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Allocation of Attention by Fishing Vessel Watchkeepers

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This study examines the way in which attention is allocated by watchkeepers on fishing vessels and identifies differences in the approach displayed by individuals with different levels of training and experience. A method of analysing the way in which attention is allocated on a sample of UK fishing vessels is described. It was found that both skippers and mates allocated disproportionate amounts of attention to fishfinding equipment at certain stages of the fishing trip, while crewmen were heavily reliant upon the track plotter both while fishing and on passage. Those with more training and experience appeared to treat the array of navigation and control components as an integrated system, while untrained crewmen dealt with each aspect in isolation.

KEY WORDS

1. watchkeeping, 2. fishing vessels, 3. attention allocation.

1. INTRODUCTION.

Human error may be the prime cause of fishing vessel collision and grounding losses. With this in mind, it is a worthwhile exercise to examine the human factors situation that prevails during the watchkeeping process on fishing boats, particularly the way in which attention is allocated. The scientific ideal of being able to change input variables, observe what happens then repeat until reliability is established is impossible to attain in a study involving fishermen and their vessels while at work. Conversely, the environment in this actual situation cannot be realistically simulated in laboratory studies, for in the laboratory the objective of the task tends to be too well-defined with low risk, and the subject often finishes up being controlled by the task rather than the other way round. The value of this study is that the data have been generated *in situ*, during observation on board working fishing vessels.

Taylor (1991), talking of merchant vessels, suggests that visual inspection of the horizon and radar screen is the basic and most common activity of the watchkeeper, although this is punctuated by other tasks and long periods of apparent inactivity. However, while the objective of a merchant vessel at sea will normally be straightforward, i.e. to make a safe and speedy passage from point A to point B, the skipper of a fishing boat must address a number of requirements, which can be summarised as;

- *safe navigation from port to fishing grounds and back again, with consideration of passage time and fuel economy*

- *control of the vessel during location of target species aggregations, often requiring simultaneous use of sophisticated electronic equipment*
- *manoeuvring of the vessel while deploying, operating and recovering fishing gear in a manner that prevents damage to the gear, injury to crewmen and fastening upon seabed obstructions*

Once fishing operations commence, the watchkeeper will often be alone in the wheelhouse and in addition to the above, his responsibilities may expand to embrace detailed seabed navigation, ship to ship and ship to shore communications and administrative work attached to compliance with fisheries regulations.

A study of safety on Dutch beam trawlers by Veenstra & Stoop (1992) includes cursory mention of the frequency of observation and operation of wheelhouse equipment. These authors agree with common anecdote in suggesting that navigation-related tasks, particularly the keeping of a good lookout, are progressively neglected as the fishing-related workload increases. There are certain times during the fishing trip that it may be appropriate to treat fishing vessel watchkeeping as a stochastic process, i.e. one in which the watchkeeper can be described as being unequivocally devoted to visual inspection or not. However the binary simplicity of this approach means that it cannot form the basis of more comprehensive analysis of watchkeeping behaviour. Because of the convoluted nature of the fishing watchkeeper's duties, an observation programme must record the circumstances that prevail during the watchkeeping process, rather than highlight individuals making specific errors that might contribute to the loss of the vessel.

The aim of this study was to analyse how the fishing watchkeeper allocates attention during the different phases of the fishing trip and to assess whether there are significant differences between skippers, mates and crewmen in this respect; the relevance of this latter point being that these designations generally indicate given levels of formal training.

2. METHODS.

Numerous biotic and abiotic factors can intrude upon the fishing vessel watchkeeper's approach to his work and influence his performance. With the object of fostering what Chapanis (1988) calls, "generalisability", a concerted effort was made to standardise the prevailing circumstances by carrying out observations only when certain criteria had been met. These were:

- *wind strength < Beaufort force 5*
- *visibility no worse than moderate to good*
- *no serious equipment defects that would radically alter the usual watchkeeping system*

It was also very important that the behaviour of each subject under observation was in accord with that which would be displayed in normal conditions. To this end, subjects were given time to acclimate to the presence of the observer and were never informed whether the procedures they were following were either "good" or "bad". Their behaviours and activities were simply accepted. Subjects were not shown the results of any observations until after the fishing trip had ended. Before the fishing trip started, it was clearly explained to all involved that the safe navigation of the vessel and the safety of the crew should take absolute

Table 1. Details of the vessels used in observations at sea.

	vessel 1 beam trawler	vessel 2 otter trawler	vessel 3 pair seiner
length	18 metres	22 metres	24 metres
date and type of construction	1982, steel	1974, steel	1989, wood
engine power	460 hp	500 hp	670 hp
area of operation	Scottish West Coast	Northern North Sea	Central North Sea
complement	5 men at sea, 1 man ashore (rotation system)	5 men	6 men plus part-time ship's husband ashore
skipper details	Class 2 fishing ticket held for 19 years	Class 1 fishing ticket held for 9 years	Class 1 fishing ticket held for 26 years
mate details	Class 2 Fishing Ticket, held for 1 year	Class 2 Fishing Ticket, held for 1 year	Class 1 Fishing Ticket, held for 5 years
crew details (watchkeepers only)	no other relevant qualifications	no other relevant qualifications	1 × class 2 fishing engineer ticket
length of observation trip	4 days (first half of trip)	3 days (first half of trip)	6 days (whole trip)

priority over the observation, particularly where secondary task measures were being employed.

Observations were made on board three British fishing boats, the essential details of which are shown in Table 1. These boats were each pursuing a different method of fishing and between them, these methods account for about 80% of the fishing activity of the British fleet.

The vessels all had a broadly similar rotational system for the allocation of watchkeeping duty with only minor variations. The skippers were not included in the rotas since they took control of the vessel when leaving and entering port, during deployment and recovery of the fishing gear and for a substantial component of the time during which the fishing gear was being towed across the seabed, especially while the crew were cleaning and gutting the catch on deck. Steaming and fishing watches were nominally of two hours duration but for a variety of reasons, some logical and others arcane, they were frequently curtailed or extended. Although the fishermen themselves viewed this watchkeeping regime as being ordered and logical, an outsider might regard it as *ad hoc*, particularly when compared to the standard UK merchant navy four-hour watch system. This system is fairly typical of that used in much of the UK demersal fishing fleet, save for some of the larger beam trawlers which operate a rota allowing for each member of the crew to have six hours unbroken rest during each day. A specific system for paired watches exists mainly on the larger vessels (over 24 metres) with more crew available and where it is often necessary to have extra personnel for fishing related tasks such as sonar monitoring while searching for fish shoals.

On all three vessels involved in this study, watchkeepers were generally on duty alone. Questionnaire data derived by the author indicate that 63% of watches on British fishing boats are taken by lone watchkeepers though interview responses to the same question suggest that this figure may much greater. Not every crewmember on the vessels involved here was an active watchkeeper; the cooks on both of the larger vessels did not take navigational watches although they did temporarily relieve whoever was on watch during mealtimes. On the mid-sized vessel, the skipper and mate shared the bulk of the watchkeeping during the time the vessel was fishing.

The range of seagoing experience among crews was wide, from four months to 49 years and although the majority had been fishermen for all of their working lives, a number had spent time in employment other than fishing at some time. All three vessels were well found and carried more than mininum required safety equipment. By agreement with all involved, including the owners, skippers and crews, neither the boats nor the experimental subjects are referred to by name.

Heinrich (1988) attempted to observe the behaviour of watchkeepers aboard a Dutch beam trawler and noted a number of problems that arose.

- *observing in darkness was difficult*
- *fatigue and seasickness experienced by the observer affected the quality of observations*
- *watchkeeper behaviour can be changed by the knowledge that he is being observed*
- *some items of equipment are monitored peripherally and can be difficult to perceive when this is happening*
- *groups of instruments may be observed in a "sweeping" action*

Some of these factors are extremely difficult to overcome in any programme of work involving watchkeepers in their working environment but the insidious effects of most can be mitigated by judicious selection of vessels used and careful consideration being given to experimental design. The most notable problem that was faced in the present work corresponds with the last in Heinrich's list where the watchkeeper made a visual sweep of the wheelhouse equipment displays. Dealing with this called for some degree of subjective analysis on the part of the observer in allocating equal proportions of time to each of the items that could be viewed during the sweep.

Another problem arose in deciding when the watchkeeper was not allocating attention to any of the listed navigational tasks and equipment. Some "distraction" activities such as reading a book or newspaper were straightforward and easy for the observer to discern. Others, for example simply staring at the wheelhouse floor, were more difficult to perceive and relied on the observer's judgement. Results presented in this section are derived from 112 blocks of observation by the same observer, taken over three fishing trips on different vessels. It is proposed that the reliability of the results is thus enhanced by the repetitive nature of this process.

The fact that the observer was himself an experienced fishing skipper helped in dealing with discernment of passive monitoring of position indicating displays, radar screens, depth/fishfinding displays, systems control and monitoring displays and of the traffic situation outside. This feature also helped deal with the potential for the "Hawthorne Effect" (Roethlisberger and Dickson, 1939), which is the tendency for workers to show improvements in efficiency simply as a result of receiving the researcher's attention.

Because the study was carried out on board working fishing vessels, using the kinds of sophisticated human factors monitoring equipment often cited in the ergonomics literature for use in accurately recording indicative variables, such as eye fixation or evoked brain potential, had to be discounted. Instead, a special computer programme was written for the work involving the use of a laptop computer's inherent timing system, which allows up to 16 timers to be running concurrently with accumulated times being recorded. The observer then spent some time training in starting and stopping the timers without visual recourse to the keyboard.

In interviews prior to the observations, fishermen frequently referred to their varied approaches to watchkeeping at different stages of the fishing cycle. Accordingly, three axiomatic phases were identified and treated as discrete in this study. They are:

- *steaming, i.e. on passage to and from port and between fishing grounds*;
- *while actually fishing*; and
- *during shooting and hauling of fishing gear*.

The mean observed percentage allocation of attention by watchkeepers on the three vessels was recorded during each of these phases. Each of the vessels used in the study had been specially chosen from an available pool of vessels because its wheelhouse layout was such that it was readily apparent when the watchkeeper was directing his attention to certain important individual components of the navigation and fishing systems. For example, because times spent monitoring or dealing with the navigation system (GPS receivers, chart table) and the track plotter were recorded separately, these had to be physically sited far enough apart in the wheelhouse that it would be obvious which of the two was being scrutinised at any one time.

At the start of the observation programme, watchkeepers were briefed in respect of the purpose of the work and it was explained that all data were confidential, with no names being attached to any of the database recordings. Subjects were also told that the observer would be very busy with his own activities and would not be able to engage in conversation, or to assist or take any part in the watchkeeping process in any way. They were not informed that the observer was himself an experienced fishing skipper.

Because of the intensity of concentration that was demanded of the observer in the observation process, the recordings were made in blocks lasting five minutes. Blocks were recorded during a watch whenever it was practicable, so long as the situation met the general experimental criteria. Ten components were common to the navigation systems in all three vessels in the study. These were:

- *looking out of wheelhouse windows*
- *checking radar display*(*s*)
- *reference to navigation system* (*receivers, charts, etc*)
- *track plotter*
- *echosounder/sonar*
- *internal communication* (*includes viewing closed circuit TV display*)
- *external communication* (*ship to ship/ship to shore*)
- *control systems* (*engine, winches, hydraulics, etc*)
- *administration/other duties*
- *absent/incapacitated*

The observation would proceed as follows; the observer would site himself in one of the rear corners of the wheelhouse where he was to the side of and slightly behind the watchkeeper. The observer would then spend some time getting used to the watchkeeper's general approach, noting behavioural idiosyncracies and asking questions where necessary to assist in differentiating between various activities. When the observer was satisfied that the watchkeeper was pursuing the watch as he

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Table 2. Comparison of percentage allocation of attention between watchkeeper ranks during phases of the fishing cycle.

	SKIPPERS			MATES		CREWMEN	
	steaming	fishing	shoot/haul	steaming	fishing	steaming	fishing
Echosounder/sonar	12·56	28·95	24·04	18·83	9·96	5·88	5·31
Look out of windows	7·79	10·03	35·52	11·45	14·95	9·25	7·53
external comms	0	18·93	17·2	0	2·81	0	0
track plotter	6·21	9·49	23·88	16·78	18·07	20·64	23·23
navigation system	10·28	10·33	15·67	6·48	3·11	0·20	0
control systems	4·97	2·35	23·62	1·79	3·56	5·08	4·32
admin/other duties	0	13·03	5·38	4·04	1·23	1·0	3·04
internal comms	0	0	25·72	0	0	1·21	3·79
radar	6·74	7·01	7·39	13·25	7·08	8·16	6·69
absent	3·87	0	6·02	1·72	0	0	0

normally would, five minute blocks of observation would be carried out. The watchkeeper was not told when the block had either started or ended. On the few occasions where a watchkeeper suddenly became aware that an observation block was in progress, and instituted an obvious change in behaviour, that block was discounted from the final data set. During the hours of darkness, it was possible to discern the activity of the watchkeeper in the light that was shed from the range of video screens (echosounder, plotter, radar, navigation system, sonar) in the wheelhouse.

3. RESULTS.

The time allocation database was transferred to the Microsoft Excel spreadsheet computer program and segregated into recordings for skippers, mates and crewmen with sub-divisions for when watches pertained to either steaming, fishing or shooting/hauling. The relevant blocks were then integrated and related to the total amount of time covered and expressed as percentages of time for which attention had been allocated, by watchkeeper rank and operational status. The results are shown in composite form in Table 2. To clarify the information in this table; while the vessel is steaming the skipper, for example, will on average allocate 12·56% of his attention to the echosounder (note: the columns may add to give more or less than 100 dependent upon attention being given to observed tasks. During shooting/hauling, skippers were often giving attention to more than one component at the same time).

While statistical techniques such as the *t*-test will test the significance of different levels of attention allocation between each phase of the fishing trip, a histogram display of results is more effective in illustrating the patterns displayed by the different ranks. The reader's attention is however drawn to the differences in the y-axis scales between each of the displays.

3.1. *Skippers.* When skippers were on watch while the vessel was steaming, they showed a tendency to spend relatively large amounts of time giving attention to the displays of information from the vessel's acoustic systems – echosounder and sonar, where these were fitted and in operation. Each of the skippers became preoccupied

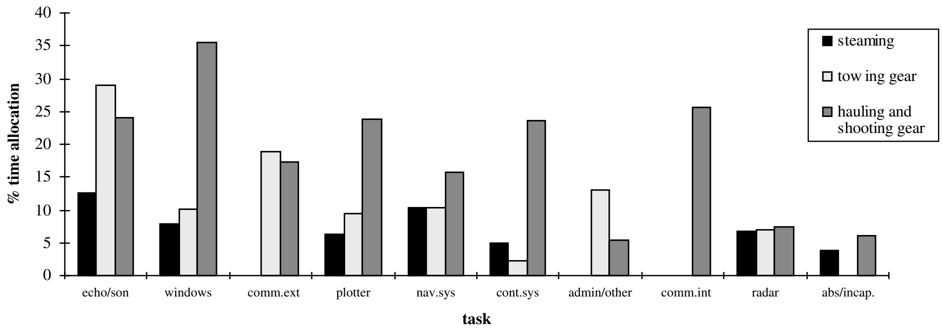

Figure 1. Comparison of mean time allocation to navigational tasks by skippers during different stages of the fishing trip.

with the navigation system from time to time and "fiddled around" with the signal receiver and display quite frequently, although this must be qualified by saying that some of the observations were made when the skipper had recently taken over from a previous watchkeeper and the vessel was soon to begin fishing. When the vessel was fishing, the skippers spent considerably more time engaged in external communications, mostly with other fishing vessels though they had allocated no time at all to this activity during steaming.

Looking out of the windows was the most frequent activity during shooting and hauling of fishing gear although this was not directly a navigational activity since the skipper was preoccupied with the deployment and recovery of the fishing gear rather than looking out for other traffic or navigational hazards. As might also be expected, the allocation of attention to vessel control systems during shooting and hauling was also exaggerated. The level of attention to the radar display was roughly even regardless of the vessel status. Figure 1 displays the time allocation to tasks by skippers.

3.2. *Mates.* No observations were made of mates during shooting and hauling operations. This was because, during the fishing trips on the vessels concerned, the skipper was on watch during this phase on every occasion that observations could feasibly have been pursued.

The pattern of attention allocation to the echosounder or sonar exhibited by the three mates observed was puzzling in that they spent more time watching these displays while the vessel was steaming than while it was fishing. They spent almost twice as much of their time looking out of the wheelhouse windows during steaming watches as the skippers, and three times as much as the crewmen. There was however little difference between the three when it came to proportions of time allocated to the radar display during the steaming phase. Mates allocated the greatest proportion of their time to the track plotter during fishing watches. Comparison of percentage attention allocation by mates during different phases is shown in Figure 2.

3.3. *Crewmen.* As with mates, there were no observations of crewmen during shooting and hauling of the fishing gear since the skippers were invariably in the wheelhouse during this time. Crewmen were observed to pay very little direct attention to the navigational positioning system while the vessel was steaming and virtually none at all while fishing. They showed notable devotion to the track plotter screen during both types of watch. See Figure 3.

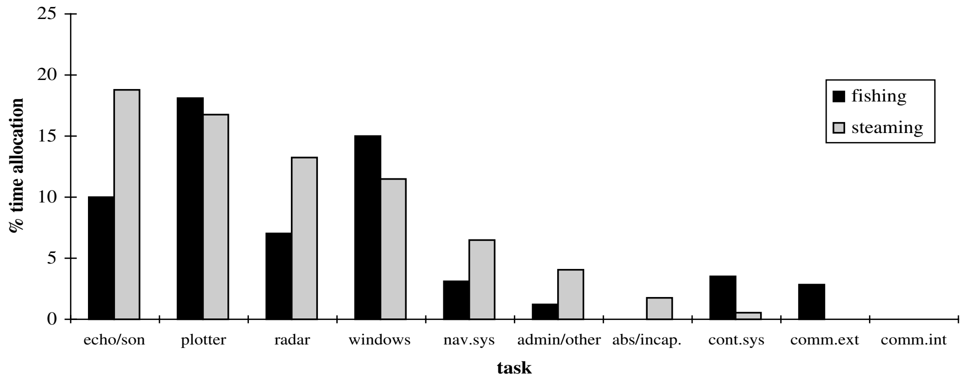

Figure 2. Comparison of mean time allocation to navigational tasks by mates during different stages of the trip.

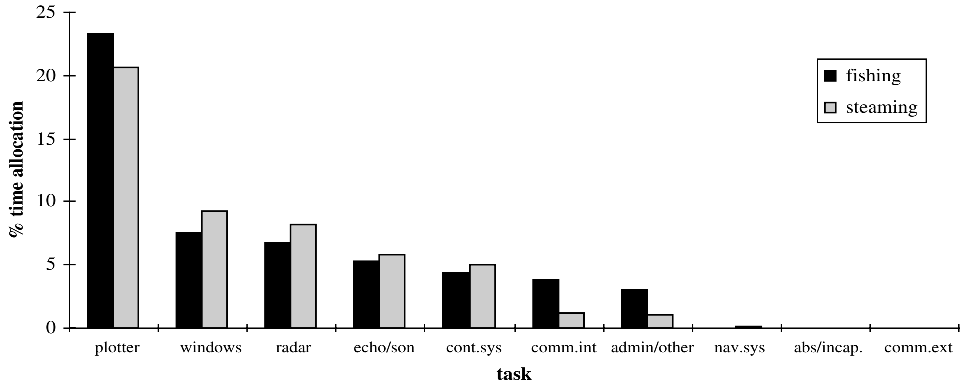

Figure 3. Comparison of mean time allocation to navigational tasks by crewmen during different stages of the trip.

The significance of differences in allocation of attention to navigational equipment at the various stages of the fishing trip was examined using the related *t*-test statistic. The results, on the basis of a one-tailed hypothesis are shown in Table 3. Data for skippers show significant differences between each of the three possible states with the greatest difference in allocation of attention occurring between the periods when they were on watch during steaming and while the fishing gear was being deployed and recovered. Mates and crewmen showed no significant difference in the way they distributed their attention while on watch during either steaming or fishing.

4. DISCUSSION. The proportions of attention allocated to the echosounder/sonar by skippers and mates both while fishing and steaming are notable (15%/26% and 18%/18% respectively). This is perhaps to be expected while the vessel is fishing but is less easily explained during steaming. Although not apparent in the figures presented, which depict mean percentage allocations over the entire trip, the extra attention to the acoustics displays was more pronounced on the way

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Table 3. Results of one-tailed *t* -test to assess significance of differences in allocation of attention to navigational equipment at different stages of the fishing cycle. (n/o = not observed)

	P⩽t		
	Skippers	**Mates**	**Crews**
Fishing cf steaming	0·076	0·345	0·467
Steaming cf hauling/shooting	0·002	n/o	n/o
Fishing cf hauling/shooting	0·031	n/o	n/o

to and between fishing grounds than it was during the homeward voyage. When subjects were asked at the end of the trip why they gave so much attention to the echosounder, the unanimous response was that they were always on the lookout for "fish marks", i.e. evidence of fish aggregations. It would appear that giving attention to fishfinding systems is a matter of habituation amongst skippers and mates and that this may even represent an incursion of the fishing task into attention capacity which might otherwise be available for navigation. Moreover a point of interest arises here. Between 1975 and 1996, most UK fishing vessel losses due to grounding occurred towards the end of the week, a time when many were returning to port (Findlay 1998). Given that most fishfinding echosounders also indicate depth changes, it may be that the extra attention allocated when proceeding to the fishing grounds reduces the likelihood of grounding, and *vice versa*.

Probably the most notable and disquieting overall feature of this part of the research was the disproportionate amount of attention allocated to the track plotter by crewmen. MSA Shipping Notice No. M.1649 (MSA, 1996) notes that, " *MAIB investigations have shown over-reliance on the video plotter to be a factor in several collisions and groundings*" and makes the point that assessments and assumptions based on the track plotter are dangerous and unreliable. The M. Notice adds, "*It* (the video plotter) *may aid navigation, but cannot replace the fundamental need to maintain a good visual lookout*". The apparent devotion to the track plotter that was observed is interesting because in questionnaire responses, very few fishermen gave this impression when asked how their vessels were navigated. In a previous study by the author involving a representative sample of 170 UK fishing crewmen, only 27% admitted to navigating using the track plotter (Findlay, 1998). Although testing the degree of actual reliance on any one piece of equipment did not directly form part of this research, it may be inferred that crewmen in particular were heavily reliant upon the track plotter display.

When asked at the end of the fishing trip why they gave so much attention to the track plotter both mates and crewmen tended to respond with the comment that they had been told to "keep her on the line". Both groups were subsequently asked how they knew if the display showing on the track plotter was actually the correct one for the position the vessel was in. The mates said that they did periodically cross check the plotter display with information from the navigation system (GPS) and added that they would in any case "just know" if things were not right, particularly they said, while fishing. Crewmen however, mainly expressed what might best be described as blind faith in the track plotter.

Heinrich (1988) noted that watchkeepers in his study paid particular attention to the autopilot in an effort to ensure that the vessel did not stray from pre-plotted tracks on the track plotter. There was some evidence of this happening in the present programme of observation when crewmen were on watch during fishing, but this was not pronounced. In fact, skippers tended to allocate more attention to vessel control systems than did either mates or crewmen in all three observed phases of the fishing trip. Heinrich also found no significant difference in the way in which wheelhouse instruments were used when the single vessel in his study was in different phases of the fishing cycle. The results of the present work agree with his finding in respect of mates and crewmen but not so far as skippers are concerned. The statistically significant difference in the manner by which attention was allocated by this latter group suggests that they were taking a completely different approach to management of the navigation system at different phases of the fishing cycle.

Shuffel *et al*. (1989) consider the navigation of a vessel as being a "hierarchical control task" in which three approach levels; planning, monitoring and handling can be distinguished. The results of the attention allocation observations show that this principle may have some relevance to the respective approaches of fishing watchkeepers. At the highest level, the skipper (well-qualified and experienced) plans the passage to and from the grounds and the track to be taken while fishing. His attention while on watch is allocated in apparently random fashion as he constantly evaluates alternative fishing strategies, often through radio communication with other skippers. The mate (intermediate level of qualification and experience), operating at the intermediate level of monitoring, cross references the skipper's planned track with information from the acoustic fish-finding equipment and the navigation system. At the lowest level, the crewman (least qualified, though often experienced) on watch simply performs a compensatory tracking task in keeping the virtual vessel shown on the track plotter on its virtual track, even though there is no guarantee that this is a true representation of the prevailing situation.

Each of the tasks that comprise the system of navigating a fishing vessel may be interpreted as being individual "functions" in the context of the statement from Laughery and Laughery, (1987);

> "*A function can be viewed as a logical unit of behaviour of a human or machine component that is necessary to accomplish the mission of the system*"

The skippers, and to a lesser extent, the mates who took part in this study were experienced and highly motivated and this is likely to generally be the case throughout the UK fishing fleet. They appeared to have a fairly solid conceptual picture of the navigating system, including the respective roles of the various items of navigational and control equipment and were for the most part operating on a logical, task-by-task basis in fulfilling the watchkeeping mission. Crewmen on the other hand, especially those with no formal training, although they may have had substantial experience, seemed to view items of equipment in isolation and were therefore faced with a random selection of tasks that had little logical connection. Their response to this situation was to narrow their attention to the track plotter and reduce the watchkeeping brief to a simple tracking function, augmented though not necessarily supported by some scanning for vessels which might pose a threat, by looking out of the windows and occasional viewing of the radar display.

This focus of attention on the track plotter by crewmen may have its explanation in what has become known as the "SRK framework" (Rasmussen, 1986). This model has three distinct levels of task performance – skill based, rule based and knowledge based – each relating to a given level of familiarity with the task and the environment in which it must be accomplished. The lowest level, skill based performance, is based upon pre-programmed instructions and would appear to be where crewmen were operating when they were simply "following the line" on the track plotter. At the intermediate level the mates tackled familiar situations using stored diagnostic rules as well as operating at the skill-based level (i.e. rule based behaviour). The skippers, in addition to these first two levels also operated at the knowledge based level, planning their actions by using conscious analytical processes combined with stored knowledge.

The different attribution of utility to the various navigation tasks may suggest that skippers are using a different set of criteria to decide whether the vessel is in a "safe" situation or not. If this is indeed the case, fishing vessel collision and grounding losses that are clearly attributable to human error need to be analysed using detailed and specific decision theory models.

Although a tempting prospect, it would probably be unwise to attempt to predict the safety of a watchkeeping system on the basis of observed allocation of attention since the *quality* of the attention may be a significant factor. Hopkin (1990) offers the useful analogy of most car drivers having had the disconcerting experience of driving for some distance before suddenly realising that they had not been concentrating on the driving task. In this situation, the lack of concentration may not affect the driving performance enough for a passenger in the car to notice, even though the safety of the car may be seriously compromised.

The sequence in which attention is allocated to various navigational tasks was not recorded in this research. This is something that would undoubtedly warrant attention in any future work in this area since it may at least have some bearing on how fishing vessel wheelhouses should be laid out. If for example it was noted that during fishing, the track plotter was repeatedly monitored immediately after the echosounder, then it might be concluded that the watchkeeper was building a mental picture of the fishing track in at least two dimensions. One might then conclude that it would be ergonomically sensible to site these two displays next to one another or possibly even to integrate the information from the two units into one display.

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