A Survey of Traffic Passing Offshore Installations in the North Sea

M. A. F. Pyman, P. R. Lyon, G. Rowe May

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1. INTRODUCTION. Since drilling for oil and gas began in the North Sea in the mid 1960s, the possibility of merchant ships colliding with offshore platforms or rigs, has been of concern to both government and operators. There are nearly 100 fixed and floating installations in the UK sector of the North Sea; they vary in size, location and type of construction, but in all cases, collision would pose serious risks to life, pollution and loss of production. Some platforms are near busy shipping lanes and some have several hundred personnel on them at certain times.

In order to evaluate the risk, and so decide what priority to place upon possible means of minimizing the risk, various studies have been carried out over the past decade. These studies have, however, suffered from a lack of definition of the location and density of shipping precise enough to relate to individual platforms. To overcome this lack of definition an attempt was made to survey the traffic in two areas selected for their inclusion of several North Sea platforms near suspected areas of high shipping density. The survey concentrated on merchant ships, since fishing vessels and vessels connected with supplying the offshore installations are too small to inflict potentially disastrous damage.

In this paper the navigational concern of merchant ships plying the North Sea is considered first, providing a basic logic for their behaviour when in the vicinity of the platforms. The traffic survey work is then presented, with particular reference to the data sources consulted.

2. NAVIGATIONAL PRACTICE. The North Sea is renowned as an area of particularly adverse weather in terms of reduced visibility and high winds. It supports a great diversity of traffic, including high densities of fishing vessels and areas of relatively high traffic congestion, in addition to the fixed structures and activities related to the exploration of oil and gas deposits. Against this background must be considered the now-established trend towards reduced manning levels on board ships and widespread use of automatic pilots, all leading towards a reduction of manpower on the bridge to maintain the essential lookout duties. In the case of the smaller coastal vessels, manning regulations are such that these ships often have only two navigators working watch-about at sea, who are also responsible for the cargo working of the ship in port. The larger ocean-going ships are often manned by officers new to the ship and to each other, because European ports are the terminal ports for the voyage. These officers again are working very long hours both in port and at sea.

In the past a ship with a draught of 8–10 m was considered deep-draughted and it would have been a comparatively easy task to shape a course from port to port across the North Sea. The principal hazards of such a voyage would be reduced visibility, depth of water, set and drift and fleets of fishing vessels, if not necessarily in that order. When planning a passage in this area today many factors have to be taken into consideration, although the earlier fear of fog has to a large extent been eliminated with the use of radar. The prime considerations before contemplating a passage may therefore now be listed as:

(i) Does the nature of the cargo (chemical/oil) permit the route to be taken?
(ii) Is there sufficient water for the ship's draught?
(iii) What local or international regulations apply?
(iv) Does a traffic-separation scheme permit the chosen route?
(v) Are any installations or rigs likely to impede the chosen course?
(vi) Are there any wrecks or salvage operations in progress?
(vii) Will there be any seismograph vessels, towing cables of up to 1–2 n.m.?
(viii) Are there likely to be heavy densities of concentrated traffic, such as international yacht races or Eastern bloc fishing fleets?
(ix) Is this the most appropriate route bearing in mind the weather forecasts?
(x) What aids to navigation will be available?
(xi) Is this the safest and most direct course to take, bearing in mind the above considerations?

Present-day navigational technology has taken much of the doubt and uncertainty out of the problems of position-fixing. It is now well within the capability of many vessels to fix their positions within ± 1 n.m. in the open sea.

Permanent offshore installations are themselves widely used as navigational marks and, if located near to a chosen source, provide a convenient method of obtaining a visual position fix. From a detailed questionnaire distributed to licensed deep-sea pilots and from discussions with ship masters and senior navigating officers it is clear that this is a widely established practice, with evidence that ships are willing to divert from their chosen course to locate an installation, particularly if a departure position is required. From the responses to the questionnaires most pilots and ship masters indicated that they would choose to pass about 2–3 n.m. off the installation to obtain a position fix. With an average visibility in the southern part of the North Sea of less than 3 n.m., it is still not uncommon for ships to pass closer than the chosen distance in order to read the nameboards displayed on the installation for identification purposes. Experienced navigators, however, draw attention to those (still relatively few) installations fitted with radar transponders, which reduce considerably the need to pass close enough for a visual fix.

Pilotage experience indicates that in general terms the standards of lookout and alertness in deep-sea ships are still high, particularly in the case of Japanese and Indian vessels. Needless to say there are other nationalities whose standards leave much to be desired. The case of the much smaller coastal vessels is not so encouraging, probably because of the manning levels and workloads referred to earlier.

3. TRAFFIC IN THE SOUTHERN SECTOR. This area of the North Sea was selected as an area typical of relatively high traffic density in the vicinity of

offshore gas fields. The area is limited approximately by latitude 54° N. marking the northern boundary and the latitude of Cromer to the south. The seaward limit is approximately 02° 30′ E. It is an area traversed primarily by shipping bound to and from the Humber and Wash ports and by coastal shipping on the main UK East Coast routes.

In terms of shipping-movement data the main information sources used are those contained within the National Ports Council Annual Digests of Port Statistics of UK Port Arrivals, trade forecasts and port origin and destination studies. These indicated that in 1979 there were 27 500 shipping movements to and from the Humber with a further 5500 movements to and from the main Wash ports of Boston and King's Lynn. The numbers of vessels on the coastal routes through the area have been estimated using the arrival data from other East Coast ports and from the various origin and destination studies.

To determine the routes actually taken discussions were held with ship masters and with deep-sea pilots, but in this instance the location of the area is such that it was possible to undertake a detailed surveillance of traffic through most of the area with the use of shore-based radar.

Shipping traffic survey. A shore-based radar surveillance of the shipping traffic was undertaken from the Humber Pilot Station at Spurn Head using a standard Decca marine radar with 16 in. displays. Four survey periods were selected to cover a complete tidal cycle each and to cover different days of the week to eliminate the effects of any daily variations in the traffic flows. Where possible, individual ships were identified with their names, ship type and size, and origin or destination noted. Fishing vessels and supply craft were specifically omitted from the survey. A total of 170 tracks was plotted from the radar screen of which 114 ships were identified, with 56 unknown.

In general, the range of ship plots from Spurn Head was in the order of 18 n.m. with a maximum range of 21 miles. The Rough gas installation was, however, clearly seen on the radar at all times. From the radar a series of plots and tracks were made for each vessel noted and summarized for each survey period. The radar plots of ships' tracks were then summarized to show all tracks recorded for ships bound to and from the Humber and for passing traffic. These are shown at Appendices 1.1 and 1.2 respectively in a schematic form.

Figure 1 therefore shows the main commercial shipping routes observed from the radar survey, indicating the width of each route. These accord very closely with the views of the deep-sea pilots and the ship masters. Route 9 is clearly taken as the major East Coast route for ships up to approximately 12·5 m draught. If entering or leaving the Humber from that route, Route 5 is then taken. Route 10 is followed by large vessels (over 12·5 m draught) as an alternative East Coast route. Other deep-draughted vessels will take the prescribed North Sea deep-water routes passing to seaward of the area. If bound for the Humber, these vessels will enter or depart on Routes 4 or 5.

Lateral distribution of traffic. Figure 1 also shows a number of 'gates' drawn across each route at which the distribution of traffic across the route has been separately assessed.

Appendix 2 shows histograms of the various tracks across the various 'gates'

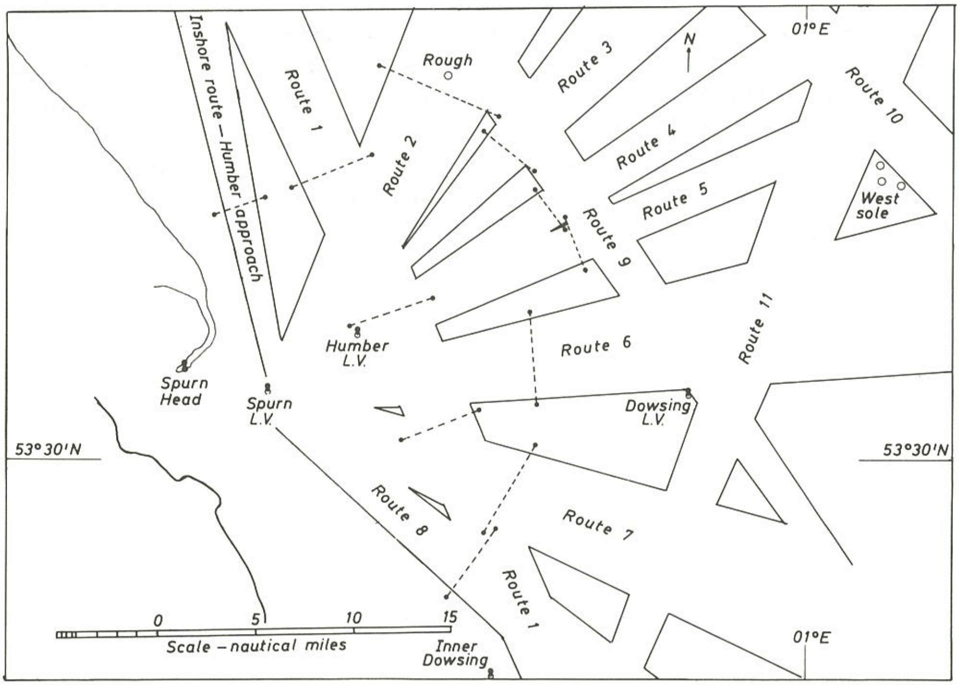

Fig. 1. Southern Sector commercial shipping routes

TABLE 1. STANDARD DEVIATION PER ROUTE

Route no.	SD (n.m)	Nav. width of route (n.m.)
Inshore route	0·38	1·8
1 north	1·44	3·5
1 centre	1·25	3·5
1 south	1·58	3·5
2	2·01	5·2
3	0·78	2·5
4	0·90	2·5
5	0·34	2·0
6	1·22	4·0
7	1·40	4·3
8	1·04	3·0

established within the traffic survey area, indicating also the route boundaries. Each block across the 'gates' is 0·25 n.m. wide, reflecting the limits of the radar plotting accuracy.

An analysis of these shows a good fit to a normal distribution, based on 163 observations used. Table 1 below shows the standard deviations calculated from a normal distribution, against each route observed and the navigational width of the route.

The relationship between the standard deviation and the observed navigational width of each route is virtually a straight-line relationship, as shown in Fig. 2. Similar conclusions regarding a normal distribution across navigation routes has been suggested from other work on traffic in the North Sea,[1] although it has been impossible to analyse that information in the same manner as above.

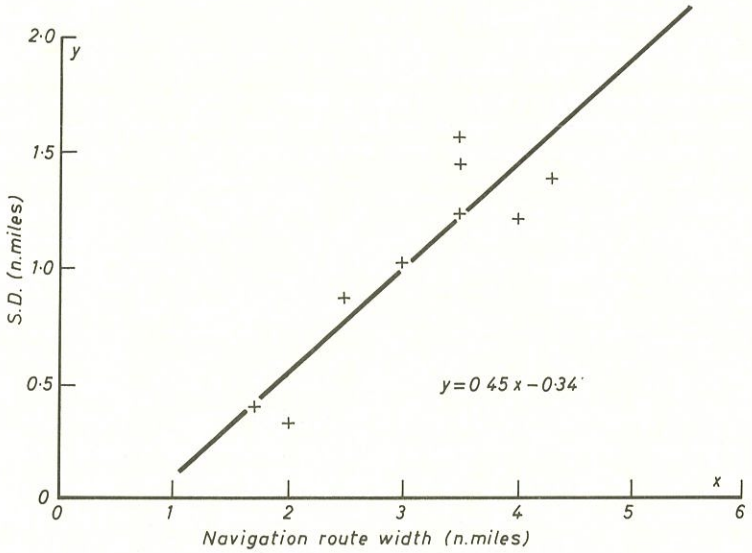

Fig. 2. Relationship between standard deviation and navigational width

Other work considered has been that concerned with the navigation route in a narrow port approach fairway,[2] and where offshore installations have provided navigational markers or traffic separation areas within a navigation route.[3] In both these cases, traffic showed a tendency to keep to the right-hand side of the route, leaving the centre of the fairway relatively clear.

This tendency to keep to the right of the centre-line of a fairway, in accordance with the normal practice of seamanship, was detected in all the nine routes observed. One exception, however, was in the inshore Humber approach, where the tendency was reversed. This could, however, be explained by the fact that inward-bound ships would close the land more gradually, while the outward-bound ships, having just cleared the Humber estuary, would be more certain of their position.

Prediction of traffic distribution. From the observed relationships between the standard deviations around a normal distribution and the navigation widths of the routes, it is reasonable to predict the traffic distribution on other routes, if the route width is known. The other routes of concern, due to their proximity to the offshore installations, are Routes 9, 10 and 11 and these are discussed below. The range of radar observations was insufficient unfortunately to observe traffic on these routes. Thus, in the absence of any other observations, some prediction will need to be made.

Route 9 is of major significance, as the main UK East Coast shipping route

TABLE 2. SOUTHERN SECTOR SHIPPING ROUTES

Route no.	Origin/Destination	Annual ship numbers
1	Minor East-coast traffic	8 000–12 000
2	Humber ports/Norway	500–800
3	Humber ports/Scandinavia	2 000–3 000
4	Humber ports/Baltic	3 000–4 000
5	Humber ports/Dutch, Belgian, Elbe	2 000–3 000
6	Humber ports/Belgian, Elbe, Dutch, Denmark	2 500–3 000
7	Humber ports/Points south, Belgian, Dutch	3 700–5 000
8	Humber and minor East-coast traffic/Points south, Belgian, Dutch	2 800–3 800
9	Main U.K. East-coast route	12 000–24 000
10	Deep-draught U.K. East-coast route	1 000–2 400
11	Wash ports/Scandinavia, Baltic, Elbe	2 000–3 000
	Total population range	40 000–70 500

used by ships of up to 12·5 m draught. In the absence of radar coverage of this route, the views of mariners were sought, indicating a maximum route width of 3 n.m. in the area adjacent to the Rough gas field. This equates with the available distance between passing to seaward of the Dowsing light-vessel on route to a position off Flamborough Head and the shallow waters of the Dowsing Shoals. From the observations made on other routes, it may be reasonably assumed that there is also a normal distribution across Route 9. From Fig. 2, the standard deviation around the distribution is expected to be 1·0.

Route 10 is the major East Coast route for large ships in excess of 12·5 m draught and is the route usually taken by piloted ships through the shoal areas further south. This passes to seaward of the West Sole installations en route for a position off Flamborough Head and points north. The width of this route is expected to be in the order of 3·5 n.m. in the area adjacent to the West Sole field. Again, assuming a normal distribution of traffic from Fig. 2, the standard deviation around that distribution is expected to be 1·25.

Route 11 is used by small ships between the Wash ports and Scandinavia and the Baltic. These ships will not be constrained by shoal depths in the vicinity of the West Sole field and the width of route is likely to fan out to seaward of the Dowsing Light Vessel. It is, however, considered that the route boundary will be defined to the west by a course line from the Wash passing to seaward of the Dowsing Light Vessel and to the east by a preference to pass north of the West Sole field as being the more direct route. On this basis, the navigational width of the route adjacent to the West Sole field should be in the order of 4 n.m. From Fig. 2, the standard deviation around a normal distribution across the route will be 1·45.

Traffic densities. From the data sources referred to earlier in this section, Table 2 has been derived to show the estimate of annual ship numbers on a per route basis, as shown in Fig. 1. While the sample size of observed ships is too small in itself for validation of the estimated shipping numbers, it is encouraging to note a comparison between the numbers of ships observed and those estimated. During the 50-hour sample period some 170 ships were observed. On those routes shown within the coverage of the radar survey, the range of estimated ship numbers for a similar period is 133–190.

Table 3 shows a breakdown of ship sizes on selected routes adjacent to the gas fields.

Additional sources of data relating to shipping traffic surveys, densities and route widths were sought for correlation purposes, such as reference 4 and 5. Some correlation can be seen with the traffic densities observed by Chalk *et al.* in a survey off the East Anglian coast,[4] and with passing distances off light vessels observed by Goodwin and Kemp.[5]

TABLE 3. BREAKDOWN OF SHIP SIZE ON SELECTED ROUTES (% OF TOTAL SHIPS)

	Ships size category (n.r.t.) as %				
Route	1 (0–499)	2 (500–1499)	3 (1500–4999)	4 (5000–79999)	5 (80000)
2	45	22	21	12	0
9	56	25	15	4	0
10	4	4	10	80	2
11	86	13	1	0	0

4. TRAFFIC IN THE NORTHERN SECTOR. The Northern Sector selected is that area between latitudes 58° N. and 59° 30′ N. and between the Pentland Skerries and longitude 02° E. This area includes the Claymore, Total, Piper and Tartan oil fields.

The location of the oil rigs in this sector is such that a shore-based radar surveillance is not feasible; thus in the absence of radar on the installations or the use of a patrol craft equipped with radar, other information sources have had to be used. Two sources of reported ship positions in the North Sea have therefore been utilized. The first source is that of the position of ships making weather reports to the Meteorological Office and the second is the position of ships using the British Telecom Coast Radio Station at Wick.

Some analysis and collation of data from ships making weather reports has already been undertaken for general traffic-density work in the North Sea, and this data source has been obtained.[6] This concerns the positions only of ships making weather reports for the years 1972–6, and these positions have been plotted on the map of the Northern Sector shown at Appendix 3.

To ascertain some further data on ship locations in the North Sea, the Maritime Radio Services of British Telecom were commissioned to undertake a radio survey from the coast radio station at Wick between 12 and 18 December 1982. The names, origins and destinations of ships working the radio station have been recorded and their positions are shown in Appendix 3 with the positions of weather-reporting ships.

The questionnaire returns from the deep-sea pilots regarding routing included some 32 courses actually taken in this sector of the North Sea, and these have been reproduced at Appendix 3 with the weather and radio-ship positions. The courses shown by the pilots are considered to be particularly relevant as they represent the routes taken on a large number of voyages with a wide range of ships. It should, however, be noted that it is usually the larger ships which avail themselves of the services of a deep-sea pilot.

Finally, these data sources have been combined with the information on ports of origin and destination referred to earlier, and a representation of the main commercial shipping routes through the Northern Sector is shown as Fig. 3.

Lateral distribution of traffic. There is much less information from which to arrive at the width of shipping routes and the distribution of tracks than there is for the Southern Sector. The most reliable data is that from the pilot

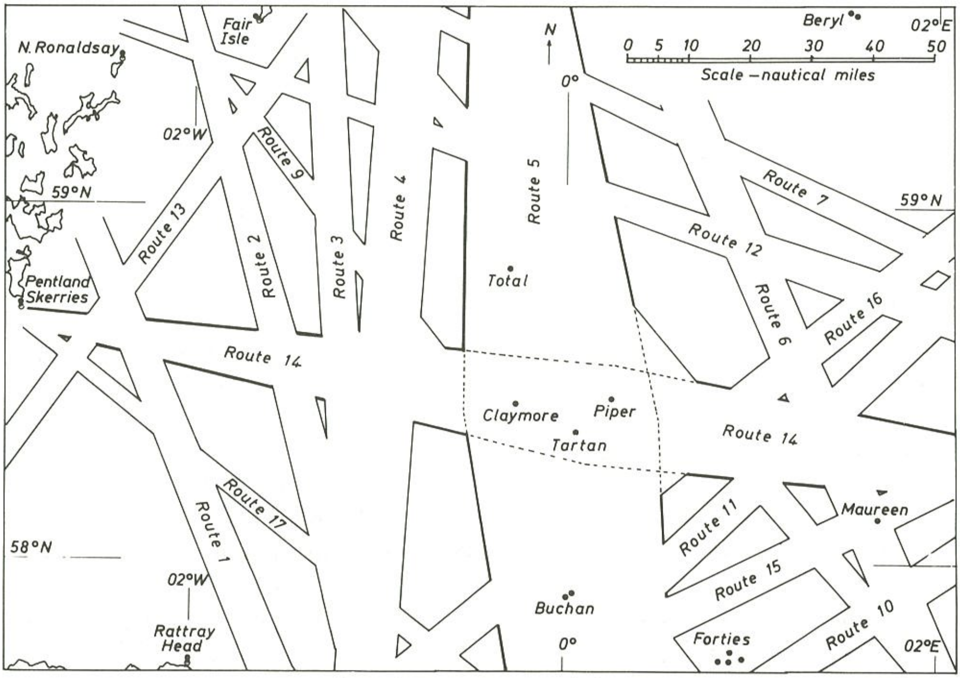

Fig. 3. Northern Sector commercial shipping routes

questionnaires, in which they have given details of their navigational procedures and the courses which they individually use when navigating in the Northern Sector. An important feature is the comment made by all the pilots that besides using radar and Decca they use the oil installations for position-fixing where appropriate.

The routes of greatest interest are the north–south Route 5 and the east–west Route 14. Both these routes pass directly through the area of the oil fields in this sector. Appendix 3 shows the piloted tracks of these two routes. It is clear from the diagram that the oil installations influence the ship tracks and this is particularly evident on Route 5, where all but one of the tracks have a course change in the vicinity of a platform. The purpose of these course changes, which are planned and not accidental, is to take ships outside the oil-field area. The exception is one pilot who preferred to take a route directly through the area. This effect is not so evident on Route 14 as there are only four tracks. However, the most southerly track has a course change in the vicinity of the Tartan field.

It seems therefore that one effect of the oil fields is to widen the navigational route in the immediate area beyond that which would normally occur if there were no obstructions. This effect is greatest on Route 5, where the five fields Total, Claymore, Piper, Tartan and Buchan enclose a larger and wider obstruction area to north–south traffic than the three fields Claymore, Tartan and Piper on the east–west Route 14.

The other important effect which is evident on Route 5 is the tendency for the majority of piloted ships to pass either side of the whole oil-field area with only a minority of ships going straight through. In this respect the Total field to the north and the Buchan field to the south give an impression of route-separating points, the whole elongated field area creating an unofficial traffic-separation scheme. This view is reinforced by two pilots who would pass to the east of Piper north-bound and to the west of Claymore when southbound.

However, it does not seem justified to infer this track-separating effect on Route 14 because of the smaller number of tracks and the more compact field area.

Prediction of traffic distribution. Based on the inference drawn in the previous section from the limited data available for the Northern Sector, estimates can be made of route widths and traffic distributions for Routes 5 and 14 in the vicinity of the oil-field areas. It should be emphasized, however, that the degree of certainty attached to these estimates is lower than for the Southern Sector.

On Route 14 it seems plausible to assume a normal distribution of ship tracks across a fairly wide route. Based on the pilot replies on avoidance distances from the oil rigs and the courses taken, we estimate a navigational route width of 18 n.m. Extrapolating from Fig. 2, this gives a standard deviation of 7·8 n.m.

On Route 5 we consider that the tendency for the tracks to separate around the area should be allowed for. This means splitting the traffic flow into three sub-routes as follows:

5 (*a*) Narrow, relatively dense route east of Piper.

5 (*b*) Broad, less dense route through the area with centre line passing through Tartan.

5 (*c*) Narrow, relatively dense route west of Claymore.

On each of these sub-routes we assume a normal distribution of track spacing.

The estimates of proportion of traffic, route widths and standard deviations are as follows:

Sub-route	Proportion of traffic (%)	Centre-line	Route width (n.m.)	Standard deviation (n.m.)
5 (a)	43	5 n.m. east of Piper	3	1
5 (b)	14	Tartan	10	4
5 (c)	43	5 n.m. west of Claymore	3	1

TABLE 4. NORTHERN SECTOR SHIPPING ROUTES

Route no.	Origin/destination	Annual ship numbers
1	Kirkwall/Peterhead and points south	400–600
2	Sullom Voe (S. of Fair Isle/Peterhead, Aberdeen, Forth Ports, Tyne, Tees, Thames, Eng. Channel ports, Dutch ports, Antwerp	90–130
3	Lerwick/Aberdeen and Sullom Voe/Forth ports, (West Shetland route)	450–650
4	Sullom Voe/Peterhead, Aberdeen, Forth ports, Tyne/Tees (East Shetland route)	220–330
5	Sullom Voe/Humber ports, Thames, Eng. Channel ports/Dutch ports/Antwerp (East Shetland route) *and* West Shetland route north of Fair Isle	150–220
6	Sullom Voe/Elbe ports (East Shetland route)	40–60
7	Sullom Voe and Atlantic/Baltic ports (West Shetland route)	50–80
8	Sullom Voe/Elbe ports (West Shetland route) north of Fair Isle	20–40
9	Sullom Voe/Elbe ports (West Shetland route) south of Fair Isle *and* Atlantic to Elbe ports	610–920
10	Forth/Stavanger	40–60
11	Forth/Bergen	40–60
12	Atlantic/Baltic ports (south of Fair Isle)	800–1200
13	Sullom Voe/Invergordon	70–100
14	Pentland Firth/Baltic *and* Flotta–Baltic	2900–4400
15	Aberdeen/Stavanger	40–60
16	Aberdeen/Bergen	40–60
17	Atlantic/Elbe ports	200–400
	Total population range	6160–9370

Traffic densities. Table 4 shows the estimate of annual ship numbers on a per-route basis, as indicated in Fig. 2.

Table 5 shows a breakdown of ship sizes on selected routes adjacent to the oil fields.

Again, other data sources were examined for the purposes of correlation, but there were fewer of relevance than for the Southern Sector. Work on route locations at U.W.I.S.T.[7] shows agreement with Routes 5, 7 and 14, and traffic surveys on the Netherlands sector of the continental shelf[3] showed traffic routes diverging around offshore installations.

5. CONCLUDING REMARKS. While a study of this nature does not in itself lead to specific conclusions, the survey has shown, at least in these two sectors of the North Sea, that shipping does move along definable routes in open sea areas with a regular and discernible pattern. The authors further believe that this approach to traffic surveys provides sufficient detail of traffic movements for an initial identification of those offshore oil and gas fields likely to be within or adjacent to the major shipping routes.

The full assessment of risk for an individual structure being struck by a passing

TABLE 5. BREAKDOWN OF SHIP SIZES ON SELECTED ROUTES (% OF TOTAL SHIPS)

	Ships size category (n.r.t.) as %				
Route	1 (0–499)	2 (500–1499)	3 (1500–4999)	4 (5000–79999)	5 (80000)
5	4	1	1	90	4
9	0	1	60	37	2
14	5	15	54	25	1

ship would, however, require a more detailed 'on site' survey where a survey such as described in this paper indicates its proximity to a main shipping route.

A further aspect to consider in the behaviour of shipping movements in the vicinity of offshore installations is that concerning the human factor. This is being considered, in terms of the incidence of human error leading to a ship/platform collision, as a further input to a risk assessment model. It is hoped that his work may be presented in a future edition of this *Journal*.

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(My Pyman is with Technica Ltd, Mr Lyon with Eagle, Lyon, Pope Associates and Mr Rowe May, a former deep-sea pilot, is a consultant.)

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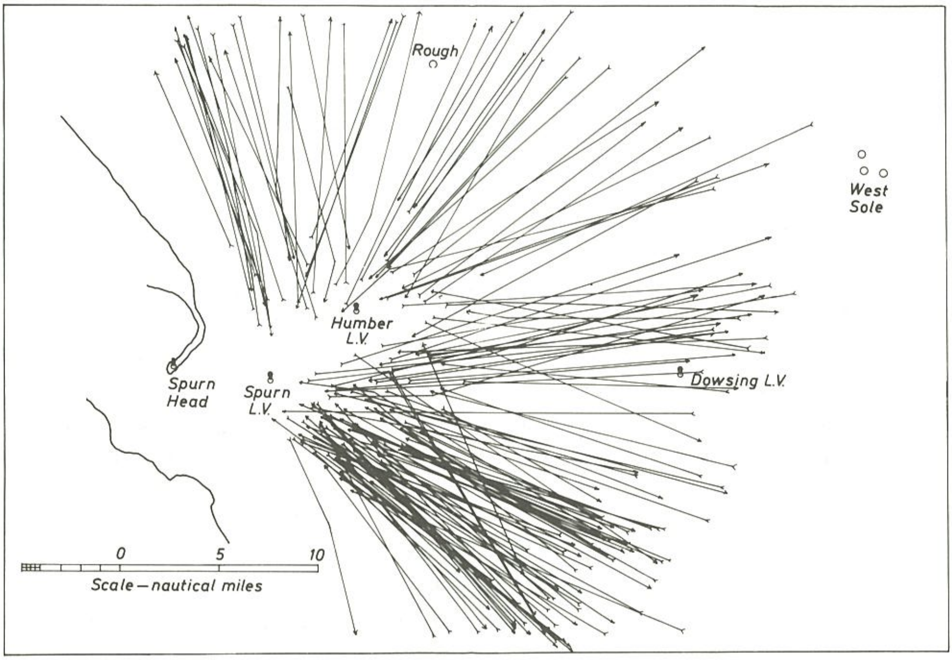
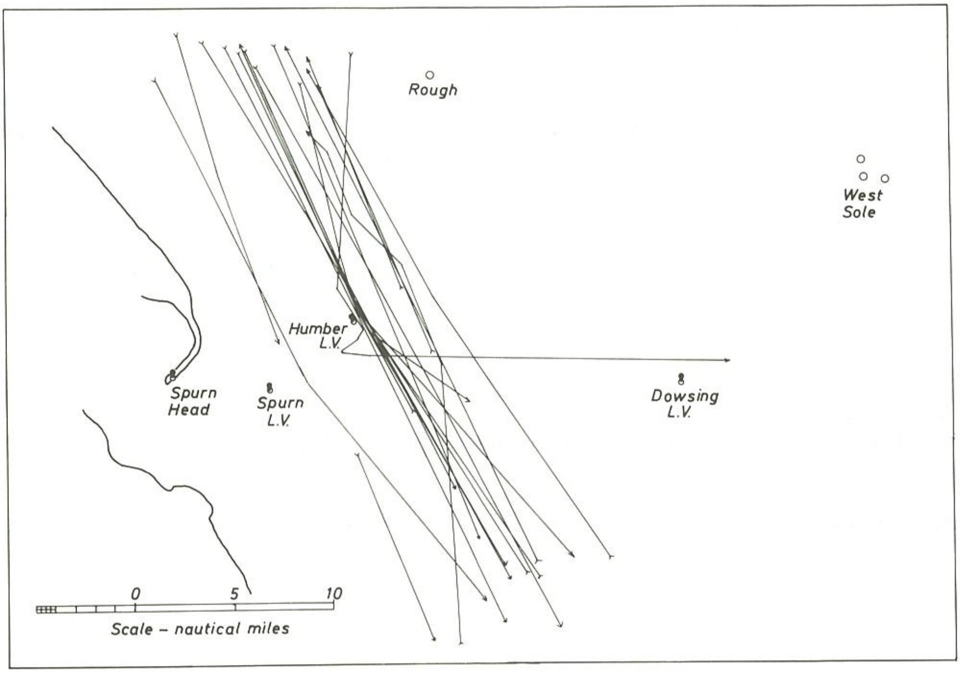
Appendix 1



Appendix 2



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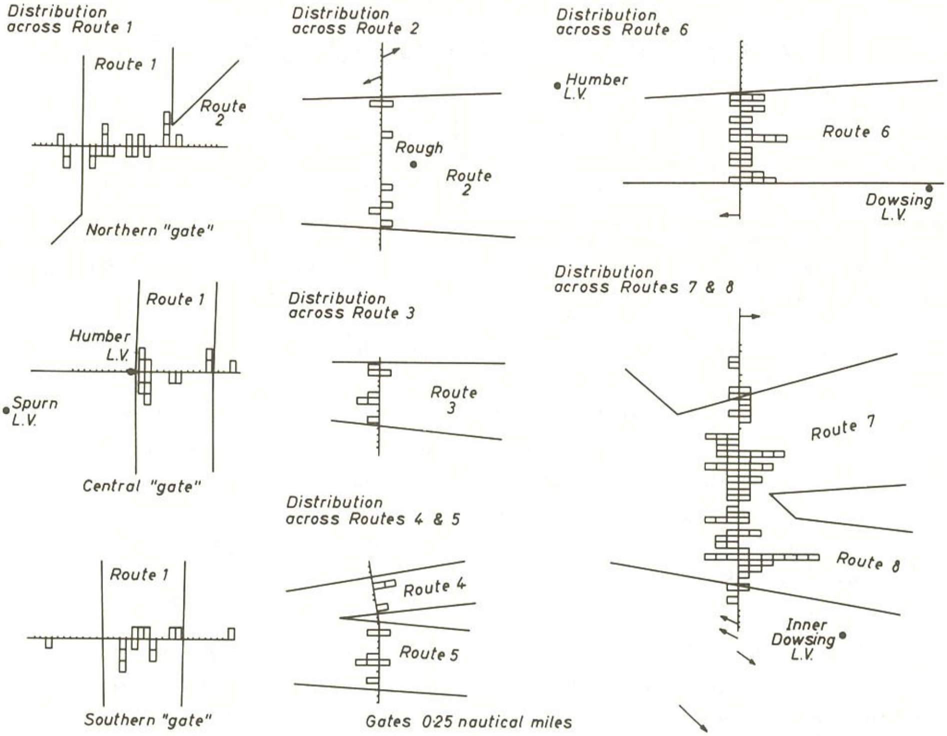
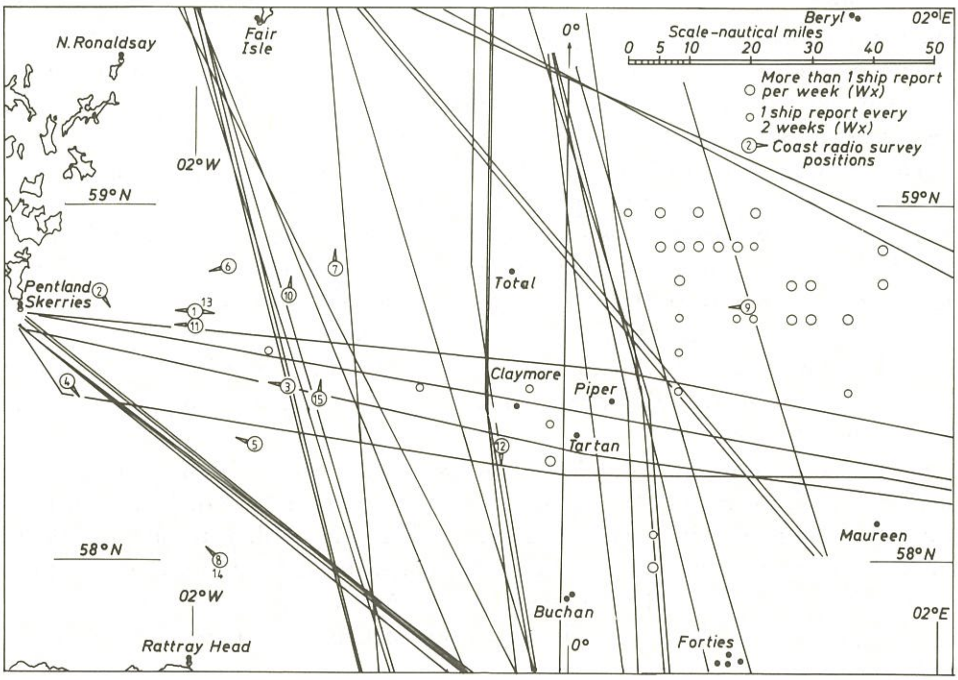


Appendix 4



Dynamic Positioning Systems

J. J. S. Daniel

(Hollobone, Hibbert and Associates)

The purpose of this paper, which was presented at a joint meeting held in London with the Nautical Institute on 1 December 1983, is to give an account of the development of Dynamic Positioning from its inception to the present day, a simple description of the principles on which it works, and makes some predictions about its future.

1. HISTORY. Dynamic Positioning (DP) has been defined in various ways. For the purpose of this paper it will be defined as 'The ability to hold a vessel in its desired position automatically without the use of physical restraints.' Physical restraints are ropes, cables, anchors or any other items which connect the vessel to the bottom or to a fixed structure, be it an offshore installation or quay. The word 'automatically' means that manoeuvring control must be achieved without manual input.

The first dynamically positioned vessels appeared in the early 1960s. They were designed for coring, cable laying or surface support of underwater work. Table 1 lists the early vessels and gives characteristics of various elements of the DP systems. The first four used analog computers but since then almost all DP computers have been digital. In none was there redundancy in computers; this was to follow. However, the main types of position reference sensors, used to this day, all made their first appearance among these vessels. Perhaps the best known of the vessels listed is *Glomar Challenger*, which successfully gathered core samples from many parts of the world to depths of 20 000 ft. None of the vessels listed was British; most were American.

The relative success of the DP systems in some of these vessels led to the building of several DP drill-ships in the early 1970s. The DP systems allowed them to drill in waters too deep for ease of anchoring. Lessons learnt in the early vessels were incorporated in them, giving them improved reliability, so that in due course the chief restriction to the depth at which drilling could be undertaken became the design of suitable marine risers. These vessels were built for US, Italian and French owners with DP computers produced in the US and France. The first British DP vessel was the coring vessel *Wimpey Sealab*, equipped with an American DP computer.

Throughout the first half of the 1970s, coring and drilling provided the principal applications of DP. However, by the mid-1970s North Sea offshore oilfield development had reached a stage where the ability to support deep, saturation diving operations from a vessel which did not suffer the restrictions of an anchor spread offered obvious advantages. And so the first DP diving support vessels appeared on the scenes. These vessels incorporated knowledge acquired during DP drilling; however, commercial pressures acted against expending more