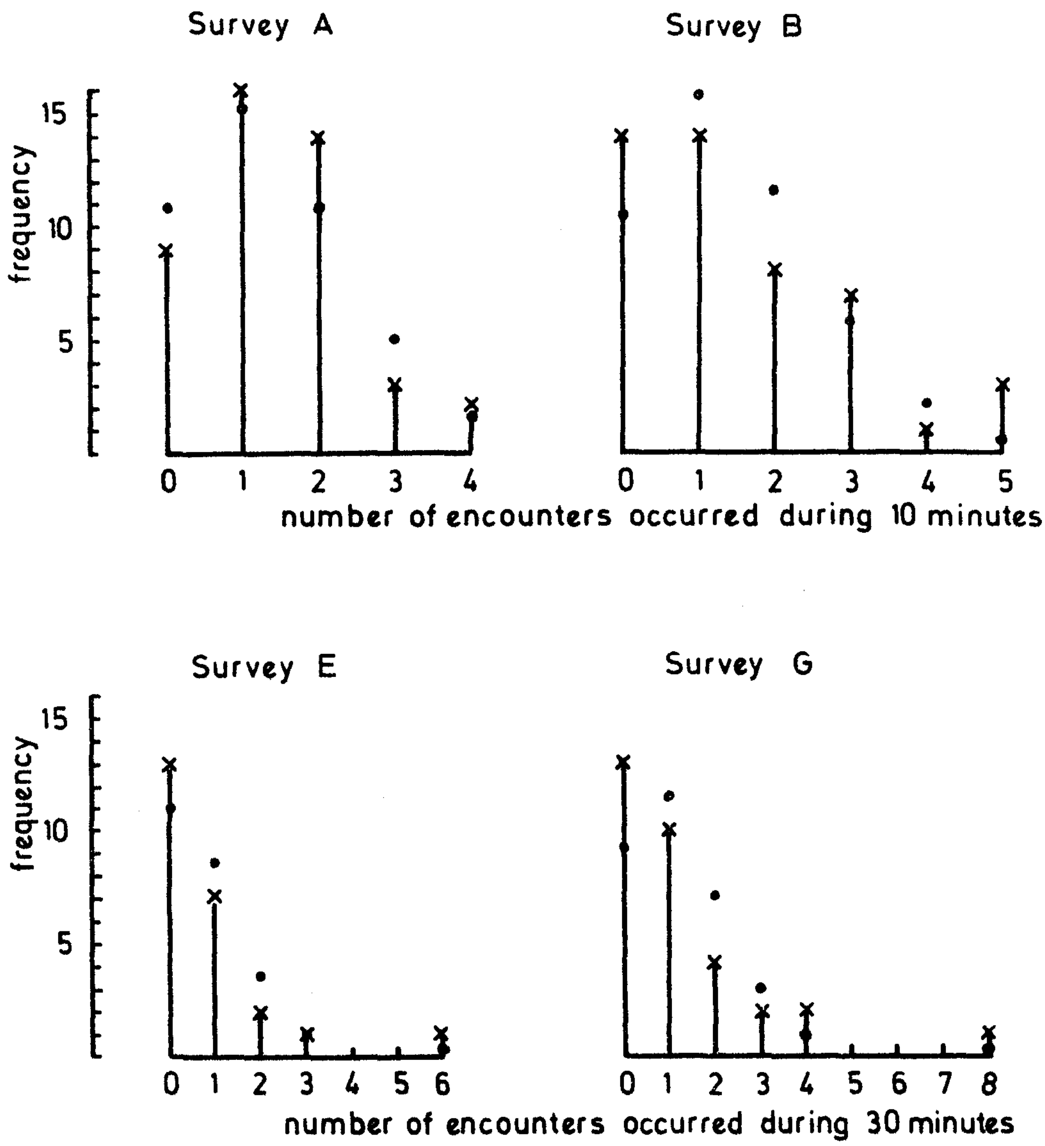

Fig. 6a

Distribution of number of encounters in certain time intervals

We will now see how the observed data fit the Poisson. In order that a variate can be adequately represented by the Poisson, its mean and variance should approximately be equal. At a first glance, Table 13 shows that mean and variance are not approximately equal and would therefore suggest that there will be substantial discrepancy between the data and Poisson. Things become different, however, if we recall that these values themselves are random variables. Thus it is necessary to take the confidence intervals into account. The confidence intervals which have been calculated for the 95% confidence level are also given in the table. Only for Survey G, C and D is there no overlap of the intervals for the mean

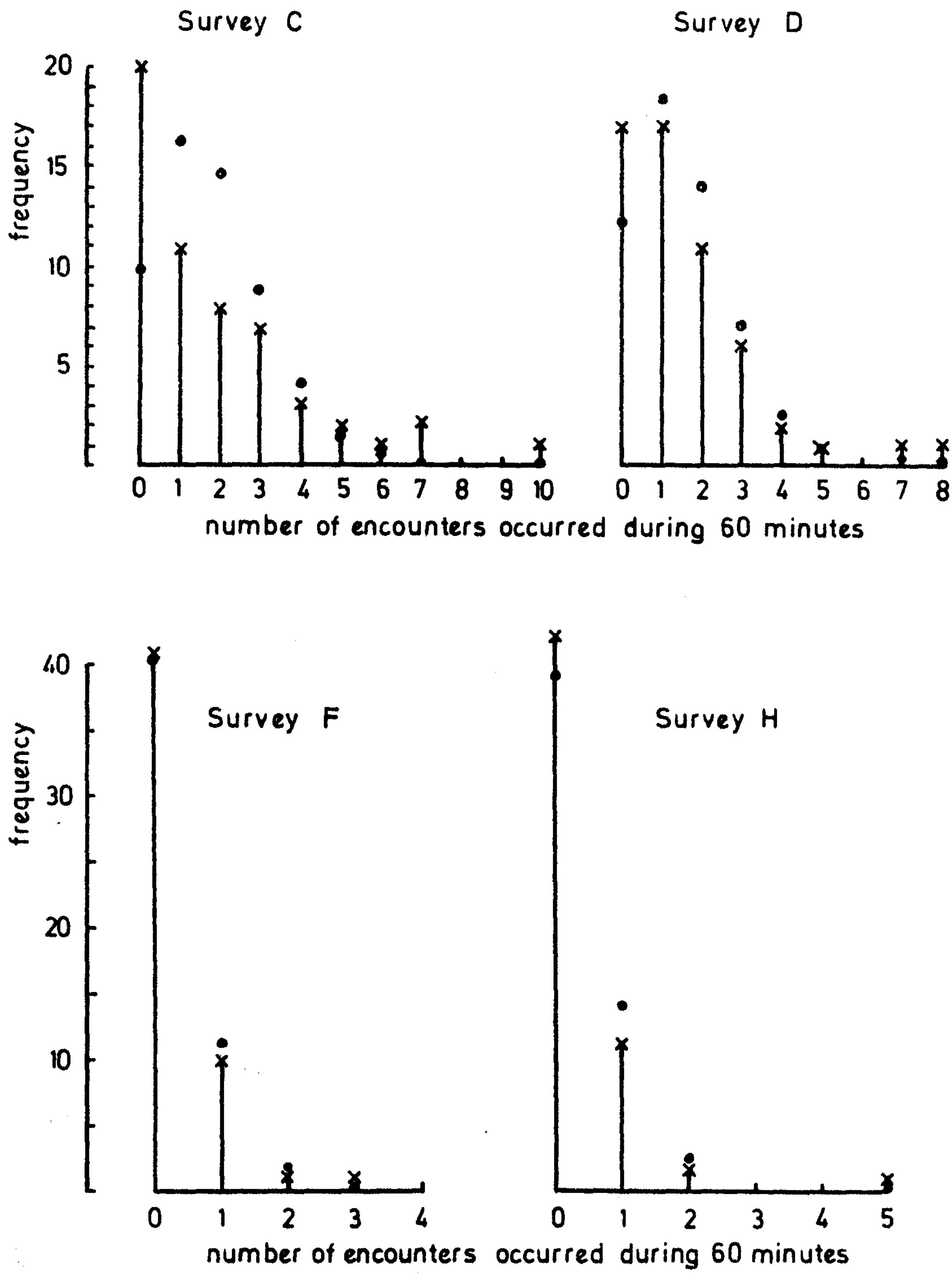

Fig. 6b

Distribution of number of encounters in certain time intervals

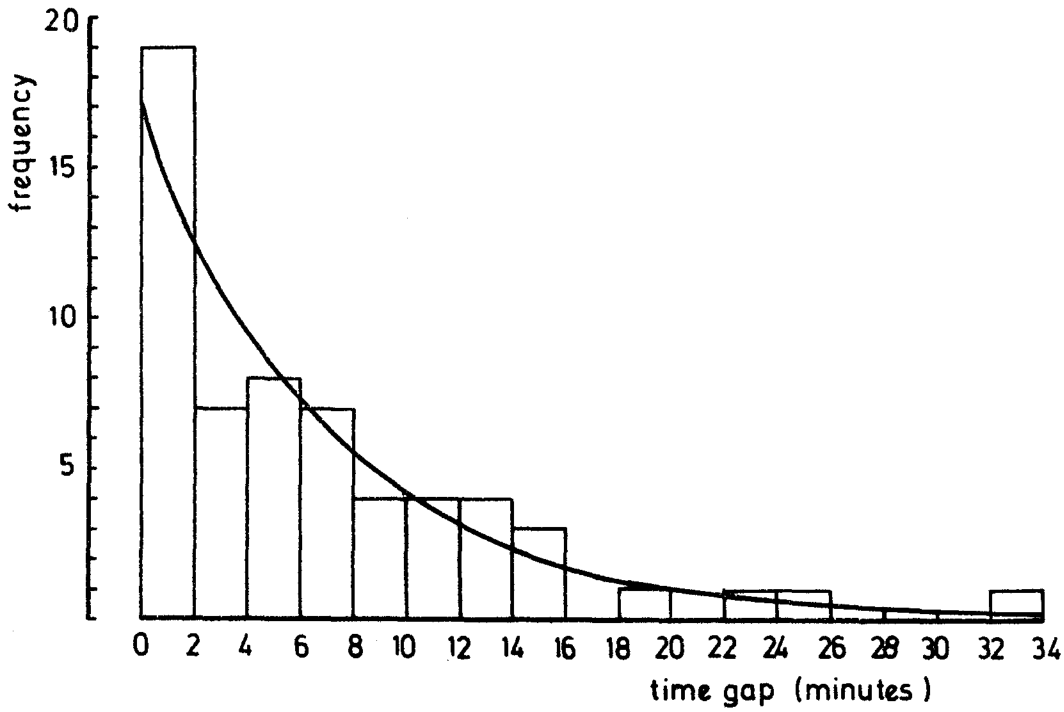

Fig. 7
Distribution of time between two successive encounters (Survey A)

and variance.

The confidence limits have been calculated using the percentiles of the χ^2-distribution as follows.

Table 14 Formulas for calculating confidence limits

Parameter	Lower bound	Upper bound
Mean	$\frac{1}{2}\chi^2_{\frac{1}{2}\alpha,2n}$	$\frac{1}{2}\chi^2_{1-\frac{1}{2}\alpha,2n+2}$
Variance	$\frac{s^2(n-1)}{\chi^2_{1-\frac{1}{2}\alpha,n-1}}$	$\frac{s^2(n-1)}{\chi^2_{\frac{1}{2}\alpha,n-1}}$

n is the sample number, s^2 the sample variance and $(1-\alpha)100\%$ the (two-sided) confidence level.

The corresponding Poisson distributions using the data mean as the distribution's parameter are superimposed in Figs. 6 a - b (dots). The conformity or non-conformity of the representation of each individual case can be seen from the graphs. A detailed discussion on the degree of agreement is beyond the scope of this paper. It is only noted here that one possible alternative to the Poisson is the negative binomial distribution.

Instead of the number of encounters in equal time intervals, the time between two successive encounters can also be used as a measure of the navigating officer's stress. Short time gaps are not necessarily dangerous if they appear only occasionally. They can be dangerous, however, if they appear frequently. Fig. 7 shows the distribution of time between two consecutive encounters for Survey A. About one-third of all encounters occur with time gaps of 2 minutes or less. If we assume the number of encounters to be Poisson-distributed, then the time gap will have a negative exponential distribution. This is undoubtedly an advantage of the Poisson: both the probability density and the cumulative distribution of the length of the intervals of the variate can be calculated easily. The curve in Fig. 7 represents the corresponding negative exponential distribution. The approximation is pretty good.

TRAFFIC DENSITY Traffic densities were determined in two ways: by counting the number of ships actually observed and by calculations using speed distributions and encounter rates. The determination by counting was performed as follows. The number of ships in an area of certain size was counted at several points of time during a survey. The densities were then determined and plotted over the time. A curve was drawn through the plotted points. The mean density for the area in consideration is the area under the curve divided by the total time. The determination by calculations was based on the assumption that each ship kept her course and speed while she was in the investigated area. The general formula for calculating the density from observations from a sailing ship is rather complicated [3] . For certain simplified cases, however, the following formulas will hold.

If encounters occur only with ships sailing in opposite direction to own ship, then

$$\text{Density} = \frac{\text{Encounter rate}}{a \cdot (\text{Speed}_{\text{own}} + \text{Speed}_{\text{other,mean}})}$$

If encounters occur only with ships sailing in the same direction as own ship and own ship's speed is larger than any of the other ship's speed, then

$$\text{Density} = \frac{\text{Encounter rate}}{a \cdot (\text{Speed}_{\text{own}} - \text{Speed}_{\text{other,mean}})}$$

a is the width of the area on which the calculation of the density is based and should cover a range in which the traffic is uniformly or nearly uniformly distributed. The formulas are applicable if the traffic is made up of oncoming ships and ships being overtaken only. On grounds of Figs. 2 a - c it appears reasonable to choose a width of 4 miles for Surveys A and B and one of 12 miles for the other Surveys. Table 15 gives the densities obtained by the two methods.

Table 15 Traffic densities

Survey	Density (ships per square mile) observed	calculated
A	0.048	0.052
B	0.069	0.070
C	0.0042	0.0040
D	0.0031	0.0029
E	0.0030	0.0031
F	0.00037	0.00013
G	0.0071	0.0052
H	0.00083	0.00032

The agreement of the results by the two methods is good for Surveys A, B, C and D where the percentage of crossing encounters in each was low. In the other Surveys, however, there was a rather high percentage of crossing encounters and the results mostly don't agree well. This, of course, is because the calculated values were obtained using abovementioned simplified formulas which neglect crossing encounters. The table indicates a density of 0.05-0.07 ships per square mile for the centre of the Malacca Strait, about 0.004 for the lane between Singapore and Hongkong and about 0.001 for the lane in the Caribbean Sea.

INDICATOR FIGURES FOR THE BEHAVIOUR OF NAVIGATORS By theoretical deliberations we came to the assumption that the solution of the most frequent navigational problems is equivalent to the choice of one possibility out of about 30000. The information provided by such solution to the navigator is thus about 15 bit. Scattered data in literature indicate that the maximum information processing capacity of the human operator will be equal to or less than 0.2 $bit \cdot s^{-1}$. Tests carried out by the authors lead to the conclusion, however, that a more realistic value would probably be about 0.05 $bit \cdot s^{-1}$. This applies for prolonged operation. If the average workload does not exceed the operator's capacity, the error rate will remain very close to zero even after several hours. Field observations and interviews made with experienced navigators have shown, however, that the number of problems solved, e.g. during a navigational watch in congested waters, is much higher than the theoretical maximum of about 170 $bit \cdot h^{-1}$ or about 12 standard navigational problems. That means that the experienced navigator reduces the information processing workload by using substantial amounts of a priori information. This is in fact one element of what we normally call experience. The experience in turn may be described as a set of probability functions the knowledge of which has been achieved by the navigator intuitively in the course of hundreds of navigational watches stood at sea. We have tried to elucidate some of these probability functions from the raw data of our investigation by looking for certain distinctive patterns in the navigator's decision making. Unfortunately for our intentions though certainly fortunately from the standpoint of safety of marine traffic the number of situations which could be evaluated was rather small. About 50 situations were recorded in the raw data which involved risk of collision in the opinion of one or both of the navigators concerned. This was concluded from the fact that in these situations at least one of the vessels manoeuvred to avoid a collision. One important element of the navigators' behaviour pattern is the distance from the other vessel at which action is commenced. Our analysis revealed that the distribution of this distance is roughly uniform between 2 and 10 nautical miles. Beyond 10 miles there is a sharp decrease in the number of evasive manoeuvres started at these long distances. This is probably due to the fact that the vessels' sensors have a range of not much more than 10 nautical miles under average environmental conditions. This applies for shipborn radar as well as for the bridge personnel's eyesight. No particular preference for evasive action to be started at a special distance could be observed so far.

Another very important element of the navigators' behaviour is the amount of change in course or speed which was chosen as an evasive manoeuvre appropriate under the prevailing conditions. Based on 21 situations listed in [2] we started with the hypothesis that the distribution of change of course might be normal with a mean of 12 degrees starboard and a standard deviation of 17 degrees. The additional 14 evasive manoeuvres conducted by own ship during the surveys covered by this paper make us more inclined to believe that changes in course follow a two-peaked distribution with peaks between 5 and 10 degrees to port and 5 and 10 degrees to starboard. The ratio between changes to port and changes to starboard is 1 to 3.25. This indicates that changes of course to starboard are doubtlessly preferred by the navigator. The preference of starboard over port manoeuvres, however, does by far not reach that level which was obviously thought to be appropriate by the IMCO-Conference on the Revision of Collision Regulations in 1972. The new Collision Regulations which came into force internationally on 15th July, 1977, give indeed very strong advice against changes of course to port, although they do not absolutely forbid such manoeuvres.

Finally we looked for a correlation between the distance at which action is taken and the extent of the manoeuvre chosen to avoid collision. The data so far available lead to the conclusion that in practice no such correlation should be deemed to exist.

It is not within the scope of this paper to judge whether individual manoeuvres or the navigators' behaviour in general were in line with the applicable Rules. We are particularly reluctant to decide whether any given manoeuvre was "made in ample time" and whether the extent of the manoeuvre executed by the vessel was "sufficient to be designated as positive". On the other hand it is our firm belief that the interpretation of such very general and highly subjective terms in the Regulations should be based on the views of those at sea instead of those administering safety at sea from the shore. A major deficiency of private or of official investigations into marine casualties is that they deal with the unsafe situation exclusively. The parameters found in such cases are usually believed to be causative or at least conditioning factors for marine accidents. A thorough survey of all situations, however, might lead to the conclusion that some of these parameters prevail under safe as well as under unsafe conditions and can by pure logic not be considered as major contributory causes of accidents at sea. On the other hand a slight increase of some of the safety margins might lead to a more than proportional increase of safety. For instance, an increase of the minimum passing distance or the minimum change of course in a collision situation might reduce the collision rate by powers. A long-term program of education to convince navigators world-wide of the benefits involved in "defensive driving" could be the most efficient means of promoting safety at sea compared with the proposed changes in formal academic training or the additional installation of hundreds of pieces of electronic equipment.

DISCUSSION WITH THE MASTER We have had an opportunity to show some of our results to the Master of CTS "TOKIO EXPRESS" and to ask him for some commentary. His comments are very useful. This applies particularly in respect of the distribution of speeds, the distribution of passing distances and the distribution of traffic across the main direction of the route.

Captain Klein said that the mean value of speed has decreased considerably since the days of the surveys. Vessels which are able to proceed with an SOA of 27 knots and more would now operate with an economic speed of 19 to 21 knots. Large tankers with a service speed of 14 to 16 knots are now sailing with an SOA of 7 to 9 knots. This would additionally lead to a smaller standard deviation of the speed distribution. Generally speaking, the trend of the past years has been towards a lower, more economic speed. It remains to be seen whether the general reduction of speed will also lead to a reduction of the collision rate.

In respect of passing distances Captain Klein told us that one of his important although very difficult tasks was to continuously educate his junior navigating officers safety-mindedness. It is easily to be understood that young ambitious men are only too emotionally inclined to drive a large and very fast ship like a race car just for a show-off. This results in decreasing passing distances if the standing orders of the Master in respect of minimum margins of safety are not continuously repeated and their obeyance to the very point continuously supervised even if that means to be thought of as "a yellowish old man" by some of them. Captain Klein was of opinion that possibly this task was not taken equally serious by every master at sea to judge from some very narrow encounters which were experienced nearly as a routine.

Regarding the distribution of traffic across the main direction of the route Captain Klein told us that in his opinion this was mainly due to the limited position fixing capacities of many vessels including his own. He reported a very interesting observation. During a passage in South-East Asian waters he was sailing in company with another vessel which was known to be equipped with a satellite navigation receiver of advanced design. In an area where opportunities for long-range electronic position fixing were not available, where traditional astronav was severely restricted by rain clouds obstructing the celestial bodies as well as the horizon during the monsoon season, where even radar navigation suffered from rain clutter obliterating the few identifiable terrestrial targets and where unpredictable currents led to quite substantial set and drift the satnav-equipped vessel was obviously still able to follow very closely a pre-determined track. In the same time his own position oscillated about the same track by up to 20 miles to both sides although all efforts were made by well trained and careful navigating staff to fix the position by all available means as often as possible. It became a sport to guess the position before fixes were taken by estimating the own position relative to the satnav-vessel, and this turned out to be a very precise method of navigation by comparison with the astronav-fixes obtained.

Captain Klein said that although he appreciated the opportunities offered by satellite navigation he was nevertheless deeply concerned about the possible detrimental side-effects. If practically all vessels try to follow the recommended routes which are given in pilots or printed in the sea-charts, and if they are distributed across a strip of water to both sides of the route due to the limitations of the position fixing capacities only, then a widespread introduction of methods and means for a continuous high precision navigation will inevitably result in a heavy concentration of traffic on or in the close vicinity of the recommended routes. Together with negligent watchkeeping habits on some ships this might lead to a substantial increase of the collision risk if no preventive measures were taken in time. Those resposible for rule-making in respect of the mandatory fitting of advanced electronic aids to navigation ought to keep these interdependencies well in mind and take care of the probable detrimental effects of their acts before they materialize.

Finally Captain Klein regretted that the new Collision Regulations did not effectively prevent the misuse of the three-red-lights signal for vessels restricted to manoeuvre by their draught, e.g. by specifying a ratio between the draught and the available depth of water in Regulation 28. (As the water depth mostly varies both in the route direction and across it, it would also be logical to lay down up to how far after leaving the point which is considered shallow the ship is permitted to carry the three red lights.) It is apparently so convenient to feel restricted in the absence of more stringent specifications that the carrying of three red lights has become standing procedure in some very crowded straits in Asian waters even by vessels which could easily and safely execute full turning circles or any other evasive manoeuvre in case of need even if not using the very centerline of the deep water. This fact is certainly a contributory cause for the concentration of traffic in rather narrow strips of the available sea space. Whilst the separation of the traffic streams proceeding in opposite directions has doubtlessly had great merits in controlling the risk of collision, much further thought appears necessary to overcome the negative side-effects of such measures.

CONCLUSIONS The number of observed ships in the Malacca Strait and Singapore-Hongkong lane surveys is sufficient to give reliable results while that in the other areas is considered too small. A continuation of the investigation is recommended, firstly, to eliminate possible casualness conditioned by the time of the year or even day of the week for the Malacca Strait and Singapore-Hongkong lane data and, secondly, to gain more data for the other areas. Based on the present results the following conclusions can be drawn.

Type of encounter Meeting and overtaking encounters predominate in all investigated areas. In the Malacca Strait and Singapore-Hongkong lane crossing encounters amount to about 10% at most, in the other areas the percentage is higher.

Encounter rates At ship's speed of about 25 knots, the encounter rate is about 0.3 per hour in a South China Sea lane, about 2 in the lane between Singapore and Hongkong and about 8 in the Malacca Strait. To a certain degree the frequency of the number of encounters within certain time periods can be represented by a Poisson distribution.

Ship distribution In the Malacca Strait ships are concentrated in a width of about 4 miles at the centre of the lane. In the Singapore-Hongkong lane they are mainly located within a width of about 12 miles. Ship distributions in these areas are peaked.

Speeds Speeds range from 2 to 20 knots in the Malacca Strait and the Singapore-Hongkong lane. The mean speed is 11-12 knots. It appears reasonable to assume that speed follows a normal distribution and that there is no correlation between speed and passing distance.

Courses Most of the encountered ships have courses reciprocal or parallel to own ship's course, own ship being on conventional shipping routes. If they cross own ship's direction, then no specific crossing angle seems to be preferred.

Traffic density The density is about 0.06 ships per square mile in the centre of the Malacca Strait, 0.004 in the Singapore-Hongkong lane and 0.001 in a Caribbean Sea lane.

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REFERENCES

[1] Kwik, K.H., Stecher, W.,
"Sea Traffic Recordings from the English Channel up to the Persian Gulf"
Marine Traffic Systems, Supplement. Delft University Press, Netherlands, 1976, pp 127-145

[2] Kwik, K.H., Stecher, W.,
"Erfassung von Kenndaten für die Sicherheit von Schiffen im Seeverkehr" (Gaining of data for the evaluation of the safety of ship in traffic)
Yearbook of Schiffbautechnische Gesellschaft, Vol. 70, 1976, pp 353-371

[3] Kwik, K.H.,
"Berechnung der Begegnungsrate" (Calculation of the encounter rate)
Institut für Schiffbau of Hamburg University, Report No. 335, 1975, 66 pp